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Nuclear Waste Repository In Basalt - Preconceptual Design Guidelines

Basalt Waste Isolation Program

June 1979

Prepared for the United States
Department of Energy
Under Contract EY-77-C-06-1030

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Rockwell International

**Rockwell Hanford Operations
Energy Systems Group
Richland, WA 99352**

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NUCLEAR WASTE REPOSITORY IN BASALT
PRECONCEPTUAL DESIGN GUIDELINES

June 1979

Prepared by

Staff
Basalt Waste Isolation Program
Rockwell Hanford Operations

with the assistance of

Vitro Engineering Corporation

Prepared for the U.S. Department of Energy
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PREFACE

This report for the Basalt Waste Isolation Program establishes guidelines for preconceptual design for the radioactive waste repository in basalt.

The repository provides the surface facilities, shafts, subsurface facilities, remote handling equipment, and systems required for receiving, inspecting, handling, transporting, storing, and retrieving encapsulated spent fuel and other nuclear waste material in deep underground basalt.

Some key criteria are yet to be established. These have been identified within the text by the initials TBD (To Be Determined). These have been given a numbered identifier to facilitate future resolution (see Appendix C).

The materials that comprise this report are organized into six parts:

Part I	Overall Project;
Part II	Surface Facility;
Part III	Shafts;
Part IV	Subsurface Facilities;
Part V	Remote Handling System;
Part VI	Systems.

It is anticipated that this document will grow as the design develops. Additional detail may be accommodated by developing each part as a separate volume of a system design description.

Supportive information and data on radioactive wastes are included in the appendix.

The repository will provide a means of permanently isolating nuclear waste from the biosphere. The wastes to be isolated include spent fuel assemblies from power reactors and other radioactive wastes. The spent fuel and other radioactive wastes will be sealed in standardized canisters and containers and stored in subsurface storage chambers. The spent fuel will have been stored a minimum of five years after removal from the reactor before receipt at the repository.

Prior to the repository operations, public protection is provided at each early step of the spent fuel disposal process. Reactor containment and subsequent at-reactor-storage facilities (using water pools with off-gas treatment facilities) provide protection for the public. The away-from-reactor-storage facility also uses water pools with off-gas treatment systems.

After a five-year storage, the spent fuel will be sent to an encapsulation or waste packaging plant where it will be packaged for storage. The waste will be packaged in standardized canisters that will be qualified for repository storage* (see frontispiece).

The capsules containing spent fuel or radioactive waste will be delivered to the repository. (Within this document, the name "capsules" is used to signify canisters and containers.)

The deep basalt overburden of the repository will provide isolation of the radioactive materials from the public and the biosphere. The spent fuel and/or radioactive waste will be deposited at a rate that will necessitate basalt excavation and repository expansion to be conducted concurrently with waste storage operations.

*See Report of Task Force for Review of Nuclear Waste Management, (Draft), DOE/ER-0004/D, U.S. Department of Energy, Washington, D.C., Appendix E, pp 55-59, February 1978.

POWER REACTOR

- FULL CORE RESERVE
- 5 YR-STORAGE

AWAY FROM REACTOR

- SEMI-PERMANENT CANISTERS
- 5-20-YR STORAGE

CASKS

CASKS

CANISTER PACKAGING

- STANDARD CANISTER
- PWR FUEL
- BWR FUEL
- OTHER FUEL
- HLW

CANISTERS
IN CASKS

CASKS
AND DAMAGED
CANISTERS

BASALT REPOSITORY

REC/INSP

EXCAVATED
ROCK

FUEL
CANISTER
TRANSPORT

WASTE CONTAINERS

SPENT
FUEL

OTHER
WASTE

Frontispiece

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PART I. OVERALL PROJECT

1.0 SUMMARY AND SCOPE

This section describes the overall repository functions and the preconceptual design criteria which relate to the facilities, services, and operations that comprise the basalt repository for the Basalt Waste Isolation Program.

The development of this program parallels the growing need for permanent, environmentally safe, and secure means to store nuclear wastes. The repository shall be located within the Columbia Plateau basalt formations where these ends can be met and radiological waste can be stored. These wastes will be stored such that the wastes may be retrieved from storage for a period after placement. After the retrieval period, the storage locations will be prepared for terminal storage. The terminal storage requirements will include decommissioning provisions.

The facility boundaries will encompass no more than several square miles of land which will be above a subsurface area where the geologic makeup is primarily deep basaltic rock.

The repository will receive, from an encapsulation site(s), nuclear waste in the form of canisters (not more than 18.5 feet x 16 inches in diameter) and containers (55-gallon drums). Canisters will contain spent fuel (after an interim 5-year storage period), solidified high-level wastes (HLW), or intermediate-level wastes (ILW). The containers (drums) will package the low-level transuranic wastes (LL-TRU). The storage capacity of the repository will be expanded in a time-phased program which will require that subsurface development (repository expansion) be conducted concurrently with waste storage operations. The repository will be designed to store the nuclear waste generated within the predictable future and to allow for reasonable expansion.

The development and assurance of safe waste isolation is of paramount importance. All activities shall be dedicated to the protection of public health and the environment. The repository shall be licensed by the U. S. Nuclear Regulatory Commission (NRC). Extensive efforts will be made to assure selection of a suitable site which will provide adequate isolation.

The repository program shall be implemented by dividing the efforts into five major systems: surface facilities; shafts; subsurface facilities; remote handling; and systems.

1.1 OVERALL FUNCTIONS

The principal function of the radioactive waste repository is to provide the capability for long-term isolation watch from the biosphere of commercial transuranic and highly radioactive nuclear waste generated in the United States to the year 2010. The design shall include provisions for expansion. Nuclear waste forms requiring isolation include these solid waste capsules:

- . Canisters containing spent fuel assemblies from boiling water reactors (BWR), pressurized water reactors (PWR), and other types of reactors;
- . Canisters containing solidified HLW from nuclear facilities;
- . Canisters of solid ILW such as cladding waste and transuranic waste from nuclear facilities;
- . Containers of solidified LL-TRU from nuclear facilities.

The reference characteristics for the solid waste capsules listed above are summarized in Tables I-1 and I-2. Two capsule types will be received. The first type will be a canister with maximum dimensions of 16-inch. Outside diameter and 18.5 feet long, and the second will be a container with dimensions of 22.5-inch diameter and 2.92 feet long (55-gallon drum).

Table I-1. Incoming Waste Thermal and Radioactivity Characteristics
Spent Fuel*

<u>Contents</u>	<u>Thermal Power** (kW/capsule)</u>	<u>Radioactivity** in MegaCuries (MCi/capsule)</u>
Three BWR Assemblies	0.975	0.26
One PWR Assembly	1	0.27
Other Assemblies	TBD	TBD

*Spent Fuel Handling and Packaging Program, TC-1076, Hanford Engineering Development Laboratory, Richland, Washington, April 1978.

**These values are based on the assumptions that the waste is aged 5 years after discharge from a reactor before being received at the repository, and that the average fuel burnup is 33,000 megawatt days per metric ton of heavy metal (MWD/MTHM) for PWR reactors and is 28,000 MWD/MTHM for BWR reactors.

Table I-2. Incoming Waste Thermal and Radioactivity Characteristics
Radiological Waste*

<u>Contents</u>	<u>Thermal Power (watts/capsule) reference/maximum</u>	<u>Radioactivity in kilocuries per capsule reference/maximum</u>
HL Waste	1,960/TBD	560/TBD
Cladding Waste	50/TBD	8.8/TBD
IL-TRU Waste	0.30/TBD	0.09/TBD
LL-TRU Waste	0.21/TBD	2E-9/TBD

*Figures are derived from information presented in Section 6 of Appendix A and the Nuclear Waste Projections and Source Term Data for FY 1977, Office of Waste Isolation, Union Carbide Corporation, Oak Ridge, Tennessee, Y/OWI/TM-34, April 26, 1978.

The projected nuclear waste amounts and rates are given in Appendix A. These rates were developed from the assumptions that the commercial nuclear power forecast to generate a nominal 395 gigawatts-electric (GWe) in the year 2000 and that there will be no recycle of plutonium or uranium from spent fuel. The rates beyond the year 2000 are based upon an extrapolation for 10 years. For rates beyond the year 2010, the design shall include provisions to accommodate expansion.

Retrieval capability for stored waste will be maintained for 25 years after initial emplacement. This capability permits shipment of stored waste to off-site facilities.

For design purposes, the repository is divided into five parts. These parts are illustrated in Figure I-1 and include the following.

Figure 1-1.. Repository Overall Functions

1.1.1 Surface Facilities to provide:

- . Repository roads, railroads, and utilities;
- . Operations facilities;
- . Interim waste storage facilities;
- . Administrative and support facilities;
- . Rock storage facilities;
- . Data collection and evaluation facilities.

1.1.2 Shafts to provide:

- . Remote handling system access;
- . Repository systems access;
- . Operating man/material access and transport;
- . Emergency entrance/exit and transport;
- . Rock transport;
- . Ventilation.

1.1.3 Subsurface Facilities to provide:

- . Access to and from storage for waste and waste handling systems;
- . Storage chambers for waste emplacement and removal;
- . Surveillance and monitoring of stored capsules;
- . Operation support of subsurface activities;
- . Subsurface facility development;
- . Access for rock handling system and repository systems.

1.1.4 Remote Handling to provide:

- . Capsule receipt and preparation for storage;
- . Capsule transfer between the surface facility and the subsurface facility;
- . Capsule transfer between the shaft and the storage position;
- . Capsule emplacement and retrieval;
- . Capsule overpack.

1.1.5 Repository Systems to provide throughout the repository:

- . Electric power distribution system;
- . Ventilation system;
- . Water supply system;
- . Compressed air system;
- . Instrumentation and control;
- . Communication network;
- . Liquid waste system;
- . Solid waste system;
- . Energy conservation system;
- . Fire protection system;
- . Emergency system;
- . Safeguards and security system;
- . Rock handling system;
- . Environmental monitoring system;
- . Basalt monitoring system.

1.2 OVERALL PRECONCEPTUAL DESIGN CRITERIA

The radioactive waste repository in basalt includes surface facilities, access shafts, subsurface facilities, remote handling systems, and systems interfacing with both surface and subsurface facilities. The overall facility breakdown structure is illustrated in Figure I-2.

The radioactive waste repository in basalt will consist of tunnels and storage chambers excavated within a qualified basalt formation, along with access shafts, handling systems, and various supportive surface structures. Wastes in specially designed canisters and containers will be received from the packaging facility.

After the repository has operated in a retrievable mode for the desired time, operations will change to the terminal storage mode. Subsequent to completion of this change, the repository will be decommissioned. The basic assumptions for these criteria are described as follows:

- . Ownership -- The repository shall be owned by the U.S. Government;
- . Period of Use -- The repository will begin full-mode operation in 1993, accommodate waste generated through the year 2010, and receive (5-year aged) waste to the year 2015; the design life for receiving wastes is 25-five years; however, the design shall allow for expansion and a longer life;
- . Licensing -- The facility will be licensed by the NRC for construction and operation (TBD-1);
- . Retrievability -- The repository will accept and hold wastes for 25 years after receipt before storage is deemed terminal;
- . Terminal Packaging -- Waste requiring shielded handling will arrive at the repository packaged and qualified for terminal storage; wastes that do not require shielding will arrive at the repository in standard 55-gallon drums; waste received will contain no liquid; packaging form and characteristics as defined for the Federal packaging facility will be used;
- . Storage Rates and Quantities -- The rates and quantities of spent fuel received will be based on those defined in the conceptual design of the

Figure 1-2. Program Breakdown Structure for the Repository

packaging facility and as defined in Appendices A and B; the rate and quantities of radioactive waste are based on the data defined in Spent Fuel Handling and Packaging Program, TC-1076, Hanford Engineering Development Laboratory, Richland, Washington, April 1978;

- . Basalt Quality -- The basaltic strata used for storage shall be continuous and satisfy acceptable criteria;
- . Rock Removal -- Many millions of tons of rock will be mined during construction of the repository; a large portion of the rock will be used to backfill terminal storage rooms and tunnels; the surplus rock will be used for fill or placed in an area of permanent residence;
- . Damaged Canisters -- Defective canisters will be overpacked for disposal within the repository.

1.2.1 FACILITY CONFIGURATION

The basic configuration of the repository includes surface facilities, shafts, and subsurface facilities. An artist's concept of a typical arrangement is shown in Figure I-3. Geology could allow the use of a modified concept whereby access would be horizontal or on an incline. A high mountain or a cliff might permit a non-vertical access.

The surface facilities will have a receiving and shipping area, a waste preparation building, shaft head buildings, a mine ventilation and cooling facility, rock handling and storage, utilities, and other administrative, maintenance, and service facilities. The surface facilities are defined in Part II.

The shafts provide access to the subsurface facilities. Personnel, materials, equipment, rock, services and utilities, and radioactive waste must traverse the shafts.

The subsurface facilities will be comprised of tunnels, laterals, storage chambers, and service areas. Space shall be provided to accommodate the remote handling system. Mining and waste storage operations will be accomplished concurrently, but will be isolated from each other.

Figure 1-3. Conceptual Terminal Storage Facility

The radioactive waste shall be handled by the remote handling system. This system shall remove the packaged waste from the shipping container, transport it through storage preparation operations, lower it through the shaft to the subsurface level, transport it to the storage locations, and place it in storage. The operation shall be reversible to provide retrievability. It shall include shielded hands-on and fully remote operations.

The repository systems will provide the support services to the surface facilities, shafts, subsurface facilities, and remote handling system such as power, ventilation, waste disposal, etc., as defined in Part VI.

1.2.2 INTERFACE DEFINITION

The design of the repository shall identify and include provisions to satisfy interfaces with the environment, offsite movement of waste, offsite services, a separate but onsite Federal packaging facility, and other government facilities involved in the spent fuel and waste cycles.

1.2.2.1 Environment

The repository, because it is a confinement barrier, includes an interface with the environment. The interface includes the overburden, the exclusion barriers, and the facilities and system to monitor and control the effluents from the repository.

Air-cleaning provisions in the ventilation system will mitigate the consequences of postulated accidental releases in conformance with the guidelines of Title 10, Code of Federal Regulations, Part 100 (10 CFR 100), and will clean effluents from operations dealing with leaking and defective canisters in conformance with 10 CFR 20.

A meteorological station will be operated to provide meteorological data on wind, barometric pressure, rain, etc., and data on climatic trends to enable evaluation of operations and reasoned responses in the event of an accident. A system of distributed monitoring

instruments (onsite and offsite) will verify safe operation and would provide some history of an accident.

A sanitary sewage system will be provided in conformance with current codes and standards. A process sewer terminating in an onsite pond will enable recovery of sludge and salts for appropriate disposal. No radioactive or potentially radioactive liquid shall be released to the pond. Liquid waste retention systems for radioactive wastes and suspect wastes will prevent radioactive liquid effluents from being released to the environment. These retention systems will include volume reduction and/or treatment of radioactive liquids.

Provisions will be made for volume reduction and shipping of solid radioactive wastes generated at the repository; ordinary waste will be placed in a sanitary landfill.

The cooling tower in the ventilation supply system may influence the environment by transferring water vapor and heat to the atmosphere. The repository exhaust air temperature will generally be higher than ambient air temperature and will heat the surrounding air.

An adjacent area will be committed to the placement of mined rock. Dust control measures shall be provided.

1.2.2.2 Offsite Movement of Materials

A standard gage rail spur connecting with commercial rail lines and a heavy-duty roadway connecting with the interstate highway system will terminate at the repository.

Support systems for casks shall be provided to maintain and monitor the internal cask environment as needed.

1.2.2.3 Offsite Services

Communications systems will be commercial telephones and a radio link to offsite cooperative security and fire departments.

Utility company transmission lines will provide redundant service for the repository electrical load. These lines should be dedicated, independent feeders that are as physically separated as practicable.

A water supply may be used to supplement the onsite wells. The terminals of the sewers (tile field and percolation pond) may be located outside the perimeter fence.

1.2.2.4 Other Government Facilities

Interfaces will exist with the packaging facility where the fuel and waste are encapsulated. This interface will primarily concern waste packaging and transfers. Interfaces may exist with nearby government facilities where utilities and services could be provided (TBD-1).

1.2.3 OPERATING AND PERSONNEL REQUIREMENTS

The repository will receive United States commercial nuclear waste through the year 2015 and shall have provisions for expansion.

Multiple receiving and handling lines (shielded and unshielded) will be manned.

A task and function analysis shall be performed to establish personnel requirements for repository operation (TBD-2). The analysis shall identify requirements and manning levels for the skills and positions required for facility operation. Consideration shall be given to the impact of safety and environmental factors on work assignments.

Personnel will be assigned to perform operational, technical, supportive, and administrative tasks. Their activities will primarily concern waste receiving and processing, maintenance, and rock removal and storage. Design basis occupancies and a skill spread shall be established for each operating, support, and service function.

1.2.3.1 Surface Requirements

Surface personnel tasks will include operation, engineering, facility support (health, safety, environment, security, etc.), and administration. These tasks will primarily concern waste receiving and processing, maintenance, and rock storage. Most surface facility operations will center around the operations building and the maintenance service facility. The maintenance philosophy and maintenance requirements shall be analyzed to determine maintenance skill requirements. Maintenance skills will (nominally) include mechanical, electrical, and instrument crafts.

1.2.3.2 Technical Support

Radiation monitoring services shall be available at all times.

Technical personnel will be assigned to meet engineering, laboratory, safety, health physics, life support maintenance, and utility needs. These persons shall be capable of consulting, training, and providing technical liaison to surface and subsurface operations personnel as required.

1.2.3.3 Administrative Support

Administrative support functions will be analyzed to determine skills required for supervision, training, safety, subsurface coordination, operating procedures, inventory control, security, and nuclear materials control tasks.

1.2.4 CLASSIFICATION OF SYSTEMS AND STRUCTURES

The systems and structures that comprise the basalt repository will be classified to meet NRC licensing requirements, Levels I, II, or III, according to the following definitions.

- Level I structures and components are those whose failure might cause (or increase the severity of) a release of radioactive, hazardous, or toxic materials and those that are vital to the safe shutdown of a crucial process or system. Examples of Level I items include isolation barriers, ventilation system, life support system, criticality monitoring system, communications, and emergency power.

- . Level II structures and components are important to the operation of the process or system, but not essential to its safe shutdown and isolation. Examples of Level II items include the canister handling equipment, storage borehole liners, security equipment, and radioactive monitoring systems.
- . Level III structures are not related to the process or system operation or control, but do provide a function or service to the facility.

A component may be classified at a lower level than its parent assembly, providing that the consequences of its failure satisfy the criteria for the lower classification. No component will be classified at a higher level than its parent assembly.

If no specific level is established for a component, it shall be considered to be at the classification level of its parent assembly.

The systems and structures shall be reviewed to determine at which level the system or structure will be classified. This assessment will be guided by three sets of considerations: safety analyses; programmatic loss potential; and industrial experience. The safety assessment shall examine repository design in normal and abnormal modes of operation with associated probabilities and risks. The following systems and crucial components shall be considered crucial equipment:

- . Repository cooling system;
- . Systems necessary to provide protective shielding;
- . Confinement systems including ventilation;
- . Radiation monitoring and alarm systems;
- . Criticality alarms;
- . Emergency systems;
- . Fire protection systems;
- . Central alarm system/security;
- . Intrusion detection system;

- . Emergency communication;
- . Emergency power supply system;
- . Cask and canister cooling.

After initial classification of systems, a balanced qualification of system components shall be considered to assure a suitable match of function and level. The impact of failures and the cost effectiveness of higher design classification versus program delays or losses will be investigated.

Industrial experience shall be reflected in evaluating the requirements of the Uniform Building Code (UBC) against the associated degree of hazard and accident probability.

1.2.5 SITE REQUIREMENTS--GENERAL

The radioactive waste repository in basalt will be sited in one or more major basalt flows. The site shall meet the minimum requirements of the repository and maximize characteristics that will isolate the radioactive waste from the biosphere. The site selection and site design shall include provisions to allow for future expansion. A study shall be made to assess the existence of physical or technical limits to site capacity; and, if none are evident, economic and practical thresholds shall be determined.

A number of criteria (TBD-3) must be investigated and applied to any repository site. These criteria affect the repository site in total and cannot be addressed as a function of shafts, systems, or subsurface facilities.

1.2.5.1 Geologic Criteria

The repository shall be isolated from the biosphere by sufficient depth of cover to ensure that credible man-induced or natural events would not cause loss of containment. The basalt flows shall

be thick enough and of sufficient lateral extent to provide space for operations and storage while assuring isolation. The rock and surrounding areas should be geologically stable, free of active faults, and in an area with a low probability for seismic, tectonic, and volcanic events.

1.2.5.2 Site Exploration Criteria

Special care must be exercised in site exploration. The site must be such that drilling programs, underground construction, shaft sinking, decommissioning, or other activity will not compromise the long-term effectiveness of the repository.

1.2.5.3 Hydrologic Criteria

The site and the storage area should minimally disturb the water-bearing strata. The water content of repository rock shall be sufficiently low that storage of waste forms will not liberate or chemically react with the water to compromise geologic containment. Water inflow to the storage area, transmission within the basalt rock, and transport of radionuclides by ground water must be minimal.

1.2.5.4 Waste/Rock Interaction Criteria

Chemical- or radiation-induced reactions between basalt and the waste capsule shall not compromise the geologic containment or operational safety of the repository. The site shall provide a system of multiple barriers to transport contaminants away from the repository.

1.2.5.5 Rock Mechanics Criteria

The rock within the repository site shall have thermal and mechanical properties, residual stresses, and competent character such that development, operation, and storage of waste will not compromise the geologic containment and operational safety of the repository.

1.2.5.6 Engineering and Transportation Criteria

The site should be located so that repository rock and surrounding material can accommodate the facility and allow retrieval of stored waste. The site shall allow for expansion, provision of utility services, disposal of excavated material, and minimal risk associated with transportation of waste.

1.2.5.7 Health and Safety Criteria

No credible man-induced or natural event should result in significant releases of radioactive materials to the biosphere within the required life of the repository. The design of the repository and the existing natural environment shall prevent such release.

1.2.5.8 Socioeconomic Criteria

The repository should be sited in an area in which exploration or development of natural resources are unlikely and where (due to loss of administrative control) planned or unplanned intrusions caused by nature or man would result in no adverse consequences.

1.2.5.9 Ownership and Control Criterion

The site should be owned and controlled by the U.S. Government to control mining, exploration, or other activity that may adversely affect the operations or containment capability of the repository.

1.2.5.10 Data and Technology from Drilling Project

The results of a research project on drilling shall be applied to the design wherever applicable. The research efforts cover:

- . Drilling of hydrologic and core holes;
- . Hydrologic testing;
- . Geophysical logging;
- . Drilling technology.

1.2.6 GENERAL DESIGN REQUIREMENTS

The general design requirements cover those items that relate to all of the parts of this report.

The basic requirements of the design shall be to provide the area, equipment, and means necessary to satisfy the basic functions identified in Section 1.1, plus the areas, systems, and equipment required to support those functions.

The design shall include considerations of commonality and standardization. Common features and characteristics shall be incorporated wherever practicable. Use of standard parts and systems shall be established wherever practicable.

- . Commonality -- Human engineering shall be applied to controls, indicators, labeling, and equipment design so as to minimize operator and maintenance errors which otherwise could result.
- . Standardization -- Appropriate parts of the U.S. Department of Energy (DOE) General Design Criteria (ERDAM 6301) and applicable local standards shall be utilized for design. In general, applicable Occupational Safety and Health Act (OSHA) standards and the "national consensus" codes and standards developed by such organizations as the American Society of Mechanical Engineers (ASME), American Concrete Institute (ACI), American National Standards Institute (ANSI), and the Institute of Electrical and Electronic Engineers (IEEE) shall be used.

The design shall make use of data and results of research and test programs conducted by the Rockwell Hanford Operations Basalt Waste Isolation Program. Research activities of special interest include the following areas of endeavor:

- . Rock testing;
- . Hydrologic studies;
- . Geologic studies;
- . Borehole plugging;
- . Multiple barrier studies;
- . In situ tests.

1.2.6.1 Architectural Design Requirements

The architectural design shall consider various surface, shaft, and subsurface layouts to optimize isolation and interfacing of functions. Mining and supportive excavation operations should be separated from radioactive waste receiving, processing, and storage. Personnel safety, efficiency, and unhindered work environs shall be provided to the maximum extent practicable.

Factors which shall be considered when establishing the facility layouts include:

- Waste cask receipt and transfers;
- Waste canister transfer and interim surface storage;
- Shaft heads for LL, IL, and HL waste and spent fuel transfer;
- Utility and ventilation shafts;
- Personnel and emergency shafts;
- Material, equipment, and excavation shafts;
- Local terrain and transport routes;
- Security and safeguards needs;
- Subsurface functions and flow paths;
- Basalt characteristics and existence of localized anomalies;
- Physical separation to enable safe, efficient waste operations to proceed without interference with competent mining operations.

1.2.6.2 Structural Design Requirements

The structural designs of the repository shall provide:

- Protection from natural phenomena;
- Structures which maintain the radiological confinement required throughout the waste handling operational lifetime;
- Structures which shall enable installation of secondary isolation barriers at decommissioning;
- Protection for personnel and equipment;
- Structures which shall conform with nationally recognized codes and standards.

Those structures, systems, and components important to safety, including their foundations and supports, shall be designated Seismic Category I and are designed to remain functional in the event of a design basis earthquake (DBE). These features include those necessary to assure: (1) the integrity of the surface facility and shaft confinement barriers; (2) the capability to shut down operations and maintain the functioning of crucial and emergency systems; and (3) the capability to prevent or mitigate the consequences of potential accidents which could result in offsite exposure comparable to the guideline exposures of 10 CFR 100 or future NRC regulations.

Seismic Category II considerations apply to the design of structures, systems, and components that shall retain integrity and/or function during and after the (site-related) operating basis earthquake (OBE). The OBE is less severe than the DBE (generally 50 percent of the DBE magnitude), but is more probable.

Seismic Category III applies design that shall be in conformance with the UBC and a specified (region-related) earthquake.

The surface facilities that include the cells, passageway, and canister shaft heads shall have biological shielding and graded confinement ventilation.

The shaft design shall consider alternative methods (as well as liners) to meet water retention and structural requirements. Of the subsurface facilities, the canister shaft foot and transporter shall have biological shielding. Tunnel activities may require the use of supplemental shielding.

1.2.6.3 Mechanical Design Requirements

Plant equipment shall be provided for cask handling, canister offload, inspection, and transfer. Architectural-mechanical systems studies shall be made to consider standardization of

equipment and handling, optimum material flow, optimum work flow, minimum interference with excavation, security, and safeguards. These considerations shall include safety to personnel, the public, and the environment as prime concerns.

Piping shall be provided for the facilities as described in Parts II, III, and IV.

1.2.6.4 Ventilation and Air Conditioning Design Requirements

Ventilation and air conditioning systems shall be provided to support surface and mine operations (see Parts II and IV). These systems shall also provide a contribution to repository cooling, heat recovery, and environmental control for the protection of the public and the environment. The exhaust ventilation filter system shall be designed to prevent airborne releases of radioactive materials to the environment. The filter system shall be designed to allow changing of filters without the spread of contamination in work areas. Shielding shall also be provided to reduce radiation from buildup of radioactive materials on the filters.

1.2.6.5 Electrical Design Requirements

Commercial power service connections at the substation, distribution, metering, switching, and maintaining functions shall be accommodated as specified in ERDAM 6301, Regulatory Guide 1.6, IEEE Standard 383-1974, and National Electrical Codes (NEC).

Design of electrical systems shall satisfy the latest NEC requirements and shall have adequate capacity to meet initial and projected power requirements. Anticipated maintenance, operation, energy conservation, and quality assurance (QA) requirements shall be determined by analysis. Extreme load conditions (such as peak periods, power switching, shorts, and maintenance interruptions) shall be accommodated.

Bus arrangements shall be designed to maintain safety, security, and control functions when nonstandard conditions occur. Where practicable, crucial loads shall be served by separate and committed circuits.

Electrical power shall be provided from two primary alternating current (ac) sources, emergency ac generators, and an uninterruptible power supply for critical monitor, security, and life support systems. Sufficient power shall be available for evacuation of subsurface personnel in the event of loss of commercial power..

1.2.7 NUCLEAR SAFETY

The safe storage of radioactive wastes shall be demonstrated. This shall be done by study, analysis, test, or other means and reported within a safety analysis report. The report shall be prepared according to DOE and NRC requirements and shall demonstrate safe storage for the operating phase and the isolation phase of the repository.

Safe storage involves having a sufficient number of barriers between the stored radioactive material and the biosphere so that public health will not be endangered. Both natural and engineered barriers shall be used. The following shall be considered in the development of the isolation barrier.

Man-Made (Engineered)

Cladding
Waste form
Capsule
Storage enclosure
Storage chamber
Rock fill
Other

Natural

Depth
Permeability
Transport time
Waste interaction
Other

The safe storage of radioactive wastes during the retrievability phase, in general, is achieved by maintaining the integrity of the storage canister as the primary barrier to the release of radioactive materials.

This section tentatively identifies abnormal and credible accident occurrences, their causes, and the postulated consequences to establish conceptual design criteria. These criteria thus provide bases for the design, enable the development of design basis accidents (DBA), and establish design loads that impact all structures, components, and systems.

The design bases will conform to 10 CFR 100 and will demonstrate that:

- The plant, as designed, can be constructed, tested, operated, and maintained to provide a highly assured capability for reliable and predictable operation and to have an intrinsic capacity to prevent the occurrence of accidents;
- The plant will be designed so that, in the event of errors, malfunctions, or off-normal conditions, the protective systems and other features will arrest an event or limit its consequences to less than codified levels;
- The plant design provides engineered safety features that will mitigate the consequences of extremely low probability hypothetical events to meet guideline values established for the protection of public health and safety.

The safety analysis will include documentation of the adequacy of the design basis, the conformance of the system design to this basis, the system capability to respond to transient conditions, the plant protective system capability to mitigate abnormal occurrences, and the development of any operational restriction necessary to ensure that an adequate margin of safety exists during normal operations and transient conditions. These evaluations shall be documented as a safety analysis report, and the analysis shall be based on the potential release of fission products contained within the canister under defined accident conditions.

The occurrences to be considered include failure, DBA, design basis threat, and natural events. The analysis shall include the following events (Table I-3) which could affect the safety, integrity, or proper functional operation of the facility.

The design basis threat shall identify a spectrum of incidents due to theft of fuel elements or facility sabotage. The facility design and security system shall be evaluated to determine the adequacy of protection to the public in the event of such an accident.

These design basis events shall be reconsidered as the design progresses.

Basic standards and regulations include ANSI N287, ERDAM 0524, ERDAM 0550, ERDAM 6301, 10 CFR 20, and 10 CFR 100.

Table I-3. Safety Events

<u>Event</u>	<u>Type</u>	<u>Location</u>		
		<u>Surface</u>	<u>Subsurface</u>	<u>Shaft</u>
Criticality	DBA (candidate)	Yes	Yes	No
Fires	DBF (candidate)	Yes	Yes	Yes
Dropping incidents	DBA (candidate)	Yes	Yes	Yes
Equipment failures	DBA (candidate)	Yes	Yes	Yes
Rockfalls	DBR (candidate)	No	Yes	Yes
Explosion (including missiles)	DBX (candidate)	Yes	Yes	No
Threat incident (including sabotage)	DBI	Yes	Yes	Yes
Earthquake	Natural	Yes	Yes	Yes
Tornado	Natural	Yes	No	No
Lightning	Natural	Yes	No	No
Flood	Natural/Accident	Yes	Yes	Yes

1.2.7.1 Design Basis Criticality

The design shall incorporate engineered safeguards to prevent criticality within the facility. The requirements include:

- Mechanical/physical interlocks and constraints to prevent placing more than one canister into one assigned storage location or canister process location;
- A double contingency principle shall be satisfied in establishing the nuclear criticality safety of all spent fuel operations;
- A storage array such that $K_{eff} \leq 0.95$ for a full complement of canisters;
- Criticality monitor and alarm coverage of all spent fuel process, transport, and retrievable active (unsealed) storage areas.

A criticality incident should be postulated to test the efficacy of repository design by the guidelines of 10 CFR 100. It may be assumed to involve 10^{18} total fissions as a single burst, since it would not involve fissile material in solution form. The principal consequences of such an incident would be the neutron and gamma radiation exposure to people in the immediate area shown in Table I-4 and the cleanup activities which would follow. Release of fission products from a ruptured canister would be a delayed process; further delays of transport (e.g., in tunnels and shafts) and cleaning by high-efficiency particulate air (HEPA) filters and activated charcoal filters will reduce the offsite consequences below the levels of 10 CFR 100.

Table I-4. Direct Whole Body Dose Due to a Criticality
(10^{18} Fissions)

<u>Distance from the Incident (feet)</u>	<u>Approximate Dose from Radiation (rem)</u>
6	11,000
13	3,000
20	700
32	300
66	40

A scenario for exposure shall be developed. The dose to operating personnel from airborne radioactive species shall be calculated.

1.2.7.2 Design Basis Fire

The most severe credible fire event involving the potential release of radioactive material shall be defined. This design basis fire (DBF) shall be used as a basis for evaluating the ability of crucial structures and fire barriers to maintain integrity under this stress. Suppression by the fire protection system is not to be considered, nor is any manual action assumed.

Surface facility DBF shall cover critical radioactive areas and include consideration of the following classes of combustibles:

- . Class A -- Wood, paper, rubber, and most plastic;
- . Class B -- Flammable liquids;
- . Class C -- Electrical fires where dielectric insulation must be maintained.

Subsurface DBF shall include electrical and instrument wire insulation Class C (power on) and Class A (power off) insulation failures.

1.2.7.3 Rockfalls (Subsurface Only)

The design basis of a rockfall is defined as one rock bolt failing and releasing a wedge of rock from the ceiling at 60 degrees to the perimeter rock supports and including the failure of one rock support. The most severe conditions of a credible rockfall involving the potential release of radioactive material shall be defined and used as the basis for evaluation.

1.2.7.4 Equipment Failures

Accident scenarios shall consider only one system "single failure" among the systems that may malfunction and impair safety. An exception is that a power failure shall be superimposed on failures of those systems not on standby power.

1.2.7.5 Explosion

The design basis explosion (DBX) shall be evaluated. If a mechanism for an explosion is postulated and found credible, the facility and systems shall be designed either to avoid the mechanism or maintain integrity and/or function.

1.2.7.6 Earthquake

The DBE shall be determined by the guidelines and criteria of 10 CFR 50 and 10 CFR 100. The safety analysis report will present the determination of relevance of such a DBE and of any OBE. Both surface and subsurface effects shall be considered. The underground criteria shall be developed by a separate study (TBD-4) during the course of the design.

The safety analysis report shall include a comprehensive description of the dynamic seismic analysis procedures, load combination formula, and acceptance stress and deformation limits to be used for the seismic design of QA Levels I and II systems.

The earthquake for QA Level III systems is set forth in UBC Section 231 (for Earthquake Zone 2, MM-VII, with a ground acceleration of 0.25 g to be used for all seismic structural analysis).

1.2.7.7 Radiological Protection

The facility shall be designed to minimize personnel exposures, to provide adequate radiation monitoring and alarm systems, and to accommodate health physics activities. Primary radiation protection assurance shall be attained by the use of physical safeguards (e.g., remote handling, equipment layout, shielding, etc.) and secondary radiation protection by administrative controls.

The design of radiological protection shall control radiation to a level that is as low as reasonably achievable (ALARA) and to meet radiological protection requirements as specified in 10 CFR 20. This level shall be achieved through a cost tradeoff (in the

design of) manpower costs for various exposure levels versus cost of shielding and other radiation control methods. The control methods to meet ALARA include control of:

- . Access to radiation zones;
- . Radiation levels by use of shielding;
- . Occupancy factors;
- . Effluents;
- . Design and operating features that influence human exposure;
- . Contamination.

a. Access Control

The design of the facility shall provide for control of access to the facility and to areas of potential contamination or radiation within the facility. Within the repository, three types of areas will be employed for radiological design purposes: uncontrolled areas; controlled access areas; and normally inaccessible areas. The facility is to be designed to limit radiation levels in uncontrolled areas to less than 0.1 mrem per hour during normal operation and normal maintenance activities. Controlled access areas include both controlled zones and radiation zones. Controlled zones are hallways, corridors, offices, tunnels, and control rooms which are adjacent to radiation zones and serve as "buffer" zones. Design radiation levels there are between 0.2 mrem per hour and 0.5 mrem per hour. Radiation zones in the controlled access areas have design radiation levels between 0.2 mrem per hour and 1,000 mrem per hour. Essentially all the radiation work will be performed in the controlled access areas.

Normally inaccessible areas are those radiation zones of the facility in which the design radiation levels exceed 1,000 mrem per hour. Access to these areas is permitted only under compelling circumstances.

b. Shielding Design

Design of shielding will comply with the shield design criteria for new facilities. For preliminary design purposes, particular guidelines (Table I-5) are to be employed for radiation zones where access is based upon exposure to an individual radiation worker. Dose rates in all cases are at the point of exposure; i.e., where an individual will actually be working and some or all of his body will be exposed to radiation.

Table I-5. Preliminary Shield Design Criteria

<u>Zone Category</u>	<u>Access Time Allowed</u>	<u>Design Level</u>	
		<u>Initial</u>	<u>Maximum</u> (mrem per hour)
1	Full time	0.2	0.5
2	Less than 1 hour per day	2	5
3	Less than 1 hour per week	10	20
4	Less than 5 hours per year	100	200
5	Less than 1 hour per year	500	1,000
6	No normal access permitted	1,000	

Although Table I-5 lists the maximum radiation levels for each zone category, the initial design effort should be directed to the lower radiation level in each case. Initial design levels are shown as guidelines, but this does not preclude designing to a lower radiation level.

c. Occupancy Factors

The following are actions that can be taken instead of or in addition to the shielding:

- . Reduce and minimize material inventory at each work station;
- . Reduce the number of operations required;
- . Shield areas rather than separate items;
- . Ensure a minimum working time in any position;
- . Employ remote operations;
- . Closely control the access and position of non-operating personnel;
- . Store material not in process in special shielded areas.

d. Control of Effluents

Systems to control effluents are provided as described in Part VI.

e. Radiation Monitoring

The facility shall be designed so that both radiation and the spread of contamination can be monitored and controlled.

All occupied areas in which airborne radioactive materials may be present shall be provided with air sampling and air monitoring systems with alarms to warn of airborne contamination. These areas include remote handling areas, radioactive waste systems, ventilation filters, and the remote equipment maintenance room.

A continuous air monitor (CAM) will monitor air before the return grill for recirculated air within buildings containing radioactive materials. The CAMs will monitor all potentially contaminated air prior to release to the atmosphere.

Sample and monitor probes in ducts shall be designed to meet ANSI Standard N13.1-1969.

1.2.7.8 Design Basis Tornado (Surface Only)

The design basis tornado (DBT) loading shall comply with NRC Regulatory Guide 1.76, "Design Basis Tornado for Nuclear Power Plants," ASCE Paper Number 3269 for radioactive confinement structures, and UBC Section 2308, Tables 23-F, 23-G, and 23-H for surface structures. The tornado characteristics are (TBD-5). The guidelines of ERDAM 6301 apply.

1.2.7.9 Lightning (Surface Only)

The design basis for lightning strikes will apply to exposed buildings and equipment involved directly with waste handling. The protection system will be based on an analysis of lightning strike consequences and will conform to the requirements imposed by ERDAM 6301.

1.2.8 FIRE PROTECTION REQUIREMENTS

Fire protection requirements shall include those aspects pertinent to prevention, suppression, and extinguishment of fires.

The principal purposes of a fire protection program for the repository are the protection of the general public from radioactive and toxic material, protection of plant personnel, protection against loss of confinement, and protection of government property.

Structures, systems, and components important to safety shall be designed and located so they continue to perform the safety functions effectively under credible fire and explosion exposure conditions. Fire-resistant and incombustible materials should be used wherever practicable throughout the facility. This is particularly needed in locations vital to the functioning of confinement barriers and systems, to methods of controlling radioactive materials within the facility, and to the maintenance of safety control functions.

The adverse effects of fires and explosions on structures, systems, and components important to safety can be minimized by providing systems with sufficient capability for detecting and suppressing explosion potential and fires and transmitting alarms to one or more central control areas. It is important in the design of the plant and fire-suppression systems to include provisions to protect against adverse effects in the event of fire-suppression system operation or failure.

Implementation of the above entails an evaluation of such factors as the expected maximum amount of combustible material in each area of the plant; severity, intensity, and duration of credible fires; assurance of confinement of radioactive and other potentially dangerous contaminants; arrangements and structural design features of buildings for control of smoke, heat, flame, and combustible and explosive gases; and systems for fire detection, confinement, control, and suppression.

Water shall be the ultimate fire suppressant; special consideration should be given to selection of water sources, water distribution systems, fire pumps, and automatic and manual fire extinguishing systems to control and extinguish a credible fire in any area. Automatic fire extinguishment capabilities should be provided throughout the facility wherever special fire control measures are justified or particular hazards exist. The shaft heads, shafts, and subsurface facilities will not have sprinkler fire protection because the potential for flooding is to be minimized.

The fire loop and fixed protective equipment shall be supplied from a storage tank, the capacity of which will be determined by the analysis of the DBF. Wells will be considered for redundant water supply to the repository.

Other than shaft heads, no area of the surface facilities has been identified as needing exclusion of water (moderator). However, areas

containing extensive electronics may employ high-temperature sprinkler heads as backup with a different primary protection system.

Incipient fires may be controlled by portable fire extinguishers. This phase of fire control is particularly important, even though automatic sprinklers have been provided. Consideration shall be given to the selection of portable fire extinguishers suitable for use on specific hazards that may be encountered.

Fire protection systems may be subject to effects of natural phenomena such as seismic motion and floods, missiles, fire and explosion, and other accidents. These systems shall continue to perform their safety functions effectively under credible accident conditions. Where practicable, continuity of fire protection systems should be assured by such means as standby equipment and fail-safe control systems.

The ability of the systems to perform their safety functions effectively shall be improved by incorporating features that permit periodic testing of safety-related components. All automatic systems shall be electrically supervised. The testing should be done during normal operation to demonstrate performance and verify availability for emergencies.

An important aspect of a fire protection program is training of a fire-fighting organization and maintenance of its competence with periodic drills. Provisions for such shall be made.

The fire protection program shall provide for the use of appliances, equipment, and materials listed by such testing organizations as the Underwriters' Laboratories, Inc. (UL), and the Factory Mutual Research Corporation (FM) as meeting their standards.

Fire protection programs shall conform to the provisions of the following codes and standards as applicable:

- . National Fire Codes of the National Fire Protection Association (NFPA);
- . Industrial Loss Prevention Standards of Factory Mutual Engineering Corporation (FMEC);
- . Standards of the American Petroleum Institute (API);
- . The UBC of the International Conference of Building Officials.

The fire detection and alarm system shall conform to ERDAM 6301 and NFPA 72A, 72B, 72E, and 73. Automatic fire detectors are to be used in all rooms throughout the facility except in the support wing. Manual pull stations and single stroke alarm gongs shall be placed throughout the facility.

1.2.9 INDUSTRIAL SAFETY

The industrial safety program for the repository shall emphasize mine safety and radiation protection. A central facility shall be located on the surface where the industrial safety activities may be housed and coordinated. These activities shall include:

- . Central and satellite first-aid stations;
- . Engineering support to the mine;
- . Monitoring of hazardous and potentially hazardous areas;
- . Support to both waste disposal and mining operations;
- . Health physics activities;
- . Facilities and equipment for training and for handling emergencies;
- . Operations liaison.

Safety showers and eye-wash lavatories will be provided near where corrosive, irritant, or radioactive materials might present a hazard to personnel.

The facility design shall comply with applicable health and safety standards, in particular, ERDAM 0550, 29 CFR 1910 (OSHA), and 30 CFR 57. For additional detail, see Sections 1.2.9 of Parts II and IV.

1.2.10 SECURITY AND SAFEGUARDS

1.2.10.1 General Requirements

The repository shall be protected from acts of industrial sabotage and from acts of theft and diversion of special nuclear material (SNM) that could directly or indirectly endanger the public health and safety by releasing radioactive particles (rather than gaseous fission products). The security and safeguards system shall prevent sabotage, safeguard nuclear material from theft and diversion, and protect employees and government property in accordance with Interim Management Directive (IMD) 6103, 10 CFR 70, 71, 73, 100, and NRC Regulatory Guide 3.24.

Provisions shall be made for the ultimate product accountability of all fuel and wastes received. The ultimate product and unopened receipts criteria of 10 CFR 70 apply, and the determination of specific weights and isotopic content is not needed. The accountability records shall show source and owner's identification.

The safeguard system shall comply with IMD 6103, IMD 6104, and 10 CFR 70, 71, and 73.

1.2.10.2 Physical Security System

a. Exclusion Area

To meet the requirements of 10 CFR 100, an exclusion area will be established around the repository. Activities within this area and access will be controlled in an emergency.

b. Limited Area and Access Guard Station

A limited and controlled access area shall be established around the operating elements of the facility. The station shall provide means for inspection and personnel surveillance devices and access identification equipment.

c. Protected Area

The area containing significant quantities of SNM shall be designated as a protected area. Surrounding the protected area shall be 2 fences which create an isolation zone and the zone shall be illuminated. The fences shall be approximately 100 feet apart and meet security standards.

d. Vital Areas

Specific areas, because of their importance for protection against sabotage, shall be designated as vital areas. These should include the onsite emergency power supply system, the central security alarm station, and the ventilation and heat-removal systems for the subsurface facilities.

e. Vehicle Access Controls

Vehicle barriers and access controls that prevent unauthorized vehicular entry or exit shall be incorporated into the facility design.

f. Mechanized Identification and Monitoring

The personnel gate at the guard station of the facility shall be equipped with mechanized identification equipment and radiation, metal, and explosives detectors to screen personnel entering and leaving the facility. The main entrance gate shall also be equipped with a vehicular radiation detector.

g. Intrusion Alarms and Detectors

Intrusion alarms and detectors shall be provided in the isolation zone between the two perimeter fences, in the storage area, on security doors, and on vital equipment essential to security (such as the emergency power generator).

h. Closed Circuit Television

Closed circuit television (CCTV) cameras shall be installed in those areas monitored by intrusion detectors, and not under direct visual contact with the guard station, for evaluation of alarm conditions.

i. Central Alarm Facility

The facility shall have a station for monitoring area access and providing facility intercommunications. Intrusion alarms and CCTV surveillance system monitors for the facility security support will be located in the central alarm facility. Alarm systems shall meet the performance and reliability characteristics described in 10 CFR 73.50(d).

j. Redundant Alarm Monitoring Station

Physical protection alarms, security response-related alarms, and the CCTV system shall be redundantly monitored at an off-site redundant alarm monitoring station.

k. Communications

Communication equipment for security and emergency purposes should be designed with appropriate redundancy and flexibility as described in 10 CFR 73.50(e) (1) through (4).

l. Spent Fuel

Openings to the spent fuel storage areas shall be secured.

1.2.10.3 Safeguards

The measurement, control, and accounting of nuclear material is included since the major function of the facility is to provide disposal of spent fuel. A safeguards system shall be established to satisfy the requirements of 10 CFR 73 (IMD 6103 and 6104).

a. Measurement

The spent fuel received at the facility shall be tamper safe and identified as to the quantity shipped. Measurement will include establishing the amount of received fuel for accountability purposes and radioactivity level for safety purposes. It has been determined that the external dose rate for spent fuel is over 100 rem per hour, unshielded at 3 feet so that the exemption from IMD 6103 provisions applies (see 10 CFR 73.6).

b. Accounting--Accountability

The continued protection of nuclear material is not needed since the material exceeds 100 rem per hour at 3 feet unshielded, and is not accessible once below the surface. The accounting functions entail verification of capsule contents and establishing that the repository waste inventory (i.e., number of assemblies) corresponds to the shipped inventory (10 CFR 71).

c. Control

The facility control of nuclear material shall be tamper safe and shall include identifying, locating, and providing security for canisters. Each canister shall be identified with unique markings and will be stored in specific vital (material storage) areas.

The control identification markings shall be recorded and subject to periodic audits so that a constant inventory control is established.

1.2.11 WASTE MANAGEMENT--FACILITY GENERATED

Wastes shall be identified as radiological and nonradiological and kept separate. Solid, liquid, and gaseous waste management systems are addressed in Part VI.

1.2.12 ENVIRONMENTAL CONSIDERATIONS AND DECOMMISSIONING

Environmental considerations will be governed by the requirements of 10 CFR 51 since the facility will be licensed by the NRC. Protection of the environment shall be compatible with Federal, state, regional, and local environmental quality standards. Environmental protection shall be included in design, construction, and operation of the facility.

A study (TBD-6) shall be conducted to analyze the radioactive releases under DBA conditions. The results will be evaluated against the regulatory requirements governing such releases into the environment.

1.2.12.1 Design

Design shall be in accordance with applicable state and local regulations and applicable sections of:

- . 10 CFR 20;
- . 49 CFR 173.393;
- . ERDAM 0511;
- . ERDAM 0524;
- . ERDAM 6203;
- . ERDAM 6301.

1.2.12.2 Construction

Construction pollution control shall be in accordance with applicable portions of guidelines established by ERDAM 6301, Part 1, Sections G and H. Particular attention shall be given to dust control.

1.2.12.3 Operation

Facility operation pollution control shall comply with requirements of ERDAM 0510, 0513, 0524, and 0550. Effluents shall be controlled within these standards.

A base line environmental monitoring plan is currently under study and development. This program will monitor hydrology, seismicity, and other items including any natural geologic activity that might prove hazardous to the safety of the repository. The results of this study shall be factored into the repository design.

1.2.12.4 Facilities Decommissioning

Facilities at the repository site will be designed, built, and operated to provide for the ready retrieval or recovery of the stored fuel canisters. When the retrievability option is no longer needed, the repository or portions thereof will be converted to permanent storage and related facilities will be decommissioned. Repository qualification procedures for changing a final storage facility to a permanent storage or disposal repository for a

similar function are discussed in Alternatives for Managing Wastes from Reactors and Post-Fission Operations in the LWR Fuel Cycle, ERDA-76-43, Volume 4, Section 24.2.6, U.S. Energy Research and Development Administration, Washington, D.C., May 1976.

The same alternative procedures for decommissioning facilities, such as fuel reprocessing plants, may be used to decommission facilities at geologic storage sites. These procedures (protective storage, entombment, and dismantling) are discussed in detail in ERDA-76-43, Volume 2, Section 15 and need only be modified to accommodate the deep underground workings.

1.2.12.5 Conversion to Permanent Storage

Procedures for converting retrievable storage to permanent storage should provide for the following operations:

- . Backfill of Underground Workings -- The magnitude of the deformation and other geologic disturbances; i.e., subsidence, room closure, etc., which can occur around the underground workings within the protective geologic formation, may be reduced by backfilling the storage rooms, access corridors, etc. While the technology for backfilling exists, the backfill material and the extent of the backfill are dependent on the type of waste, the emplacement method, and the rock formation.

The need and benefits for backfill (TBD 7) shall be verified by study.

- . Sealing the Underground Workings -- The mine shafts, etc., which provide access from the surface to the underground workings, penetrate the protective geologic formations and potentially compromise the containment. These penetrations will be sealed. The ability of the seal to preserve the integrity of the repository containment should equal or surpass that of the protective rock formation surrounding the repository. The technique, criteria, and testing methods for placing and monitoring such seals are being developed.
- . Post-Decommissioning Site Control -- Site control procedures may be based on government ownership of the land and include appropriate fencing, warning signs, and a low level of surveillance. This surveillance would be an extension to the base line environmental monitoring program established during the operating phase. This surveillance might include monitoring of land surface level over underground workings, ground water, and a few wells which approach but do not penetrate the geologic formation. This surveillance would likely be supported by infrequent patrol of the restricted area.

1.2.13 DESIGN LIFE AND RELIABILITY ASSURANCE

The repository shall have a design life sufficient to support waste storage operations for 25 years and a retrievability period for a subsequent 25 years. A plant availability design goal shall be established for the operating and retrievability phases. The availability factors shall consider the relative rates of waste receipt, waste storage, and subsurface development. Process flow times for storage and retrieving shall also be considered.

The design shall provide a high degree of system reliability. Mechanical equipment, seals, lubricants, electrical equipment, etc., which can be replaced readily, may have a design goal service life of five years. Radiation- and environment-tolerant material shall be used as practical to keep the design life of all equipment as close as possible to the stated goals. Where this is not practical, ease of replacement shall be a requirement. Safety systems shall be designed to be fail safe.

The shaft structure shall be designed for a long lifetime as limited by supplier capabilities. See subsequent sections for requirements of the specific systems of the repository.

1.2.14 MAINTENANCE

Maintainability shall be a major design consideration. Hands-on maintenance shall be a design goal for the facility. Materials selection shall be compatible with this goal, as practical.

The maintenance criteria shall consider nonremote equipment, mine and shaft structure, and remote handling inspection, repair, and upkeep. Mining, shaft, and subsurface structures require periodic inspection, upkeep, and repair to maintain a safe working environment with good housekeeping maintained. Nonradioactive handling areas and equipment are maintained by standard in situ methods or by modular equipment exchange with attention to effects on scheduling, safety, and downtime. Remote handling equipment subject to a radiation environment or contamination shall be designed to be maintained by methods resulting in ALARA personnel exposure.

1.2.15 ENERGY CONSERVATION

The facility design shall be analyzed to identify the energy requirements and to establish any design changes for energy conservation that should be incorporated or investigated.

Energy recovery of the waste heat shall be considered in the design. Both local and offsite uses shall be explored.

A detailed life cycle economic analysis is required.

1.2.16 LICENSING REQUIREMENTS

The repository shall be a Federally licensed facility per the requirements of the NRC as defined in 10 CFR. In addition, state and local licenses and permits will have to be obtained for various purposes such as siting, zoning, effluent releases, etc.

1.2.16.1 Federal Licenses

The following is a list of regulations in the CFR relevant to the major areas of Waste Isolation Program facility design and management:

- . 10 CFR 20, Radiation Protection Standards;
- . 10 CFR 30, Possession and Use of Byproduct Materials (Licensing);
- . 10 CFR 40, Possession and Use of Source Materials (Licensing);
- . 10 CFR 50, Licensing of Production and Utilization Facilities;
- . 10 CFR 51, Implementation of NEPA;
- . 10 CFR 60, Disposal of High-Level Radioactive Wastes in Geologic Repositories;
- . 10 CFR 71, Containers for Transportation of Nuclear Materials (Licensing);
- . 10 CFR 73, Physical Protection Standards (Security) for Fixed Facilities and Transportation;
- . 10 CFR 100, Reactor Site Criteria;
- . 10 CFR 150, Agreement State Program.

Since the NRC has not developed specific regulations relating to terminal waste storage, a design basis licensability shall be developed (TBD-8) for interim guidance pending NRC development of appropriate regulations and guides. The study shall identify applicable regulations and regulatory guides.

Three items, not specific to the Basalt Waste Isolation Program, stand out as of particular importance. These are:

- . Confinement components, systems, and structures important to safety to be designed and constructed to withstand natural phenomena and credible accidents;
- . Quality assurance criteria such as those of Appendix B, 10 CFR 50 to be applied to safety-related structures, systems, and components;
- . Site criteria as enumerated in 10 CFR 100.

The licensing is expected to require the preparation of the following documentation:

- . Environmental report;
- . License application (preliminary and final safety analysis reports);
- . Security plan;
- . Emergency plan.

1.2.16.2 State and Local Licenses and Permits

The site and facility design shall acknowledge state and local regulations.

1.2.16.3 Transportation Regulations

Federal requirements for transport of nuclear materials are defined in 10 CFR 71 (NRC) and 49 CFR 170-179 (Department of Transportation). The requirements of ERDAM 0529 must also be met. This manual chapter requires that intra-facility and inter-facility transportation of nuclear materials by road or rail meets the federal requirements stated above unless it is not technically and economically practical to do so.

The above requirements shall be considered in the design if road or rail transport beyond that of the approved cask carrier is contemplated.

1.2.17 QUALITY ASSURANCE

The repository shall be designed, constructed, operated, and decommissioned under a QA program meeting the requirements of 10 CFR 50, Appendix B.

The structures, systems, and components will be classified into three levels for control and management of the QA program, depending on the importance of a failure to facility safety and to the environment.

- Level I -- Includes physical systems, portions of systems, structures, and components whose failure might cause, or increase the severity of, a release of radioactivity or a release of hazardous or toxic materials to the environs. These structures and components are vital to the safe shutdown or isolation of the process or system. These are items that directly affect operability, performance, security, or safety of the facility.
- Level II -- Includes physical systems or portions of systems, structures, or components that are important to the operation of the process or system, but are not essential to safe shutdown and isolation. Failure of these items may create a serious impact on the operation, performance, security, or safety of the facility. Level II failures create an impact on cost, schedule, or programmatic results.
- Level III -- Includes the structures and equipment that are related to the process or system operation; these are not essential to safe shutdown, but do provide a function or service to the facility. Level III also applies to commercial, off-the-shelf items for which existing commercial quality control practices are adequate. (Level III commercial items may be used in Level I and Level II systems with appropriate testing of the system.)

The following items are candidates for assignment to QA Levels I and II:

- Systems for canister handling, repair, decontamination, and overpack;
- Systems for environmental radiation monitoring and criticality alarm;
- Ventilation system and confinement barriers;

- . Emergency power system including switching means;
- . Fire protection system;
- . Emergency evacuation provisions;
- . Measurement, control, accounting, and protection of nuclear material;
- . Critical security systems.

Development of quality designs and adequate safeguards will satisfy requirements of IMD 6103 and IMD 6104. Further, these design activities will contribute directly to the satisfaction of licensing documentation requirements (Part I, 1.2.16).

1.2.18 CODES, STANDARDS, AND REGULATIONS

The following listings include the codes and standards for use in design, construction, operation and decommissioning of the repository. The NRC licensing regulations (10 CFR), DOE guidelines and directives, NRC regulatory guides, and technical codes and standards are included in the listings. Additional codes and standards may be selected by the architect-engineer.

Code of Federal Regulations (to be used pending new regulations)

- . 10 CFR 20, Standards for Protection Against Radiation.
- . 10 CFR 30, Rules of General Applicability to Licensing of Byproduct Material.
- . 10 CFR 40, Licensing of Source Material.
- . 10 CFR 50, Licensing of Production and Utilization Facilities.
- . 10 CFR 51, Licensing and Regulatory Policy and Procedures.
- . 10 CFR 60, 62, and 72 (pending).
- . 10 CFR 70, Special Nuclear Material.

- . 10 CFR 71, Packaging of Radioactive Material for Transport and Transportation of Radioactive Material Under Certain Conditions.
- . 10 CFR 73, Physical Protection of Plants and Materials.
- . 10 CFR 100, Reactor Site Criteria.
- . 10 CFR 150, Exemptions and Continued Regulatory Authority in Agreement States Under Section 274.
- . 29 CFR 1910, Occupational Safety and Health Standards.
- . 29 CFR 1926, Safety Health Regulations for Construction.
- . 30 CFR 57, Federal Health and Safety Standards Metal and Non-Metal Underground Mines.
- . 49 CFR 170-179, (Materials Transportation Bureau), Subchapter C, Hazardous Materials Regulations.

Manual Chapters and Interim Management Directives (U. S. Department of Energy)

- . Manual Chapter 0510, Reporting Requirements in Connection with the Prevention, Control, and Abatement of Environmental Pollution at Existing Federal Facilities.
- . Manual Chapter 0511, Radioactive Waste Management.
- . Manual Chapter 0513, Effluent and Environmental Monitoring and Reporting.
- . Manual Chapter 0524, Standards for Radiation Protection.
- . Manual Chapter 0529, Safety Standards for the Packaging of Fissile and Other Radioactive Materials.
- . Manual Chapter 0530, Nuclear Criticality Safety.
- . Manual Chapter 0550, Operational Safety Standards.
- . Manual Chapter 0552, Fire Protection.
- . Manual Chapter 6301, General Design Criteria.
- . IMD 5001, Safety, Health, and Environmental Protection.
- . IMD 5101, Interim National Environmental Policy Act Directive.
- . IMD 6101, Personnel Security Program.

- . IMD 6102, Physical Protection for Classified Matter and Information.
- . IMD 6103, Physical Protection of Special Nuclear Material.
- . IMD 6104, Control and Accountability of Nuclear Materials.
- . IMD 6105, Physical Protection of DOE Property.

Regulatory Guides (U. S. Nuclear Regulatory Commission) These and Others May Be Used Pending New Regulations and Guides).

- . 1.6, Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems.
- . 1.9, Selection of Diesel Generator Set Capacity for Standby Power Suppliers.
- . 1.21, Radiation Monitors.
- . 1.32, Criteria for Safety-Related Electrical Power Systems for Nuclear Power Plants.
- . 1.41, Preoperational Testing of Redundant Onsite Electric Power Systems to Verify Proper Load Group Assignments.
- . 1.52 (Rev. 1), Design, Testing, and Maintenance Criteria for Engineered-Safety-Feature Atmosphere Cleanup System Air Filtration and Absorption Units of Light-Water-Cooled Nuclear Power Plants.
- . 1.75, Physical Independence of Electric Systems.
- . 1.76, Design Basis Tornado for Nuclear Power Plants.
- . 1.101, Emergency Planning for Nuclear Power Plants.
- . 1.104, Overhead Crane Handling Systems for Nuclear Power Plants.
- . 3.12, General Design Guide for Ventilation Systems of Plutonium Processing and Fuel Fabrication Facilities.
- . 3.24, Guidance on License Applications Siting, Design, and Plant Protection for an Independent Spent Fuel Storage Installation.
- . 3.9, Concrete Radiation Shields.
- . 4.12, Measuring and Reporting of Radioactive Environs of Nuclear Power Plants.
- . 4.8, Environmental Technical Specifications for Nuclear Power Plants.

- . 5.7, Control of Personnel Access to Protected Areas, Vital Areas, and Material Access Areas.
- . 8.2, Guide for Administrative Practices in Radiation Monitoring.
- . 8.8, Information Relevant to Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable.
- . 8.15, Acceptable Programs for Respiratory Protection.

Codes for Structural Metals

- . American Institute of Steel Construction, Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings.
- . American Institute of Steel Construction, Code of Standard Practice for Steel Buildings and Bridges.
- . American Institute of Steel Construction, Specification for Structural Joints Using ASTM A325 or A490 Bolts.
- . American Institute of Steel Construction, Standard Specifications and Load Tables for Open Web Steel Joists, J-Series, and H-Series.
- . American Iron and Steel Institute, Specification for the Design of Cold-Formed Steel Structural Members.
- . Metal Deck Institute, Standard Specification for Steel Roof Deck Construction.
- . Uniform Building Code (applicable sections).

American National Standards Institute

- . ANSI N13.1-69, Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities.
- . ANSI N13.3-69, Dosimetry for Criticality Accidents.
- . ANSI N13.10-74, On Site Instrumentation for Continuously Monitoring Radioactivity in Effluents, Specifications and Performance of.
- . ANSI N16.2, Criticality Accident Alarm System.
- . ANSI N18.5-74, Earthquake Instrumentation Criteria for Nuclear Power Plants.
- . ANSI N28.7-76, Siting, Design and Operation of Plants for the Manufacture of Mixed Oxide (U-Pu) Fuels, Criteria for.

- . ANSI N41.10, Standard for Typical Test of Class IE Electric Cables, Field Splices and Connections for Nuclear Power Generating Stations.
- . ANSI A11.1-73, Industrial Lighting Practice for (IES RP 7-1973).
- . ANSI A58.1, American Standard Building Code Requirements for Minimum Design Loads in Buildings and Other Structures.
- . ANSI N509, Nuclear Power Plant Air Cleaning Units and Components.
- . ANSI N510, Testing of Nuclear Air Cleaning Systems.

American Concrete Institute

American Petroleum Institute

American Society of Mechanical Engineers

- . ANSI/ASME Boiler and Pressure Vessel Code.

American Water Works Association

- . AWWA Manual M-14, Cross Contamination Control.
- . AWWA Standard C-506-69, Backflow Protection Devices.

American Welding Society

- . AWS D1.1, American Welding Society, Structural Welding Code.

California State Mine Safety Orders

National Fire Protection Association

- . NFPA 10, Model Enabling Act, Portable Fire Extinguishers.
- . NFPA 70, National Electric Code.
- . NFPA 72A, Installation, Maintenance and Use of Local Protective Signaling Systems for Watchman, Fire Alarm and Supervisory Service, Standard for 1975 Edition of Number 72A.
- . NFPA 72B, Installation, Maintenance and Use of Auxiliary Protective Signaling Systems for Fire Alarm Service, Standard for 1975 Edition of Number 72B.
- . NFPA 72C, Installation, Maintenance and Use of Remote Station Protective Signaling Systems, Standard for 1975 Edition of Number 72C.

- . NFPA 72D, Installation, Maintenance and Use of Proprietary Protective Signaling System for Watchman, Fire Alarm and Supervisory Service, Standard for 1975 Edition of Number 72D.
- . NFPA 72E, Automatic Fire Detectors, Standard for NFPA Number 72E-1974.
- . NFPA 73, Installation, Maintenance and Use of Public Fire Service Communications, Standard for 1975 Edition of Number 73.
- . NFPA 78, Lightning Protection Code.
- . NFPA 90A, Standard for the Installation of Air Conditioning and Ventilation Systems.
- . NFPA 801, Facilities Handling Radioactive Materials.

Illuminating Engineering Society

Occupational Safety and Health Act

See CFR listing.

Mine Safety and Health Administration

See CFR listing.

U.S. Army Corps of Engineers

- . USCE, Manual EM 1110-2-2901, Tunnels and Shafts in Rock

Washington State Safety Standards for Tunnels, Shafts, and Subways.

Other Codes and Standards

- . IEEE Standard 387-1972, Criteria for Diesel Generator Units Applied as Standby Power Supplies for Nuclear Power Stations.
- . Underwriters' Laboratory, List of Inspected Appliances, Equipment, and Materials.
- . Factory Mutual Approved Equipment Listing.
- . Factory Mutual Engineering Corporation.
- . Sheet Metal and Air Conditioning Contractors National Association Duct Construction Standards.
- . American Society of Heating, Refrigeration and Air Conditioning Engineers Guides and Data Books.
- . ERDA 76-21, Nuclear Air-Cleaning Handbook.

- Bureau of Mines Bulletin 503, Limits of Flammability of Gases and Vapors.
- Bureau of Mines Bulletin 627, Flammability Characteristics of Combustible Gases and Vapors.
- National Electric Code (NEC) (ANSI C1) (NFPA No. 70).
- National Electrical Safety Code (ANSI C2) (NBS H30).

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PART II. SURFACE FACILITIES

1.0 SUMMARY AND SCOPE

The surface facilities of the repository are comprised of operations facilities, support facilities, and protective barriers. The facilities are located above the underground storage and provide the vital support services to the subsurface operations.

The surface facilities constitute the interface with the environment and the public. The site selection process will be influenced by the surface facilities criteria.

The surface facilities receive the waste and process the waste through two separate handling lines: one for spent fuel and waste canisters; and the other for 55-gallon drum waste containers.

The rock to be removed for construction of the subsurface facilities will be stored on the surface.

The surface facility functions are provided in Section 1.1; design criteria are provided in Section 1.2.

1.1 FUNCTIONS OF THE SURFACE FACILITIES

The principal functions of the surface facility are to receive waste destined for the repository, provide facilities to house operations and support functions for the repository, and ship empty casks and retrieved waste from the repository. The specific functions of the surface facility are illustrated in Figure II-1 and include the following.

1.1.1 Operation Facilities to provide facilities to accommodate:

- . Receipt and inspection of waste shipping casks and containers;
- . Preparation and return of unacceptable waste shipments;
- . Confinement barriers and shielding of radioactive materials;
- . Protection from natural phenomena, accidents, and security incidents;
- . Preparation for transfer of waste to subsurface facility;
- . Preparation for shipment of retrieved waste;
- . Return of empty casks;
- . Site-generated waste;
- . Systems equipment.

1.1.2 Administrative and Support Facilities to house:

- . Engineering services;
- . Inventory control of waste capsules;
- . Personnel support and safety operations;
- . Plant safety systems;
- . Management support;
- . Maintenance support.

Figure II-1. Surface Facilities Functions

1.1.3 Offsite Development to provide:

- . Access to public roads and railroads;
- . Access to offsite utilities;
- . Communications to the repository.

1.1.4 Onsite Development to provide:

- . Service roads to surface facilities;
- . Grading to permit drainage and construction;
- . Facilities perimeter barriers to control access;
- . Exclusion area barriers to limit access;
- . Drainage system to control runoff;
- . Railway system to receive and ship materials.

1.1.5 Data Collection and Evaluation Facilities to provide:

- . Analytical laboratory;
- . Health physics and radiation monitoring;
- . Security status monitoring;
- . Environmental monitoring system;
- . Basalt monitoring system.

1.1.6 Rock Handling Facilities to receive the mined materials, store for possible return to subsurface facilities, and provide means of surplus disposal.

1.2 PRECONCEPTUAL DESIGN CRITERIA FOR THE SURFACE FACILITIES

The surface facilities are comprised of those buildings, structures, and areas within the repository that are located above ground.

1.2.1 FACILITY CONFIGURATION

1.2.1.1 Breakdown

The surface facilities shall include the following facilities, structures, and areas:

- . Waste operating facilities;
- . Operations support facilities;
- . Engineering and administrative facilities;
- . Utilities (offsite development);
- . Access ways;
- . Monitoring stations;
- . Rock handling facilities;
- . Security and safeguards facilities;
- . Area for plant expansion.

1.2.1.2 General Arrangement

The surface buildings, structures, and areas of the repository will be located within an exclusion area and within a protected area. The exclusion area shall meet the requirements of 10 CFR 100 and shall identify an area of restricted use in which all personnel may be readily evacuated. Within the exclusion area, there shall be a protected area in which there shall be controlled access to all site operations. The arrangement shall consider future expansion.

1.2.1.3 Surface Operations Facilities

The surface operations facilities shall include the following:

- . Receiving and shipping area;
- . Lag storage area;
- . Cask unloading area;

- . Storage preparation cell;
- . Shaft head house;
- . Operations area;
- . Ventilation supply building;
- . Heat recovery and ventilation exhaust facility.

The receiving and shipping area shall provide for the receipt, handling, and shipment of waste from both truck and rail carriers (refer to Appendix A for quantities). The area shall also provide for the receipt and shipping of non-waste material, equipment, and supplies. The cask and container handling areas shall be separate from the other handling areas.

The rail line shall be located to mutually benefit operations and construction. Sufficient space and handling equipment shall be provided within the site to accommodate (TBD-9) batch deliveries and lag storage requirements. Dock areas shall accommodate waste handling equipment including a cask handling crane. Space shall be provided for truck approach, turning, and parking at the dock.

The lag storage area will store casks from an entire rail shipment and will have means to power the cask-environment support equipment.

Parallel processing facilities shall be provided for the canisters and the containers. This shall be verified by a trade study (TBD-10). This study shall consider the differences in weight, length, safeguards and security, radioactivity, heat generation, shielding, and processing rates.

a. Canister Processing

The transfer of canisters to the repository may or may not require a cask, since the packaging facility will be located on the site. If a cask is used a cask, unloading area shall be provided adjacent to the cask unloading port in the wall of the

storage preparation cell. This facility shall provide for decontamination of cask and commercial carrier and for collection and retention of the wastes. The cask unloading area shall be a confinement facility.

The storage preparation cell shall provide the space, shielding, and provisions to process and handle the spent fuel canisters and the HLW and IL-TRU canisters. The structure shall contain shielded areas for sound canisters and a shielded/confinement cell for failed and suspect canisters. The confinement area shall be of sufficient size to handle the waste quantities expected in the various modes of retrievability (TBD-11). Canisters will be introduced to the cell through transfer ports which will mate with the cask and extend the shielding and environmental control through the duration of the transfer.

The confinement cell shall provide stations for the following canister operations:

- . Inspection;
- . Decontamination;
- . Repair or assembly of an overpack;
- . Storage;
- . Transfer to other cells.

Shielded operating cells shall be provided with remote provisions, viewing means, and other specialties. Once through these operations, the prepared canister will be transferred to the canister shaft head. A shielded and confined structure will be required to house the transfer by the remote handling system from storage preparation to the canister shaft hoist system.

b. Container Processing

After receipt and unloading, the waste containers will be sent to the container storage preparation facility. This facility shall meet shielding and confinement requirements and include the following stations.

- . Inspection;
- . Preparation for storage;
- . Overpack and repair.

Space shall be provided for the container handling system (reference Part V). Lag storage space shall be provided for (TBD-12) containers.

Once through these operations, the prepared container will be transferred to the container shaft head.

Shaft head houses shall cover the surface access to each shaft. These structures shall meet climatic, isolation, shielding, ventilation, personnel, and service and utility requirements. Some will have specialty requirements such as supply air cooling, heat recovery, rock handling, etc.

An operations building shall be located adjacent to the storage preparation facilities and shall house the repository control room, change rooms, lunchrooms, and offices for shift supervisors.

A mine ventilation building shall be provided to house supply blowers, chillers, and ancillary equipment. It shall be located near or over the shaft supplying the ventilation.

A heat recovery building shall be provided to house heat recovery equipment that utilizes waste heat from the exhaust ventilation shaft. The exhaust system shall be comprised of prefilters and

blowers and with provision to interpose HEPA and activated charcoal filters in the effluent stream upon detection of radioactivity in the exhaust.

1.2.1.4 Operations Support Facilities

Several facilities shall be provided to accommodate operations support activities. These shall include the following:

- . Fire station;
- . Maintenance shop;
- . Warehouse;
- . Garage and equipment yard;
- . First-aid/medical station;
- . Health physics station;
- . Emergency power station;
- . Laboratories (located in engineering and administrative facility).

Portable and mobile fire-fighting equipment and firemen shall be housed in a station where both surface and subsurface facilities may be serviced.

A maintenance and service facility shall be provided. It shall house necessary electrical, mechanical, instrument, and carpentry shops. Hot shops shall be provided to repair, maintain, and store radioactive tools and equipment. A warehouse shall be provided to store supplies, parts, tools, and equipment that need protection from the weather.

A garage shall provide an indoor and outdoor work area for repair and maintenance of vehicles. It shall contain fuel storage and supply facilities. A fenced area shall be provided for outdoor equipment storage. Available facilities, if nearby, shall be used.

A first-aid and medical station shall be provided to accommodate a nurse and necessary medical and emergency equipment and supplies.

Facilities shall be provided to support health physics activities. These shall include such things as personnel decontamination, monitoring equipment, and office space in which to administer the radiation control areas.

Space and housing shall be provided for the emergency power generator and the power source for the uninterruptible power.

1.2.1.5 Engineering and Administration Facility

Office space shall be provided for (TBD-13) engineering and administrative personnel. Space for office support services such as janitorial, lunchrooms, reproduction equipment, conference rooms, library, etc., shall be included. Such space shall be located in the proximity of the center of operations.

Space shall be provided for (TBD-14) laboratory personnel and equipment. These shall include a geotechnical laboratory.

1.2.1.6 Utilities (off-site development)

An offsite source shall provide the electric power service for site operation. The power shall be delivered from a utility-provided substation located near the site. Power needs are as follows:

- (TBD-14) Voltage;
- 60 Hertz (hz);
- (TBD-14) Megavolt amps (MVA).

The substation shall have access control and be protected by use of a physical barrier. Offsite sources of water will be required only if site conditions make it favorable. No offsite waste disposal

services will be needed. Offsite communications connections shall be made. These shall include commercial telephone and emergency radio.

Roadways and rail lines will be provided by another agency to connect public/commercial transportation systems to the site.

1.2.1.7 Onsite Development

On site, the roads shall accommodate passenger needs and freight trucks that transport casks, equipment, materials, and supplies; these loads are (TBD-15). Passenger car, bus, and freight truck parking areas shall be provided; the location of these areas shall be convenient to normal work stations.

ERDAM 6203 shall be used as a guide.

Onsite, the railroad shall be compatible with the servicing track. The road layout shall consider traffic flow, storage spurs, and transport delivery time for efficient movement of casks, equipment, materials, and supplies. A means shall be provided to switch cars in the rail yard.

1.2.1.8 Monitoring Stations

The surface facilities shall include a meteorological station, a basalt monitoring system, a seismic monitoring system, and the space needed to install an offsite/onsite radiological monitoring system.

1.2.1.9 Rock Handling Facilities

An area within the site shall be designated for use as a storage site for the excavated/mined rock. The storage area shall, if practicable, be located near the mine shaft to minimize transport, handling, and disposal. Space shall be provided to accommodate the rock handling equipment.

Provisions and equipment, as needed, shall be provided to prepare the rock (crushers, classifiers, etc., as defined by terminal storage requirements) and deliver it to the rock handling shaft.

1.2.1.10 Security and Safeguards Facilities

The plant site shall be secured to meet the requirements of 10 CFR 73 and DOE IMD 6103 (see Section 1.2.1.6, Part VI). Protective fences, guard stations, a security operations control center, and a patrol headquarters building shall be provided as physical facilities to support the installation and operation of the security and safeguards system. The protected area fences shall be designed to accommodate the installation of an intrusion detection system. An exclusion area barrier (TBD-16) shall be established. Perimeter fences around surface facilities shall establish the controlled peripheral zone (see Section 1.2.10, Part I).

The guard stations shall have sufficient space and be arranged to accommodate access control equipment and to meet security guard needs.

1.2.2. INTERFACE DEFINITION

The design of the surface facilities shall both identify and include provisions to satisfy interfaces with other parts of the repository.

1.2.2.1 Shaft and Subsurface Facilities Interface

The interface with the shaft systems and the subsurface facilities will include:

- . Confinement involving structure, air locks, seals, and penetrations;
- . Access, space, mountings, etc., for passage of utility and service runs;
- . Space for shaft and subsurface operation controls, instrumentation, communication, and alarm connections;
- . Personnel and material traffic, access, and handling systems;

- . Rock handling;
- . Ventilation, air;
- . Security.

1.2.2.2 Remote Handling System Interface

The interface with the remote handling system will include:

- . Remote handling system entrance and exit;
- . Mounting and supports;
- . Space envelope;
- . Utilities and services for the waste handling system;
- . Cooling of the canister during transport;
- . Remote handling maintenance requirements;
- . Remote displays and site operation controls.

1.2.2.3 Surface Facilities Interface with Systems

The interface with the repository systems includes:

- . Ventilation system;
- . Power substation to electrical systems;
- . Utility needs of surface facilities;
- . Arrangement of system facilities on the surface;
- . Water supply system;
- . Compressed air supply system;
- . Emergency power;
- . Communications and alarms;
- . Fire protection;
- . Waste disposal;
- . Cask handling;
- . Security and safeguards;
- . Energy conservation;
- . Rock removal;
- . Mine cooling system.

1.2.3 OPERATIONS AND PERSONNEL REQUIREMENTS

Surface personnel will be assigned to perform operational, technical and engineering, supportive, and administrative tasks. Their activities will primarily concern waste receiving and processing, maintenance, and rock storage. A design basis occupancy level shall be established as the activities are defined in greater detail (TBD-17).

1.2.3.1 Operations

Operations personnel shall be assigned to operate the facilities, the operations building, and the maintenance service facility. These personnel shall be capable of operating the equipment and performing maintenance tasks.

Rock-handling personnel will be required to operate the equipment necessary to receive and store the rock from the mining operations. Where permissible, it may be advisable for operations personnel to possess qualifications to perform both surface and subsurface activities.

Maintenance personnel shall be capable of maintaining the surface and subsurface facilities and equipment. Mechanical, electrical, and instrument skills shall be available.

1.2.3.2 Technical Support

Technical personnel shall be assigned to meet engineering, laboratory, safety, health physics, geologic, life support maintenance, and utility needs. These persons shall be capable of consulting, training, and providing technical liaison to surface and subsurface operations.

Personnel to perform radiation monitoring services shall be available at all times. These personnel shall be capable of establishing and controlling radiation areas, monitoring and decontaminating personnel, monitoring all radiation areas, administering

radiation dosage data, and operating necessary radiation measuring and monitoring instrumentation.

1.2.3.3 Administrative Support

Administrative support personnel will be assigned to meet the administrative needs related to supervision, training, safety, subsurface coordination, operating procedures, inventory control, security, nuclear materials control, visitors, etc.

1.2.4 CLASSIFICATION OF SYSTEMS

The classification of structures and systems shall include consideration of safety analyses/assessments, programmatic loss potential, and industrial experience.

A safety analysis shall be performed and will involve examination of the response of the plant to natural phenomena and postulated accidents and determination of the potential consequences as related to occupational risk and the public safety considerations of 10 CFR 100. The safety analyses shall show which (if any) structures, components, or systems need be Seismic Category I or II.

Once an initial classification of systems has been accomplished, a balanced qualification of system components shall be considered to assure that there is no mismatch of function and level.

The QA level definitions are given in, Section 1.2.17, Part I. The QA classifications shall be applied as follows:

- Level I systems shall include isolation barriers, the ventilation system, life support systems, the criticality monitoring system, communications, and emergency power (TBD-18);
- Level II systems shall include the canister-handling equipment, the storage borehole lines, security equipment, and the radioactive monitoring systems (TBD-18);
- Level III systems shall include the other items of the surface facility.

1.2.5 SITE REQUIREMENTS

The arrangement of the surface facility shall be considered in the site requirements. Items to consider include:

- . Access by road and by rail; these data shall be reconsidered as studies are completed and updated accordingly;
- . Interrelationship of construction, mining, and repository activities;
- . Facilities orientation based on hazard (i.e., fire, flood, contamination);
- . Local terrain, transport routes, prevailing winds, drainage, water deposits, and aesthetic appearance.

These arrangement considerations along with the results of other studies shall be used to make the best use of the selected site. The following shall be established:

- . Size of exclusion area (TBD-16);
- . Size of protected area (TBD-19);
- . Size of rock storage area (TBD-20);
- . Capacity of onsite and offsite water supply (TBD-21).

Siting requirements shall consider the prospective location of the substation and offsite utility routing.

1.2.6 GENERAL DESIGN CRITERIA

General design criteria for the surface facilities include architectural, civil, structural, mechanical, and electrical requirements.

1.2.6.1 Architectural Design Requirements

The surface facility location and arrangements shall evolve from the results of a repository arrangement study. The surface layout design shall provide roadways, facility access, buildings, and related site functions. Material handling and transfer operations shall be designed for effective traffic flow.

Radioactive support areas shall be located to minimize the transport of materials with contamination potential through "clean" areas. The layout shall minimize radiation exposure to personnel by shielding, spacing, and shortened transport times.

Cask and waste receiving, handling, storage, and transfer areas shall be established. Work areas shall be provided as needed to support equipment operations, inspections, and accounting.

Space shall be provided to accommodate the transportation and handling systems, including areas for maintenance, service, and inspection of loaded or unloaded transporters.

Radiation safety support areas shall be established to accommodate health physics needs (including space for radiation monitors, calibration, and servicing of detectors) and the testing, maintenance, and calibration of radiation monitoring systems. Personnel change rooms, decontamination facilities, and controlled step-off areas shall be provided for operations involving a potential for contamination. Decontamination by mobile unit shall be considered.

Plot plans of various radiation zones shall be established to evaluate design goal exposures for each radioactive and potentially radioactive occupancy area.

Storage space shall be provided for spare parts, cask rigging and handling gear, packaged contaminated waste awaiting disposal, in-cell equipment to be installed, in-cell equipment removed and awaiting repair, and shipping casks awaiting transfer.

Provisions shall be made, where applicable, to accommodate the handicapped and female staff.

1.2.6.2 Civil Design Requirements

The civil design aspects of site preparation include grading, fencing, drainage, roadways, and railways. ERDAM 6203 shall be used as a design guide.

Drainage design and site hydrology shall be such that the danger of floods or flash floods will not threaten key facilities or any shaft.

Loose rock shall not have a slope greater than 1:3 in areas other than that dedicated to mined rock disposal.

Perimeter fencing shall conform to DOE IMD 6102 and the security requirements prescribed by these criteria.

The roads shall be suitable for use by trucks engaged in the transport of a spent fuel shipping cask.

Railway spurs shall be provided to handle the loads of a cask rail car.

1.2.6.3 Structural Design Requirements

Structural design, including loading combinations and construction of crucial safety and fire protection items, shall be in accordance with current editions of pertinent nationally recognized codes and standards, as a minimum, and the design criteria contained in this section. The analyses shall include seismic and tornado loads.

The structural design requirements should show a list of the buildings which must be tornado and earthquake resistant.

1.2.6.4 Mechanical Design Requirements

Mechanical systems shall comply with industrial codes and standards. Cranes and hoists not supplied by the remote handling system shall be provided.

1.2.6.5 Electrical Design Requirements

Primary power shall be furnished from public utilities. The electrical system (Part VI) will transmit to load distribution centers, which in turn will distribute the power to meet individual demands.

1.2.7 NUCLEAR SAFETY

Nuclear safety for the surface facilities concerns radiation protection, effective cleaning of effluents, and ameliorating the consequences of accidents due to natural phenomena, equipment malfunction, security incidents, or human error. The requirement for a safety analysis report and related general criteria are presented in Section 1.2.7, Part I. The safety aspects of capsule transport shall be addressed where applicable.

1.2.8 FIRE PROTECTION

The general design requirements for fire protection are provided in Section 1.2.8, Part I. Fire protection system requirements are provided in Section 1.2.8, Part VI.

Surface facility features requiring fire protection include:

- . The environmental barrier;
- . The emergency power system;
- . Vital subsurface support functions;
- . Exhaust ventilation including HEPA filters;
- . Radiological waste materials;
- . People and government property.

Ventilation openings shall be protected by UL-listed automatic closing fire dampers. Ventilation ducting and filters shall be constructed of incombustible materials.

Other penetrations required for electrical systems shall be sealed to maintain the integrity of the fire area.

1.2.9 INDUSTRIAL SAFETY

Industrial safety design requirements for the surface facilities are provided in Section 1.2.9, Part I.

1.2.10 SECURITY AND SAFEGUARDS

Security and safeguards systems shall be established according to the requirements of Section 1.2.10, Part I, and in accordance with IMD 6101, 6102, 6103, 6104, and 6105 and 10 CFR 70, 71, and 73. The surface facility shall be capable of providing security coverage for all activities within its boundaries and shall maintain close liaison with local, county, and state enforcement facilities.

1.2.11 WASTE MANAGEMENT--FACILITY GENERATED

Provisions shall be made to accommodate the radioactive liquid wastes that may be generated in the following locations:

- . Cask and capsule decontamination and leakage;
- . Personnel decontamination;
- . Floor drains of the storage preparation cell;
- . Radioactive maintenance area wash-down.

A liquid waste retention system will collect contaminated and suspect liquid wastes. A treatment system and disposal system shall process the collected wastes.

Radioactive solid wastes may be generated in the storage preparation cell, in the solidification of liquid waste, and in the hot maintenance area. The waste shall be collected, packaged, and disposed per the requirements of Part I, Section 1.2.11.

Waste management techniques to be implemented with repository-generated wastes include volume reduction (e.g., compaction, incineration, and evaporation), solidification, packaging, and compacting biodegradable nonradioactive waste.

1.2.12 ENVIRONMENTAL CONSIDERATIONS AND DECOMMISSIONING

The overall environmental requirements of Part I shall apply to the surface facilities.

Decommissioning shall prepare the surface facility for another use. A surface facility decommissioning plan shall be prepared. In decommissioning, the mine shafts, boreholes, etc., which provide access from the surface facility to the underground workings, shall be sealed. Site control shall be based on government ownership of the land. Appropriate security barriers shall be provided along with warnings and surveillance.

1.2.13 DESIGN LIFE AND RELIABILITY ASSURANCE

The surface facilities shall have a design life of (TBD-22) years.

Reliability design goals shall be established for the safety- or design life-related components of the surface facilities. Specific attention shall be given to critical systems and components.

1.2.14 MAINTENANCE

Maintenance support equipment and hand tools shall be provided as necessary to perform maintenance on the facilities, equipment, and utilities of the surface facilities. (See Section 1.2.14, Part I, for general maintenance requirements.)

1.2.15 ENERGY CONSERVATION

Energy conservation shall be considered in each of the power needs. Goals shall be established during conceptual design. The use of recovered heat and supplemental solar heating shall be considered.

1.2.16 LICENSING

Surface facility license requirements are described in Part I.

1.2.17 QUALITY ASSURANCE

The QA program requirements described in Part I shall apply to the surface facilities.

1.2.18 CODES AND STANDARDS

Refer to Part I for codes and standards applicable to the surface facility design.

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PART III. SHAFTS

1.0 SUMMARY AND SCOPE

Nuclear waste storage, mining operations, maintenance, and emergency operations require transfers between the surface and the subsurface facilities. The transfer may involve a 3,000-foot change in elevation. The shaft systems provide the means for this transfer.

The shaft facility includes surface and subsurface interfaces and the means for hoisting and transporting nonradioactive equipment, material, rock, and personnel. The remote handling system (Part V) will accommodate radio- active capsules.

Utilities, services, and ventilation air and ducts will be routed through the shafts; these will require space, support, and services compatible with other shaft functions.

The functional requirements are presented in Section 1.1 and the design criteria in Section 1.2.

1.1 SHAFT FUNCTIONS

The principal function of the shafts is to provide controlled penetration of the isolation barrier (basalt formation) for access for personnel, equipment, support services, and materials between surface and subsurface facilities during the operating phase of the repository. The shafts shall isolate ground water. The specific functions are illustrated in Figure III-1 and include the following.

1.1.1 An Isolation Barrier to provide:

- A confinement barrier to the biosphere and ground water;
- Ultimately upon decommissioning, a containment barrier.

1.1.2 Access and Accommodations for Systems to provide:

- Space within the shafts for the pipes, conduits, cables, and wires for the repository systems;
- Space for ventilation, cooling, and other life support systems to personnel;
- Structural support for equipment, mining operations, and other systems of Part VI.

1.1.3 Access and Accommodations for the Remote Handling System to provide:

- Space within the shafts for mechanisms, conduits, cables, and wires for the remote handling system;
- Shielding during capsule transport;
- Structural support for necessary alignment and loads.

1.1.4 Man/Material Transport to provide:

- Access for mining equipment to the basalt formation to permit development of subsurface facilities for storage of waste;
- Access of personnel to subsurface facility;
- Access for supplies and equipment to support waste storage operations;
- A means of transporting men and materials.

Figure III-1. Shaft Functions

1.1.5 Emergency Access/Escape to provide:

- . An emergency escape route from the subsurface;
- . Operational and life support services;
- . A means of transporting personnel.

1.1.6 Rock Transport to provide:

- . Removal of mined rock;
- . Replacement of mined rock;
- . Operational services.

1.2 SHAFT PRECONCEPTUAL DESIGN CRITERIA

1.2.1 FACILITY CONFIGURATION

These criteria describe requirements for the means to satisfy the functions defined in Section 1.1 of this Part III and assume that the site selected for the repository will require shaft development.

The shaft system shall be the means by which personnel, materials, and equipment are moved between the surface and subsurface facilities (approximately 3,000 feet of elevation, TBD-23). The shafts may not be vertical depending on site characteristics. Design criteria for remote handling are separately presented in Part V.

The shaft system shall include the following:

- . Excavation and Structure;

- Liner/aquifer control,
 - Hoist system mounts,
 - Mounting hardware for services,

- . Hoist Systems;

- Head frame,
 - Hoist motor and cable drums,
 - Controls,
 - Cage.

1.2.1.1 Excavation and Structure

Excavations through the isolation barrier shall provide access to the subsurface facilities. Each excavation shall have barriers (TBD-24) as necessary to assure confinement. The barrier shall be adequate to provide public and operator safety and to protect the facility when subjected to both internal and external forces. Protection against external water, geologic forces, internal accidents, and other structural loads shall be provided.

The bottom of the shaft shall drain to a sump where possible.

1.2.1.2 Subsurface Service and Support Provisions

The shaft systems shall accommodate repository systems (Part VI) that support subsurface activities and pass through the shaft (ventilation included). Space, mountings, and other provisions for pipes, wires, conduits, ducts, etc., shall be provided for these utilities and service systems.

1.2.1.3 Remote Handling System Provisions

The capsule shaft(s) shall include provisions for the remote handling systems such as mountings, structure, space, and power. The capsule shaft(s) shall accommodate remote handling systems of size and load necessary to handle the waste characteristics and dimensions shown in Appendix A. The capsules may be either palletized, magazined, or collectively moved by other means. Refer to Part V.

1.2.1.4 Personnel Hoist System

A system shall be provided within a shaft or shafts to raise and lower personnel between the surface and subsurface facilities. The system shall include a cage or lift, a hoist and drive unit, and a control and safety system. The system shall include a means of meeting emergency requirements for evacuating (TBD-25) personnel and transporting (TBD-25) emergency personnel and supplies. Emergency requirements are defined in Section 1.2.1.11, Part VI.

1.2.1.5 Material Hoist System

A system shall be provided within a shaft or shafts to raise and lower materials and equipment necessary to support the subsurface waste processing and mining activities. The system shall include a lift of sufficient size and capacity to handle mining equipment (TBD-26), remote handling system components, operational support equipment (TBD-26), emergency and fire equipment (TBD-26), and all other subsurface items not amenable to ready disassembly (TBD-26).

It shall include a hoist, drive unit, and control and safety system. Consideration shall be given to isolating the hoisting of contaminated items.

1.2.1.6 Emergency Access/Escape

Means shall be provided to permit personnel access or escape under emergency conditions (TBD-25).

1.2.1.7 Rock Hoist System

Means shall be provided to raise to the surface or return for backfill that rock removed by excavation. The size, capacity, and configuration shall meet the needs of the subsurface and surface handling system. The system will include a rock conveyance, a hoist and drive unit, and a control and safety system.

1.2.1.8 Utility and Services for Shaft Systems

Power, water, air, steam, etc., as needed by the shaft systems shall be provided by the repository systems (Part VI).

1.2.2 INTERFACE DEFINITION

The design of the shaft systems shall identify and include provisions to satisfy interfaces with other parts of the repository.

1.2.2.1 Surface Facilities Interface

The interface with the surface facilities will include:

- . Confinement involving structure, air locks, seals, penetrations;
- . Structure involving space and bearing for hoists and drive units, lifts, and cages;
- . Access, space, mountings, etc., for passage of service runs to the subsurface facilities;
- . Space for hoist system controls and electrical and instrumentation connections;
- . Ventilation;

- . Personnel and material traffic, access, and handling systems;
- . Rock handling;
- . Decommissioning provisions.

1.2.2.2 Remote Handling System Interface

The interface with the remote handling system includes:

- . Remote handling system ingress and egress;
- . Mounting and supports;
- . Space envelope;
- . Utilities and services for the remote handling system;
- . Cooling of canister during transport (if required);
- . Impact arrester.

1.2.2.3 Subsurface Facilities Interface

The interface with the subsurface facilities includes:

- . Confinement involving structure, access, ventilation, penetrations, etc;
- . Structure involving space and loads;
- . Access, space, mounting for subsurface utilities and services;
- . Personnel and material traffic and handling systems;
- . Rock handling system access;
- . Ventilation;
- . Sump services;
- . Emergency provisions.

1.2.2.4 Shaft Interface with Systems

The interface with the repository systems includes:

- . Ventilation;
- . Service distribution systems--access, penetrations, mountings, etc.;
- . Connection to provide utilities and services needed by the shaft systems;

- . Emergency power;
- . Lighting;
- . Communications and alarms;
- . Fire protection;
- . Waste disposal for radioactive and nonradioactive liquids and solids;
- . Maintenance.

1.2.3 OPERATIONS AND PERSONNEL REQUIREMENTS

Operators shall be assigned to the shaft system if necessary. Supportive engineering, inspection, safety, maintenance, hoist, and utilities personnel shall be supplied.

The crew size per shift is (TBD-27).

1.2.4 CLASSIFICATION OF SYSTEMS

Seismic, hydrologic, geologic, and safety analyses shall be performed to determine classification and design bases.

1.2.5 SITE REQUIREMENTS

The shafts will be situated according to planned geologic determinations to optimize process flow and reduce the amount of mining with a minimum of operational interference. Site characteristics could prompt a shaft that deviates from the vertical. Operations which affect the shaft layout include: rock transport and disposal; isolated remote handling of fuel and HLW; handling of ILW and LL-TRU, personnel transport; and supportive system runs.

Such areas as the presence of ground water, the presence of layers of alluvium, abnormally high-pressured subsurface aquifers, and the existence of local faults* shall be considered; and the need for shaft lining and similar sealants and supportive techniques shall be determined.

*Preliminary Feasibility Study on Storage of Radioactive Wastes in Columbia River Basalts, ARH-ST-137, Atlantic Richfield Hanford Company, Richland, Washington, November 1976.

Site seismic conditions shall be considered in shaft site selection and in shaft design.

1.2.6 GENERAL DESIGN REQUIREMENTS

Shaft needs and arrangements shall be established (number, location, orientation, size, and type, [TBD-28]) after consideration of site selection and facility layout studies (Section 1.2.7.1, Part I). Certain shaft(s) will be dedicated to the transport of waste material and will have the remote handling systems. The remaining functions shall be studied to determine the best combination of the following types of shafts:

- . Canister shaft;
- . Container shaft;
- . Personnel shaft;
- . Emergency shaft;
- . Men and Materials shaft;
- . Ventilation shaft.

The shafts shall be of sufficient size, number, and arrangement to provide surface-to-subsurface transfer for personnel, equipment, material, and services for mining and waste storage operations.

The minimum diameter of the material/equipment shaft to permit lowering mining equipment will be (TBD-28). The diameter of the personnel shaft will be large enough to permit (TBD-28) personnel to descend to the subsurface facility and ascend to the surface facility in (TBD-25) minutes. The diameter and wall surface of each shaft will be sized to permit (TBD-29) cubic feet per minute (cfm) of air and (TBD-29) pounds per square inch (psi) pressure drop.

1.2.6.1 Architectural

Cross-section size and configuration of the shafts shall provide space for the conveyances for transporting personnel, equipment, and material in the shaft. Space around the conveyance will be provided for cables, guides, braking mechanism, and maintenance. Considerations to be studied include:

- . Equipment dimensions;
- . Material cage dimensions;
- . Rock removal lift needs.

The upper shaft terminal located in the surface facility will house the hoist machinery structure. The space envelope for hoist head frame and equipment will include access for maintenance. A confinement barrier shall be provided which may be part of the surface facility.

The lower shaft terminal will be located on the subsurface facility. A confinement barrier shall be provided which may be part of the subsurface facility. Space envelope for unloading the material will include access for subsurface equipment.

1.2.6.2 Structural

The structural design shall interface with other repository structures, include the mechanical loads, and satisfy barrier requirements. The characteristics of the adjacent rock shall be considered in the development of external forces; likewise, internal loads from decommissioning activities (i.e., plugging).

Determinations of the effects of the DBE (TBD-30), for surface and subsurface, DBT, and DBF shall be made (see Part I) and the results factored into the design.

Structural loads during construction shall be included in the design analysis. The support of the liner installation during construction will be a major load to be considered.

Structural support for the lift mechanisms shall be provided. The following shall be considered:

- . Type of mechanism;
- . Load and speed of lift;

- . Cage safety brakes as a means of arresting any fall that might create a safety hazard;
- . Use of air seals or drop arrestors to reduce the effects of free-fall (brake failure).

1.2.6.3 Construction

The shaft requirements for construction purposes shall be determined and considered in designing for operational use. The impact of the shaft construction on the design of the surface facilities foundations and layout will be evaluated.

1.2.6.4 Mechanical

In-depth studies shall be performed to determine design and configuration of equipment, rock, personnel, and material hoists. The studies will consider (TBD-31):

- . Size and form of waste rock;
- . Rate of rock removal;
- . Rate of personnel movement;
- . Optimizing shaft design with subsurface equipment design.

Special consideration shall be given to mountings and other interfaces involving ground water isolation and the dewatering system.

The design of the subsurface equipment shall be coordinated with shaft design to determine optimum size for equipment shafts.

1.2.6.5 Electrical

Some form of permanent lighting may be provided in the personnel shafts. The other shafts shall have provisions to be lighted as need may dictate. Electrical loads to be considered for the hoisting system include connected load (TBD-32), operating load (TBD-32), and emergency load (TBD-32).

1.2.7 NUCLEAR SAFETY

Nuclear safety requirements shall be developed from the safety analyses (see Part I).

1.2.8 FIRE PROTECTION

The general requirements for fire protection, suppression, and extinguishment are provided in Section 1.2.8, Part I.

The shaft system shall have adequate capacity for emergency evacuation of personnel and for transport of mobile fire equipment.

Fire stops, sprinkler systems, and conduit enclosures shall be considered. No flammable materials shall be used in vulnerable areas of the shafts. Combustible materials used during construction shall be minimized.

1.2.9 INDUSTRIAL SAFETY

The shaft lifts shall contain adequate emergency and life-support equipment. Lighting battery packs and emergency telecommunications shall be provided on the human occupancy lifts.

Each lift shall be sized to accommodate at least one litter for injured personnel. At least two appropriately separated elevators shall have emergency power for evacuation/escape purposes.

1.2.10 SECURITY AND SAFEGUARDS

Personnel movement to the subsurface waste facilities shall be restricted.

1.2.11 WASTE MANAGEMENT--FACILITY GENERATED

Water located external to the shaft barrier shall be either diverted or collected and channeled to a controlled waste management system (refer to Part VI). Liquid or solid waste removed from the liner walls of the remote handling shaft as the result of an accident shall be included in the waste management design criteria.

1.2.12 ENVIRONMENTAL CONSIDERATIONS AND DECOMMISSIONING

Environmental considerations for the repository are provided in Section 1.2.12, Part I. The shafts shall provide means of isolation to protect the integrity of the isolation barrier.

The shafts shall have provisions to accomplish isolation through decommissioning of the repository including removal of the liner or equipment as necessary.

1.2.13 DESIGN LIFE AND RELIABILITY ASSURANCE

The shaft system shall be capable of operation over the operating life span of the plant. Life standards shall be set on replaceable parts.

Effects of reverse bending on cable life should quantitatively be determined in the selection of the hoist mechanism layout. The brake system will have a reliability of (TBD-33). The emergency stop devices will have a reliability of (TBD-33).

1.2.14 MAINTENANCE

All shafts shall have means to permit inspection and to apply corrective maintenance.

The time that a given type hoist may be out of service for or because of shaft maintenance shall be limited to (TBD-34) days per year.

1.2.15 ENERGY CONSERVATION

The DOE energy conservation practices shall be used in the design. Trade studies to establish size and capacity of the hoist systems shall consider energy consumption along with other design parameters.

1.2.16 LICENSING

The shaft systems shall be designed to NRC licensing requirements.

1.2.17 QUALITY ASSURANCE

Items directly related to confinement and/or safety where failure might cause or permit a radioactive release shall be designed according to QA Level I. All safety-related items shall meet QA requirements as determined in the safety studies.

1.2.18 CODES AND STANDARDS

Refer to Section 1.2.18, Part I.

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PART IV. SUBSURFACE FACILITIES

1.0 SUMMARY AND SCOPE

The subsurface facilities are comprised of storage areas for the waste capsules, connecting tunnels, staging areas, and mine development areas and equipment.

The criteria for capsule storage and the distribution of stored capsules will govern the size and configuration of the repository. A significant related feature is the ventilation system which must accommodate various area temperature and air quality requirements.

The storage operations and mining operations will go on concurrently during the active storage mode. The storage and mining operations will use shared services originating at the surface facility.

Section 1.1 provides the functional requirements for the subsurface facilities, and Section 1.2 provides the design criteria.

1.1 FUNCTIONS OF THE SUBSURFACE FACILITIES

The principal function of the subsurface facility is to provide a shielded and ultimately contained storage area within the isolation medium (basalt). The specific functions are illustrated in Figure IV-1 and include the following.

1.1.1 Access for Remote Handling System to and from Storage to provide:

- . Access tunnels to storage areas for storage and retrieval of capsules;
- . Handling areas within the tunnel matrix;
- . Shielding and confinement of capsules before emplacement;
- . Support services for waste handling operation;

1.1.2 Chambers for Capsule Storage and Removal to provide:

- . Storage chambers with capsule storage positions;
- . Access to storage positions by the remote handling system;
- . Support services for remote handling equipment for emplacement of waste into storage;
- . Shielding, confinement, and ultimately containment of stored capsules;

1.1.3 Operations Support of Subsurface Facility to provide:

- . Access for personnel to storage chambers and waste handling and emplacement system;
- . Subsurface maintenance facilities;
- . Subsurface administrative facilities;
- . Shaft foot receiving and transporter loading cell;

1.1.4 Protection of Isolation Capability to provide:

- . Barriers to unauthorized entry;
- . Monitoring integrity of storage parameters;

Figure IV-1. Subsurface Facilities Functions

- . Means of inspection;
- . Capability for decommissioning.

1.1.5 Provisions for Subsurface Development to include:

- . Mining and use of mining support equipment;
- . Access for personnel to the development area;
- . Separation of the development area from the waste storage activities;
- . Subsurface development support services;
- . Space for rock handling system.

1.2 PRECONCEPTUAL DESIGN CRITERIA FOR THE SUBSURFACE FACILITIES

The subsurface facilities shall provide the space, equipment, and support services necessary to conduct concurrent waste storage operations and subsurface development activities.

1.2.1 FACILITY CONFIGURATION

1.2.1.1 Breakdown

The subsurface facilities shall include the following facilities, structures, and areas:

- . Interconnecting tunnels;
- . Handling areas;
- . Storage chambers;
- . Personnel and administrative areas;
- . Utility and service areas and access ways;
- . Subsurface development areas;
- . Rock handling system.

1.2.1.2 General Arrangement

The arrangement shall consider:

- . The quality and quantity (i.e., thickness, lateral extent) distribution of the basalt;
- . The geology of the site (qualification of the basalt) including the proximity and potential discovery of faults and aquifers;
- . Heat transmission and physical properties of the basalt and their relationship to the placement of heat sources (storage chambers).
- . The amount of tunneling required per storage chamber and enclosure;
- . The number and location of the shafts;
- . The impact upon the ventilation system;

- . The storage quantity/time requirements;
- . The quantities and schedule for rock removal;
- . Elevation (level) differentials;
- . Inflow and drainage;
- . Isolation of mining/construction from waste disposal operations;
- . Security and safeguards;
- . Confinement of radioactive materials;
- . Operating efficiency;
- . Emergency procedures and escape.

Using these considerations, trade-off and cost effectiveness studies shall be run to support layout and arrangement decisions.

1.2.1.3 Interconnecting Tunnels

Tunnels shall connect the shafts with the storage chambers and shall provide passage ways for personnel and equipment. Approximately (TBD-35) miles of tunnels shall be provided.

The tunnels shall have adequate space to accommodate waste and rock handling equipment, ventilation requirements, and other support services. The tunnels shall provide confinement and, where possible, provide the shielding necessary for radiation protection throughout the subsurface facilities.

The design of the tunnels shall minimize the quantity of rock to be removed and shall be reinforced, as necessary, to meet structural requirements. Natural rock support shall be used wherever possible.

1.2.1.4 Handling Areas

Handling areas shall be provided at the foot of each material and personnel shaft. These areas shall be of a size and structure adequate for the transfer of appropriate materials, equipment, and personnel to and from the shaft.

Other handling areas shall be provided as necessary to handle canisters, containers, contaminated waste, equipment, rock, or other supplies. Areas which will handle radioactive materials shall be separate from those that do not. The radioactive material handling areas will require additional space for interim storage of canisters and containers.

1.2.1.5 Storage Chambers

Storage chambers shall be provided of sufficient capacity and size to receive waste capsules, provide storage space (enclosures), permit adequate environmental control, provide space for monitoring and surveillance equipment, and enable waste retrieval.

Both canister and container storage chambers shall be provided.

The potential need for decontamination shall be considered. Space shall be provided for personnel, environmental, and radiological needs.

The storage chambers shall be designed to meet confinement criteria during operation and the containment criteria of decommissioning.

a. Canister Storage Chamber

The canister storage chamber shall have a capacity to store (TBD-36) canisters with (TBD-36) canisters to be placed within a storage enclosure. The spacing and orientation of the storage enclosures within the storage chamber shall be established from the results of test data and design trade-off studies. The spacing determination shall be based on analysis of test data from the Near-Surface Test Facility (NSTF), on fuel canister, and on other heat source factors necessary to maintain a stored canister temperature of less than (TBD-37) for a (TBD-37) period.

Storage area temperature requirements include:

- . Maximum temperature in canister;
- . Maximum temperature of air within storage chamber;
- . Maximum temperature of basalt;
- . Maximum temperature in area when personnel must be present;
- . Maximum design temperature for temperature sensing environment.

A total of (TBD-38) canister storage chambers shall be provided within the repository.

b. Container Storage Chamber

The internal temperature of a container shall not exceed (TBD-37) degrees. The container storage chamber shall have a capacity to store (TBD-36) containers; (TBD-38) container storage chambers shall be provided.

1.2.1.6 Storage Enclosures for Canisters

Storage enclosures shall be provided within the canister storage chambers to receive waste canisters. The design shall permit retrievability.

Each storage enclosure shall be capable of receiving the canisters and shall provide radiation and thermal shielding sufficient to permit required storage chamber personnel access (TBD-39).

Confinement shall be provided as may be necessary to meet safety criteria in the event that canister failure should occur during the retrievability period (TBD-40).

Containment shall be provided as may be necessary to meet decommissioning criteria (TBD-41).

The shielding and confinement features of the storage enclosure shall be compatible with the waste handling system.

The storage enclosures shall be located in appropriately qualified basalt and spaced to meet heat and criticality requirements.

The actual dimensions, linings, etc., shall be determined through use of data from the NSTF and other sources.

1.2.1.7 Personnel and Administrative Areas

Areas and facilities necessary to conduct subsurface operations shall be provided. These shall include:

- . Storage areas (equipment, supplies);
- . Health physics support area;
- . First-aid and emergency supply areas;
- . Maintenance and repair area;
- . Tool cribs;
- . Lavatory areas;
- . Control and monitoring centers.

1.2.1.8 Utility and Service Access Ways

Access ways shall be provided to accommodate equipment and runs for the following systems:

- . Process water;
- . Power supply;
- . Dewatering;
- . Instrumentation;
- . Alarm;
- . Telephone and communication;
- . Ventilation;
- . Compressed air;
- . Repository cooling;
- . Fire protection.

These access ways shall be integrated wherever possible with the tunnels and other subsurface areas.

1.2.1.9 Rock Handling System

A subsurface rock handling system will be provided for use by construction personnel. During the initial operating period (until rock may be needed to backfill storage chambers), rock movement by operations forces will be confined to maintenance; i.e., cleaning up rock falls, expanding room or tunnel area, etc. The rock handling system will be transferred to the mine development area for subsequent construction use.

The return of rock that has been stored on the surface will be accomplished in the terminal mode of operation.

1.2.1.10 Subsurface Development Areas

A mine development area will be located near the subsurface operating facility. Construction forces will be working in this area to provide an extension to the repository capacity. It shall cease to be a mine development area on beneficial occupancy.

The mine development area services, activities, and facilities shall be integrated with those of the repository whenever it is economically justified and does not jeopardize safety and/or confinement.

The construction activities within the mine development area will include:

- . Mining or excavation;
- . Rock crushing (pending decision on mining methods);
- . Rock removal;
- . Installation of storage equipment;
- . Inspection and acceptance.

1.2.2 INTERFACE DEFINITIONS

The physical and functional interfaces between the subsurface facilities and the following shall be defined:

- . Shafts;
- . Waste handling system;
- . Subsurface development (mining operations);
- . Systems.

1.2.2.1 Interface with Shafts

a. Physical

The configuration of the subsurface receiving area shall match that of the shaft configuration such that all structural and mechanical requirements are met. The shaft wall interface shall provide means to control any water collection from the shaft. Isolation barriers and penetrations will be part of the subsurface facilities.

The utility/services interfaces shall be accommodated and meet the requirements of both the shaft and subsurface systems.

b. Functional

The interface between the shafts and the subsurface facilities shall accommodate the handling and movement of waste canisters, waste containers, operational support equipment, maintenance support equipment, waste rock, materials and supplies, air, and personnel. The interfaces shall be matched according to shaft function.

1.2.2.2 Interface with Remote Handling System

This interface involves the functions of transfer, handling, transport, placement, and retrieval in storage chambers and storage enclosures.

Space, utilities, and services to support the waste handling system shall be provided. The waste handling system shall be sufficiently flexible to accommodate the changes in storage locations and the subsurface development.

1.2.2.3 Interface with Subsurface Development Operations

Waste handling operations must be conducted concurrently with subsurface mining and storage expansion operations. The excavation and removal of rock shall be kept independent of the waste handling system and the normal waste storage and retrieval operations except where a combined or staggered operation or where common support services may prove cost effective and meet safety and health requirements. The installation activities to be conducted after the excavation shall also be kept separate from waste storage operations, except where common services may prove cost effective and meet safety and health requirements.

1.2.2.4 Interface with Systems

Physical and functional interfaces with each system shall be defined.

a. Physical:

- . Space;
- . Structure;
- . Mechanical (fixed and portable);

b. Functional:

- . Electrical loads;
- . Air flow;
- . Waste flow;
- . Other.

1.2.3 OPERATING PERSONNEL REQUIREMENTS

Personnel will be required to perform operational, mining, engineering, supportive, and administrative tasks within the subsurface facilities. Their activities will primarily concern waste storage and repository development operations. Design basis occupancy levels shall be established (TBD-8). Nominal requirements are shown in Waste Isolation Facility Description for the Spent Fuel Cycle--Bedded Salt, Parsons Brinkerhoff Quade & Douglas, Inc., Columbus, Ohio, May 1977.

1.2.3.1 Operations

a. Waste Storage

Operations personnel will be required to operate the facilities and equipment in the shaft receiving areas, tunnels, and storage areas. These personnel shall be capable of functioning under ground, operating the equipment, and performing maintenance tasks.

Maintenance personnel capable of repairing and maintaining all subsurface facilities and equipment will be required to support the operational activities. Mechanical, electrical, instrument, and mine repair skills shall be available.

Waste storage operations will require approximately (TBD-42) people per eight-hour shift.

b. Subsurface Development (mining and construction)

Repository development personnel will be required to perform mining and installation operations necessary to continue the expansion of the subsurface facility. Approximately (TBD-42) miners and construction personnel per shift will be required.

1.2.3.2 Technical Support

Technical personnel shall be assigned to meet safety, health physics, geotechnical, life support, maintenance, and service needs.

These persons shall be capable of consulting, training, and providing technical support and liaison as required by subsurface operations.

Personnel to perform radiation monitoring services shall be available during waste disposal operations. These personnel shall be capable of establishing and controlling radiation areas, monitoring and decontaminating personnel, monitoring storage area status, administering control of radiation dosage, and operating necessary radiation measuring and monitoring instrumentation.

1.2.3.3 Administrative Support

Administrative support personnel shall be assigned to meet the administrative needs related to supervision, training, safety, surface coordination, operating procedures, inventory control, security, nuclear materials control, access, etc.

1.2.4 CLASSIFICATION OF STRUCTURES AND SYSTEMS

The classification of subsurface structures, systems, and components shall be determined as discussed in Part I.

1.2.5 SITE REQUIREMENTS

Subsurface characteristics such as geology, hydrology, etc., will influence the layout of the subsurface facilities and can significantly impact site selection and site requirements (refer to Part I). A continuing geologic review will assist in guiding the design and arrangement of the mine development areas.

1.2.6 GENERAL DESIGN REQUIREMENTS

1.2.6.1 Architectural Design Requirements

Capsule handling, storage, and transfer areas shall be established at the receiving shaft foot. Personnel access areas are needed to support operations, maintenance, inspections, and waste accounting. Health physics and industrial health support areas shall be

established. Area shall be provided for lavatories, personnel decontamination, and clothes change. Safety refuge areas shall also be provided.

Portable facilities shall be used wherever possible; i.e., lavatories, first-aid, decontamination, etc. Space development by adaptations to tunnels shall be used when more efficient than excavating a specialized area. The design shall consider flexibility and changing the locations of the more numerous activities.

Space shall be provided to accommodate the transportation and handling systems. The waste handling system shall be provided with supportive areas for maintenance, servicing, disassembly, and inspection. Storage areas shall be provided.

Fire protection provisions for underground enclosures and doors, ventilation openings and other penetrations, and construction materials, as identified in Section 1.2.8, shall be incorporated.

A study of personnel and handling traffic shall be made to increase efficiency of operations, reduce the amount of tunneling, and keep radiation exposure levels ALARA.

Utility and service access ways shall be integrated with the tunnels and rooms.

1.2.6.2 Structural Design Requirements

Tunnels, portals, and foundations for waste handling equipment, ventilation systems, and electrical equipment shall be in accordance with State of Washington Safety Standards for Tunnels, Shafts, and Subways, and 30 CFR 57. Storage liner construction shall conform to containment and decommissioning requirements.

A computer model of the mine cross sections shall be prepared and used to determine the maximum permissible dimensions for tunnels, storage chambers, and support areas. The programs shall include the heating effects of the spent fuel and HLW. The computer model shall use the modeling routines developed and confirmed in the NSTF.

Shaft foot, transporter, and storage area support systems will require analysis and use of data from the NSTF and other sources.

Mine structures shall be inspected and evaluated during construction.

1.2.6.3 Mining Design Requirements

The amount of mining to be accomplished in construction prior to waste storage operations shall be estimated (TBD-43). Alternate methods of basalt mining shall be evaluated, and, based upon a study of these data, the mining method (TBD-43) and the required mining equipment by type and number shall be selected.

The mine shall be developed to a specific size prior to the start of storage of waste. The extent of excavation shall be such that mining can continue and storage can be safely undertaken without hazard to miners or storage operation. The extent of the mine shall be such as to balance mining costs and storage costs, as well as the cost of rock removal.

Core hole samples will be taken and other exploration techniques used as excavation progresses. These samples shall be analyzed (in geotechnical laboratory, Section 1.2.1.5, Part II) or interpreted and the results used to guide construction and verify the qualifications of the basalt at the storage locations.

The NSTF will provide information as to the acceptable rock bolts or lining for the tunnel and storage chamber. This information shall be factored into the design as well as precautions related to faulting.

1.2.6.4 Mechanical Design Requirements

Subsurface mechanical systems that are not associated with the waste handling system shall be identified and provided. Since most maintenance support of subsurface components shall be provided by the surface facility, modular equipment shall be used to permit component exchange whenever replacement is necessary. Refer to Section 1.2.12, Part IV for maintenance philosophy and maintenance requirements.

Mining, rock removal, and rock transport equipment and all support tools shall be provided to support maintenance and operations. The subsurface rock handling system shall be capable of receiving rock at the shaft and transporting it to the storage chambers.

Isolation doors and door penetrations, seals to retain confinement, and other mechanical facets pertinent to maintaining radiological isolation shall be identified and provided.

1.2.6.5 Electrical Design Requirements

Power supply and distribution needs shall be ascertained by consideration of the following:

- . Subsurface facilities layout;
- . Voltage and power needs at different locations;
- . Facility growth;
- . Emergency needs;
- . Mining and safety regulations.

Emergency ac power from the surface is required for backup. This emergency power source shall be completely independent of both the

preferred and alternate primary feeders. This power source shall start automatically in the event both preferred and alternate sources fail. The emergency power source shall have adequate capacity to carry those loads (TBD-44) which are necessary to maintain the integrity of the facility and provide for personnel safety.

An uninterruptible power system (UPS) shall be provided to operate crucial circuits, switchgear, and monitors/alarms as needed. A battery power source shall enable the UPS to maintain full operation for not less than (TBD-45) hours. Battery power shall be instantaneous and automatic upon failure of the primary power source. Battery or other emergency power sources shall be used as necessary to power emergency equipment.

1.2.7 NUCLEAR SAFETY

The overall design philosophy and general design criteria for nuclear safety are provided in Section 1.2.7, Part I.

Radiological safety within the subsurface facilities shall include the use of monitoring instrumentation and the use of health physicists. Area and equipment shall be provided to support the health physics program. These shall include radiation monitors, test and service equipment (portable), and portable decontamination equipment.

1.2.8 FIRE PROTECTION

Fire protection requirements include the prevention, suppression, and extinguishment of subsurface fires. General design requirements are identified in Section 1.2.8, Part I.

Fire protection will be provided by specifically assigned personnel and will use surface-located equipment for major (uncontrolled) fires (TBD-46). Surface support equipment may include a self-contained water pumper and high-expansion foam cars. A team of personnel shall

be established, trained, equipped, and drilled for use of this equipment. Self-contained breathing apparatus must meet the requirements of the Mine Safety and Health Administration.

Subsurface fire protection equipment shall include extinguishers so located to provide immediate control of appropriate class fires. Electrical disconnect switches shall be identified on mine layouts and by posting so that electrical insulation fires can be controlled and extinguished by Class A means.

Ventilation openings shall be protected, as necessary, by UL-rated automatic closing fire dampers. Ventilation ducting and filters shall be constructed of incombustible materials. Other penetrations of isolation doors/bulkheads required for electrical systems shall be sealed to maintain the integrity of the fire area.

The subsurface facility shall, where applicable, conform to the requirements of 30 CFR 57, the requirements of the Mine Safety and Health Administration, and other regulations approved by DOE. Design considerations shall include minimizing or eliminating flammable material from the subsurface facility and using nonflammable hydraulic, lubricating, and cooling fluids. The high temperature of the waste canisters shall be considered.

Passive sensors and reporting manual alarms shall be installed. These facilities shall be readily visible and be operational during loss of ac power as might occur when power is shut down for isolating fires. Alarm systems are presented in Section 1.2.1.6, Part VI.

1.2.9 INDUSTRIAL SAFETY

General requirements for industrial safety are provided in Section 1.2.9, Part I.

Industrial safety support shall be provided to meet operating and construction personnel needs for space and equipment. Current mining

codes shall be surveyed and used. The Federal standard governing mine and tunnel safety is 30 CFR 57. This standard, however, does not cover a repository and therefore can only be considered a guide. The requirements of the State of Washington Safety Standards for Tunnels, Shafts, and Subways shall be met. The California State Mine Safety Orders will be used as a guideline on mining safety whenever a particular subject is not covered by 30 CFR 57.

The mine layout shall be documented. A system of warning and cautions shall be established and posted. Alternate exits and methods of normal evacuation shall be established. All areas open to occupancy shall provide at least two exits where practicable, and at no time shall exiting paths be in excess of current mining practices. Radiation area emergency exits shall consider personnel exposure when determining exit routes/portals.

Adequate disposal facilities shall be provided to support good house-keeping practices.

1.2.10 SECURITY AND SAFEGUARDS

The subsurface security needs can be met by using surface support and personnel control. A personnel control and logging system is needed during construction for facility expansion, modification, or repair. Construction operations shall be separated from the spent fuel handling and storage and shall require corresponding security barriers, escort services, and access controls.

A safeguards system shall be established to provide material control and accounting and "item control area" needs (reference 10 CFR 70).

A system that will control and record the whereabouts and identification of all spent fuel canisters shall be provided. Individual fuel element measurement and control will not be required providing each and every canister can be considered as "tamper safe" and contain "ultimate product" material controlled by "unopened receipts" (reference 10 CFR 70).

Storage locations which have been terminally sealed (closed off) shall be considered exempt from continuing protective safeguards and security support (reference 10 CFR 73.6 and IMD 6103).

Entrance areas to subsurface storage shall be alarmed and monitored. Barriers, alarms, access controls, and CCTV shall be used as necessary to meet protection requirements.

1.2.11 WASTE MANAGEMENT--FACILITY GENERATED

Radiological and nonradiological subsurface-generated wastes shall be identified, categorized, and removed. The methods of disposal shall be selected depending upon the quantities, hazards, and handling requirements (TBD-47).

1.2.12 ENVIRONMENTAL CONSIDERATIONS AND DECOMMISSIONING

All environmental considerations relate to a release of radioactive materials to the biosphere and thus concern confinement, waste management, and ventilation (see Parts II and VI for further detail).

Refer to Part I for general decommissioning program requirements.

1.2.13 DESIGN LIFE AND RELIABILITY ASSURANCE

Equipment or portions of the facility that cannot be replaced without affecting operations shall have a design life of (TBD-48) years or better. The QA Level I systems and components shall have defined reliability requirements. Redundancy shall be used wherever necessary.

1.2.14 MAINTENANCE

Maintenance support equipment and hand tools shall be provided as necessary to perform maintenance on the subsurface facilities and equipment (see Section 1.2.6.4).

Maintainability shall be considered in the design and selection of the subsurface equipment.

1.2.14.1 Maintenance Philosophy

The philosophy of design as related to maintenance shall ensure that radiation doses to maintenance personnel be ALARA.

If major mobile equipment faults occur in a high-radiation exposure zone, the equipment shall be manually retrievable to a low-exposure area such that hands-on maintenance can be performed with a minimum of protective equipment.

Routine maintenance shall be performed on a periodic basis as recommended by the equipment manufacturers. The system design shall consider maintenance activities in the following order of preference:

- . Adjust or repair in place;
- . Replace component with spare unit (then repair the disabled unit);
- . Remove component, repair, and replace same component.

The capability for remote maintenance shall be considered. When, due to the location of a particular item, access would be restricted (e.g., during canister movement), redundancy of equipment or operations shall be provided.

1.2.14.2 Preventive Maintenance

A preventive maintenance program shall be developed and implemented. Specific attention shall be given to the handling and mining equipment.

Equipment and instruments shall be monitored either manually or remotely for malfunction or misadjustment. Idle equipment shall be tested on a routine basis.

Rock structure shall be checked periodically. Rock bolts shall be retorqued, steel sets tightened, lagging replaced or tightened, or

other required procedures performed. The rock mass shall be scaled to remove loose material on a periodic basis.

1.2.14.3 Corrective Maintenance

Before performing corrective maintenance, operating systems shall be shut down, disconnected, or adjusted such that the component can be repaired without damage to other components. Special tools and equipment required to perform most repairs or adjustments shall be on hand. Personnel qualified to make repairs or adjustments shall either be onsite or on call.

Rock falls shall be removed and additional structural support provided as needed.

1.2.14.4 Special Maintenance Requirements

Crucial items shall be designed to permit inspection, maintenance, and testing to assure their continued functioning. Ancillary equipment (such as pumps, blowers, motors, compressors, drive motors, gear trains, and controls) should be located in an area unlikely to be contaminated.

1.2.15 ENERGY CONSERVATION

Energy conservation shall be considered in each of the power needs. Design goals shall be established.

Energy recovery shall be considered and trade studies run to determine feasibility (see Part VI).

1.2.16 LICENSING

The subsurface facilities shall be designed to be licensed by the NRC (refer to Section 1.2.16, Part I).

1.2.17 QUALITY ASSURANCE

Refer to Section 1.2.17, Part I for the general program requirements.

1.2.18 CODES AND STANDARDS

Refer to Section 1.2.18, Part I for a complete listing of codes and standards.

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PART V. REMOTE HANDLING SYSTEM

1.0 SUMMARY AND SCOPE

The remote handling system is comprised of handling and transport mechanisms, equipment for capsule transfer between surface and subsurface levels, storage equipment, and remote viewing and control systems.

Capsules will be processed by the remote handling system from receipt through preparation-for-storage operations, transfer to subsurface, subsurface transport, emplacement in storage, and retrieval operations.

The extent of the remoteness is a function of the radiation and temperature protection required in the capsule processing. Containers will require shielding that is different from canisters.

Two remote handling lines will be provided: one for canisters; and one for containers. Consideration shall be given to isolation of fuel canisters from HLW and ILW canisters.

The capsule orientation (vertical or horizontal) is a significant factor in the remote handling line, not only in terms of the actual translation, but also in terms of area and facility design to provide clearances.

Section 1.1 provides the functional requirements and Section 1.2 provides the design criteria for the remote handling system.

1.1 FUNCTIONS OF THE REMOTE HANDLING SYSTEM

The principal function of the remote handling system is to transport waste capsules from the point of receipt to emplacement in the subsurface storage positions and return if necessary. Specific functions are accomplished within the surface facilities, the waste transfer shaft, and the subsurface facility. These are illustrated in Figure V-1 and include the following.

1.1.1 Capsule Receipt and Preparation for Storage to provide for:

- . Receipt of capsules from packaging facility;
- . Capsule inspection;
- . Overpacking of defective capsules;
- . Transfer of capsules to waste handling shaft.

1.1.2 Waste Transfer between Surface Facility and Subsurface Facility to provide a conveyance with hoisting capability located within the waste handling shaft.

1.1.3 Waste Transfer between Shaft and Storage Position within the Subsurface Facility to provide:

- . Capsule transfer from shaft;
- . Capsule transport to storage chamber.

1.1.4 Waste Emplacement to provide:

- . Capsule orientation and placement;
- . Closure of storage position;
- . Preparation for integrity surveillance.

1.1.5 Capsule Retrievability to provide:

- . Retrieval from emplacement position;
- . Return to waste handling shaft;
- . Return to waste preparation area;
- . Load into shipping cask or transfer to packaging facility.

Figure V-1. Remote Handling Facilities

1.2 PRECONCEPTUAL DESIGN CRITERIA FOR THE REMOTE HANDLING SYSTEM

The remote handling system shall provide the means to handle, transport, process, and transfer radioactive waste capsules (canisters) in the surface, shaft, and subsurface facilities of the repository. The container handling system will permit hands-on operation and will not require remote handling techniques.

1.2.1 SYSTEM CONFIGURATION

1.2.1.1 Breakdown

The remote handling system can be broken down into the handling and transport of canisters and containers.

1.2.1.2 General Arrangement

Capsule processing shall use separate waste storage handling lines for canisters and containers (TBD-49). Also, consideration shall be given to the isolation of fuel-containing canisters.

The system for handling canisters shall provide remote handling in the canister storage preparation cell, in the access way between the cell and the shaft head, through the shaft, in the subsurface receiving area, and in the tunnels and canister storage areas.

The system for handling containers shall provide container handling in the container storage preparation cell, access way between the cell and the shaft head, the shaft, the subsurface receiving area, tunnels, and container storage areas.

1.2.1.3 Canister Receipt

The transfer of canisters to the repository will require a cask since the packaging facility will not be located on the site. With the cask, the following shall be considered.

a. Cask Positioner and Opening Device

The cask positioner and opening device shall perform the final alignment of the cask to the canister preparation cell transfer port. It shall open the cask to reveal the canister.

b. Cask Unloading Port

The cask unloading (transfer) port shall provide the interface between the storage preparation cell and the cask. The port shall be sized to permit the canister extractor to enter the cask, grapple a canister, and move it from the cask into the cell. The port shall provide cell confinement and canister environmental control between the cask and the storage preparation cell.

c. Canister Extractor

The canister extractor shall be remotely operated. It shall have a grapple to enter the cask through the cell port. The grapple will grasp the canister, remove it from the cask, and move it through the port and into the storage preparation cell.

1.2.1.4 In-cell Canister Handling

Canister handling in the preparation for storage cell shall include:

- . Canister acceptance station;
- . Canister inspection equipment;
- . Canister in-cell transport system;
- . Canister repair and overpack equipment;
- . Remote manipulators and operator equipment;
- . Overpacked canister storage equipment;
- . In-cell decontamination equipment.

1.2.1.5 Decontamination

The remote handling system shall provide the means of remotely operating the in-cell decontamination system to:

- . Decontaminate irradiated capsules, structural materials, etc., for transfer or shipment to other facilities;

- . Decontaminate in-cell equipment to permit hands-on maintenance.

1.2.1.6 Canister-To-Shaft Transfer Equipment

Canister handling between the storage preparation cell and the subsurface facilities shall include:

- . Canister shaft transfer equipment -- Remotely operated equipment shall move the canister from the cell into the shaft and place within the lifting cage;
- . Canister shaft hoist -- This hoist system shall raise or lower cages/canisters between the surface and subsurface facilities; the hoist shall include a lifting cage or attachment, a hoist and drive unit, and a control and safety system; the cage shall accept the canister and provide canister environment control; the degree of shielding required and the number of canisters per lift shall be determined by a trade study (TBD-50);
- . Canister transfer equipment (shaft to subsurface facility);

1.2.1.7 Canister Subsurface Handling

Subsurface canister handling equipment shall include:

- . Canister transport;
- . Canister storage and retrieval equipment.

1.2.1.8 Container Transfer Equipment (dock-to-preparation area)

Handling equipment shall be provided to move containers from the dock receiving and inspection area into the preparation for storage area.

1.2.1.9 Container Preparation for Storage Equipment

The container handling equipment shall include:

- . Preparation for storage inspection equipment;
- . Container overpack/repair equipment;
- . Container decontamination equipment;
- . Container packaging (for storage) equipment.

1.2.1.10 Surface-To-Subsurface Transfer

The surface-to-subsurface transfer equipment shall include:

- . Container-to-shaft transfer equipment;
- . Container shaft hoist -- A system shall be provided within the shaft to raise and lower ILW and LL-TRU containers between the surface and subsurface facilities; the system shall include a lifting cage or attachment, a hoist and drive unit, and a control and safety system; the hoist capacity shall be (TBD-51) containers per trip; the trip travel time shall be (TBD-51); container shielding shall be (TBD-51);
- . Container subsurface transfer equipment.

1.2.1.11 Container Subsurface Handling

Subsurface container handling equipment shall include:

- . Container transport;
- . Container storage and retrieval equipment.

1.2.2 INTERFACE DEFINITION

The remote handling system interfaces are with the surface facilities, the shaft(s), and subsurface facilities. Processing rates and processing parameters (cooling, shielding, etc.) are also interfaces. These interfaces shall be identified and accommodated in the design.

1.2.2.1 Surface Facilities

The remote handling system will interface with the packaging facility transfer mechanisms (perhaps a loaded shipping cask through the cell transfer ports). Operating galleries provide the operator interface with the system in the cells. Container waste handling will interface with the receiving dock inspection facility.

1.2.2.2 Container and Canister Shaft Facilities

This interface involves the transfer and handling at the head and foot of the shaft(s) and the passage through the shaft(s).

1.2.2.3 Subsurface Facilities

This interface involves acceptance of waste at the shaft foot, transfer, transport, handling, and placement of waste in storage, and retrieval therefrom. A canister or container which has become defective (and/or contaminated) in storage or handling shall be (TBD-52) bagged and transferred to the surface for overpacking and returned to the packaging facility.

1.2.2.4 Systems

The interfaces for the repository systems include:

- . Ventilation;
- . Electrical power;
- . Emergency power;
- . Communication alarm;
- . Fire protection;
- . Waste disposal;
- . Maintenance.

1.2.2.5 Throughput

This interface is related to the size and number of flow paths (number of preparation cells), the estimated quantity of waste and fraction defective, the batch-wise receiving, and the transit time along a particular path (e.g., a two-mile tunnel run from shaft to emplacement location).

1.2.3 OPERATIONS AND PERSONNEL REQUIREMENTS

The remote handling systems will require skilled operators experienced with hot cell operations and with indirect viewing and controlling. Maintenance support personnel will be required in the optics, electronics, mechanisms, and services crafts.

The remote handling system shall have the capability to handle any capsule conforming to the characteristics shown in Appendix A. Capacities for the handling tasks shall conform with the requirements presented in Appendices A and B (TBD-53).

1.2.4 CLASSIFICATION OF SYSTEMS

Drop and impingement incidents will be considered in the safety analysis, Section 1.2.7. All items related to safety, for which there may be a risk of violating canister/container integrity, shall be identified and have appropriate QA levels and seismic categories assigned.

1.2.5 SITE REQUIREMENTS

The thickness, orientation, and inclination of the basalt formation will influence the mine layout and shaft location and thus influence the design of the remote handling system. The remote handling system will, in turn, impact on the layout of the subsurface facility with respect to the waste storage locations. The subsurface layout shall provide a route of the canister transfer system which will minimize travel time from shaft to the waste placement. The speed of travel of the transfer system shall be balanced against the cost of mining and ventilation and shall assure safety of personnel.

1.2.6 GENERAL DESIGN REQUIREMENTS

The general design requirements are presented according to overall, architectural, structural, mechanical, electrical, and reliability needs.

The waste handling equipment shall be capable of handling and processing these capsules:

- . Spent fuel canister;
- . HLW canister;
- . ILW canister;
- . LL-TRU container;
- . Repository-generated waste container.

The remote handling system shall be capable of keeping temperatures below established maximums (TBD-54) while performing operations. The

design shall be coordinated with the design of the ventilation system to accomplish this. Handling equipment shall be radiation resistant.

The remote handling system shall provide sufficient shielding to satisfy radiation exposure limits within all associated occupancy zones.

Canister in-cell processing and examination equipment shall be designed to be: remotely maintained and replaced using in-cell manipulators and equipment; modular so as to facilitate maintenance and modification operations; and capable of in-place calibration.

The remote handling equipment shall be designed to protect capsules from damage due to equipment failure.

The systems and mechanisms handling spent fuel shall conform to the criteria of Section 1.2.7.1, Part I.

1.2.6.1 Architectural Design Requirements

In the surface facility, the remote handling equipment for the canisters shall be housed in shielded areas. The area layout shall provide for capsule inspection, repair and decontamination, and preparation for transfer to the lag storage area or to the shaft head. The transfer to the shaft head shall be within the cell structure or in a shielded transfer device.

The shaft head design shall be a continuation of the cell or shall afford shielding commensurate with the transfer procedures.

Within the subsurface facilities, the canister remote handling system shall be located within a cell for elevator off-load, lag storage, and transporter loading. The transporter shall provide shielding to effect (TBD-55) radiation levels in transit and (TBD-55) during emplacement operations.

In the surface facilities, the remote handling equipment for the container receiving area will have a space envelope sufficient for unloading of containers from rail or truck, inspection, palletization of containers, and preparation of containers for movement to the shaft head.

Within the subsurface facility, the containers may be off-loaded from the shaft convenience by means of conventional material handling equipment and moved either to a lag storage area or directly to storage.

1.2.6.2 Structural Requirements

The remote handling system shall be capable of safely and reliably handling the weights and configurations of the canisters and containers to be processed.

Vital equipment shall be designed to (TBD-56) Seismic Category II requirements. All other equipment shall be designed to Seismic Category III. A seismic study shall be run to determine the accelerations, velocities, and displacements of the remote handling equipment. These data shall be used in the structural analysis.

Structural design, including loading combinations and construction of crucial safety and fire protection items, shall be in accordance with current editions of pertinent nationally recognized codes and standards as a minimum and with the design criteria contained in this section. Safety factors to avoid fatigue/aging failures shall be employed.

1.2.6.3 Mechanical Requirements

The remote handling system will require extensive development of mechanical design to determine type, control, degree of remote (versus contact) operation, and capability needs. The waste material classes and capsule type shall determine the method of handling and design of mechanisms.

The remote handling systems will require interconnects and mountings, shields, power and control line runs, and mechanical support. Envelopes of capsule dimension maxima shall be established. The design shall consider the potential for capsule damage and mishandling. Placement and identification of control boxes, maintenance access panels, personnel access areas, and safety barriers shall be included in the mechanical design.

1.2.6.4 Electrical Requirements

The system shall be designed with sufficient controls and instrumentation such that the operation can be controlled and monitored effectively. This shall include operating switches, status lights, process information indication, abnormal operation annunciation, and other control equipment. An annunciator shall be provided in the main control room to indicate when an abnormal operation annunciation has occurred at any control panel.

1.2.7 NUCLEAR SAFETY

Analyses shall be conducted to identify equipment whose failure could lead to a release of radioactive material. Credible drop and impingement incidents shall be identified. Engineered safety features shall mitigate the consequences of incidents.

The degree of remoteness and shielding requirements shall be determined by a trade study that considers the ALARA recommendations and criteria of 10 CFR 20.

1.2.8 FIRE PROTECTION

Crucial or vital components of the remote handling system shall maintain mechanical integrity under conditions of the DBF. Protective measures shall be provided to support this requirement.

General design requirements for repository fire protection are provided in Section 1.2.8, Part I.

1.2.9 INDUSTRIAL SAFETY

Both surface and subsurface industrial safety requirements shall be met (see Section 1.2.9 in Parts II and IV). Handling system design shall minimize hazards to maintenance personnel (e.g., electrical shock, sharp edges).

1.2.10 SECURITY AND SAFEGUARDS

Facility protective means will provide the necessary protection for the remote handling system.

1.2.11 WASTE MANAGEMENT

Waste quantities and radiological levels are (TBD-57) (see Parts II and IV).

1.2.12 ENVIRONMENTAL CONSIDERATIONS AND DECOMMISSIONING

The waste handling system can only affect the environment if it fails to retain or properly handle a waste canister or container. Such incidents are to be covered in the safety analysis (see Section 1.2.7, Part I).

General design criteria for decommissioning are provided in Section 1.2.12, Part I.

1.2.13 DESIGN LIFE AND RELIABILITY ASSURANCE

Design life shall be determined from a reliability analysis which covers the degree of difficulty of maintenance. The cost of maintenance shall be evaluated and include a study of cost for decontamination of components and original equipment cost.

Reliability design goals shall be established. Specific attention shall be given items related to safety (drop incidents, seismic, etc.).

1.2.14 MAINTENANCE

Maintenance philosophy and supporting maintenance concepts are provided in Section 1.2.14, Part II.

All equipment shall be or shall have been designed for minimum maintenance. The equipment designs should minimize requirements for special test equipment and remote tooling. Tools, test equipment, spares, and technical documentation shall be provided consistent with maintenance philosophy and requirements.

The in-cell equipment shall be designed to permit remote replacement and removal. Equipment modules shall be of size and weight to be handled readily by manipulators and include features to facilitate replacement of the modules or parts. In-cell measuring devices shall have provisions for remote in-place calibration where required. The in-cell equipment shall be designed to facilitate decontamination. Materials which are not corrosion resistant shall have a suitable protective coating which is compatible with the operating environment and decontamination solutions.

1.2.15 ENERGY CONSERVATION

Standard energy conservation practices shall be used in the design. Trade studies in sizing the shaft hoists shall consider energy consumption along with other parameters.

1.2.16 LICENSING

General design requirements for licensing are provided in Section 1.2.16, Part I.

1.2.17 QUALITY ASSURANCE

The general requirements for QA are provided in Section 1.2.17, Part I.

1.2.18 CODES AND STANDARDS

Refer to Section 1.2.18, Part I.

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PART VI. SYSTEMS

1.0 SUMMARY AND SCOPE

The systems are comprised of facilities, equipment, and services that, together with the remote handling system, complete most of the requirements for repository operations. Systems operate within the surface, shaft, and subsurface facilities.

Some of the major systems include those involving ventilation, electric power distribution, and waste.

Offsite/onsite interface requirements exist within electric power, communications, and water systems.

The functional requirements for the systems are provided in Section 1.1 and the design criteria are provided in Section 1.2.

1.1 SYSTEMS FUNCTIONS

The principal functions of the repository systems are to provide the ventilation, cooling, and life supports for operating personnel and the energy and material necessary to efficiently and safely operate the systems and equipment in the surface facility, subsurface facility, and shafts. Specific functions are illustrated in Figure VI-1 and include the following.

1.1.1 Electric Power Distribution System to provide:

- . Normal power from the commercial power intertie to the equipment, lighting, and convenience outlets;
- . Emergency power for safe shutdown;
- . Uninterruptible power for critical equipment and functions.

1.1.2 Ventilation System to provide:

- . Conditioned air for personnel;
- . Cooling or heating for equipment;
- . Control of airborne radioactive particulates;
- . Control of gaseous radioactive effluents.

1.1.3 Water Supply System to provide:

- . Sanitary water;
- . Process water;
- . Cooling for equipment;
- . Fire protection water;
- . Mining water.

1.1.4 Compressed Air Supply System to provide:

- . Process requirements;
- . Instrument requirements.

SYSTEMS	
Electrical	Mine Cooling
Ventilation	Instrumentation & Control
Water & Steam	Alarms
Compressed Gases	Environmental Surveillance
Communications	Rock Monitoring
Wastes & Effluents	Accountability
Heat Recovery	Isolation/Confinement
Fire Protection	Basalt Testing
Emergency System	
Safeguards & Security	

Figure VI-1. Systems Functions

1.1.5 Communication Network to provide communication within the repository and between the surface and subsurface facilities and with cooperating agencies.

1.1.6 Liquid Waste Removal System to provide:

- . Dewatering of subsurface facility;
- . Radioactive liquid collection and treatment.

1.1.7 Solid Waste Disposal System to provide:

- . Collection, processing, and packaging of radioactive solid waste;
- . Collection, transport, and disposal of nonradioactive solid waste.

1.1.8 Energy Conservation System to supplement offsite power supplies and to reduce site power demand as practicable.

1.1.9 Fire Protection System to provide:

- . Protection of general public against release of radioactive and toxic materials;
- . Protection of plant personnel;
- . Protection of crucial systems and against loss of confinement;
- . Protection of government property.

1.1.10 Emergency System to provide:

- . Personnel escape from the subsurface in the event of an emergency;
- . Protective and life support equipment;
- . Means for evacuation.

1.1.11 Safeguards and Security System to provide:

- . Protective barriers;
- . Intrusion detection system;

- . Access control systems;
- . Surveillance, control, and communications systems;
- . Measurement and accountability of SNM.

1.1.12 Mine Cooling System to provide temperature control within the subsurface facility.

1.1.13 Instrument and Control System to provide measurement and control of the waste storage and mining operations.

1.1.14 Alarm System to ensure the safe and efficient operation of the facility.

1.1.15 Radiological Monitoring System to provide:

- . Data and information pertinent to the release and distribution of effluent materials from the repository;
- . Weather and climatological data related to effluent dispersal.

1.1.16 Rock Monitoring System to provide

- . Early warning of rock falls by a network of ultrasensitive acoustical detectors;
- . Location of activity using computer-aided discrimination, enhancement, and triangulation.

1.2 SYSTEMS PRECONCEPTUAL DESIGN CRITERIA

This section covers the supportive systems for the surface facilities, shafts, subsurface facilities, and remote handling system.

1.2.1 SYSTEMS CONFIGURATION

1.2.1.1 Electrical Power System

a. Normal Electrical Power

The repository requires approximately (TBD-58) MVA of electrical power. The electrical power shall be brought from the sub-station through a switching station to the site.

b. Emergency Power

The repository will require an automatic normal-to-emergency power system which will operate on loss of normal power. The emergency power system shall provide power for:

- . Emergency shaft hoists;
- . Fire and radiation detection and alarm systems;
- . Subsurface and cell ventilation;
- . Key instrumentation and control circuits;
- . The UPS system.

Battery-operated lighting fixtures will be utilized for emergency purposes within the shafts and subsurface facilities and for entrance and exit signs.

c. Uninterruptible Power Supply

Uninterruptible power shall be supplied to those systems and equipment crucial to safety.

d. Temporary Power

Temporary power to the repository will be necessary during the construction period. During this time, 480 volt, 3 phase, 60

Hz, (TBD-58) kilovolt amps (KVA) power shall be provided for facility and building construction. Mining activities will require (TBD-58) KVA.

e. Lighting Systems

Where appropriate, lighting systems will be designed to comply with ANSI A11.1 in accordance with Illuminating Engineering Society recommendations. In general, footcandle (fc) levels will be as follows:

- . Office and laboratory areas 100 fc;
- . Maintenance shops 100 fc;
- . General equipment 30 fc;
- . Operating areas and major equipment locations 50 fc;
- . Subsurface mine areas (per standard mine practices and codes).

Fluorescent lighting fixtures will be utilized in all areas where high fc levels with low glare and visual comfort are required.

Metallic vapor lighting fixtures will be utilized in equipment areas and work areas where ceiling heights and usage permit.

f. Lightning Protection System

Lightning protection shall be designed in accordance with NFPA 78 with UL-listed material.

g. Grounding System

Grounding for the repository electrical systems shall be included in the facility design.

1.2.1.2 Ventilation System

The repository ventilation system shall include:

- . Subsurface ventilation;
- . Cell ventilation;
- . Surface building ventilation.

a. General Requirements

The ventilation system(s) shall meet the requirements imposed for personnel breathing, cooling and/or heating for temperature control, radiological confinement and control, dust control, subsurface cooling, and dilution of any combustible fumes.

The ventilation system shall be designed to control migration of airborne radioactive material, provide a confinement barrier to nuclide release to the environment, and keep inhalation exposure to airborne nuclides ALARA for operating personnel and the general public. Ventilation systems shall be designed and appropriately tested to assure confinement of radioactive materials during normal or abnormal conditions. To accomplish this objective, these systems should be designed according to the following:

- . ANSI N509, Nuclear Power Plant Air Cleaning Units and Components;
- . ANSI N510, Testing of Nuclear Air Cleaning Systems;
- . Regulatory Guide 3.12, General Design Guide Ventilation Systems of Plutonium Processing and Fuel Fabrication Plants;
- . Regulatory Guide 1.52, Design, Testing and Maintenance Criteria for Engineered-Safety-Feature Atmosphere Cleanup System Air Filtration and Absorption Units of Light-Water Cooled Nuclear Power Plants.

Air shall flow from zones of lesser potential for airborne radioactivity to zones of higher potential. The design of ventilation systems shall assure that, in normal operation, proper airflows are maintained at all times.

The number of exhaust filtration stages shall be determined by analysis. Quantities of airborne radioactive or toxic materials released to the environment during normal and accident conditions shall be in conformance with applicable standards, policies, and guidelines.

The principle of compartmentalization shall be employed to limit the extent of contamination and minimize loss of productivity and property in the event of a DBA.

The ventilation system and associated fire suppression system shall be designed for fail-safe operations.

The ventilation system shall be appropriately instrumented and alarmed (with readouts in control areas) to report and record the operating parameter of flow rate, pressure differential, and temperature. Consideration shall be given to installing both automatic and manual controls to alter system operation during unusual conditions.

Provisions shall be made for maintenance and/or replacement of components in the supply, exhaust, and filtration systems. Multiple units shall be incorporated to assure continued functioning.

b. Subsurface Ventilation System

The design of the mine ventilation facility shall consider push-pull operation of supply blowers and exhaust blowers (18U-59). Prefilters shall be used in the normal operation mode. Exhaust air shall be drawn from the tunnel extremities. The fan shutoff dampers will be designed so that their operation does not bring about pressure waves in the mine. Supply airflow rate will be monitored; an alarm system will be activated when flow falls below a preset minimum flow rate.

Safety analyses shall be performed to develop the design basis, verify the need and extent of filtration of radioactive particulates, and verify system compliance to 10 CFR 100 for offsite release and ANSI N287 for onsite release. These analyses shall include detailed evaluations of radioactive releases from the capsules, a study of radioisotope diffusion through the subsurface facilities, and an appraisal of the maximum credible release through the shaft system and through the isolation barrier.

In the event that the analyses show that airborne radioactivity exceeds permissible limits, the design shall provide a system in which the air supply blowers will be shut down and the exhaust air shall be diverted to appropriate filters (HEPA or HEPA and activated charcoal).

The mine air supply shall be designed to meet mine cooling requirements (TBD-60). Heating, ventilating, and air conditioning (HVAC) analysis and mine safety codes will determine the required flow capacities and the active and passive tunnel air-change rates.

Subsurface air design temperatures are as follows:

<u>Temperature</u>	<u>Maximum</u>	<u>Mean</u>	<u>Minimum</u>
Ambient	TBD	TBD	TBD
Inlet	TBD	TBD	TBD
Outlet	TBD	TBD	TBD

c. Ventilation of Confined Surface Structures (cells)

All surface structures in which contaminated waste is handled shall be operated at a negative pressure with respect to the atmosphere. Exhaust air from these facilities shall be discharged through fire-resistant HEPA filters. The flow shall be from the operating gallery to the cell. The systems shall have adequate capacity and appropriate controls to sustain 100 to 150 linear feet per minute inward airflow through the maximum credible breach.

d. Heating, Ventilating, and Air Conditioning Systems for Surface Buildings

The HVAC system for administration, laboratory, and office/warehouse-type support structures will be a combination of HVAC conventional, heat recovery, and solar-energy systems. A design trade study shall be run to optimize a system that will make maximum use of waste heat from the mine.

The HVAC systems for the repository shall provide year-round environmental control. The outdoor supply of air to the buildings shall be filtered. To the maximum extent practicable, the conditioned air shall be recirculated.

The environment in the central control room will be maintained by a separately controlled system. To ensure proper operation of the computer and peripheral equipment, the required temperature and relative humidity must be controlled. High-temperature alarm units and remote alarm contacts are required.

1.2.1.3 Service Systems

Service systems will serve all systems and facilities of the repository.

a. Water and Steam

Surface well(s) and a water treatment plant with a capacity of (TBD-61) gallons per day shall be provided. Plumbing and process piping shall be used to distribute this water.

The water supply to the subsurface shall have a means of reducing the high head pressure to a more standard operating pressure.

b. Potable Water

Potable water shall be supplied for personnel use and for makeup water to other systems.

c. Hot Water

Hot water shall be supplied for personnel use, to the decontamination stations, and for the receiving and shipping station.

d. Laboratory Water

Hot and cold water shall be provided to the laboratory(s).

e. Fire Protection Water

The design of the water supply system shall provide water for fire protection systems in accordance with the appropriate requirements of Section 1.2.8, Part I; ERDAM 6301; FM; Industrial Risk Insurers (IRI); and NFPA standards. Fire protection water supply and distribution design required for the protection of crucial items shall assure continuity of protection in the event of a DBA (see Section 1.2.8, Part I).

f. Process and Cooling Water

A process and cooling water system shall be provided for various uses and heat removal from the following equipment and systems:

- . Chillers (recirculation);
- . Mine cooling;
- . Air compressors;
- . Mine equipment;
- . Other.

g. Steam Supply

A low-pressure steam supply (100 pounds per square inch gage) of (TBD-62) pounds per hour shall be provided for waste evaporation and other needs such as cleaning and decontamination.

1.2.1.4 Compressed Gases

Compressed gases will be stored and manifolded on the outside of the using facility and piped to the area of use, where practicable. An air supply shall be provided to meet process, mining, and instrumentation requirements.

1.2.1.5 Communication Systems

Communications for the repository shall include commercial telephone services, a multiple master/slave intercommunication (intercom) system between operating locations, a public address system, and those communication systems related to security and emergency needs.

The vital communication systems shall be powered by the UPS. These vital systems shall include the public address and plant intercom.

1.2.1.6 Radiological Waste Management

All plant effluent systems shall be designed, where practicable, to include means for measuring and recording the concentration of radionuclides in any effluent. In order that the data thus measured and recorded can be used to determine quantity, the flow of diluting media, either air or water, shall be determined.

The design of the plant shall include means to control the release of radioactive effluents (whether gas or liquid) during normal operations and under accident conditions. Systems provided to guard against the release of radioactive materials shall be designed to be monitored and tested and shall be provided with alarms. Capability shall be provided for prompt cessation of the flow of contaminated liquid effluents or for retention of such liquids. The concentrations of radioactive materials in liquid effluents shall be maintained ALARA and within the limits of 10 CFR 20.

a. Radioactive Liquid Waste Systems--General

A radioactive liquid waste collection system shall be provided to collect contaminated liquids resulting from cask decontamination, personnel decontamination showers, cell wash down, and other specific areas handling radioactive substances. The design shall be capable of reducing the radiological hazard of waste to a level ALARA and be in accordance with the following codes, standards, and guides:

- . 10 CFR 20 and ERDAM 0524, Standards for Radiation Protection;
- . ERDAM 0511, Radioactive Waste Management;
- . ERDAM 0513, Effluent and Environmental Monitoring and Reporting;

- ANSI N13.10, Specification and Performance of Onsite Instrumentation for Continuously Monitoring Radioactive Effluents.

The design basis for the system components shall provide reasonable assurance of protection against natural phenomena and the consequences of postulated accidents.

The liquid waste system, its components, and required supporting services should be capable of handling the expected volume of potentially radioactive waste generated during normal plant operations and preventing release under credible emergency conditions resulting from internal accidents or natural phenomena.

The system design should provide for redundancy or diversity of components required to prevent release of radioactive materials to the environment or needed for the safe operation of the liquid waste system.

Tank and piping systems used for liquid waste handling and treatment should be of welded construction to the fullest extent practicable.

Tank and piping systems used for liquid waste handling and treatment should be designed to take advantage of gravity flow to reduce the potential for contamination associated with pumping and pressurization.

The area in which liquid radioactive waste is treated should be isolated from loading, storage, and support facilities.

Cleanup systems should be provided which are designed to safely contain water collected from fire-fighting activities.

Drain systems for storm water and sanitary sewage should be separate from contaminated waste drain systems. Personnel decontamination facilities should be designed so that spent liquids will be sent to the radioactive liquid waste treatment system.

Waste collection system pipe and drain lines should be tagged, labeled, or painted in a manner which permits easy identification.

The waste treatment system should include means (solidification, evaporation, or other process) for conversion of radioactive waste to liquid and/or solid forms suitable for disposal.

b. Suspect and Contaminated Liquid Waste

The liquid waste retention system shall collect, monitor, and store suspect liquid waste and treat as appropriate. These wastes shall be sampled after collection and directed to either the process drain or the contaminated liquid treatment system.

Equipment of the suspect and contaminated liquid waste system shall be appropriately shielded. Tanks and piping shall be of stainless steel with provisions to be suitably cleaned to prevent contamination buildup with use. Pumps shall have shaft seals to prevent leakage.

A means shall be provided to sample suspect water for radioactive and industrial contaminants. Water found to be contaminated in excess of codified allowables shall be transferred to a holding tank for subsequent processing.

Radioactive liquid wastes shall be transported to the surface in special containers. A support system at the surface shall be established to receive, collect, transfer, and treat the radioactive liquid waste.

c. Radioactive Air and Gaseous Effluents

The ventilation system will be used to control contamination in air and gaseous exhausts from the facility. Ventilation systems are described in Section 1.2.1.3, Part VI., All radioactive air and gaseous effluents will be monitored. Radioactive material discharged from all exhausts will be ALARA.

The effluent concentrations will not exceed the maximum permissible concentration (MPC) for uncontrolled areas as given in 10 CFR 20 and ERDAM 0524.

All ducts (or stacks) exhausting potentially contaminated air will be provided with two systems: one will be of the alarm-generating type (CAM system); and the other a passive type (fixed sampler). Samplers will be equipped with airflow measuring devices and elapse timers (to indicate sample time in case of power interruption to the units). The probes for air measurement purposes will be designed for isokinetic sampling. The CAM system electronics will be designed to discriminate against natural airborne radioactivity and electrical interference. Each system will be individually connected to the emergency power supply system.

The design of each engineered-safety-feature atmosphere-cleanup system should be based on the maximum pressure and pressure differential, radiation dose rate, relative humidity, maximum and minimum temperature, and other conditions resulting from the postulated DBA and on their duration.

d. Radioactive Solid Waste Systems

All solid wastes generated within the repository shall be collected, packaged, categorized, and disposed. The LL-TRU shall be packaged for disposal on the site per routine operations. The ILW and HLW shall be packaged for disposal.

The total curie quantity and radionuclide composition of the solid waste should be determined. Provisions should be made to monitor all packages containing solid radioactive waste both before being moved to temporary storage locations and before being loaded for transfer or transport.

1.2.1.7 Nonradiological Waste

Gaseous and solid wastes will be accommodated by routine plant services (rock wastes excluded). Common trash which is free of radioactive contaminants shall be collected and transported to a central landfill.

Solid waste which is free of radioactive contaminants shall be collected and transported to the surface and disposed in the site sanitary landfill.

Liquid waste systems shall be provided as follows.

a. Sanitary Waste

Sanitary drains, sewer lines, and a sanitary treatment facility of (TBD-63) capacity shall be provided. Subsurface sanitary wastes shall be collected at the subsurface level and hoisted to the surface for disposal. The sanitary sewer system shall meet the requirements of ERDAM 6301, Part I.G.4, and the public health regulations of the county and state.

b. Process Sewer System

The process sewer shall drain the non-sanitary waste water that has radioactivity levels less than those specified in 10 CFR 20 and in Table 2 of ERDAM 0524. These wastes shall be collected and drained to a settling pond.

c. Storm Drainage

Provisions for surface runoff of storm water shall be included in the design (see Part I).

d. Mine Dewatering System

For subsurface waste water, staged piping or tank containers may be used. Waste water drains, sumps, and catch basins shall be designed so that suspect wastes and any liquid wastes containing radioactive material in excess of codified limits shall be kept separate from other liquid wastes. The dewatering system shall be appropriately sized and capable of detecting contaminated water.

Mine waste water, if sufficiently turbid, shall be treated for solids removal before discharge to the settling pond.

Where applicable, practices recommended in AWWA Manual M-14 shall be followed, and backflow protection devices meeting AWWA Standard C506-69 shall be specified.

1.2.1.8 Heat Recovery System

Design studies (TBD-64) shall be run to determine the practicality of:

- . Recovering heat from the mine exhaust air;
- . Removing and recovering heat from the subsurface basalt;
- . Recovering heat from the ventilation chillers.

1.2.1.9 Fire Protection System

The fire protection requirements of the surface facilities, shafts, and subsurface facilities shall be integrated into a repository fire protection system.

1.2.1.10 Emergency System

An emergency plan shall be developed, coordinated with the result of the safety analysis (Section 1.2.7, Part I) and factored into the repository design. Particular emphasis shall be afforded to actions and responses to be taken with the ventilation and emergency power supply systems and mine evacuation. Equipment, facilities, and supplies necessary to support the emergency plan actions shall be provided.

1.2.1.11 Safeguards and Security System

The safeguards and security system shall include the following:

- . A protective barrier enclosing the operating facilities;
- . An intrusion detection system;
- . Guard stations;
- . Access control equipment;
- . A security operations and control center;
- . An accountability and record system.

All elements of the safeguards and security system shall comply with DOE IMD 6101, 6102, 6103, 6104, and 10 CFR 73.

The protective barrier shall consist of two fences separated by an alarmed isolation zone. The fences shall meet the requirements of 10 CFR 73.2(f)(1).

An intrusion detection system shall be provided and designed to meet local environmental conditions. It shall include a CCTV system for surveillance.

Access control equipment shall be provided and installed in the guard stations. This shall include an identification system and detection systems for metal, explosives, and SNM.

An accountability system for SNM (included in the spent fuel and wastes) shall be designed and used as a basis for repository design.

The physical structures within this system shall be provided under Part II.

1.2.1.12 Mine Cooling System

A mine cooling system will be provided if the ventilation system is inadequate or not the preferred choice.

1.2.1.13 Instrumentation and Control Systems

Instruments and controls that are crucial to the safe operation of the repository shall be provided with uninterruptible electrical power.

Instruments and controls shall be centralized in the operations control room to the maximum practicable extent.

The following systems shall be included.

a. Mine Ventilation Exhaust Monitoring

The ventilation exhaust from the mine shall be monitored for temperature, pressure differentials, radioactivity, and gas content as determined by industrial health (i.e., oxygen, carbon monoxide, etc.).

In the event of radioactivity in the exhaust, the monitors shall make a quantitative determination, generate an alarm, and initiate the diversion of exhaust air to the filter system.

b. Earthquake Instrumentation

The requirements of ANSI N18.5-1974 shall be considered in the design.

c. Temperature Measurement

Temperatures of basalt and subsurface air in the ventilation, cooling, and heat recovery systems shall be measured.

d. Nuclear Accident Dosimetry

Provision will be made for a dosimetry system in accordance with requirements of ANSI N13.3-1969.

e. Spent Fuel Canister Monitoring

Canisters shall be monitored for temperature and radiation status during waste storage operations.

f. Power Outage

The primary power supply shall be monitored and a control system set automatically to start the emergency generator, to transfer power load, and to annunciate an alarm at a central station. A supervisory circuit shall annunciate failure or a disabled condition of the system. The design shall conform to Regulatory Guide 1.32.

g. Effluent Monitoring System

Liquid and gaseous plant effluents shall be monitored. Releases shall be controlled to not exceed allowable thresholds. Systems measuring radioactivity shall comply with ERDAM 0513 and Regulatory Guide 1.21. These systems shall be connected to the UPS.

Industrial health measurements shall be taken as necessary to assure safety and meet applicable regulations.

h. Control Systems

The facility control system shall provide direct control of plant operations and support systems and include the following features:

- . The system shall be designed to provide a high degree of reliability;
- . The mean time to repair control system component failures in any of the safety-related systems shall not exceed two hours;
- . The central control station shall be configured to be manned by one operator;
- . The operator-control interface shall be designed to minimize operator-initiated errors;
- . Wherever practicable, automatic operation shall be provided such that no operator control action is required during normal operating conditions;
- . The annunciator shall assemble and display facility parameters, alarm (visual and aural) an abnormal condition, and have "annunciate," "acknowledge," and "reset" modes.

i. Data Logging System

A high-speed solid-state data-logging system shall be considered to monitor all significant process, temperature, ventilation, radiation, and utilities variables in the facility control room. The capabilities of performing scan-alarming, recording, indication, logic, and switching functions shall be made available as needed.

1.2.1.14 Alarm Systems

All alarms that involve a guard force response will annunciate in the hardened central alarm facility.

The following alarm systems are required to ensure the safe and efficient operation of the facility and to provide the security required for the spent fuel canisters.

a. Instrumentation Alarms

Various temperatures throughout the repository (such as compressor, ventilation, and cooling system temperatures) shall be alarmed as necessary.

Important radioactivity measurements as well as other operating and safety parameters shall be alarmed. Critical industrial health measurements (oxygen, carbon monoxide, etc.) shall be alarmed.

b. Security Alarms

The overall requirements for the instrumentation and equipment necessary to protect the facility and the spent fuel canisters are outlined in a subsequent section. Security alarms shall be provided to support the system. The alarms shall emanate from the hardened central alarm facility.

c. Fire Alarm System

Alarms shall be provided to support the UL- or FM-approved automatic fire detector systems (see Section 1.2.8, Part I).

Alarms shall indicate the specific area initiating the alarm. A supervisory circuit shall annunciate a failed or a disabled condition in the system. The design shall conform to ERDAM 0552 and 6301.

Manual pull stations and single stroke alarm gongs shall be placed throughout the facility. The fire alarm system shall annunciate all fire conditions.

d. Evacuation Alarm System

An evacuation alarm system for civil defense shall be provided with audible alarms located throughout the facility.

e. Criticality Alarm System

The criticality alarm system shall meet requirements of ANSI N16.2-1969 and the NRC. The monitoring system shall comply with the requirements of and ERDAM 0530.

Detectors shall be spaced so as to provide complete coverage of operation areas where fuel is either stored temporarily or handled. The detectors shall be sensitive to radiation emanating from a criticality.

The criticality alarm system (detection and alarm) shall be a UPS load and be designed to minimize false alarms from electrical interference or vibration. It shall be designed to continue to function during and after a credible earthquake and all credible accidents.

The system shall provide flashing red lights and horns audible to all areas as a signal for evacuation.

1.2.1.15 Environmental Surveillance System

An environmental surveillance system shall be provided. It shall possess both onsite and offsite monitors and shall cover meteorological, ground water, and gaseous considerations. A

meteorological station shall be established to provide current and predictive data to assist in evaluation of normal operations and consequences of an accidental release, dust control, and avoidance of adverse effects due to weather extremes.

A dispersed system of radiological instruments shall be provided to acquire data for the documentation requirements of ERDAM 0513. Other instruments will be dispersed and monitored as determined in a base line study described in Section 1.2.12.3, Part I.

1.2.1.16 Rock Monitoring System

The rock monitoring system will be comprised of a computer and a dispersed network of ultrasensitive acoustical detectors. The computer will receive signals from disturbed sensors, discriminate against unwanted signatures, perform triangulation and enhancement of the selected signatures, and display the reduced data at the console. Such a system is discussed in Hecla's Seismic Detection Systems, 17th United States Symposium on Rock Monitoring, Snowbird, Colorado, August 1976.

1.2.1.17 Capsule Accountability System

All wastes shall have an accountability verification on receipt. An accountability shall be kept on these materials (per NRC and DOE requirements) for each step in the process until certification of ultimate disposal. Information to provide guidelines on what the system may include is presented in Alternatives for Managing Wastes from Reactors and Post-Fission Operations in the LWR Fuel Cycle, ERDA 76-43, Volume 3, U.S. Energy Research and Development Administration, Washington, D.C., May 1976, p. 20.30.

1.2.1.18 Isolation/Confinement

a. Integrity

The design of the facility shall provide isolation from the environment (i.e., confinement) during normal, emergency, and accident conditions.

The design for terminal storage and shaft area decommissioning shall provide isolation from the environment (containment).

b. Access and Removal Stations

Special design features shall be considered to assure no breach of confinement during access and removal of personnel and materials from the repository.

c. Penetrations

Penetrations of the operating area compartments, other than those for confinement ventilation and access, shall have seals to prevent the migration of contamination out of the more rigorously confined areas.

d. Air Locks

Access between the areas with a potential for airborne radio-activity and clean areas shall be through air locks. Emergency equipment shall be provided for, in or adjacent to the air locks. Considerations shall be given to emergency lighting, paging, interlocked access door switches, hand and foot monitors, storage for emergency clothing and equipment, warning lights, air sampling, and breathing air outlets.

1.2.1.19 Basalt Testing

A basalt testing service shall be provided to support repository construction and operation. This service shall include the provisions necessary to take basalt samples and measurements and to interpret or transport samples to the laboratory. These provisions shall include:

- . Sample taking tools;
- . Sample identification;
- . Sample accountability;
- . Transfer container.

1.2.2 INTERFACE DEFINITION

Service distribution, loads and use factors, and interconnections are interfaces which shall be scoped in conceptual design and detailed in Titles I and II design. The interfaces of systems with facilities and other systems shall be as discussed in the configuration sections (1.2.1) of each part.

1.2.3 OPERATIONS AND PERSONNEL REQUIREMENTS

Refer to Section 1.2.3, Part I for personnel requirements.

1.2.4 CLASSIFICATION OF STRUCTURES AND SYSTEMS

The classification of the structures and systems is dependent upon each system addressed in Part VI and is discussed in Section 1.2.1.

1.2.5 SITE REQUIREMENTS

Site requirements are covered in Part II. Site requirements of particular systems are covered in Section 1.2.1, Part II.

1.2.6 GENERAL DESIGN REQUIREMENTS

The general design requirements for systems are presented in Section 1.2, Part I. In addition to these requirements, appropriate portions of design codes and standards (Parts II through V) will apply.

1.2.7 NUCLEAR SAFETY

Consideration shall be given to requirements for nuclear safety. The systems that interface with nuclear materials handling, processing, and storage shall comply with the design requirements presented in Section 1.2.7, Part I.

1.2.8 FIRE PROTECTION

The general requirements for fire protection are covered in Section 1.2.8, Part I.

1.2.9 INDUSTRIAL SAFETY

The industrial safety design requirements for the systems shall be consistent with the general safety requirements for the basalt repository (Section 1.2.9, Part I) as well as the more specific facility requirements (Section 1.2.9, Parts II and IV). Particularly, the appropriate portions of ERDAM 0550, 29 CFR 1910 (OSHA), and 30 CFR 57 shall apply.

1.2.10 SECURITY AND SAFEGUARDS

Security and safeguards shall be established for systems consistent with requirements provided in Section 1.2.1.7, Part I, and Section 1.2.10, Part I.

1.2.11 WASTE MANAGEMENT

The contamination in the air and the gaseous and liquid effluent shall be ALARA. Each system design shall be compatible with waste management requirements presented in Section 1.2.11, Part I.

1.2.12 ENVIRONMENTAL CONSIDERATIONS AND DECOMMISSIONING

System design shall be governed by requirements of 10 CFR 51. General requirements are provided in Section 1.2.12, Part I.

Design shall include provisions for decommissioning. The general requirements for decommissioning are provided in Part I, Section 1.2.12.

1.2.13 DESIGN LIFE AND RELIABILITY ASSURANCE

Design life shall be established for each system consistent with overall facility operation and the particular design requirements.

The utilities shall provide reliability consistent with operational and safety requirements.

1.2.14 MAINTENANCE

Maintenance requirements shall be established for each system. These requirements shall be consistent with the maintenance philosophy and operational requirements of the repository.

1.2.15 ENERGY CONSERVATION

Energy conservation shall be considered in the design of each system. Goals shall be established during system conceptual design and shall include consideration of a new HVAC system concept which is a combined conventional, heat-recovery, solar energy design.

1.2.16 LICENSING

The major requirements for licensing the repository are presented in Section 1.2.16, Part I. System design requirements relating to licensing shall be consistent with requirements identified therein.

1.2.17 QUALITY ASSURANCE

The QA program will cover systems, design, installation, fabrication, and operation. Systems design shall be subject to requirements corresponding to those described in Section 1.2.17, Part I.

1.2.18 CODES AND STANDARDS

Codes and standards applicable to the design, documentation, fabrication, and operation of the repository are provided in, Section 1.2.18, Parts II and IV. These codes and standards, as appropriate, shall apply to systems design. Codes and standards particularly relevant to systems design are provided below.

- Regulatory Guide 1.6 (Safety Guide 6), Independence Between Redundant Standby (Onsite) Power Sources and Between Their Distribution Systems.
- Regulatory Guide 1.9 (Safety Guide 9), Selection of Diesel Generator Set Capacity for Standby Power Supplies.
- Regulatory Guide 1.41, Preoperational Testing of Redundant Onsite Electric Power Systems to Verify Proper Load Group Assignments.
- Regulatory Guide 1.75, Physical Independence of Electric Systems.
- IEEE Standard 383-1974 (N41.10-1975), IEEE Standard for Typical Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations.
- IEEE Standard 387-1972, Criteria for Diesel Generator Units Applied as Standby Power Supplies for Nuclear Power Stations.

- . 10 CFR 50, Licensing of Production and Utilization Facilities, Appendix A, General Design Criteria 17 and 18.
- . Industrial Risk Insurers.

APPENDIX A

NUCLEAR WASTE DOCUMENTATION

NUCLEAR WASTE DATA

The repository will be designed to receive and to store four forms of nuclear waste, including spent fuel, HLW, ILW, IL-TRU, and LL-TRU. The assumptions used to establish the quantities of the various types of wastes that will be generated include the following.

1. That the United States' nuclear electric power generating capacity expands as shown in Table A-1 and Figure A-1. This projection is based on the DOE April 1977 low-growth case, which subsequently became the medium-growth case. The nuclear power capacity projection will be subject to periodic revision by DOE, but the one presented here will provide an adequate basis for preconceptual design of the repository.
2. That the characteristics of light water reactors in the United States and of their fuel assemblies are as given in Tables A-2 and A-3, respectively. These characteristics ^(1,2) represent estimated mean values for the two major types of reactors. For the purposes of the preconceptual design, it has been assumed that all reactors in the United States are either BWR or PWR.
3. That the capacity factors over the life of a reactor are as follows.

<u>Years of Operation</u>	<u>Capacity Factor</u> ^(1,2)
1	42 percent
2-3	65 percent
4-15	70 percent
16-40	Declines 2 percent per year to 40 percent

It was further assumed that the capacity factor for the nuclear electric power industry for any given year is 56 percent, which is equivalent to the 40-year lifetime capacity factor of an individual reactor. It is further assumed that only United States' waste shall be received and stored.

Table A-1. Projected installed United States' nuclear capacity

<u>Year</u>	<u>Capacity (GWe)</u>
1973	-
1974	-
1975	-
1976	-
1977	41
1978	48
1979	53
1980	60
1981	70
1982	80
1983	95
1984	110
1985	124
1986	139
1987	153
1988	168
1989	183
1990	198
1991	212
1992	229
1993	245
1994	262
1995	282
1996	307
1997	330
1998	354
1999	374
2000	395
2005	496*
2010	598*
2015	699*
2020	800

*The projection for the years 2005, 2010, and 2015 was slightly modified to a linear extrapolation.

Figure A-1. Nuclear Capacity Projections Through Year 2020

Table A-2. Assumed characteristics of light water reactors⁽¹⁾

	<u>BWR</u>	<u>PWR</u>
Electric power, MW(e)	1,250	1,250
Thermal power, MW(t)	3,800	3,800
Average specific power, ^a MW(t)/metric ton	25.9	37.5
Average fuel burnup, MWd/metric ton	27,500	33,000
Fuel residence time at 80% capacity factor, days	1,328	1,100
Steady-state charge, kg/year ^c		
²³⁵ U	1,110	1,081
Total U	40,368	33,778
Steady-state discharge, kg/year		
²³⁵ U	304	268
Total U	38,871	32,299
Fissile Pu ^b	237	208
Total Pu ^c	340	307
Total actinides	39,223	32,629

^aBased on full power and fuel charged.

^b²³⁹Pu + ²⁴¹Pu.

^c²³⁸Pu + ²³⁹Pu + ²⁴⁰Pu + ²⁴¹Pu + ²⁴²Pu.

This assumption implies an even distribution of the ages of the reactors which will not be the case when the generating capacity is expanding non-linearly. The error introduced will lead to a somewhat higher projection of spent fuel discharges during a period of rapid expansion, but will not significantly affect the preconceptual design.

4. That there will be no commercial reprocessing of spent fuel to recover and/or recycle plutonium and uranium. Under this assumption, which is consistent with current United States' policy,⁽³⁾ essentially all of the nuclear waste generated will be either SURF or LL-TRU.
5. That the ratio of the PWR electric power capacity to the BWR electric power capacity is two to one. This results in a ratio of BWR assemblies to PWR assemblies of three to two.^(1,2)
6. That uncompacted LL-TRU is generated at a rate of 14 cubic meters per GWe capacity and that the LL-TRU compaction factor is 10.

Based on the above assumptions, the annual and cumulative quantities of SURF and LL-TRU were calculated and tabulated in Tables A-4, and A-5, respectively. The amount of other waste forms that will be generated cannot be estimated, but can be expected to be relatively insignificant when compared to SURF and LL-TRU.

Table A-3. Physical characteristics of LWR fuel assemblies (4)

	<u>BWR</u>	<u>PWR</u>
Overall assembly length, m	4.470	4.059
Cross section, cm	13.9 x 13.9	21.4 x 21.4
Fuel element length, m	4.064	3.851
Active fuel height, m	3.759	3.658
Fuel element OD, cm	1.252	1.07
Fuel element array	8 x 8	15 x 15
Assembly total weight, kg	275.7	657.9
Uranium/assembly, kg	183.3	461.4
UO ₂ /assembly, kg	208.0	523.4
Zircaloy/assembly, kg	57.9 ^a	108.4 ^b
Hardware/assembly, kg	9.77 ^c	26.1 ^d
Total metal/assembly, kg	67.7	134.5
Nominal volume/assembly, m ³	0.0864 ^e	0.186 ^e

^aIncludes Zircaloy fuel-element spacers.

^bIncludes Zircaloy control-rod guide thimbles.

^cIncludes stainless steel tie-plates and Inconel springs.

^dIncludes 10 kg stainless steel nozzles and Inconel-718 grids.

^eBased on overall outside dimension.

Table A-4. Nuclear waste projection calculations

DATA:

U_{BWR} BWR Annual Uranium Charge* = 40,368 kg/year;
 U_{PWR} PWR Annual Uranium Charge* = 33,778 kg/year;
 P Electric Power Capacity = 1,250 MWe = 1.25 GWe;
 E Reactor Capacity Factor = 56%;
 M_{BWR} BWR Assembly Uranium = 183.3 kg/assembly;
 M_{PWR} PWR Assembly Uranium = 461.4 kg/assembly;
 LLW LL-TRU** Generated = 1.4 m³/GWe capacity.

CALCULATIONS:

D_{BWR} BWR Assemblies Discharged at 56% Capacity Factor;
 $(U_{BWR}/M_{BWR}) (E/80\%) : P,$
 $(40,368/183.3) (56/80) : 1.25,$
 123.4 Assemblies/GWe-yr,
 D_{PWR} PWR Assemblies Discharged at 56% Capacity Factor;
 $(U_{PWR}/M_{PWR}) (E/80\%) : P,$
 $(33,778/461.4) (56/80) : 1.25,$
 41.0 Assemblies/GWe-yr,
 D Average Assemblies Discharged at 56% Capacity Factor;
 $0.6 (123.4) + 0.4(41),$
 90.8 Assemblies/GWe-yr,
 V_{LLW} Volume of LL-TRU Generated;
 $LLW : D = 1.4/90.8,$
 0.0154 m³/SURF Assembly Discharged.

*At 80% capacity factor.

**Compacted.

Table A-5. Projection of nuclear waste

Year	SURF Assemblies		LL-TRU (m ³)	
	Annual	Cumulative	Annual	Cumulative
1973	-	3,714	-	57
1974	2,074	5,788	32	89
1975	1,906	7,694	29	118
1976	2,716	10,410	42	160
1977	3,723	14,133	57	217
1978	4,358	18,491	67	284
1979	4,812	23,303	74	358
1980	5,448	28,751	84	442
1981	6,356	35,107	98	540
1982	7,264	42,371	112	652
1983	8,626	50,997	133	785
1984	9,988	60,985	154	939
1985	11,259	72,244	174	1,113
1986	12,621	84,865	195	1,308
1987	13,892	98,757	214	1,522
1988	15,254	114,011	235	1,757
1989	16,616	130,627	256	2,013
1990	17,978	148,605	277	2,290
1991	19,250	167,855	297	2,587
1992	20,793	188,648	321	2,908
1993	22,246	210,894	343	3,251
1994	23,790	234,684	367	3,618
1995	25,606	260,290	395	4,013
1996	27,876	288,166	430	4,443
1997	29,964	318,130	462	4,905
1998	32,143	350,273	496	5,401
1999	33,959	384,232	524	5,925
2000	35,866	420,098	553	6,478
2005	45,037	627,009	694	7,172
2010	54,298	879,774	827	7,999
2015	63,469	1,178,845	979	8,978
2020	72,640	1,523,771	1,120	10,098

WASTE CHARACTERISTICS

The thermal and radioactive characteristics of the waste forms to be stored at the repository are dependent upon the definition of waste and upon the age of waste since discharge from the reactor. By definition, SURF is the spent fuel after discharge from the reactor and before any reprocessing; HLW is the solidified raffinate from the first solvent extraction stage of the PUREX reprocessing cycle; CW is the fuel cladding and assembly materials after the spent fuel has been removed by dissolution in PUREX head-end process; ILW is any solidified nuclear waste other than SURF, HLW, and CW which requires biological shielding; and LL-TRU is any solidified nuclear waste which can be handled directly without biological shielding, but which contains alpha emitters such as plutonium in concentrations greater than found in natural formations. These waste forms have in common their long-term potential for a detrimental impact on the biosphere.

The hazard of the waste forms listed above decreases with time as the various radioisotopes decay. For SURF and HLW, which contain large amounts of fission products, there is a very significant drop in thermal power (see Figure A-2) and radioactivity (see Figure A-3) each year and the specific age will impact the design of the repository.

Figure A-2. Decay Heat Curves for Typical PWR and BWR SURF

Figure A-3. Radioactivity Curves for Typical PWR and BWR SURF

PACKAGING

The packaging of the nuclear waste will not be a function of the repository itself, but does impact the design of the repository. The number of types of packages (by outside dimensions) must be minimized to minimize the complexity of the repository remote handling system.

For preconceptual design purposes, only 2 packages will be considered. The SURF, HLW, ILW, and CW will be packaged in a standard canister sized to handle all forms and LL-TRU will be packaged in U.S. Department of Transportation-approved 55-gallon drums.

In order to handle the largest units of waste, that is the SURF assemblies, the canister must be a minimum of 14-inch Schedule 40 pipe 18.5 feet long. This container, though, would only hold 2 of the BWR assemblies instead of 3 (3 would be roughly equivalent to 1 PWR and packaging that way would minimize the total number of canisters needed). To hold either 3 BWR or 1 PWR, the canister must be 16-inch Schedule 40 pipe 18.5 feet long. The optimum packaging of HLW, ILW, and CW in a canister of these outside dimensions requires extensive study.

The quantities of the SURF canisters (based on 3 BWR and 1 PWR per canister) and LL-TRU drums generated are given in Table A-6. The quantities of HLW, ILW, and CW canisters are indeterminate, but will not significantly affect the total number of canisters received or the subsurface storage area.

Table A-6. Projected quantities of waste packages

<u>Year*</u>	SURF Canisters		LL-TRU Drums	
	<u>Annual</u>	<u>Cumulative</u>	<u>Annual</u>	<u>Cumulative</u>
1973	-	2,228	-	275
1974	1,244	3,472	154	429
1975	1,144	4,616	141	570
1976	1,630	6,246	201	771
1977	2,234	8,480	276	1,047
1978	2,615	11,095	323	1,370
1979	2,887	13,982	356	1,726
1980	3,269	17,251	404	2,130
1981	3,814	21,065	471	2,601
1982	4,358	25,423	538	3,139
1983	5,176	30,599	639	3,778
1984	5,993	36,592	740	4,518
1985	6,755	43,347	835	5,353
1986	7,573	50,920	936	6,289
1987	8,335	59,255	1,030	7,319
1988	9,152	68,407	1,131	8,450
1989	9,970	78,377	1,232	9,682
1990	10,787	89,164	1,333	11,015
1991	11,550	100,714	1,427	12,442
1992	12,476	113,190	1,541	13,983
1993	13,348	126,538	1,649	15,632
1994	14,274	140,812	1,763	17,395
1995	15,364	156,176	1,898	19,293
1996	16,726	172,902	2,066	21,359
1997	17,978	190,880	2,221	23,580
1998	19,286	210,166	2,383	25,963
1999	20,375	230,541	2,517	28,480
2000	21,520	252,061	2,659	31,139
2005	27,022	376,205	3,338	34,477
2010	32,579	527,864	4,025	38,502
2015	38,081	707,307	4,705	43,207
2020	43,584	914,263	5,385	48,592

*Year assembly discharged; emplacement will occur after aging.

REFERENCES

1. ORNL/TM-6008, October 1977, C. W. Alexander, et al., Projections of Spent Fuel to be Discharged by the U. S. Nuclear Power Industry.
2. Y/OWI/TM-34, April 26, 1978, R. A. Kisner, et al., Nuclear Waste Projections and Source Term Data for FY 1977.
3. HEDL-TC-1076, E. M. Greene, L. D. Jacobson, Spent Fuel Handling and Packaging Program, Subtask 1.4, Centralized Fuel Data, Preliminary Report, April, 1978.
4. DPSTD-SFHP-78-10, Spent Fuel Receipt and Lag Storage Facility for the Spent Fuel Handling and Packaging Program, Savannah River Laboratory, Aiken, South Carolina.

APPENDIX B

PERFORMANCE PARAMETERS

PERFORMANCE PARAMETERS

GROSS THERMAL LOAD

The allowable gross thermal load for storage of SURF is defined as the maximum heat input per unit area of the subsurface strata which does not have a detrimental effect on the retrievability of the SURF, the long-term isolation of the SURF, or the biosphere.

Preliminary estimates based on canister-scale analysis, room-scale analysis, and regional-scale analysis have been made by the University of Minnesota in a parametric design study. These estimates are dependent upon the required retrievability period and SURF age and are, in kilowatts per acre, as follows.

RETRIEVABILITY PERIOD

<u>SURF Age</u>	<u>5-Year</u>	<u>25-Year</u>	<u>50-Year</u>
5 Years	153 ⁽¹⁾	-	-
10 Years	100 ^(2,3)	80 ¹	-
20 Years	80 ⁽²⁾	-	-

(1) Limiting factor is regional-scale temperature rise.

(2) Limiting factor is canister borehole stress.

(3) Similar to 25-year retrievability.

In summary, the allowable gross thermal loading decreases as the retrievability period or the age of the SURF increases. The allowable canisters per acre actually increase with the age of the SURF, since the thermal heat per canister decreases more rapidly than does the allowable gross thermal load.

The specific value of the parametric study, though, is very limited, since only one parameter was varied at a time and interactions between parameters were not investigated. For design purposes, the five-year retrievability data were used and it was assumed that canister borehole reinforcing would be used, if necessary, for longer retrievability periods.

The material properties for basalt that were used in the study were assumed. The assumed values were developed with Rockwell Hanford Operations input.

Additionally, two-dimensional models were employed in order to simplify programming. The results for three-dimensional analysis could be significantly different. As emphasized by the University of Minnesota authors, any results or conclusions taken from this study must be considered preliminary. These can be subject to change based on NSTF data.

SURF AGE

The age of SURF at the time it is placed into repository storage affects the repository subsurface area requirements both by modifying the allowable gross thermal loading and the number of canisters available at a given time. By allowing the SURF to age longer before storage, the number of canisters per acre of area will be increased (the thermal power per canister drops more rapidly than does the allowable gross thermal loading). Subsurface development can be delayed as well as reduced, since SURF will not be available for storage until a later time. Figures B-1 and B-2 show the delay effect and Figure B-3 shows the reduced area requirements.

Countering these benefits are the increased surface storage costs as a result of delaying emplacement. In order to store SURF more than the minimum five years, away-from-reactor (AFR) storage would need to be developed and additional transportation costs would be incurred.

In order to define the most efficient SURF age at the time of emplacement in the repository, an economic study will be needed. The cost data for this study are not available and require further development of the AFR storage facilities and of the repository.

Figure 3-1. Spent Fuel Caristers Available for Repository Emplacement

Assumes that the spent fuel handling and packaging facility begins operation in 1986 and processes 3,300 MTU per year until accumulated spent fuel is processed. Additional spent fuel handling and packaging facilities available as needed.

Figure B-2. Cumulative Spent Fuel Canisters Available for Repository Emplacement

Assumes that the spent fuel handling and packaging facility begins operation in 1986 and processes 3,000 MTJ per year until accumulated spent fuel is processed. Additional spent fuel handling and packaging facilities available as needed.

Figure B-3. Repository Area Required Per Gigawatt-Electric Year

For the purposes of the preconceptual design of the repository, five-year aging was assumed. This assumption will result in the most conservative design and is subject to change as the costs of the alternatives can be determined.

RETRIEVABILITY PERIOD

The retrievability period is defined as the period of time during which access to stored waste is maintained for the purpose of recovering the waste for either storage in another part of the repository or for shipment.

The design retrievability period is a function of technical, safety, economic, and political requirements and constraints which have not been clearly defined at this time. Examples of conditions which could require that the waste be retrieved include the development of a superior, alternate disposal method such as transmutation, the identification of localized, excessive thermal effects, actual subsurface basalt properties different than design parameters which disqualifies the site, and a reversal of the current United States' position on spent fuel reprocessing.

Costs associated with retrievability result from structural support and reinforcement requirements to handle increased stresses and time-dependent rock movements and from reduced allowable gross thermal loading.

The specified retrievability period for the preconceptual design of the repository is 25 years. This preliminary value is considered conservative and may be modified as the result of an in-depth study of the factors.

REPOSITORY DESIGN LIFE

The repository operations will take place at different times and for different periods. Waste receiving and emplacement and repository expansion will start in 1991 (by the current schedule). For the purpose of preconceptual design, these activities are projected only to the year 2015. This end date was chosen since a 25-year equipment technology life

is reasonable and because the nuclear capacity projection becomes more unreliable as it is extrapolated beyond the year 2000.

Retrievable storage starts with the first waste receipts. Each waste canister is held in a retrievable mode for a 25-year period after which it enters the terminal storage mode. Retrievability activities will continue for up to 25 years after the final waste emplacement.

The conversion to terminal storage includes decommissioning of specific storage tunnels (perhaps by backfilling with crushed rock). This activity will start 25 years after the first receipt and continue until all of the received waste has been placed in terminal storage.

Following the full conversion to terminal storage mode, the subsurface facilities, the shafts, and the surface facilities, in that order, will be decommissioned.

ONSITE PACKAGING

For the purposes of preconceptual design, it has been assumed that the canistered waste is transferred to the repository from an offsite facility.

APPENDIX C

CRITERIA NEEDING RESOLUTION

Within the narrative of this report, certain key criteria have been identified as TBD (To Be Determined). These involve reference to a need for verification by a trade-off study or an undefined (as yet) engineering or technical parameter. Numbers are used with the TBDs to provide cross reference.

CRITERIA NEEDING RESOLUTION

PART I. OVERALL PROJECT

TBD-1 Interfaces with the Federal Packaging Facility

There are several interfaces between the repository and the conceptual design of the Federal packaging facility that require further investigation and resolution. Some of these include: (a) the packaging of the spent fuel; (b) spent fuel decay time; (c) spent fuel processing rates and quantities; and (d) radioactive wastes, characteristics, and form.

The decision as to an optimum number of fuel assemblies per canister for BWR and PWR fuels will require an input from the repository design. The repository parameters of major concern are diameter limitations and maximum thermal power. These both relate back to the geological waste heat density limitations (perhaps on the order of 100 kw per acre) that are not yet defined.

The DOE and NRC fuel storage plans are not firmly established and may extend to 10 years. No data are currently available on radioactive waste processing by the packaging facility.

TBD-2 Personnel Requirements

A task and function analysis shall be performed to establish personnel requirements for repository operation.

TBD-3 Site Selection Criteria

The site criteria will be developed using data from a site selection study and will be included at the end of the preconceptual design study. The 10 CFR 100 and other NRC requirements (pending) shall be incorporated (see TBD-8).

TBD-4 Subsurface Seismic Criteria

Subsurface seismic effects are sufficiently different from surface effects that the methodology of seismic analysis requires special study. This study shall define the methodology and apply it to the subsurface designs.

TBD-5 Design Basis Tornado

The DBT depends upon the site location. If located at Hanford, the DBT will be developed using established Hanford criteria and appropriate Regulatory Guides.

The effects of flying debris (missiles) shall be included. This missile criteria shall be developed from NRC-accepted criteria for Washington Public Power Supply System, Inc. plants in this area, and Regulatory Guides.

TBD-6 Radioactive Releases from the Repository

Radioactive releases from the repository shall not exceed the limitations of 10 CFR 100 and DOE regulations. Based upon conceptual data and assumed accidents, a study shall be run to predict potential releases of radioactive material. These data shall serve as the basis for the environmental impact statement and preliminary design.

The study data will be superseded by the results of the preliminary safety analysis report.

TBD-7 Backfill

The needs and benefits of backfill shall be verified by study.

TBD-8 Licensing Study

Since the NRC licensing requirements are under development and will not be available except to subsequent phases of the program, a licensing study shall be performed to establish a basis for the preconceptual and conceptual work. The study shall use the best available data that are applicable to the siting, environmental, and safety aspects of the project.

PART II. SURFACE FACILITIES

TBD-9 Size and Frequency of Capsule Delivery Batches

The amount of receiving storage space and facilities that will be required will depend upon how repository capsule receipts are batched. Batching quantities might be influenced by onsite packaging facilities, delivery by trucks, multi-car rail line delivery, and combinations of delivery modes.

Waste generation rates, AFR storage capacities and programming, carrier availability and transfer scheduling, weather impact on road clearance, and socio-economic factors affecting carrier performance (e.g., strikes) are some of the factors that can contribute to batch receipts of variable quantities of waste capsules. The batch size and frequency shall be defined.

TBD-10 Parallel Processing Study (Facilities)

This study shall contribute to the Part V study that will verify the economic and safety feasibility of parallel processing of canisters and containers. This study shall concentrate on the facility aspect of dual and combined processing of the capsules.

TBD-11 Modes of Retrievability

The retrievability modes shall be defined. The rate of retrieving for each mode shall be established.

TBD-12 Container Storage within Cell

The required lag storage space for containers shall be determined. This will depend upon the rate of receipt, the batch size, and the rate of processing.

TBD-13 Occupancy of Engineering and Administration Facility

An occupancy shall be established.

TBD-14 Power Requirement

The repository power needs in terms of MVA and voltage shall be established. It shall be determined by estimating and totaling load requirements.

TBD-15 Loads on Roadways

The maximum expected truck loads shall be established. Waste transport studies shall be researched to determine expected cask and gross transporter weights.

TBD-16 Size of Exclusion Area

The size of the exclusion area will primarily depend upon the site characteristics and the results of the safety analysis. The safety analysis report will determine the amount and extent of potential radioactive releases. The geography required to meet 10 CFR 100 requirements can then be established.

TBD-17 Design Basis Occupancy

Each work area within a radiation zone or possible radiation zone shall be identified. For each of these areas, an average radiation level and occupancy requirement shall be established.

TBD-18 Quality Assurance Levels

Systems and equipment that must meet QA Levels 1 and 2 requirements shall be identified.

TBD-19 Size of Protected Area

The size of the protected area shall be determined.

TBD-20 Size of Rock Storage Area

The size of the rock storage area shall be determined. It will depend upon the amount of mining to be done before rock is returned to the mine for terminal closure of storage chambers, and the rate of such usage.

TBD-21 Water Supply

The onsite and offsite water supply needs shall be determined. Total repository occupancy, mining methods, etc. will influence the total need.

TBD-22 Design Life (Surface Facilities)

The design life shall be established for the various surface facilities.

PART III. SHAFTS

TBD-23 Repository Depth

The depth of the repository shall be established. This will depend upon the overburden necessary to provide isolation and the geologic characteristics of the chosen site.

TBD-24 Isolation Barriers within the Repository

Studies shall be run to define the isolation barrier requirements. Safety studies will define the degree of confinement and the degree of ultimate containment required. Various mechanical methods of accomplishing this shall be explored such that the isolation barrier for both the operating and decommissioned modes can be established for each type of shaft and penetration.

TBD-25 Emergency Hoisting

The emergency evacuation requirements shall be established (see Section 1.2.1.11, Part VI). The requirements for each type of shaft shall be determined.

TBD-26 Equipment Envelopes for Hoisting

The maximum envelopes (size, weight, etc.) of equipment and supplies to be hoisted shall be established. Mining, operational support, emergency, and fire equipment require investigation.

TBD-27 Shaft System Operator

It shall be determined if an operator(s) is required for the shaft systems to function.

TBD-28 Number, Type and Size of Repository Shafts

A study shall determine the optimum number and type of shafts to use in the repository. The size shall also be determined. (See TBD-26 for equipment envelopes and load; TBD-25 for emergency needs.)

TBD-29 Shaft Ventilation Requirements

The shaft design shall accommodate HVAC requirements as determined by systems studies (Part VI).

TBD-30 Seismic Design of Shafts

A study shall be made of the DBE and its effects upon shaft design and function.

TBD-31 Characteristics of Hoisted Items

The specific characteristics of hoisted items shall be identified.

TBD-32 Shaft Electrical Loads

Shaft loads for each type of shaft shall be established.

TBD-33 Hoist Reliability

A reliability requirement shall be established for each type of shaft.

TBD-34 Hoist Downtime

The downtime limit of each type of hoist shall be specified.

PART IV. SUBSURFACE FACILITIES

TBD-35 Layout Studies

Subsurface layout studies shall be run. From these studies, the total amount of excavation shall be determined on a time-phased basis. Likewise, the length of tunnels to be provided by the project can be estimated (see TBD-43).

TBD-36 Storage Chamber Capacity Study

A study shall be run to establish the capacity of a given storage chamber. The number of storage enclosures per storage chamber and the number of capsules per storage enclosure shall be determined. Maximum allowable storage temperatures within the basalt and within the capsules shall be considered.

TBD-37 Temperature Limits for Storage

A study shall be run to establish temperature limits for storage (see TBD 39 on human access requirements).

TBD-38 Total Storage Capacity of Repository

The number of canister and container storage chambers required shall be determined.

TBD-39 Storage Chamber Access

A study shall be run to determine the human access requirements to the storage areas. These requirements shall be defined and used to establish design radiation and temperature levels within the storage chambers.

TBD-40 Canister Confinement in Storage

A study shall be run to determine the confinement requirements of a canister enclosure. The results will depend upon the length of the retrievability period, the probability of a canister failure, and the access needs to the storage chamber.

TBD-41 Capsule Containment

Based upon decommissioning criteria, capsule containment methods shall be developed.

TBD-42 Subsurface Occupancy

Based upon layout studies (TBD-35) and work area determinations, the design basis occupancies for the subsurface work areas shall be established. From these data, a total occupancy shall be determined with a breakdown by waste storage operations and subsurface development.

TBD-43 Mining Study

A mining study shall be run (see Part IV). The mining method shall be selected. This must be selected before services can be determined, mine shaft and hoist sizes established, schedules made, or occupancy levels determined.

TBD-44 Emergency Power Loads

The emergency power loads for the subsurface facilities shall be established.

TBD-45 Uninterruptible Power

The time requirement for maintaining UPS shall be established.

TBD-46 Subsurface Fire Equipment

A study shall be run to verify that surface-located equipment is the most effective system.

TBD-47 Subsurface Wastes

A study shall be run to identify the types and quantities of wastes that will be generated in the subsurface facilities. The study shall include an analysis of the methods of disposing of these wastes. Methods shall be selected for use in the conceptual design.

TBD-48 Design Life

The design life shall be established for each of the major systems, components, and equipment within the subsurface facilities.

PART V. REMOTE HANDLING SYSTEM

TBD-49 Capsule Handling Lines

A study shall be run to determine if parallel processing lines are the most cost and safety effective. Input from a Part II study on facilities shall be used.

TBD-50 Canister Hoist Study

A study shall be made to determine the optimum number of canisters per lift (cage capacity).

TBD-51 Container Hoist Study

A study shall be made to determine the optimum number of containers per lift (cage capacity).

TBD-52 Overpack Location Study

A study shall be run to determine if a subsurface bagging/surface overpack is more cost and safety effective than a subsurface overpack.

TBD-53 Capsule Handling Rates

Handling rates for each step in remote processing require definition.

TBD-54 Maximum Capsule Temperature during Remote Handling

The subject temperature shall be established and used as a design basis for remote handling.

TBD-55 Shielding (Subsurface Transport and Emplacement)

Allowable radiation levels shall be established for each area that the subsurface transporter encounters. These shall be used to calculate shielding requirements.

TBD-56 Seismic Categories

Remote handling structures, systems, components, and equipment that must be designed to Seismic Categories I and II shall be identified.

TBD-57 Design Life

The design life for major elements of the remote handling system shall be determined.

PART VI. SYSTEMS

TBD-58 Electrical Power Requirements

The total electrical power load at the repository shall be determined. The determination shall separately identify the power load and characteristics during the construction (temporary) period, the mining power requirements, and the normal/emergency operating requirements.

TBD-59 Subsurface Ventilation System

A study shall be conducted to determine if the most effective ventilation system uses push-pull supply blowers and exhaust blowers.

TBD-60 Mine Cooling

A study shall define the mining heat loads. Subsurface maximum, mean, and minimum design temperatures shall be determined. The air-change rates will be designed to satisfy the temperature requirements.

TBD-61 Water Treatment Plant

The gallons-per-day capacity shall be determined for the water treatment plant. This capacity will be based on total repository requirements.

TBD-62 Steam Supply

The steam requirements for the repository shall be determined (pounds per hour) to meet requirements of waste evaporation and other needs such as cleaning and decontamination.

TBD-63 Sanitary Waste

The sanitary treatment facility capacity shall be determined. The capacity will meet the total need of the repository.

TBD-64 Heat Recovery System

A design trade study shall be conducted to optimize a heat recovery system that makes maximum use of waste heat from the repository. The study will include heat from basalt and exhaust air and may consider supplemental solar energy.

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