Reference Design Description for a Geologic Repository

Revision 01

September 1997

Civilian Radioactive Waste Management System

Management & Operating Contractor

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SUMMARY OF CHANGES

Revision 00	Initial issue
Revision 01	Added Primary Repository Performance Parameters (pages 8 & 9), Clarified use of co-disposal container and updated dimensions of the canistered fuel-waste package assembly (page 41), corrected the time period to maintain the option to retrieve in order to be consistent with the Mined Geologic Disposal System Requirements Document (page 43), Waste Emplacement System details expanded/clarified (page 45), updated the EBS Design Options (page 58 and 59) and editorial text/graphic changes.

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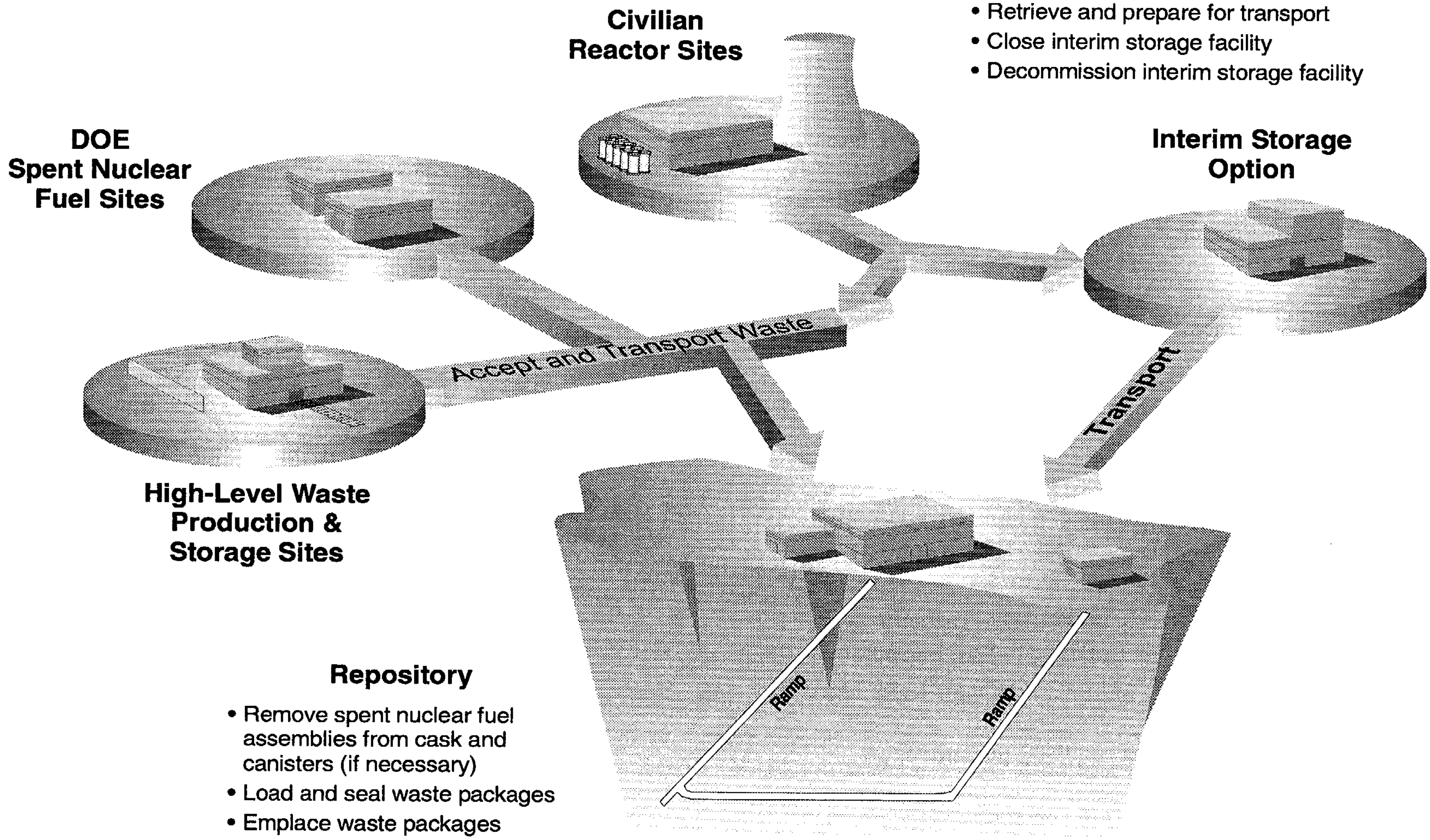
- Store
- Retrieve and prepare for transport
- Close interim storage facility
- Decommission interim storage facility



Repository

- Remove spent nuclear fuel assemblies from cask and canisters (if necessary)
- Load and seal waste packages
- Emplace waste packages
- Monitor and confirm performance
- Retrieve (if required)
- Close repository

WMS.CDR.121.RDD/7-25-97

INTRODUCTION

This document describes the current design expectations for a potential geologic repository that could be located at Yucca Mountain in Nevada. This Reference Design Description (RDD) looks at the surface and subsurface repository and disposal container design. Additionally, it reviews the expected long-term performance of the potential repository. In accordance with current legislation, the reference design for the potential repository does not include an interim storage option.

The reference design presented allows the disposal of highly radioactive material received from government-owned spent fuel custodian sites; producer high-level waste sites; and commercial spent fuel sites. All design elements meet current federal, state, and local regulations governing the disposal of high-level radioactive waste and protection of the public and the environment.

Due to the complex nature of developing a repository, the design will be created in three phases to support Viability Assessment, License Application, and construction. This document presents the current reference design. It will be updated periodically as the design progresses. Some of the details presented here may change significantly as more cost-effective solutions, technical advancements, or changes to requirements are identified.

System Roles

The potential repository is an integral part of the Civilian Radioactive Waste Management System (CRWMS) being developed by the U.S. Department of Energy's Office of Civilian Radioactive Waste Management. The CRWMS integrates the acceptance, transportation, storage, and disposal of spent nuclear fuel and high-level radioactive waste. Regional service agents under contract to the U.S. Department of Energy (DOE) will arrange delivery, acceptance, and transportation of the wastes. Safety of the CRWMS will be independently reviewed and approved through licensing by the U.S. Nuclear Regulatory Commission (NRC).

Table 1.
Spent Nuclear Fuel and High-Level Waste to be Accepted at the Repository

Type	Amount (MTU)
Commercial SNF	63,000
Commercial HLW	640
Defense HLW	4,027
DOE SNF	2,333
Total	70,000

Table 2.
Annual Repository Receipt Rates

Year	Commercial Spent Nuclear Fuel (MTU)	Commercial High-Level Waste, Defense High-Level Waste, and DOE Spent Nuclear Fuel (MTU)
2010	300	TBD*
2011	600	TBD
2012	1,200	TBD
2013	2,000	TBD
2014	3,000	TBD
2015	3,000	400
-	3,000	400
-	3,000	400
-	3,000	400
2031	3,000	400
2032	3,000	200
2033	1,900	0

* TBD = To Be Determined

REPOSITORY REFERENCE DESIGN PERFORMANCE PARAMETERS

Regulatory Requirements

The primary requirements that govern the design of the proposed repository are contained in the following Act and Federal regulations:

- the Nuclear Waste Policy Act, 42 USC 10101 et seq.;
- 10 CFR 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories";
- 10 CFR 20, "Standards for Protection Against Radiation";
- 29 CFR 1910, "Occupational Safety and Health Standards"; and
- 29 CFR 1926, "Safety and Health Regulations for Construction."

General Requirements

The design of the repository will allow waste retrieval after waste emplacement operations begin.

All site-generated hazardous, low-level radioactive, and mixed wastes will be collected and packaged for transport to government approved off-site facilities for disposal. The hazardous, non-hazardous, and radioactive wastes will be segregated to preclude the generation of mixed wastes, during normal operations.

The design will be a robust design with options.

Waste Handling Requirements

The potential repository will be capable of accepting the 70,000 metric tons of initial uranium (MTU) or equivalent of spent nuclear fuel of high-level waste as listed in Table 1. Table 2 specifies the annual receipt rates for the repository. The repository will not accept or dispose of waste that is subject to the Resource Conservation and Recovery Act requirements.

The repository will be capable of receiving (by rail, heavy haul, and legal weight truck) and packaging (which includes opening non-disposable canisters) the following types of waste:

- bare commercial spent nuclear fuel assemblies;
- commercial spent nuclear fuel in disposable canisters (multi-purpose canisters/large canisters);
- commercial spent nuclear fuel in non-disposable canisters;
- DOE and Navy spent nuclear fuel in disposable canisters (large or small canisters);
- DOE spent nuclear fuel in non-disposable canisters, on a case by case basis; and
- commercial and defense high level waste in disposable canisters (small canisters).

Waste Emplacement Requirements

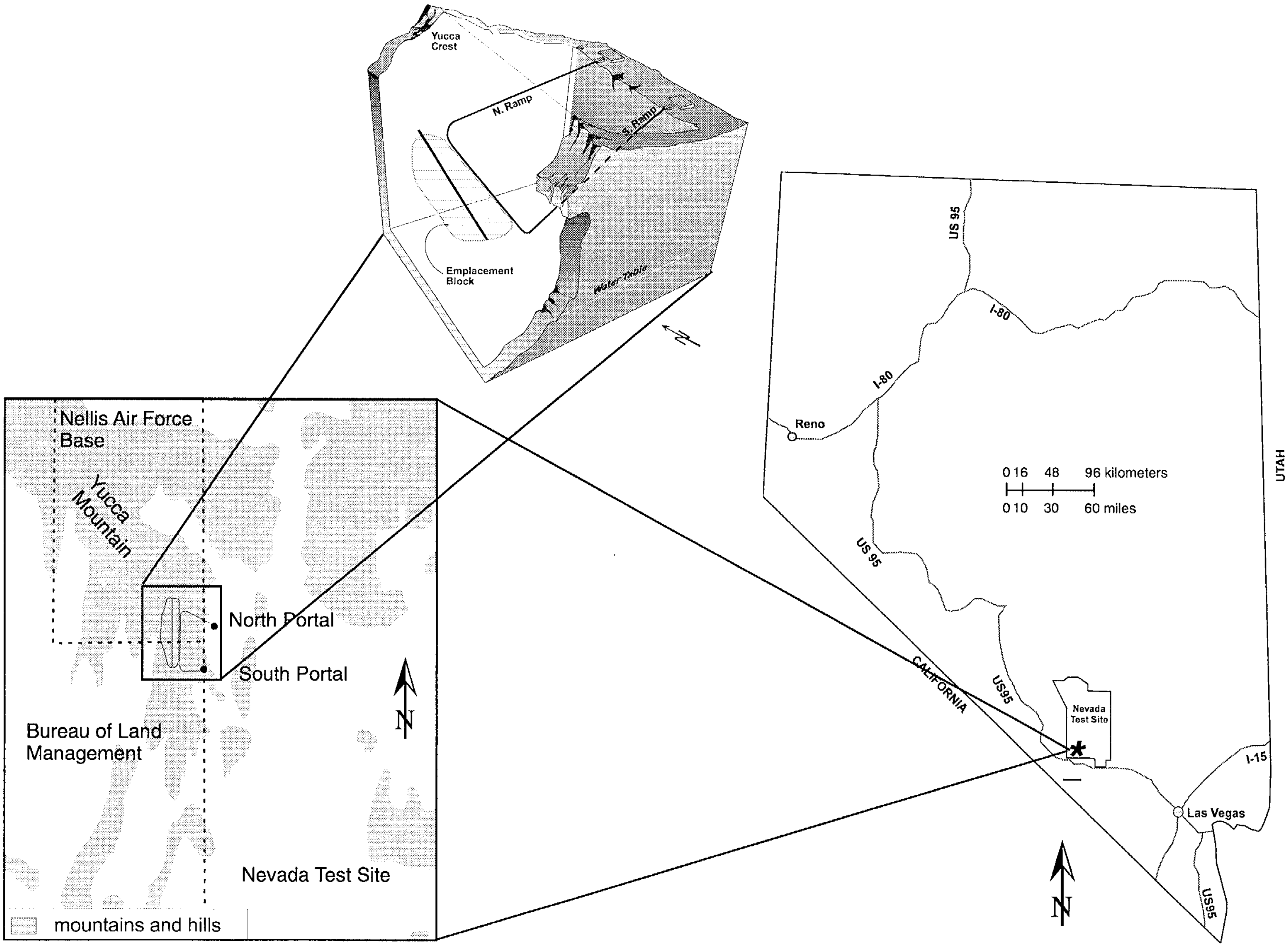
The emplacement area will have an areal mass loading of between 80 and 100 MTU per acre and be located at least 200 meters below the directly overlying ground surface.

Waste Isolation Interim Standard

The waste packages will initially contain the spent nuclear fuel and high-level wastes. These waste packages will be designed so that no more than one percent of the waste packages breach during the first 1000 years.

Until the EPA promulgates a new standard, the following will be used as an interim standard. The repository design will ensure that during the first 10,000 years after closure, an individual living 20 kilometers from the repository will not be exposed to more than 25 mrem per year from all pathways and all radionuclides. In addition, an overall goal of the repository design is to continue limiting the annual dose below 25 mrem during the period after 10,000 years.

Site Layout



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REPOSITORY SITE LAYOUT

Yucca Mountain is a potential site for a geologic repository. Yucca Mountain is located in an area of uninhabited desert on federal land in Nye County in southern Nevada, about 160 kilometers (100 miles) northwest of Las Vegas. The potential site is located beneath Yucca Crest, one of four major ridges of the mountain.

Surface Layout

The surface site layout will consist of the following four major surface areas:

- North Portal area: This 80-acre area will contain the radiologically control area and the balance of plant facilities. This area will be used to receive and package the waste for emplacement.
- South Portal area: This 12-acre area at the southern entrance to the potential repository will support the excavation of the underground. Facilities will be provided for maintenance, warehousing, material staging, security, and transportation.
- Emplacement shaft area: This 3-4-acre site is located on the surface at the opening of the exhaust shaft. Facilities in this area will provide the emplacement ventilation exhaust fans and support their maintenance.
- Development Shaft Area: This half-acre site is located on the surface at the opening to the intake shaft and will have a facility to house the development intake fans and emergency hoisting system.

Subsurface Layout

The underground site layout will include the north and south ramps which will allow access to the emplacement block. The emplacement block will be located in the Topopah Spring tuff, which is a welded tuff unit of the Paintbrush Group. This strong volcanic rock responds well to mechanical excavation and yields stable openings with appropriate ground support. The emplacement block will be located in the unsaturated region of the site.

The potential site for the emplacement block was chosen because it will be in an area free of significant faults. This was determined after looking at detailed fault investigations at Yucca Mountain.

The waste will be placed in underground emplacement drifts located in the emplacement block. The distance between the drifts and the spacing of the waste packages within the drifts will be calculated to provide an areal mass loading of about 85 MTU per acre, which represents the density at which commercial spent nuclear fuel waste packages will be placed in the potential repository. High-level waste packages will be placed in drift areas between the commercial spent nuclear fuel packages.

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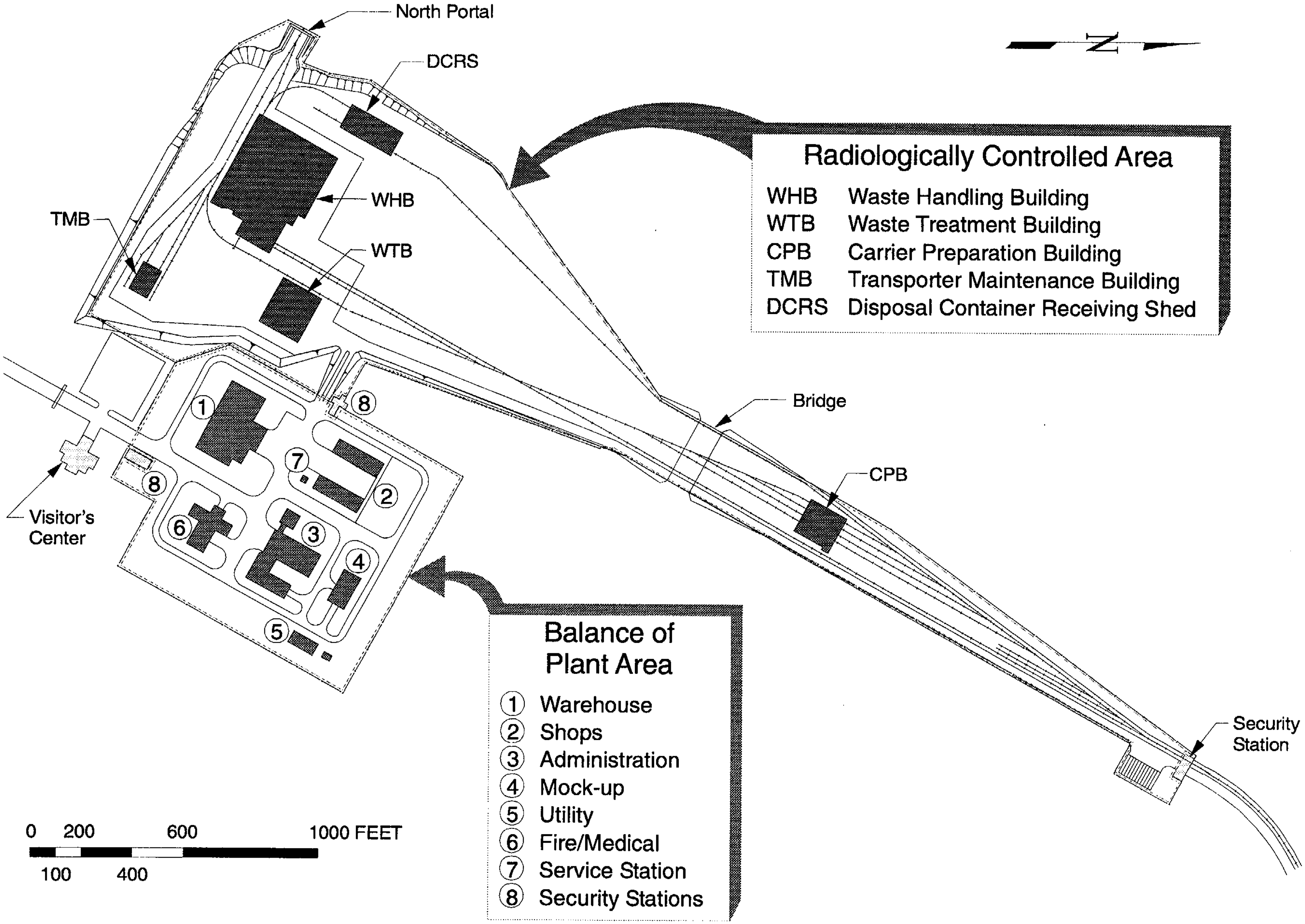
North Portal Area



NRTHPORT.CDR.121.RDD/9-2-97

Surface Layout

The potential repository's surface layout will follow the necessary engineering standards to support the arrangement of the surface repository facilities and systems for safe and efficient operations. The repository's surface layout will have the following key features:

- organized around subsurface accesses;
- consideration of radiological exposure boundaries;
- consideration of flood areas, fault zones, and meteorological patterns;
- support for surface and subsurface operations (facility and transportation);
- consideration of preclosure radiological safety; and
- minimization of environmental impacts.

North Portal Area

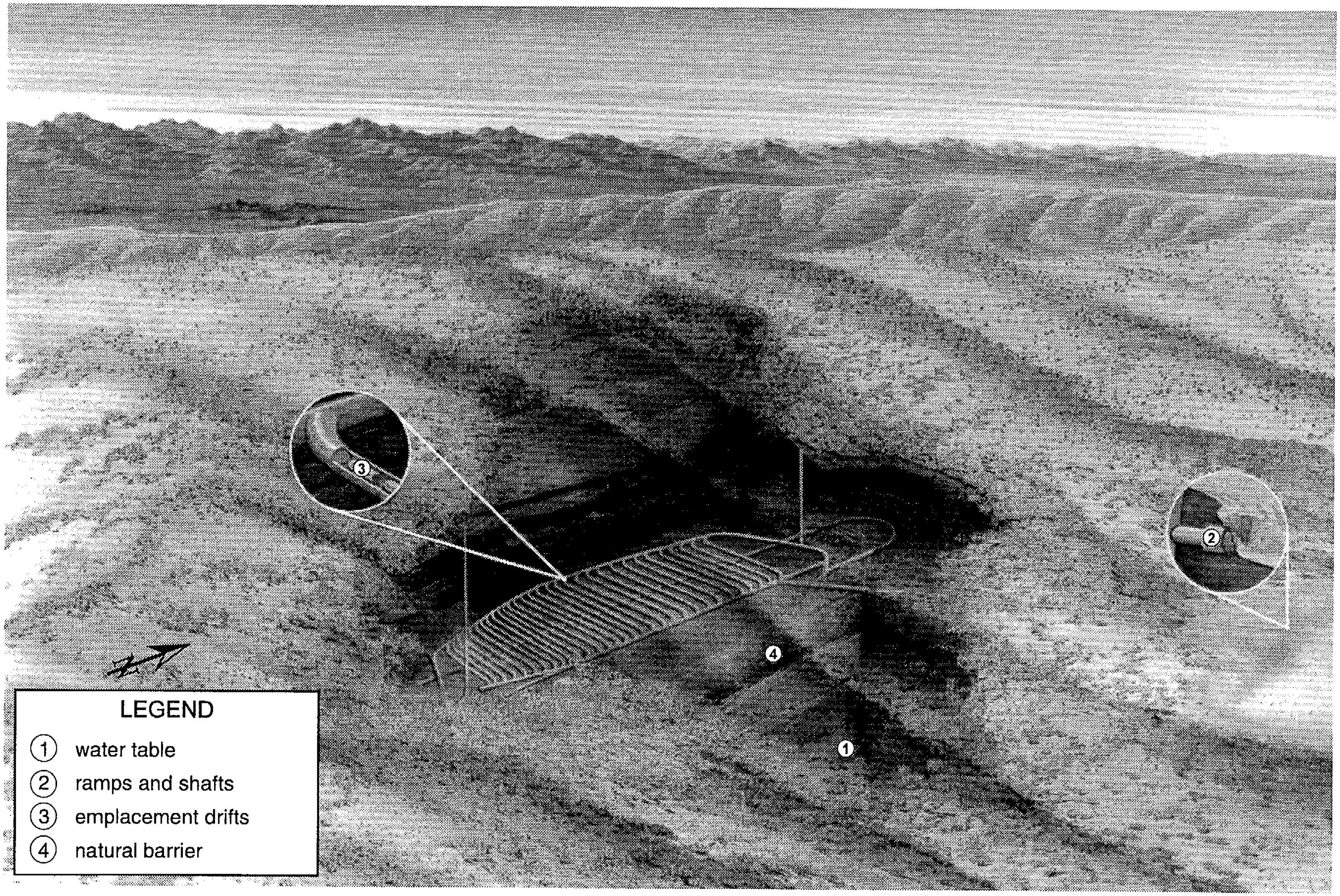
The materials to be disposed will be received and packaged for emplacement in an 80-acre area located at the northern entrance to the potential repository (the North Portal). The operations involving radioactive materials will be conducted in the radiologically controlled area and the support operations will be performed in the balance of plant area.

The radiologically controlled area will include the following facilities:

- carrier preparation building, where shipping casks will be prepared for removal from rail or truck carriers;
- waste handling building, where spent nuclear fuel assemblies and disposable waste canisters will be packaged into disposal containers;
- disposal container receiving shed, where empty disposal containers will be received and prepared for loading;
- waste treatment building, where low-level waste for off-site disposal will be treated; and
- transporter maintenance building, where the vehicles used to transport and emplace waste will be serviced.

The balance of plant area includes the following facilities: security stations, administrative building, fire/medical center, warehouse, central shops, motor pool and facility service station, mock-up building, utility building, and visitor center.

Subsurface Facility



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Subsurface Facility

The subsurface facility will include a main tunnel, accesses, alcoves, drifts, and boreholes. The subsurface facility will provide access to the underground for the emplacement of waste and overall repository stability through widely spaced emplacement drifts.

The subsurface facility's physical location and general arrangement, as well as the mountain's natural geologic barrier will provide long-term waste isolation. The subsurface facility will enhance the isolation characteristics of the waste packages by locating the emplacement drifts away from major faults and above the water table.

Design Description

Two inclined access ramps, two vertical ventilation shafts, and a waste emplacement block with main drifts and waste emplacement drifts will make up the subsurface facility. The ramps, shafts, drifts, and boreholes will be sealed during the potential repository's closure phase.

The Subsurface Facility will be designed to allow water to drain from the emplacement drifts toward the main drifts. Once in the main drifts, the water will drain toward the north and away from the emplacement area.

The waste emplacement block will be located at least 200 meters (660 feet) below the surface and at least 100 meters (330 feet) above the water table. The block will cover 300 hectares (740 acres) and will accommodate about 11,000 waste packages in a large waste package and high thermal load configuration. The emplacement drifts in the block will run in an approximate east-west direction. The completed layout will involve about 150 kilometers (93 miles) of drifts.

The facility will contain two types of main drifts.

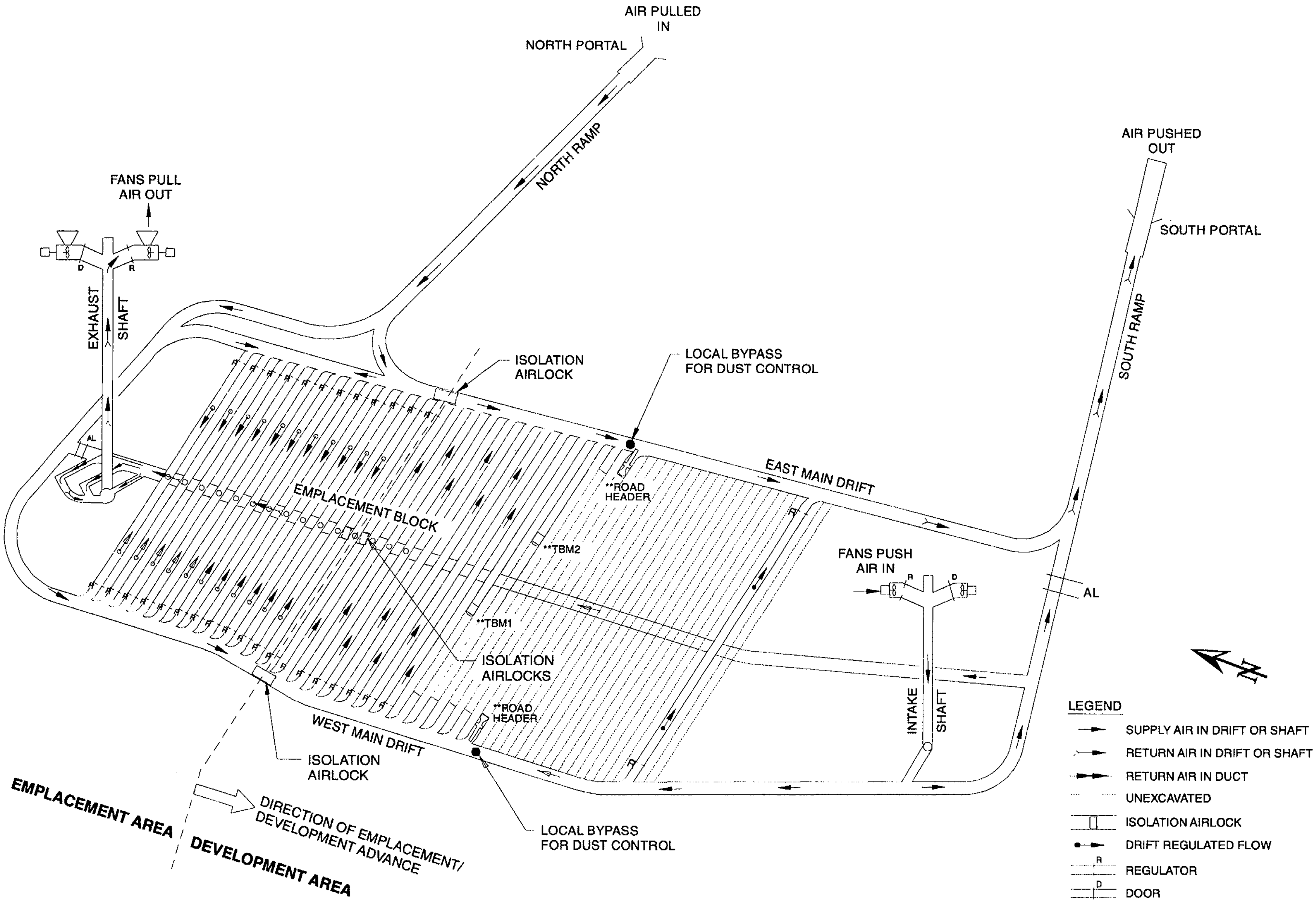
- Service main drifts (including ramps) for access, which will have the following features:
  - 7.6 meters (25 feet) in diameter;
  - excavated using a tunnel boring machine; and
  - maximum grade in ramps of 2.7% to accommodate rail transport.
- Exhaust main drift for ventilation, which will have the following features:
  - 7.6 meters (25 feet) in diameter;
  - excavated using a tunnel boring machine;
  - located 10 meters (33 feet) below the emplacement drifts; and
  - connected to emplacement drifts by a series of ventilation raises.

The emplacement drifts will be designed according to the following criteria:

- 5.5 meters (18 feet) in diameter;
- 28 meters (92 feet) spacing between centers of emplacement drifts;
- 500 meters (1640 feet) to about 1200 meters (3940 feet) in length with a raise from the exhaust main drift near the center of the emplacement drift;
- remotely controlled doors at the entrance to control access; and
- raised floor above the main drift to allow a waste package to be off-loaded directly out of the transporter in preparation for emplacement.

Approximately 5 percent of the emplacement drifts will be completed prior to the start of waste emplacement operations. The remaining 95 percent will be completed while waste is being emplaced in the completed drifts.

Subsurface Ventilation System



VENTSYS.CDR.121.RDD/7-16-97

Subsurface Ventilation System

The Subsurface Ventilation System will support the development and emplacement operations of the subsurface repository by providing

- air to personnel;
- confinement of radioactive particles; and
- limited temperature control of the underground facility based on air-flow volume and outside air temperature.

To prevent the spread of any unlikely radioactive releases from the emplacement area, the development and emplacement operations will be physically separated from each other, and each will have its own ventilation system and ramp access. A high efficiency filtration system will control radioactive releases.

The system will consist of ducting, fans, seals, and electronic controls. It will interface with the surface for air intake and exhaust, electric power, and monitoring. Major equipment will be located above ground.

Design Description

During the operation phase, underground openings will be developed in parallel without interfering with waste emplacement. Physical and functional separation of the two activities will be maintained using isolation air locks.

Two separate, independent ventilation systems will operate simultaneously during repository operations. One system will provide ventilation for the excavation operations required to develop the emplacement drifts, while the other will supply air to the waste emplacement operations. Temporary walls (isolation air locks) in the main drifts at the points that divide the two sides will keep ventilation of the two systems separate. As excavation and emplacement progress, these walls will be moved to new points in the main drifts. This will provide access to newly excavated drifts for waste emplacement. Each area will have its own dedicated fans with appropriate backup capability.

The ventilation system on the subsurface development (excavation) side will

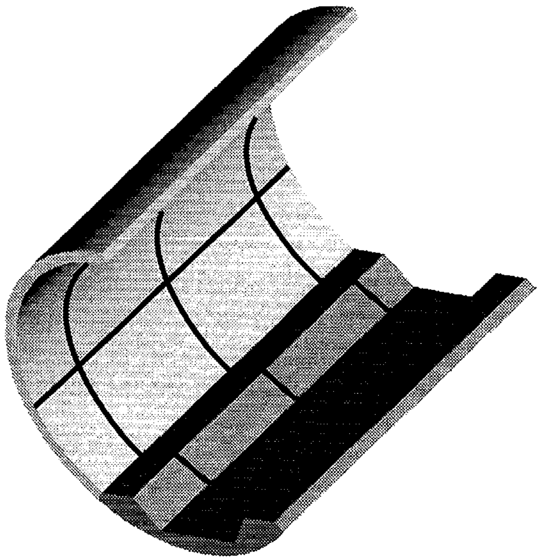
- force air into the subsurface excavation drifts by way of fans at the intake shaft;
- exhaust air through the south ramp; and
- maintain air pressure on the excavation side above the air pressure on the emplacement side.

The ventilation system on the emplacement side will

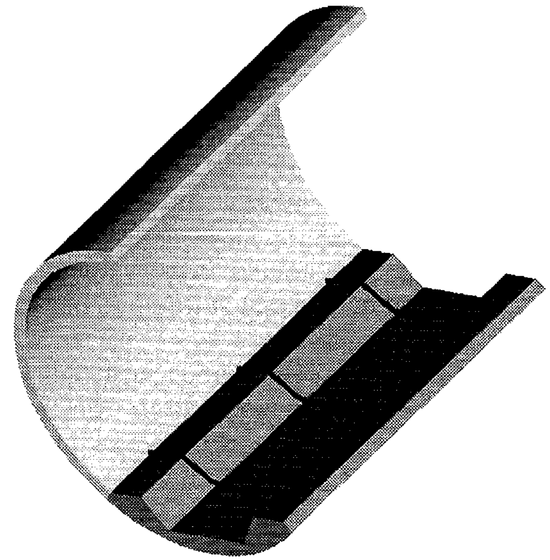
- pull air into the north ramp and emplacement areas using fans in the exhaust shaft;
- exhaust the air through the exhaust shaft;
- maintain a lower air pressure than on the excavation side of the subsurface layout; and
- contain high efficiency filters that will activate in the event subsurface contamination is detected.

This combination of systems will ensure that even in the event that one system shuts down, the pressure differential between development and emplacement will be maintained. This will ensure any potential radioactive releases will be contained to the emplacement side.

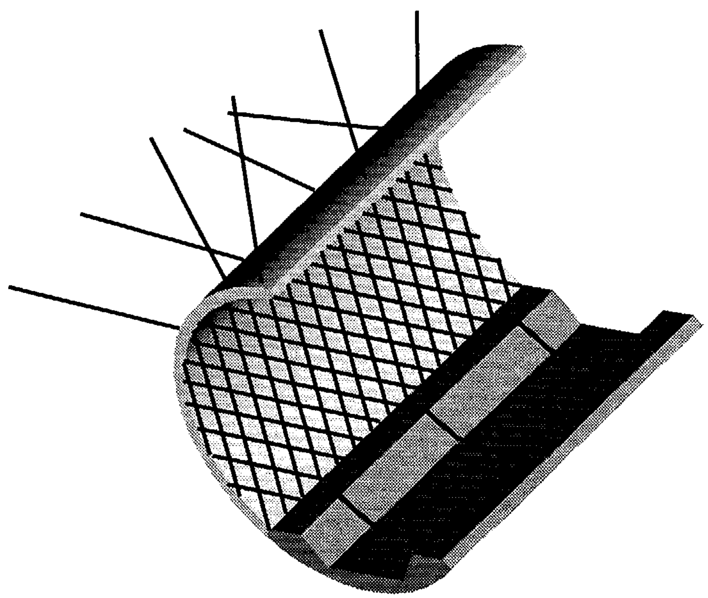
Ground Control System



PRECAST CONCRETE LINING



CAST-IN-PLACE CONCRETE LINING



ROCK BOLT AND MESH SUPPORT

GCS.CDR.121.RDD/7-29-97

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Ground Control System

The Ground Control System will provide for the safe construction and operation of the subsurface facility (main and waste emplacement drifts) by providing a concrete lining, steel sets, or rock bolts for structural support in the main and emplacement drifts.

The maintenance philosophy for underground openings is to have a robust ground support so that routine or regular maintenance will not be necessary once the waste packages are emplaced. Shafts, ramps, and main drifts, which do not have high temperatures or radiation levels during normal operations, can rely on periodic, planned maintenance.

Design Description

The Ground Control System will consist of the structures installed within the excavated openings or reinforcement made to the rock surrounding the opening. Three ground control systems are under consideration for use in the emplacement drifts. The current design uses precast concrete segments in 90 percent of the emplacement drifts to facilitate installation, provide superior quality control, minimize maintenance requirements, provide for long-term performance, and control costs.

For the remaining 10 percent of the emplacement drifts, rock bolts and mesh supports will be used to allow mapping of these drifts. Cast-in-place concrete linings then will be placed in the emplacement drifts after mapping of rock parameters is completed.

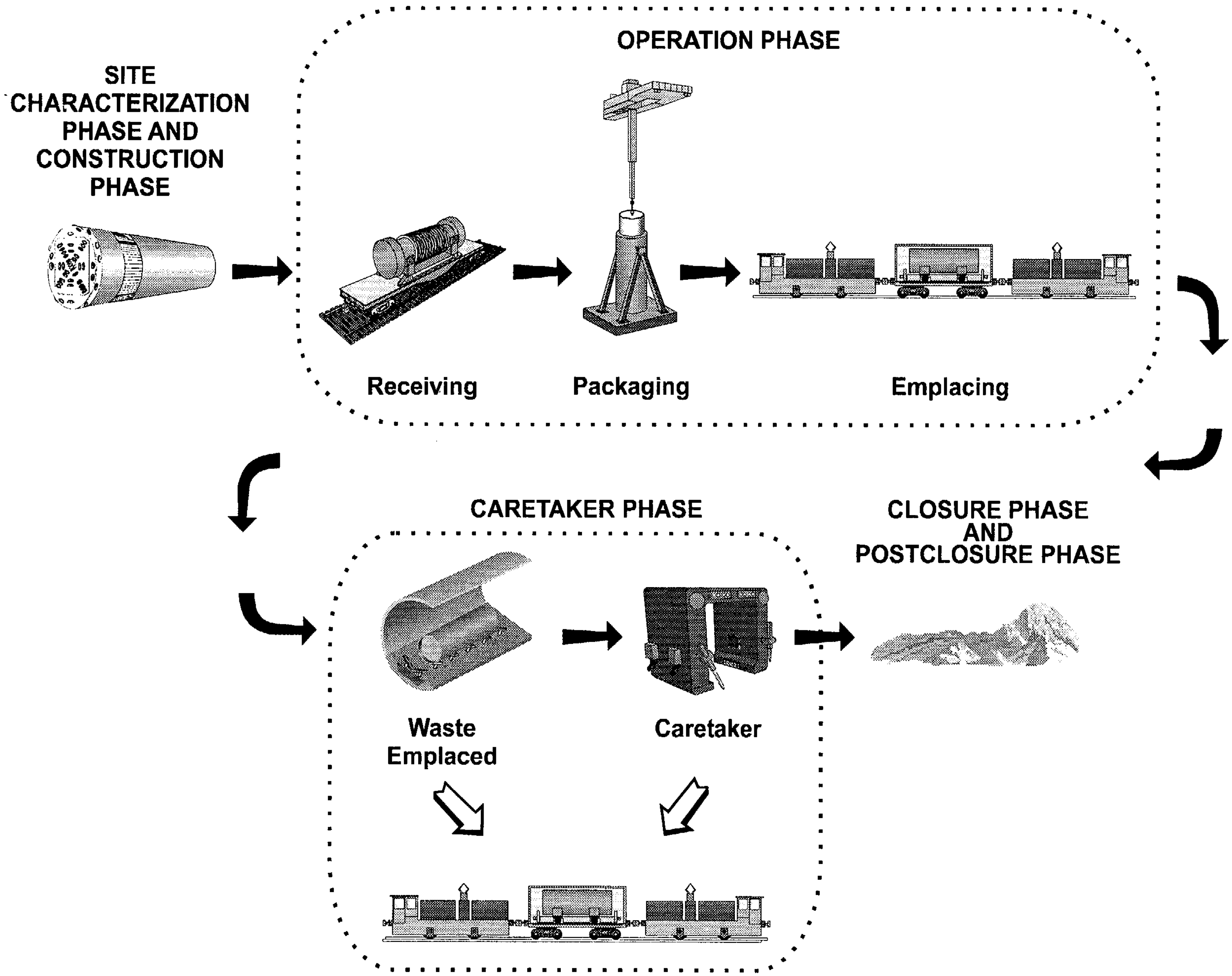
Cast-in-place concrete linings currently are planned for the access ramps and main drifts.

The Ground Control System will be selected and designed to

- provide a robust support system with minimal maintenance requirements;
- maintain stable underground openings, under the range of anticipated conditions, during the operations and caretaker phases, and during decommissioning; and
- facilitate mapping of the rock mass in selected areas.

The reference design for the emplacement drift lining is currently based on a precast concrete lining. However, cast-in-place concrete and steel sets also are being considered for use in the emplacement drifts. In addition, the use of special types of concrete are being evaluated.

Repository Phases



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REPOSITORY PHASES OVERVIEW

Six phases comprise the evolution of the potential repository: site characterization, construction, operation, caretaker, closure, and postclosure. This RDD presents design of the key engineering systems for the operation, caretaker, closure, and postclosure phases.

Site Characterization Phase

This phase will include those activities associated with gathering and evaluating data to determine the suitability of the site for a geologic repository; predicting the performance of the repository; preparing the repository designs; and assessing the system performance. The Exploratory Studies Facility which has been constructed will be enhanced as deemed necessary during this phase.

Construction Phase

This phase will include constructing and equipping of surface facilities, refurbishing Exploratory Studies Facility openings, continued excavation and equipping of subsurface facilities, gathering data to support predictions of the repository performance, fabrication of the disposal containers, and demonstration of some of the repository operations.

Operation Phase

Receiving. The potential repository will receive transportation casks loaded with waste by rail or truck. The casks will be moved to the carrier preparation building, removed from their carriers, and moved to the waste handling building.

Packaging. The casks will then be opened and the waste removed. The waste then will be loaded into a disposal container, thus creating a waste package. Next, the waste package will be loaded into a transporter to be taken to the underground emplacement location.

Emplacing. After the transporter is loaded, it will move the waste package from the waste handling building to the emplacement drift. The waste package then will be pushed into the emplacement drift and positioned within the drift using a remotely controlled gantry.

Caretaker Phase

The caretaker phase will begin when all waste packages have been emplaced. This also will include continuing of performance confirmation activities and maintenance of the subsurface facility. The capability to retrieve the waste packages also will be maintained.

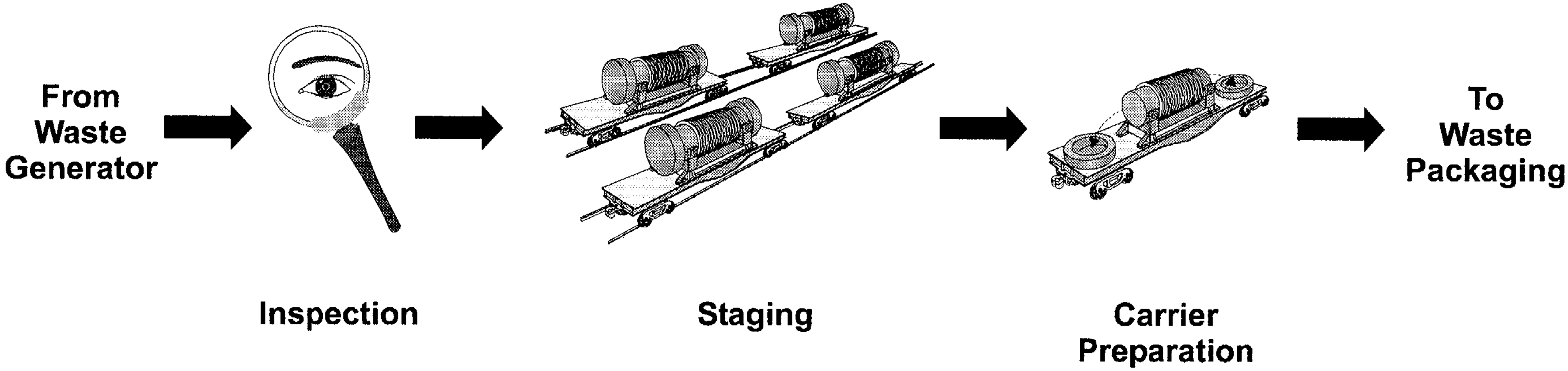
Closure Phase

The closure phase will begin after the license to close the repository has been received from the NRC and caretaker activities have ended. Closure will include placement of backfill, if any, and seals and the dismantlement of the surface facilities

Postclosure Phase

The repository will require no human support during the postclosure phase. The potential repository will continue to isolate the waste for thousands of years.

Waste Receiving Operations



WASTRECV.CDR.121.RDD/7-21-97

Waste Receiving Operations

The potential repository will receive high-level waste and spent nuclear fuel in shielded shipping casks licensed for nuclear waste transport by the NRC on carriers pulled by locomotives or trucks (prime movers). About 700 casks will be received annually. Rail lines will be provided to the site to support the transportation of large shipping casks. Truck access also will be provided to the site for legal weight trucks and, if necessary, heavy haul trucks.

The shipments will pass through a security station and enter the radiologically controlled area near the North Portal. After inspection, the off-site prime mover will move the shipment to a rail or truck carrier parking area, where the shipment will be inspected for radiological contamination. The off-site prime mover waits in the radiologically controlled area until an empty cask is ready to be transported back to the waste shipper.

Once on site, the Carrier/Cask Transport System will handle the carrier and cask. This system will haul the carrier and cask to the carrier preparation building with the on-site prime mover. The carrier preparation building will be a single-level metal structure with about 20,000 square feet of floor space. The facility will contain the systems and components needed to support the Carrier Preparation Building Materials Handling System. The facility will provide

- staging for truck or rail carriers;
- work platforms;
- a 10-ton bridge crane;
- two gantry-mounted manipulators; and
- an office area.

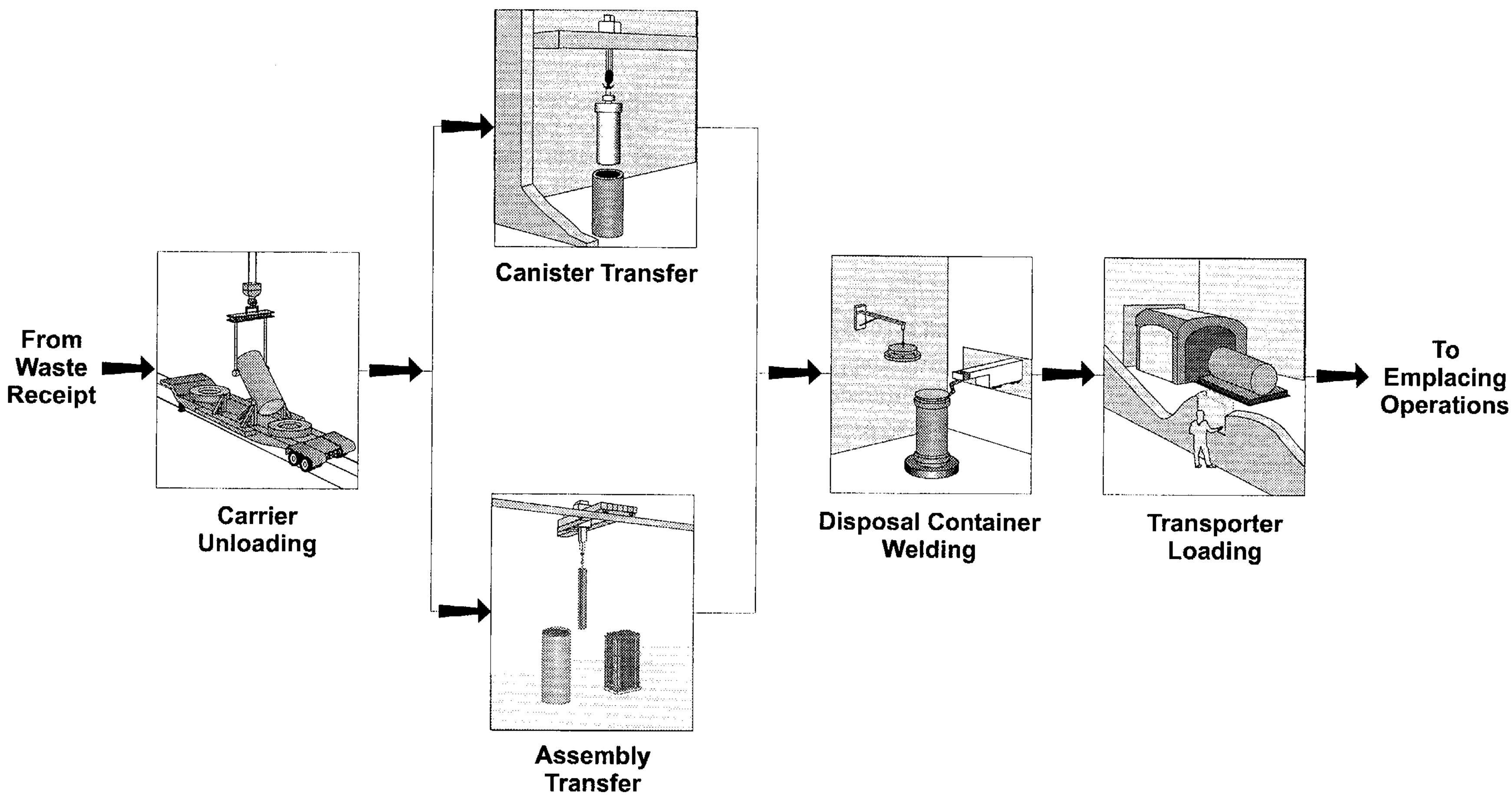
The Carrier Preparation Building Materials Handling System will

- remove or retract the personnel barriers from the cask;
- perform a radiological survey; and
- remove the cask impact limiters.

When the carrier and cask have been prepared for cask removal and the waste handling building is ready to receive a waste shipment, the Carrier/Cask Transport System will haul the carrier and cask with the on-site prime mover to the waste handling building to conduct the waste packaging operations.

After waste removal, the carrier with the empty cask will be hauled back from the waste handling building to the carrier preparation building. The impact limiters and personnel barriers will be reinstalled. The carrier and empty cask will be staged in the carrier parking areas and hauled from the repository by the off-site prime mover.

Waste Packaging Operations



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Waste Packaging Operations

Once the nuclear waste has been received, the loaded shipping casks will be transported to the waste handling building, located in the radiologically controlled area at the North Portal, where the waste will be transferred to disposal containers, sealed closed, and loaded into an underground transporter. These operations will be performed in the waste handling building by the four systems listed below. The waste handling building will house a variety of support systems to provide a secure, controlled environment that protects the workers and confines contamination.

- Carrier/Cask Handling System will remove loaded casks from the truck and rail carriers and place empty casks and empty dual purpose canisters on carriers. A dual purpose canister will be licensed by the NRC for transportation and dry storage but will not be designed for disposal in the repository.

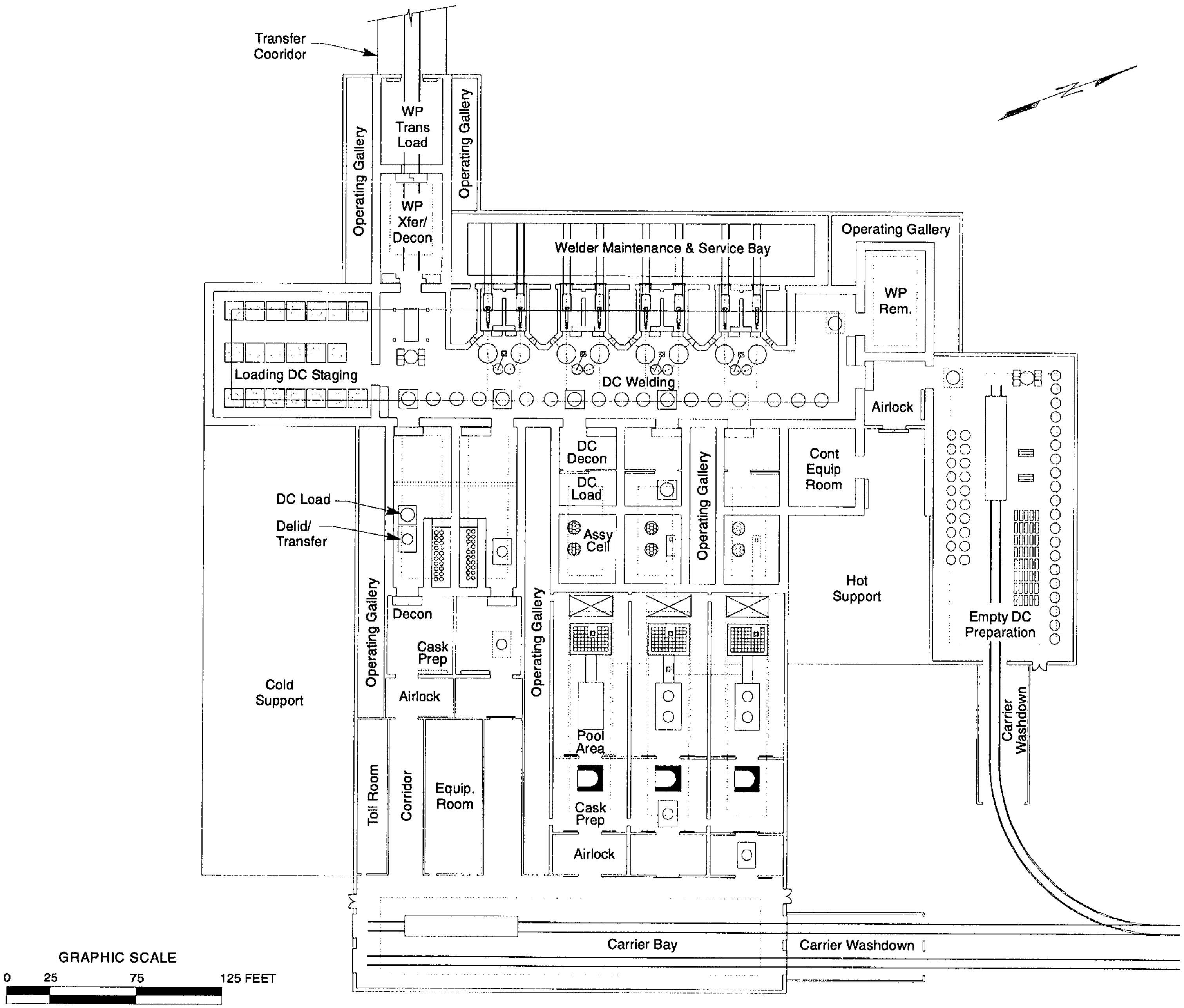
- Assembly Transfer System will receive casks containing uncanistered spent nuclear fuel assemblies or dual purpose canisters and transfer the assemblies to disposal containers.

- Canister Transfer System will receive casks containing waste in disposable canisters and transfer the canisters to disposal containers.

- Disposal Container Handling System will weld the lids onto disposal containers and load the waste packages (loaded and sealed disposal containers) into a shielded transporter for haulage to the underground emplacement area.

A description of each of these systems is provided in later sections of this document.

Waste Handling Building



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Waste Handling Building

The waste handling building will provide the structures, systems, and components that support the waste packaging operations including: electrical, security, fire protection, ventilation, communications, and radiological monitoring. The waste handling building will provide a controlled environment for the dry and pool-handling operations. It will serve as a contamination structure to confine contamination and provide radiological protection for personnel and the public.

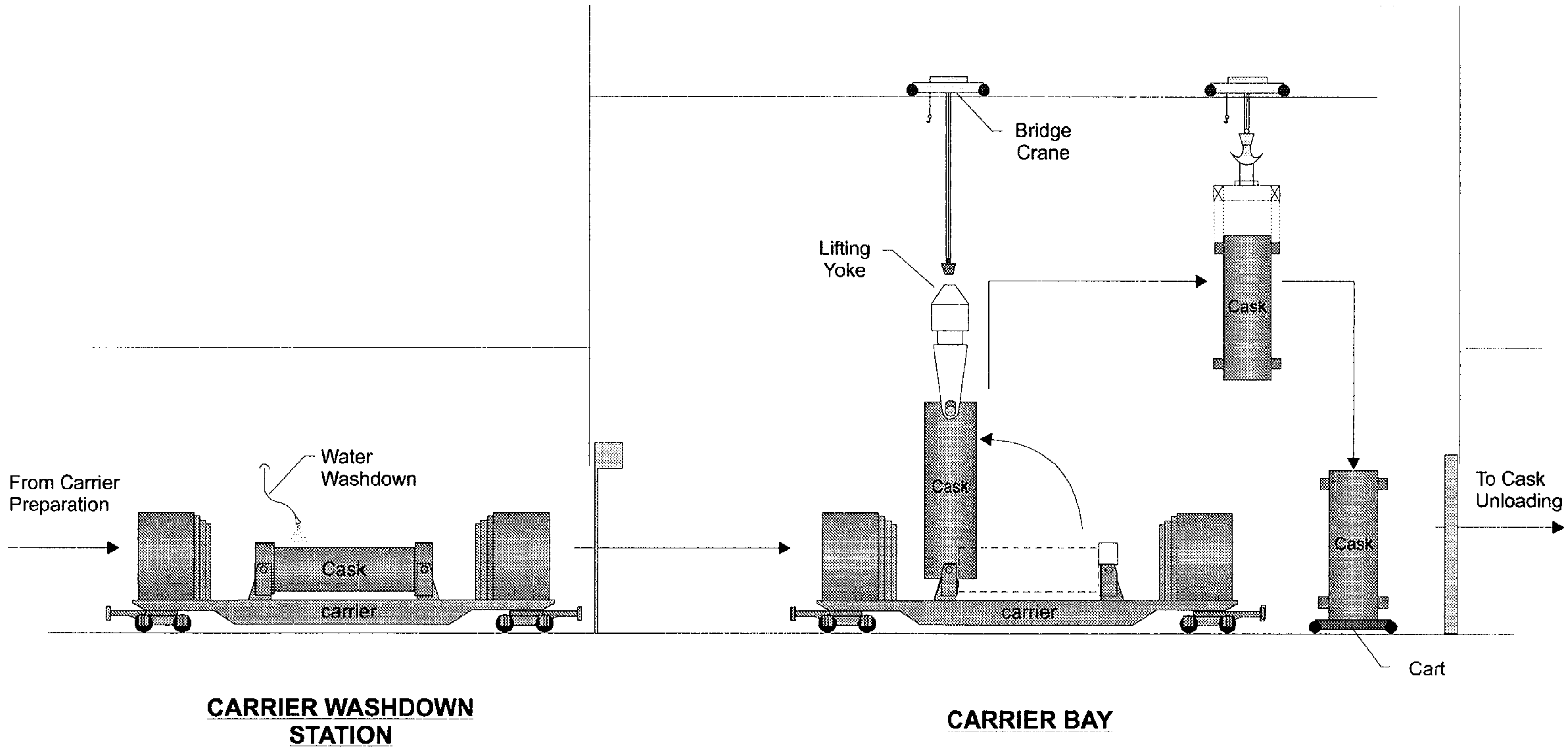
Design Description

The waste handling building will include the waste handling areas, support areas, and features described below:

- five-level concrete structure;
- about 480,000 square feet of floor space and a footprint of about 320 feet by 490 feet;
- one large bay for loading and unloading truck and rail carriers;
- three assembly transfer lines, each with pools for unloading and staging assemblies and three hot cells for conducting the other Assembly Transfer System operations;
- two canister transfer lines, each with a cask preparation area and one hot cell for conducting the Canister Transfer System operations;
- one large hot cell for staging and welding disposal containers;
- one small hot cell for placing a loaded disposal container in an underground transporter;
- one general purpose hot cell for mitigating an off-normal disposal container;
- operating galleries to view and control hot cell operations;
- contaminated equipment maintenance area;
- laboratories, mechanical equipment rooms, electrical equipment rooms, and tooling and maintenance store rooms; and
- support areas for administrations, personnel, central control, and security access controls.

Selected assembly handling operations will be conducted underwater in pools. This approach uses water to shield the workers from direct radiation while providing direct access to the waste forms. Operations conducted outside the pools in the presence of spent nuclear fuel assemblies, canisters, and disposal containers will be conducted remotely in hot cells to protect the workers from direct radiation. The remote equipment will be designed for ease of decontamination and maintenance. Interchangeable components will be provided where appropriate. Semi-automatic and manual controls will control remotely operated equipment.

Carrier/Cask Handling System



CARRIER.CDR.121.RDD/6-3-97

Carrier/Cask Handling System

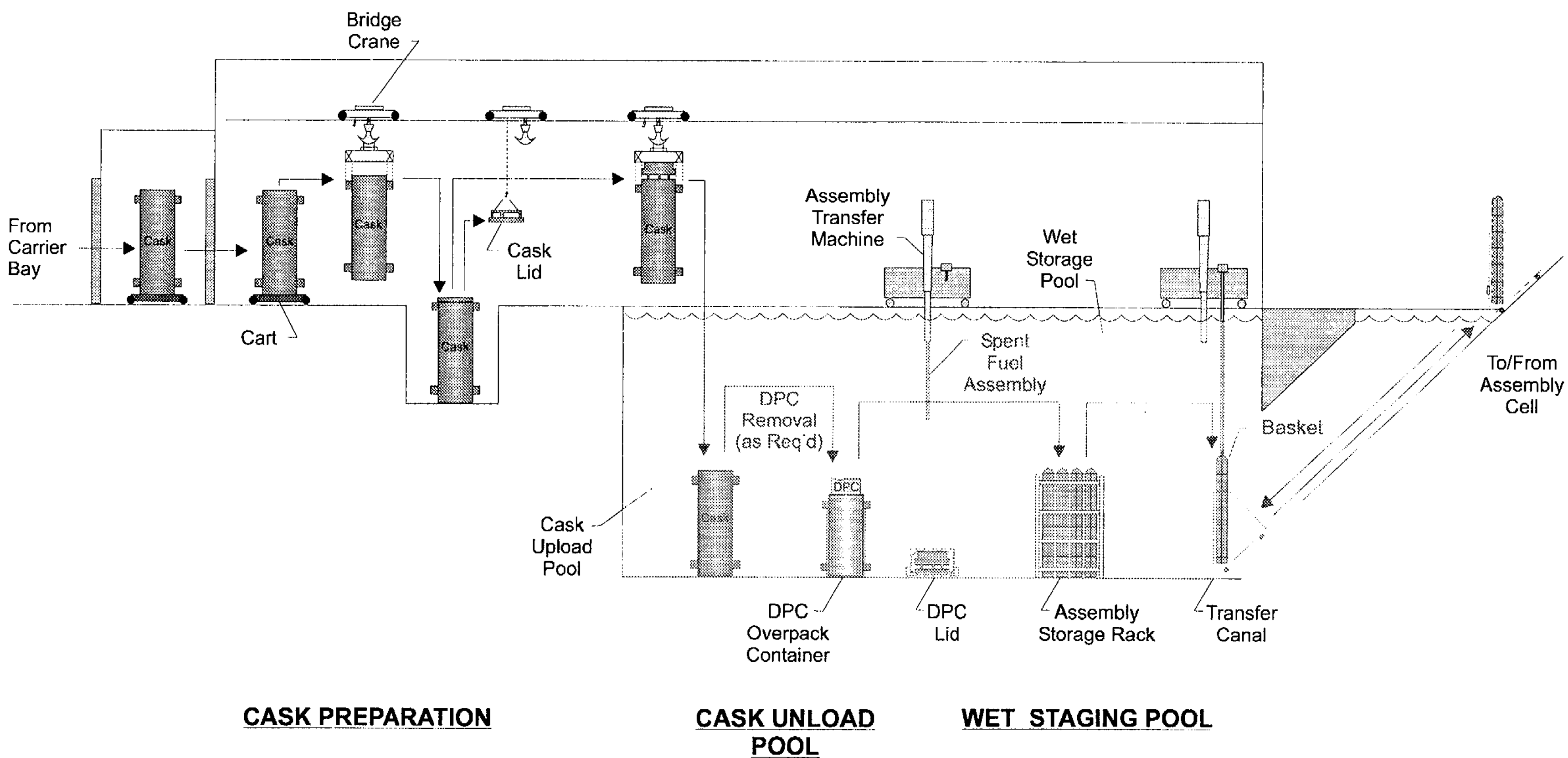
The Carrier/Cask Handling System will remove loaded casks from the truck and rail carriers and place empty casks and dual purpose canisters on carriers for off-site shipment. In a peak year, the system will receive and ship about 700 casks and ship about 400 empty dual purpose canisters. The 700 casks will be a combination of casks with bare spent nuclear fuel, dual purpose canisters, high-level waste/DOE spent nuclear fuel canisters, or multi-purpose canisters. Since the peak yearly receipts for the various types of waste casks will not be received in the same year, the sum of these peak yearly receipts will exceed 700 casks. The system will support the waste packaging operations and will be located in the waste handling building.

Design Description

Operations will begin as a truck or rail carrier is hauled to the waste handling building by the Carrier/Cask Transport System. Prior to entering the building, the impact limiters and personnel barriers will have been removed or retracted. Road grime will be removed in a washing station, then the carrier will be moved into the carrier bay. A large bridge crane will lift the cask from a horizontal to a vertical orientation and place it on a transfer cart. The remotely operated cart will move through an airlock into one of the five waste transfer lines. Where possible, operations on loaded casks will be conducted remotely to limit worker exposure to radiation. Empty casks and empty dual purpose canisters will be removed from the waste transfer lines and loaded on the carriers in the reverse sequence. The large, open carrier bay will have the following features:

- two flush-mounted rail spurs;
- a 125-ton bridge crane;
- lifting yoke staging areas; and
- access to the cask carts.

Assembly Transfer System



WETLINE.CDR.121.RDD/7-21-97

Assembly Transfer System

The Assembly Transfer System will receive casks containing uncanistered fuel assemblies and dual purpose canisters and will transfer the assemblies to disposal containers. Empty shipping casks and dual purpose canisters will be prepared for off-site shipment. In a peak year, the system will receive and transfer about 12,000 assemblies from 540 casks into 380 disposal containers. The system will support the waste packaging operations and will be located in the waste handling building.

Design Description

Operations will begin as a vertically loaded shipping cask enters one of the three identical assembly transfer lines from the Carrier/Cask Handling System. The cask, on a remotely operated cart, will pass through an airlock and into a cask preparation area. In the preparation area, a cask containing uncanistered fuel assemblies will be prepared for unloading by sampling the interior gas, venting, cooling, filling the cask with water, and remotely loosen the lid bolts. A large bridge crane then will move the cask into an assembly unloading pool. For casks containing a dual purpose canister, preparation includes removal of the cask lid and preparing the dual purpose canister for unloading by sampling the interior gas, venting, cooling, and filling the dual purpose canister with water. The preparation area will include:

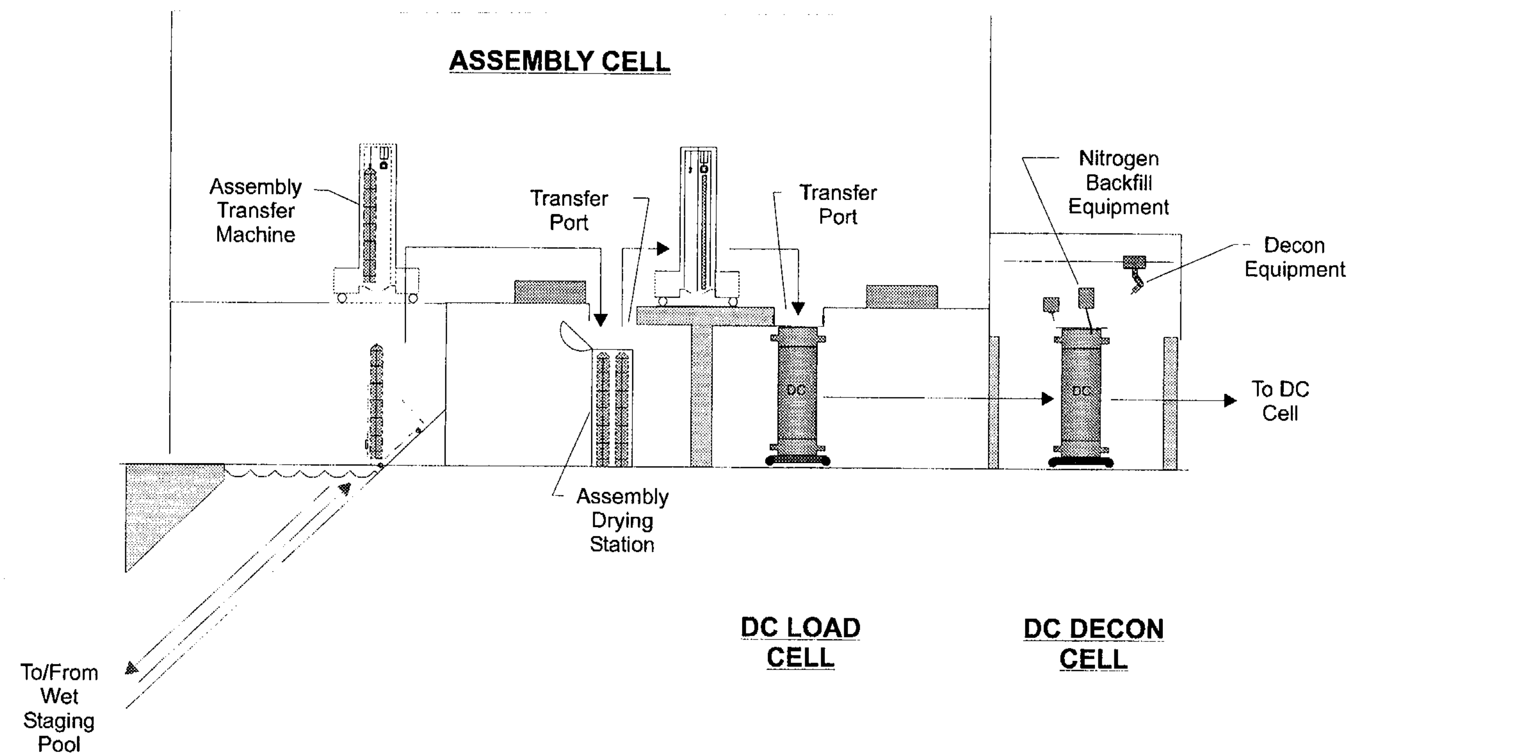
- a preparation pit;
- a manipulator;
- a preparation manifold;
- decontamination equipment; and
- a 125-ton bridge crane that is shared with the pool area.

The decontamination equipment will be used after waste transfer to prepare empty casks and dual purpose canisters for shipment.

In the pool, depending on the cask type, either the cask lid will be removed or the dual purpose canister will be unloaded from the cask with the bridge crane, and the dual purpose canister lid will be cut off. The exposed assemblies will be transferred with a fuel-handling machine to a staging rack or directly to an underwater transfer cart. The cart will transfer the assemblies through a canal to the assembly hot cell. The empty cask will be transferred to a preparation area for dewatering and decontamination. The empty dual purpose canister will be internally cleaned and dewatered in the pool area and transferred to the preparation area for over packing and decontamination. The overpacked dual purpose canister and lid will be transported to the Carrier/Cask Handling System for preparation for shipment offsite. The pool area includes:

- the unloading and staging pools;
- a 125-ton bridge crane;
- a wet fuel transfer machine;
- staging racks for about 240 to 540 assemblies;
- dual purpose canister cutting tools;
- a wet cleaning system;
- an underwater assembly transfer cart; and
- underwater cameras.

Assembly Transfer System (cont'd)



WETLINE.CDR.121.RDD/7-21-97

Assembly Transfer System (cont'd)

In the assembly hot cell, a vacuum system will dry the assemblies , which will then be transferred to an empty disposal container with a dry-fuel-handling machine. During the transfer, the disposal container will be mated to the assembly hot cell through a transfer port to limit the spread of airborne contamination. All operations will be conducted remotely. The assembly hot cell will include:

- the dry-fuel-handling machine;
- a mating port system;
- two vacuum drying vessels;
- five-foot thick shield walls;
- cameras; and
- shield windows.

The cell also will have:

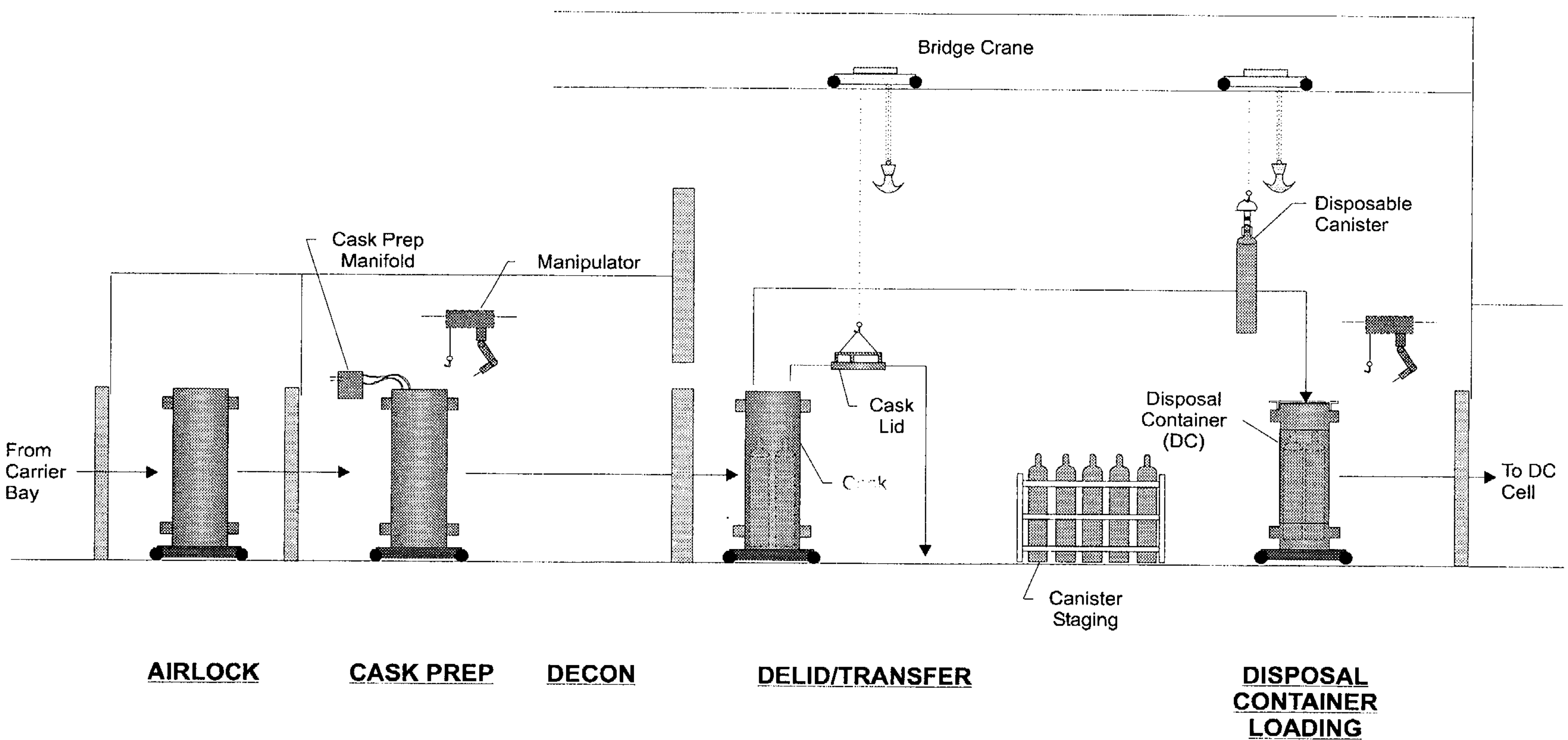
- a bridge crane;
- a manipulator; and
- maintenance bay to support maintenance and repair.

A disposal container loading and decontamination hot cell will be located below the transfer port. In this cell, the loaded disposal container will be temporarily lidded, disengaged from the port, and transferred on a cart to a decontamination station.

The disposal container will be decontaminated, filled with nitrogen, and transferred to the Disposal Container Handling System for sealing. All operations will be conducted remotely. The disposal container loading and decontamination cell will include:

- a disposal container transfer cart;
- decontamination system;
- a manipulator;
- nitrogen addition system;
- five-foot thick shield walls;
- cameras; and
- shield windows.

Canister Transfer System



DRYLINE.CDR.121.RDD/7-15-97

Canister Transfer System

The Canister Transfer System will receive casks containing waste in disposable canisters (canister which can be disposed, multi-purpose canister or high-level waste/DOE/Navy canisters) and transfer the canisters to disposal containers. Empty shipping casks will be prepared for off site shipment. In a peak year, the system will receive and transfer about 800 small canisters (e.g., vitrified defense high-level waste) from 160 casks into 200 disposal containers and has the capability to transfer about 300 large canisters (e.g., multi-purpose canisters). The system will support the waste packaging operations and will be located in the waste handling building.

Design Description

Operations will begin as a vertically loaded shipping cask enters one of the two identical canister transfer lines from the Carrier/Cask Handling System. The cask, on a remotely operated cart, will pass through an airlock and into a cask preparation and decontamination area. In this area, a cask containing a disposable canister will be prepared for unloading by sampling the interior gas, venting, and remotely de-tensioning the lid bolts. A cart will move the prepared cask into a hot cell. Operations on a loaded cask generally will be conducted remotely. The preparation and decontamination area will include:

- a cask transfer cart;
- a cask prep manipulator;
- a cask sampling/venting system;
- decontamination equipment;
- cameras; and
- shield windows.

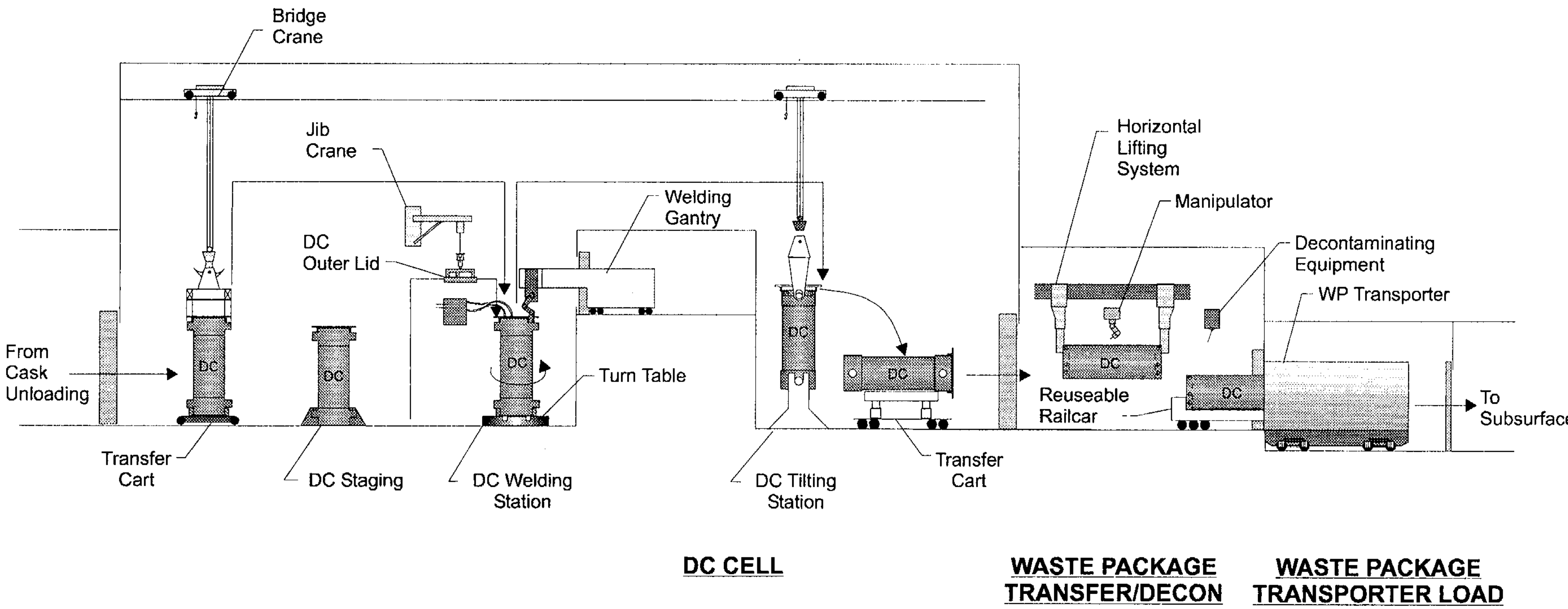
The decontamination equipment will prepare empty casks for shipment after waste transfer.

In the hot cell, the cask lid will be removed and the canister(s) will be lifted from the cask. A large canister will be loaded directly into a disposal container. Small canisters will be loaded directly into a disposal container or will be accumulated in a staging rack until enough compatible canisters are available to fill a disposal container. The loaded disposal container will be transferred to the Disposal Container Handling System on a cart for sealing. All operations will be conducted remotely. The hot cell will include:

- an 85-ton bridge crane;
- a disposal container loading manipulator;
- a staging rack for about 15 small canisters;
- various lifting fixtures;
- a disposal container transfer cart;
- five-foot thick shield walls;
- cameras; and
- shield windows.

A crane maintenance bay will support maintenance and repair operations.

Disposal Container Handling System



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Disposal Container Handling System

The Disposal Container Handling System will weld the lids on the loaded disposal containers and load the disposal containers into a shielded transporter for hauling to the underground emplacement area. The system will provide empty (new) disposal containers to the waste assembly lines. In a peak year, the system will receive, seal, and transport underground about 580 disposal containers. The system will support the waste packaging operations and be located in the waste handling building.

Design Description

Operations will begin as a vertically loaded disposal container enters the disposal container cell from one of the five waste transfer lines (i.e., from the Assembly Transfer System or the Canister Transfer System). The disposal container will be on a remotely operated cart and moved to within the reach of a large bridge crane. The crane will move the disposal container to a staging fixture or directly to a welding station. At the welding station, the inner lid will be welded on and inspected, and the disposal container will be filled with helium. The outer lid will be welded on and inspected. The robotic welder will be mounted on a movable boom that can be withdrawn through the cell wall and into a maintenance bay. The disposal container will rotate during welding.

The sealed and loaded disposal container will be lifted from the weld station and placed in a staging fixture or directly in a tilting fixture. At the tilting fixture, a crane will lay the disposal container onto a transfer cart. The cart will transfer the disposal container from the disposal container cell to a disposal container transfer and decontamination hot cell. All disposal container cell operations will be conducted remotely. The disposal container cell will include:

- an 85-ton bridge crane;
- about eight welding stations;
- four jib cranes to support the welders;
- about 20 disposal container staging fixtures;
- six vertical disposal container transfer carts (five for the transfer lines, one for empty disposal container);
- a horizontal transfer car;
- tilting fixture;
- a manipulator;
- various lifting yokes;
- five-foot thick shield walls;
- cameras; and
- shield windows.

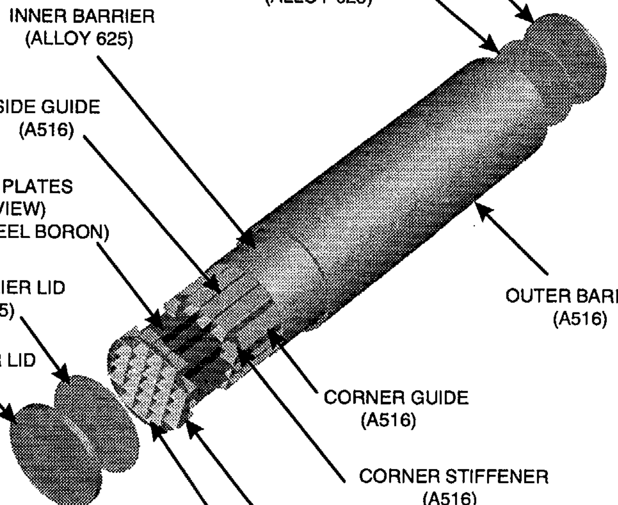
The cell will have a crane maintenance bay to support maintenance and repair operations.

In the disposal container transfer and decontamination hot cell, an overhead lifting system will lift the disposal container from the cart and the cart will be returned to the disposal container cell. While suspended, the disposal container will be decontaminated as needed. A railcar will be pushed under the disposal container from the underground transporter. The disposal container will be lowered onto the railcar and the loaded railcar pulled back into the transporter. The shielded transporter will leave the waste handling building to complete the waste packaging operations. All disposal container transfer and decontamination cell operations will be conducted remotely. This cell will include:

- an 80-ton large lifting system;
- decontamination equipment;
- a manipulator;
- a horizontal transfer cart;
- five-foot thick shield walls;
- cameras; and
- shield windows.

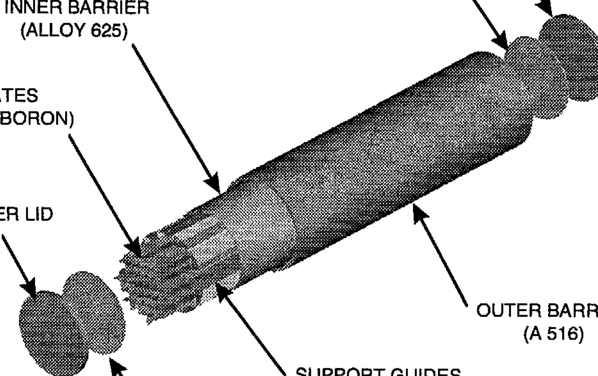
Spent Nuclear Fuel Disposal Containers

21-PWR UNCANISTERED FUEL DISPOSAL CONTAINER ASSEMBLY



LENGTH = 5335 mm
DIAMETER = 1650 mm
TARE WEIGHT = 34,039 kg
LOADED WEIGHT = 50,423 kg

44-BWR UNCANISTERED FUEL DISPOSAL CONTAINER ASSEMBLY



LENGTH = 5335 mm
DIAMETER = 1604 mm
TARE WEIGHT = 31856 kg
LOADED WEIGHT = 46424 kg

SNFDISP.PPT.121.RDD/6-3-97

Spent Nuclear Fuel Disposal Containers

The spent nuclear fuel disposal containers have been designed to hold bare spent nuclear fuel assemblies. The disposal containers will support the confinement and isolation of waste within the potential geologic repository. The spent nuclear fuel disposal containers will be loaded with spent nuclear fuel assemblies from either boiling water reactors (BWRs) or pressurized water reactors (PWRs).

Design Description

Two BWR and three PWR disposal container designs will be developed to provide long-term confinement of the commercial spent nuclear fuel; the dimensions for each are shown in the table below.

Waste Package Type	Outer Diameter	Outer Length	Outer Barrier Thickness	Inner Barrier Thickness
21 PWR	1.65 m	5.34 m	0.10 m	0.02 m
12 PWR	1.30 m	5.34 m	0.10 m	0.02 m
12 PWR	1.30 m	5.86 m	0.10 m	0.02 m
44 BWR	1.60 m	5.34 m	0.10 m	0.02 m
24 BWR	1.27 m	5.34 m	0.10 m	0.02 m

These disposal containers will be designed to hold as much spent nuclear fuel as possible without exceeding the physical limits placed on the containers. The corrosion-resistant inner barrier will be constructed of a high-nickel steel (Alloy 625) and the corrosion-allowance outer barrier will be made of carbon steel (Alloy A516). The two metal barriers will support the design philosophy of using materials with different failure mechanisms to protect against the release of radioactive materials.

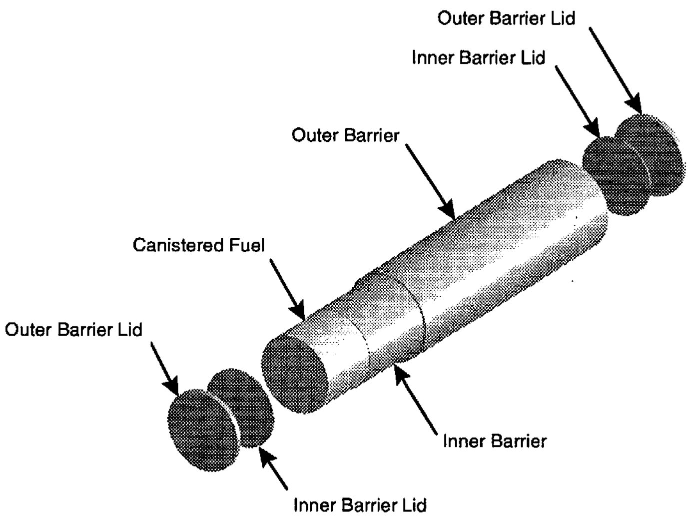
An internal metallic structure, a basket, will hold the spent nuclear fuel assemblies. The basket will provide for criticality control, structural support, and heat conduction paths to cool the spent nuclear fuel. Neutron absorbers also can be used to control criticality, if water were to flood the disposal container.

The 21 PWR disposal container will use a basket either with or without neutron-absorber plates, depending upon the reactivity of the spent nuclear fuel. In addition, neutron-absorber rods will be inserted in PWR fuel assemblies as needed for reactivity control. The 12 PWR disposal container will come in two lengths. The shorter (5.34m) 12 PWR disposal container can be used without a neutron absorber, and the longer disposal container (5.86m) can be used with neutron-absorber plates for spent nuclear fuel assemblies that are significantly longer than other PWR assemblies. The 44 BWR container will be used without neutron absorbers or with neutron-absorber plates. The 24 BWR container will use thicker neutron-absorber plates to control reactivity.

The 24 BWR and 12 PWR disposal containers will be used for those spent nuclear fuel assemblies with high heat-outputs in order to maintain a maximum disposal container heat-output of 18 kilowatts.

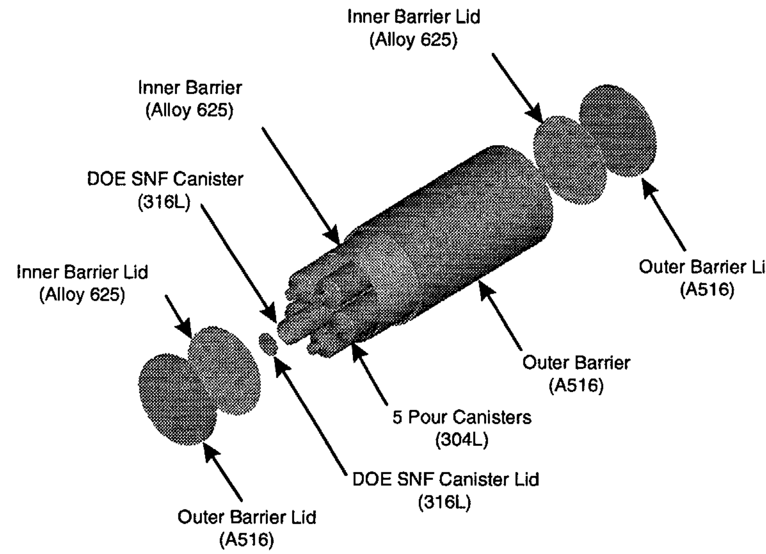
Canistered Waste Disposal Containers

CANISTERED FUEL-WASTE PACKAGE ASSEMBLY



LENGTH = 5657 mm
DIAMETER = 1946 mm
TARE WEIGHT = 34,576 kg
LOADED WEIGHT = 65,900 kg (PWR)
LOADED WEIGHT = 68,351 kg (BWR)

5 DHLW/DOE WASTE PACKAGE ASSEMBLY



LENGTH = 3790 mm or 5370 mm
DIAMETER = 1970 mm
TARE WEIGHT = 24,782 kg
LOADED WEIGHT = 35,692 kg

CANDISP.PPT.121.RDD/7-15-97

Canistered Waste Disposal Containers

The canistered waste disposal containers will be used for direct disposal of either canistered spent nuclear fuel (including multi-purpose canisters) or high-level waste. Canistered waste disposal containers also will be designed for the co-disposal of DOE spent nuclear fuel and high-level waste. The disposal containers will support the containment and isolation of canistered waste within the engineered barrier of the potential repository. Disposable canisters filled with spent nuclear fuel or high-level waste will be loaded and sealed in the canistered waste disposal containers in the waste handling building.

Design Description

The canistered spent nuclear fuel disposal containers for direct disposal will be sized to hold canistered fuel within the overall size and weight limits of the waste package. Direct disposal containers for DOE spent nuclear fuel or Navy spent nuclear fuel are currently being designed.

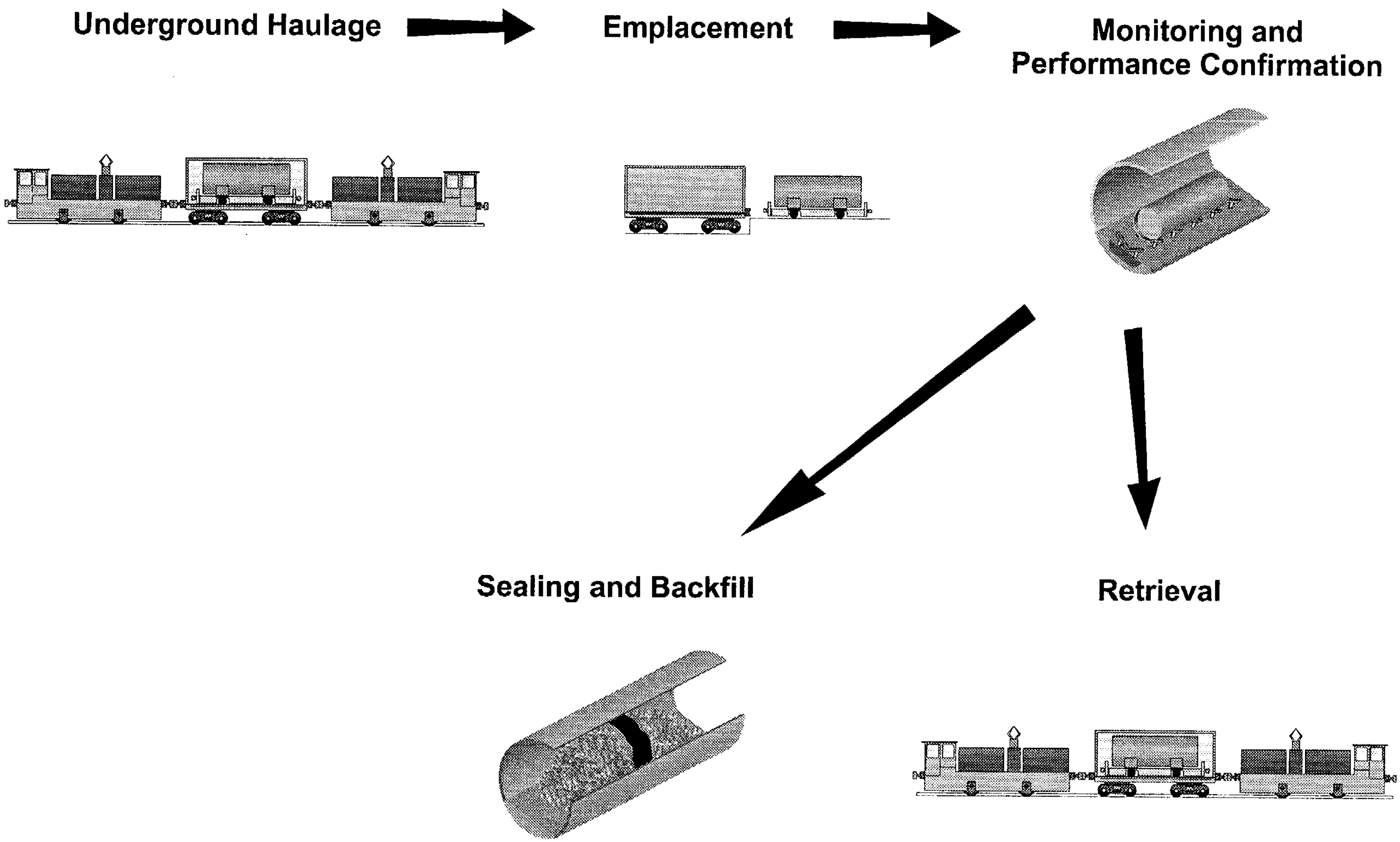
The co-disposal container for DOE spent nuclear fuel and high-level waste disposable canisters will hold five high-level waste disposable canisters. A DOE spent nuclear fuel disposable canister will be inserted in the middle of the high-level waste disposable canisters. The disposable canister dimensions will be based on the defense waste processing facility canisters from the Savannah River Site or Hanford Site.

The co-disposal container characteristics are as follows:

High-level waste co-disposal container

- outer length of 3.79 meters or 5.37 meters;
- outer diameter of 1.97 meters;
- 0.10 meter thick, carbon steel (Alloy A516) corrosion-allowance outer barrier; and
- 0.02 meter thick, corrosion-resistant inner barrier of high-nickel steel (Alloy 625).

Waste Emplacing Operations



WASTEMP.CDR.121.RDD/7-16-97

Waste Emplacing Operations

Waste Emplacing Operations will consist of five steps:

- transferring the waste underground (see the Waste Emplacement System);
- emplacing the waste in the emplacement drift (see the Waste Emplacement System);
- conducting monitoring and performance confirmation activities (see Performance Confirmation);
- backfilling the emplacement drift, if required; and
- retrieving the waste packages, if required.

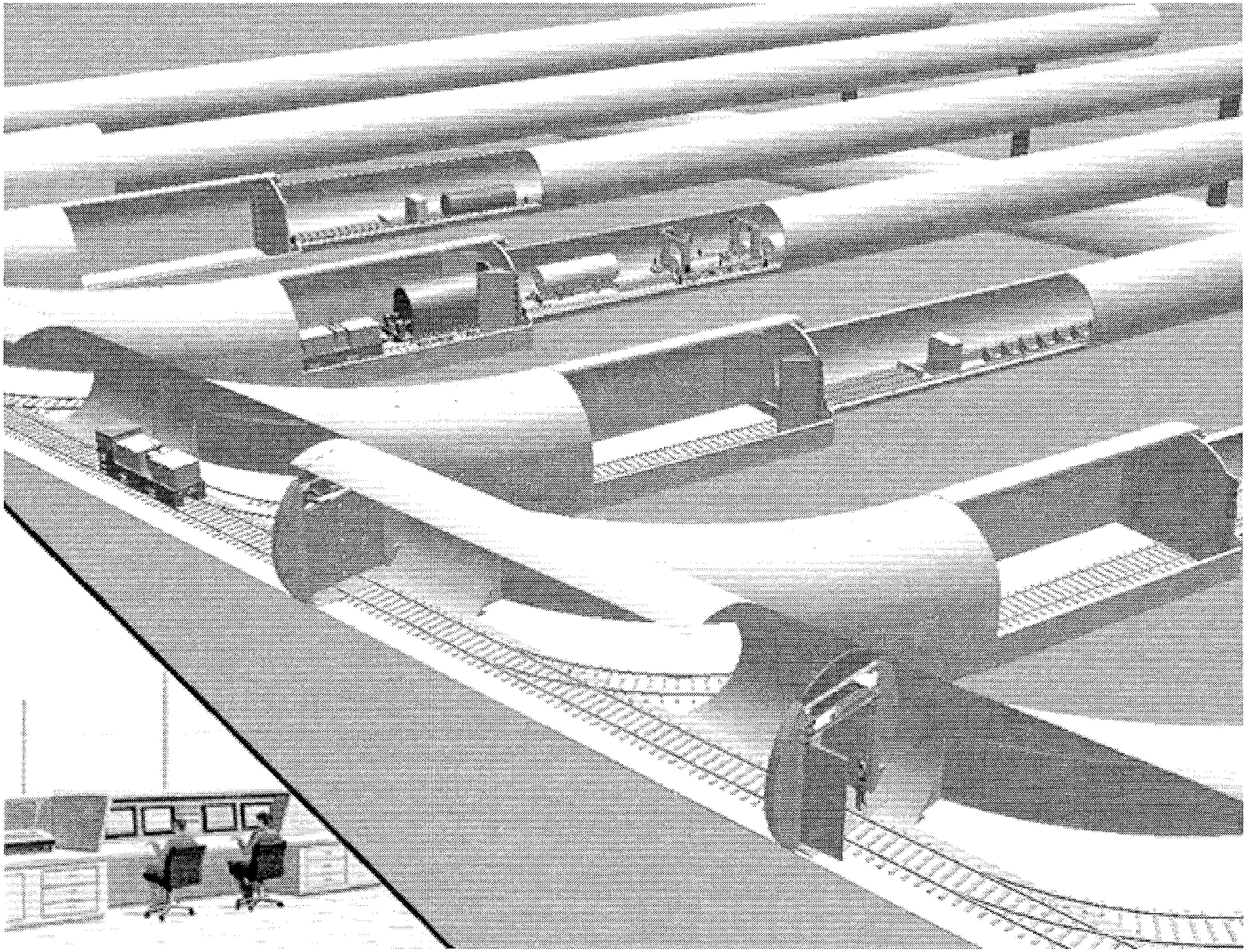
Backfilling of the emplacement drifts is not currently planned. However, flexibility will be included in the design so that backfilling will not be precluded. The option to backfill the emplacement drifts is discussed in the Design Options section of this document.

Retrieval may be required at any time during or after emplacement. The option to retrieve will be in place for 100 years from the start of emplacement. At the end of this retrievability period, a decision may be made to close the repository. If a decision is made to retrieve the waste packages, they will be removed from the emplacement drift by following the emplacement steps in reverse order after first cooling down the emplacement drift with forced ventilation.

Remote inspection of the emplacement drift to identify potential obstructions and removal or shifting of other waste packages may be required for retrieval operations.

The retrieval of all waste packages under normal conditions with no backfill may be accomplished in 34 years. This includes a 10 year planning period and a 24 year retrieval period.

Waste Emplacement System



Waste Emplacement System

The waste emplacement system will transport the loaded and sealed waste packages from the waste handling building to the area of emplacement. The system will transport each waste package to the emplacement area and place the waste package in the emplacement drift.

Design Description

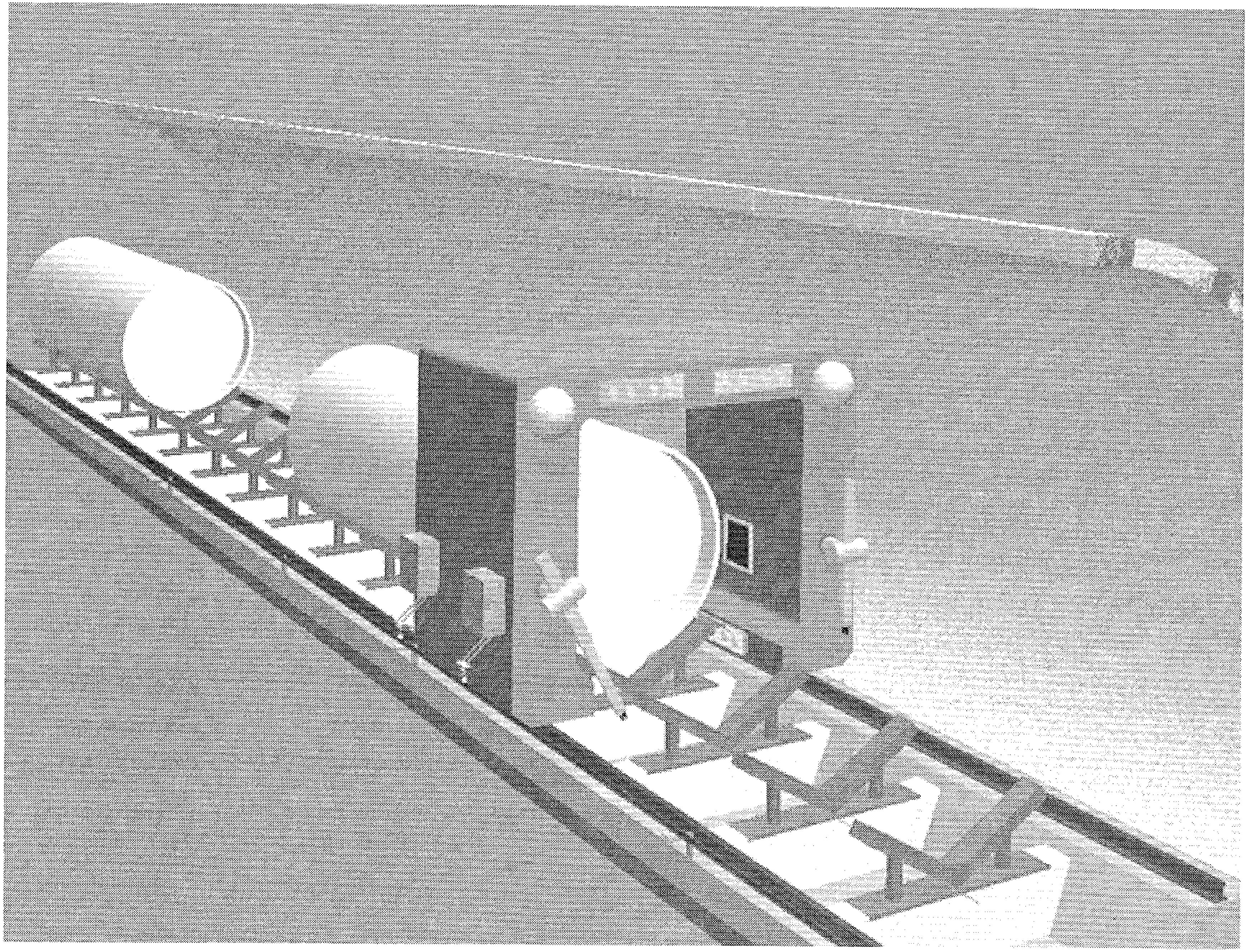
Two manually controlled transport locomotives, with radiation shielding as necessary to protect the operator, will haul the shielded transporter containing the waste package down the north ramp and the main drifts. Using one locomotive, remotely controlled operations will back the transporter against the transfer dock at the emplacement drift entrance. The waste package then will be unloaded out of the transporter and onto the emplacement drift transfer dock located behind a set of drift isolation doors.

The emplacement gantry, already positioned in the drift, will be moved into position over the waste package. The gantry will lift the waste package off the transfer rail car and carry each waste package through the drift to its final location. The gantry will lower the waste package onto its supports and return to the emplacement drift entrance to await the arrival of another waste package.

The following major equipment will be used to emplace waste packages.

- Transport locomotives with the following features:
  - electrically powered overhead trolley wire system
  - controls for both manual and remote operations
  - approximately 680 horsepower per locomotive; each weighing of 45 tons
- Waste Package Transporter with following features:
  - empty weight of 168 tons
  - loaded weight 256 tons (with heaviest waste package on transfer rail car)
  - integrated remotely controlled loading/unloading mechanism to accept and deploy waste packages on a transfer rail car
  - radiation shielding consisting of 4-inch thick carbon steel and 6-inch thick borated polyethylene for gamma/neutron shielding, sandwiched between inner and outer layers of 0.2-inch stainless steel
  - remotely operated doors with manual override.
  - redundant, fail-safe braking system with control from transport locomotives and surface control system
- Emplacement Gantry with the following features:
  - electrically powered through third rail system
  - rail mounted with driven wheels on all four corners and redundant critical systems
  - all gantry functions remotely controlled
  - one type of gantry handling full range of waste package sizes and weights
- Gantry Carrier with the following functions and features:
  - for transfer of gantry to all emplacement drifts
  - for movement by transfer locomotive
  - with powered third rail for gantry transfer onto carrier

Caretaker Phase

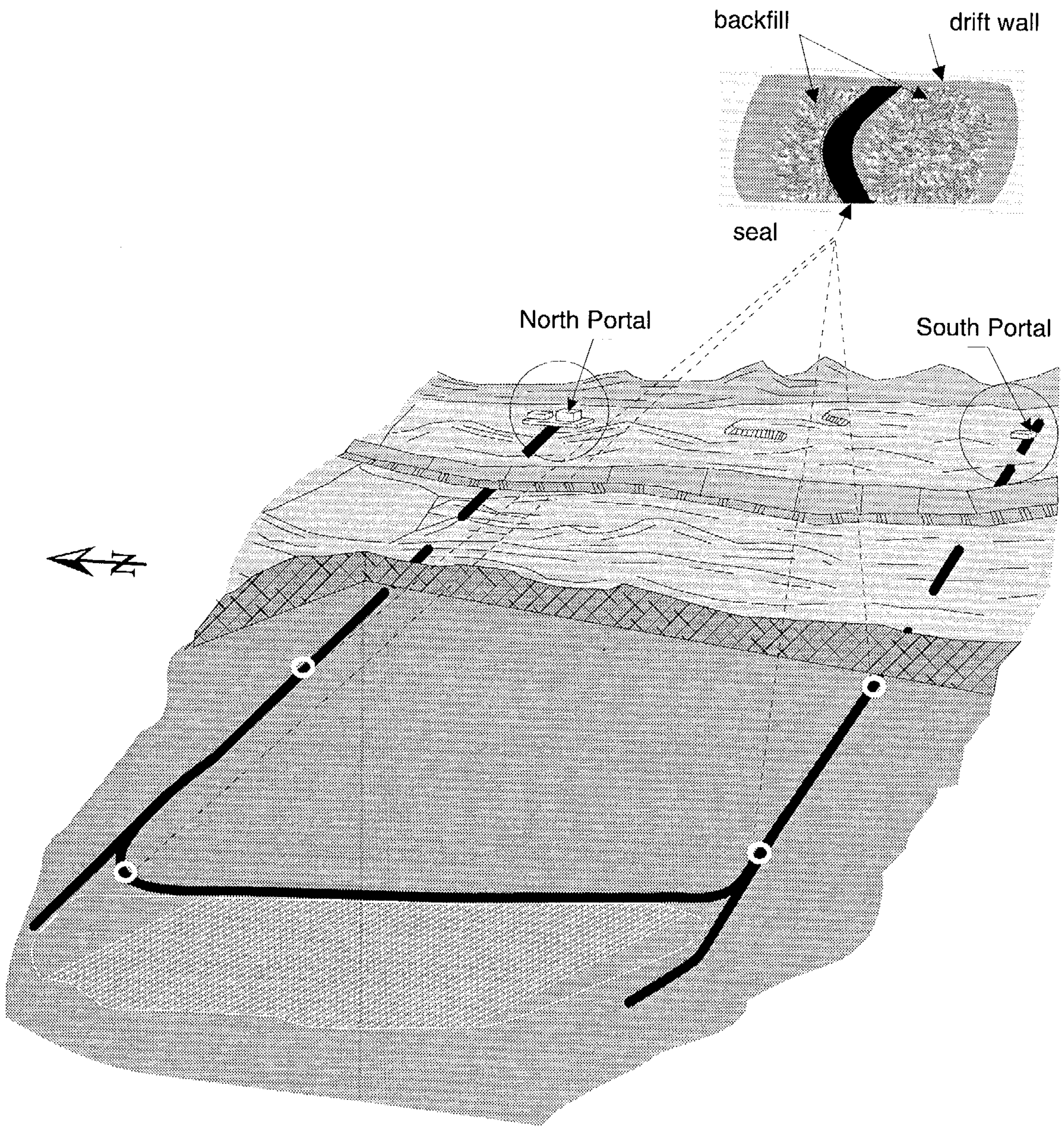


Caretaker Phase

The repository will be monitored and maintained between the time the last waste package has been emplaced and the time the repository is closed. Permanently installed sensors will monitor waste packages, drifts, and the surrounding rock and provide the data required by the performance confirmation activities. A remotely operated inspection gantry will investigate conditions in the emplacement drifts. This will eliminate risk to workers from heat and radiation emanating from the waste packages.

Specific facilities and equipment will be maintained to support the performance activities. Facilities and equipment needed to respond to emergencies and treat low-level waste also will be maintained. Planning and preparation will be conducted during this time in anticipation of closing the repository.

Closure Phase



CLOSURE.CDR.121.RDD/7-16-97

MGDSDOC.P65.121.RDD/9-4-97

Closure and Postclosure Phases

Closure

After emplacement of the nuclear waste inventory has been completed, and it has been determined that the repository will perform as expected, the repository will be closed. Closure of the repository will require the following activities:

- sealing all openings;
- dismantling the surface facilities;
- restoring the surface area; and
- protecting the repository from unauthorized intrusion.

The sealing of all repository openings will discourage human intrusion and retard the flow of water and gas into and out of the closed facility through engineered openings. Sealing will be accomplished by

- removing all nonpermanent equipment from the subsurface facility;
- placing backfill in the main drifts, shafts, and ramps; and
- installing seals in all openings to the surface, including shafts, ramps, and any boreholes that have been drilled to the repository level.

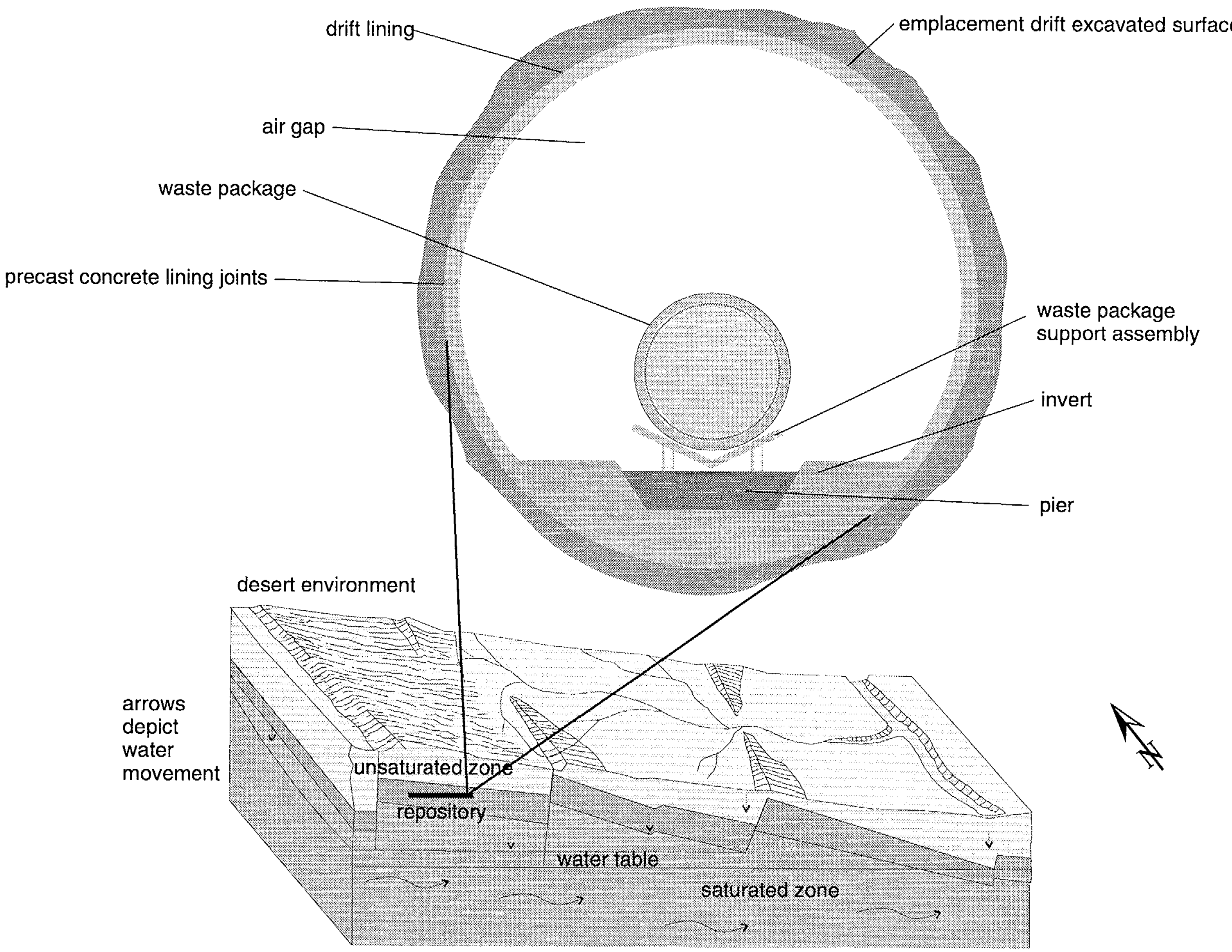
In addition, the surface facilities will be decontaminated and decommissioned during the closure period to restore the site to near its prerepository condition to the extent reasonable and feasible. To facilitate this process, the surface facilities will be designed to simplify final decontamination and decommissioning. During this time, the waste treatment building will provide solid and liquid low-level waste treatment and packaging for transport to low-level waste disposal sites.

Detailed records and information on the repository will be distributed to government organizations. Permanent monuments also will be put in place at the closed repository.

Postclosure

During postclosure, the government will use the detailed records and information supplied during closure as well as legal means—such as laws, permits, and zoning—to control access to the site, thus creating institutional barriers. In addition, fences and warning signs will be maintained.

Waste Isolation



MGDSDOC.P65.121.RDD/9-4-97

WASTE ISOLATION

The primary mission of the potential repository is the containment and isolation of the waste. This mission will be accomplished by integrating the data collection, design, analysis, and modeling capabilities of the scientific, design, and performance assessment disciplines to define or develop three key systems:

- the Natural Barrier System;
- the Engineered Barrier System; and
- the Performance Confirmation System.

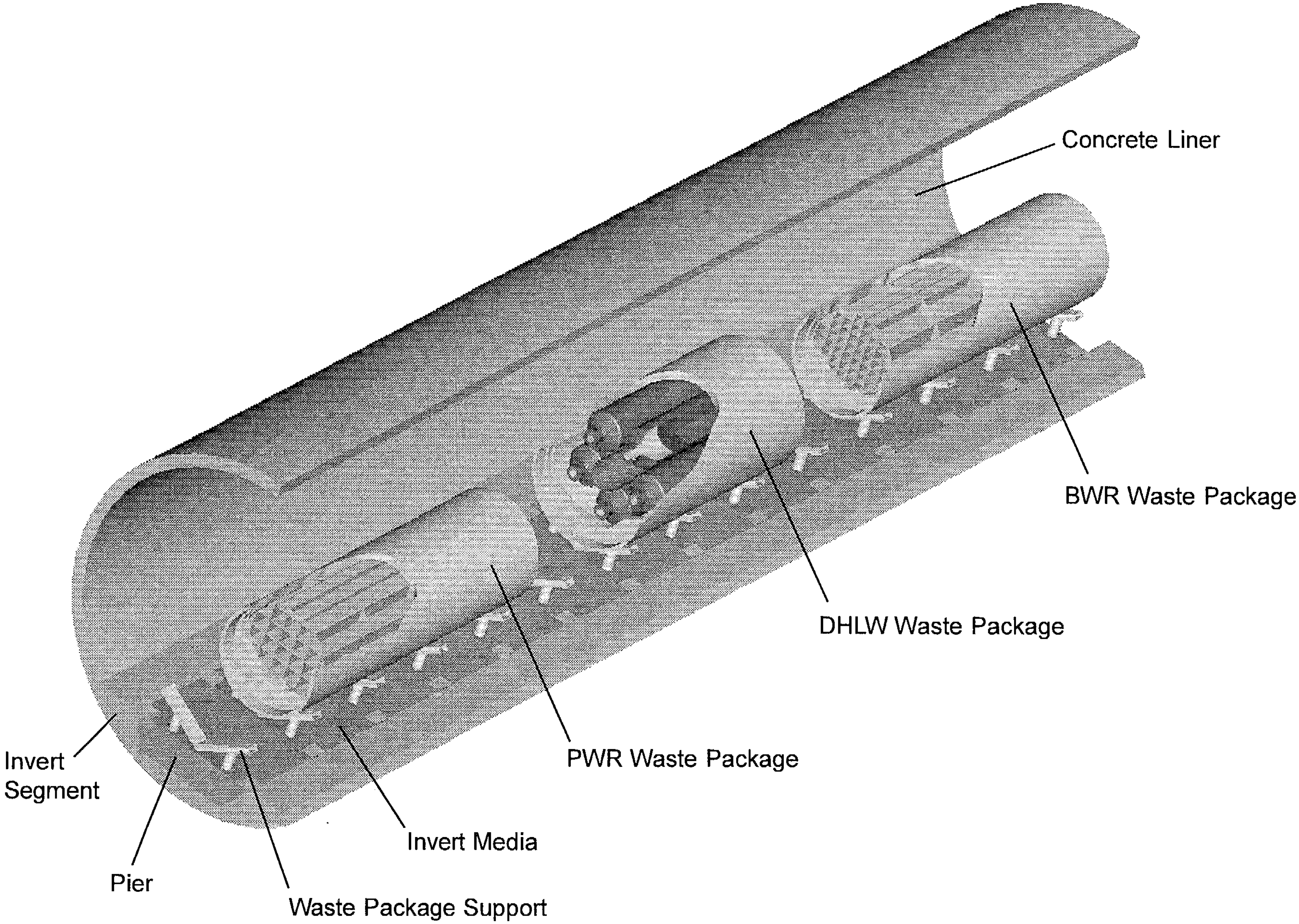
The Natural Barrier System will isolate the waste after the waste packages eventually corrode and deteriorate and the Engineered Barrier System's function is degraded. The Natural Barrier System will consist of the natural environment surrounding the potential repository. This includes the geologic, mechanical, chemical, and hydrological properties of the site.

The stratigraphy, or overall description of the rock layers, provides the basic framework for the Natural Barrier System. Yucca Mountain consists of several thousand meters of layered volcanic tuffs ranging in age from 11.5 to 15 million years. The potential repository will be located in the Topopah Spring tuff, a welded tuff unit of the Paintbrush Group. At Yucca Mountain, this unit is 180 to 230 meters thick and is located in the unsaturated zone. These various rock layers, their distinctive zeolite content, and the distance the repository will be located above the water table will retard the movement of any released radioactive material to the accessible environment.

The Engineered Barrier System will provide the first means of containment for the waste. The heat from the waste packages will keep the rock immediately around the drift dry for hundreds of years, which will reduce the corrosion rate of the waste packages. The components of the Engineered Barrier System, in the dry environment of the drift, are intended to contain the waste for thousands of years.

Based on the design of the Engineered Barrier System and the data and analysis gathered on the Natural Barrier System and the Engineered Barrier System, the overall performance assessment of the potential repository will be analyzed. This information will be used to predict changes during construction and operation. As the potential repository is constructed and operated, the Performance Confirmation System will perform confirmation testing to verify that the repository is performing as anticipated.

Engineered Barrier System



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Engineered Barrier System

General Criteria

The Engineered Barrier System will support the key geologic repository mission by containing the waste, limiting radionuclide release to the natural barrier, controlling the external impacts on the engineered system, controlling impacts on the natural system, and providing waste package support and spacing. Collectively, the Engineered Barrier System will consist of the waste packages, waste package support hardware, and performance enhancing barriers. Alternative designs for the Engineered Barrier System are presented in the Design Options section of this document.

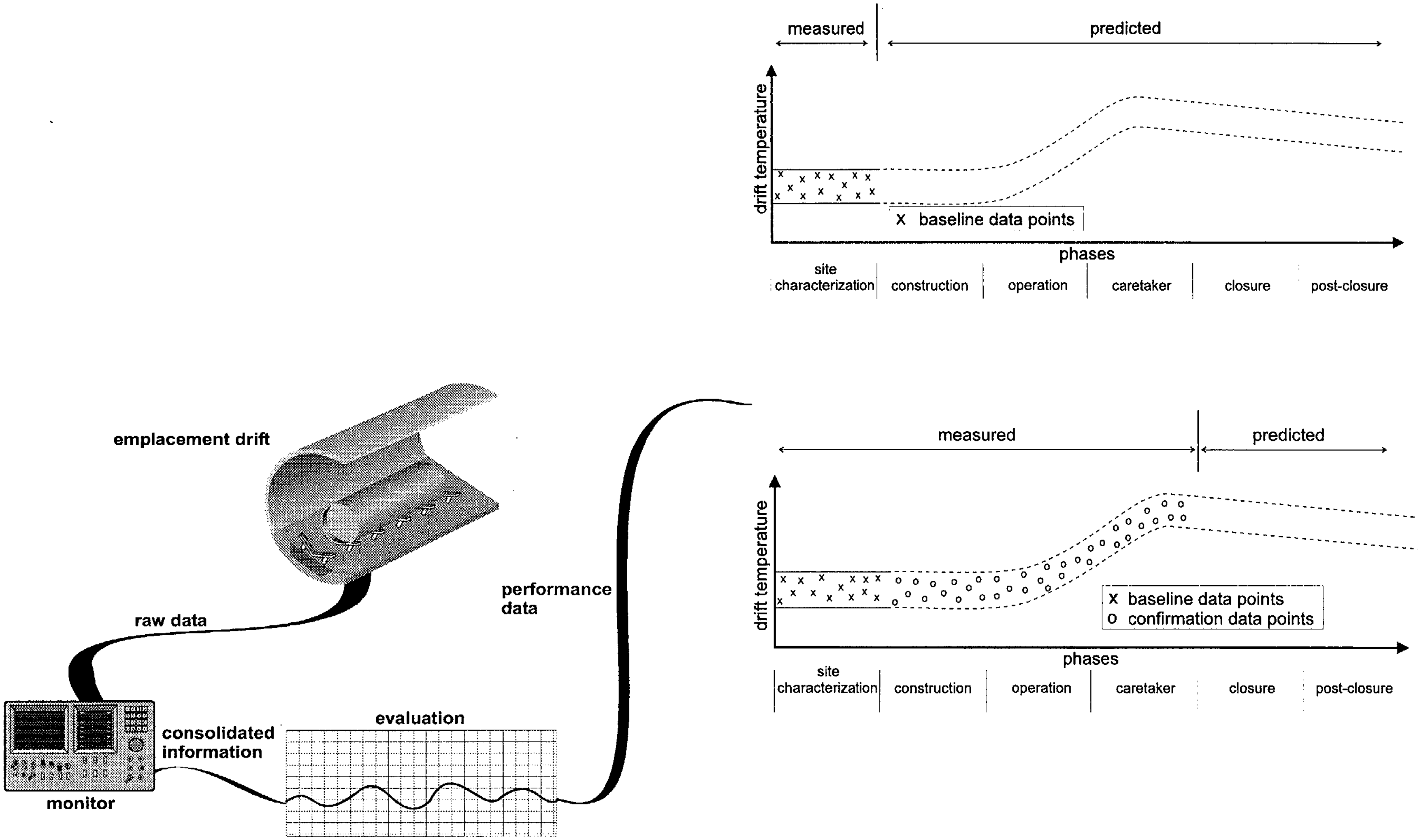
Design Description

The heat produced by the spent nuclear fuel in the waste packages will keep the rock around the drift dry for hundreds of years, which will reduce the corrosion rate of the waste packages. The components of the waste package are intended to contain the waste for thousands of years. The design characteristics of the waste packages were presented in the discussion on disposal containers.

The waste package support assembly will consist of a waste package pedestal and a waste package support. The pedestal and support will hold the waste package off the invert to prevent water from contacting the waste package if water is in the emplacement drift. The waste package support assembly is a modular design that allows flexibility in the waste package placement in the drifts and replacement of individual components in the event the support structure is damaged.

The invert will be made out of precast concrete. The main purpose of the invert is to provide a level drift floor and enable transport and support of the waste packages.

Performance Confirmation System



Performance confirmation involves gathering data on the waste packages, drifts, and mountain. The data will be evaluated and used to confirm the repository is performing as expected.

Performance Confirmation System

The performance confirmation system will provide data verifying that the subsurface conditions during construction, waste emplacement operations, and during the caretaker period are as expected. It also will verify that the natural and engineered systems and components are functioning as intended. The system will operate from the site characterization phase to the closure phase.

During the baseline period (the site characterization period), the performance confirmation system will develop information on the subsurface conditions and natural systems. The system also will monitor and analyze changes to the baseline information as a result of the site characterization and construction activities.

The goal of the confirmation period activities is to verify that actual subsurface conditions and changes resulting from the construction and operation of the repository are within limits.

The performance confirmation system will operate in the subsurface repository, as well as on the surface and in laboratories, acquiring and analyzing the data.

Design Description

To accomplish the performance confirmation activities, the following equipment and facilities will be required:

- five permanent observation or monitoring drifts with instrumented boreholes;
- an emplacement drift ventilation monitoring system;
- test alcoves in non-emplacement subsurface areas;
- a remotely operated gantry inspection system to monitor waste packages;
- a multi-purpose hot cell in the waste handling building with
    - about 225 square feet of area by 30 feet high,
    - 5-foot ordinary concrete stainless steel lined walls,
    - master-slave and electro-mechanical manipulators,
    - heavy duty dolly, and
    - 5-ton in-cell crane;
- a performance confirmation support area (about 10,000 square feet);
- a data acquisition system;
- surface-based monitoring and testing equipment; and
- laboratory testing equipment.

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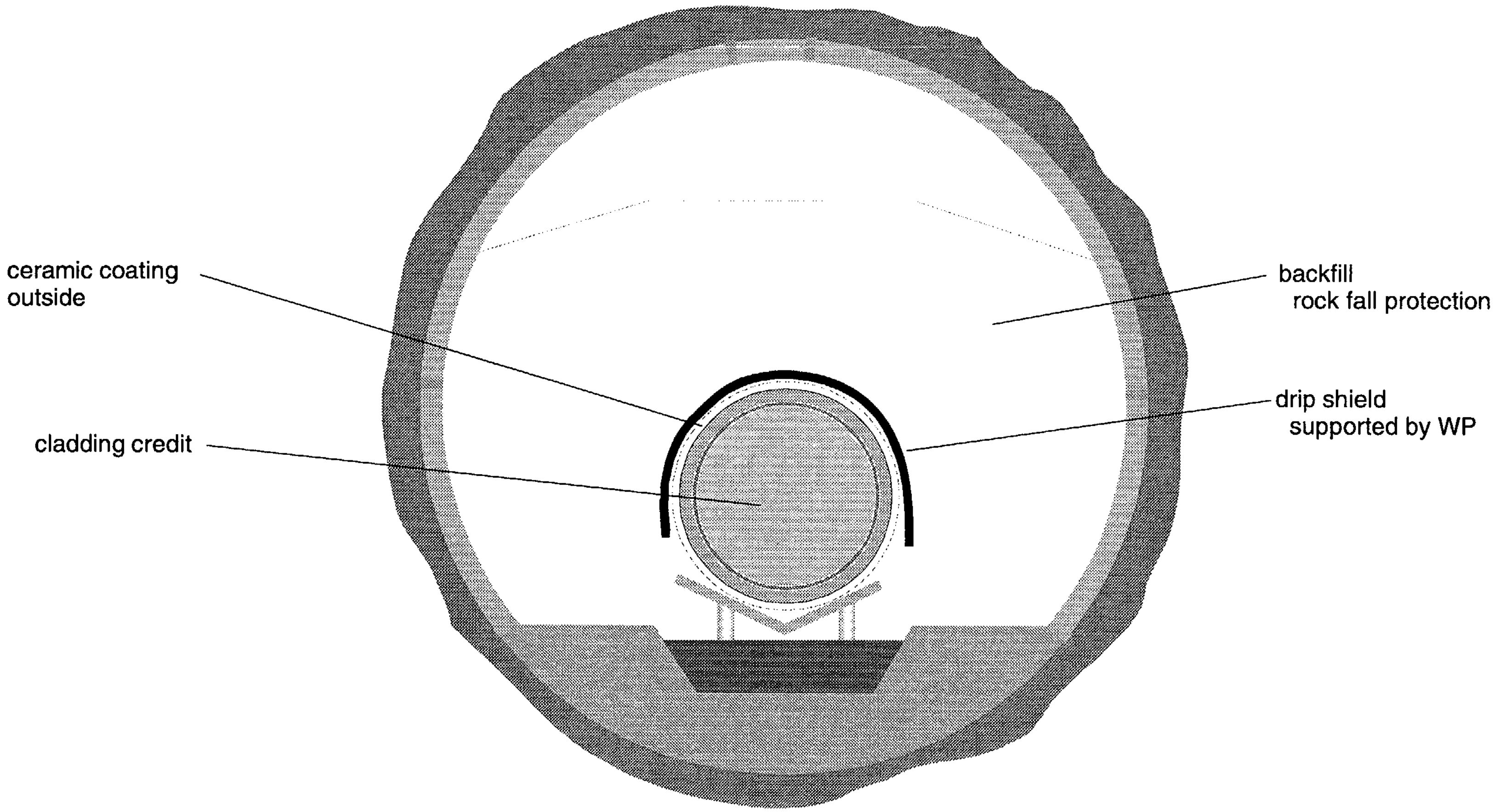
DESIGN OPTIONS

Engineered Barrier System VA Design Options



Engineered Barrier System VA Design Options

In addition to the features of the Engineered Barrier System described previously, four design options are being evaluated, as part of the viability assessment design, to enhance the performance of the Engineered Barrier System. The design options include using backfill, ceramic coating and/or drip shields and taking credit for the fuel cladding.

If backfill is to be placed in the emplacement drifts, it will be placed just prior to closure after the period of retrievability is over. The backfill to be emplaced is currently being studied and may consist of a dry granular material, possibly tuff excavated from the repository or quartz sand. This backfill material will be selected to ensure that corrosion of the waste packages is not enhanced and it will not lessen the waste isolation capabilities of the natural barrier.

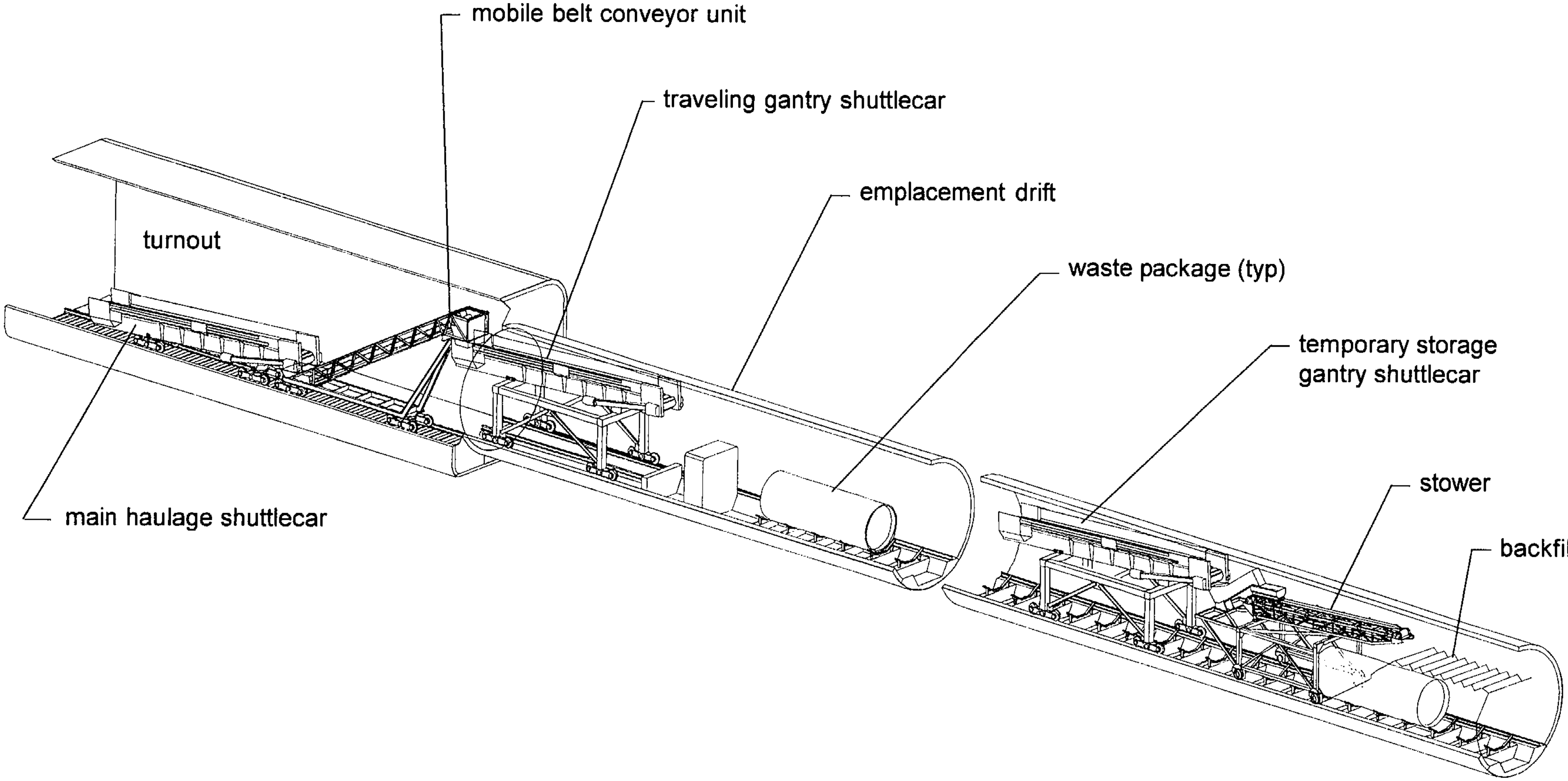
The waste packages in the reference design include a corrosion allowance barrier and a corrosion resistant barrier. The two barriers provide galvanic protection for the inner barrier and defense-in-depth by necessitating two different corrosion mechanisms for the respective barriers. In addition, a ceramic coating is being studied for placement on the outside of the waste package. The ceramic coating will be designed to minimize degradation of the waste package in wet environments. If a ceramic coating is utilized, backfill will also be used to protect the ceramic coating from rock fall in the emplacement drift

Long-life drip shields may be used to divert any dripping water that may periodically enter the drifts around the waste package. The use of drip shields will be determined after evaluating their effectiveness for reducing corrosion rates and for reducing the annual radiological doses at the accessible environment. If a ceramic drip shield is utilized, backfill will be used for rock fall protection.

In addition, performance assessment models and material testing will be conducted to determine if credit can be taken for the spent nuclear fuel cladding. The inclusion of this design feature will further enhance the defense-in-depth philosophy for waste isolation.

The design selection process used to evaluate these options will be based on the scenarios predicted for the waste isolation period (temperatures, humidity, water flow, chemistry, and mechanical loads) as a function of time and location. The functions of the design options for the engineered barrier components then will be determined and evaluated with respect to their capability to delay breaching of the waste package; slow the release of radioactive materials from the waste package; and retard the release of radioactive materials from the Engineered Barrier System.

Backfill Emplacement System



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Backfill Emplacement System

The Backfill Emplacement System will place backfill in the emplacement drifts (if required). This section presents the equipment and operations that may be used to emplace the backfill in the emplacement drifts (if required) to support waste isolation.

The ventilation system will provide increased air flow in the fully loaded emplacement drifts to cool down the emplacement drifts. The cool down decreases the temperature in the emplacement drifts to allow the operation of the remotely operated backfill equipment. If the backfill is emplaced, it will not completely fill the emplacement drifts. The current concept would include placing the backfill in the emplacement drifts to ensure the waste packages are covered to a minimum depth of 0.6 meter. Backfill operations will be conducted remotely due to the high radiation field within the emplacement drifts.

Design Description

The Backfill Emplacement System will include the equipment required to prepare the backfill material at the surface of the repository, the equipment required to transport the backfill to the emplacement drift, and the remotely operated equipment required to emplace the backfill in the emplacement drifts.

An electrically powered locomotive will transport a main haulage shuttle car underground and back it into the turnout for the emplacement drift. Because the emplacement doors will be open when the haulage car is backed into place, the operation will be conducted remotely to prevent radiation exposure to workers.

Once the main haulage car has been backed into place, a mobile conveyor belt unit will transport the backfill to the traveling gantry shuttlecar. A chain conveyor in the bottom of the gantry shuttlecar will move the material from one end of the unit to the other. The traveling gantry shuttlecar then will travel over the waste packages and engage the temporary storage gantry shuttlecar. Once engaged, the backfill will be discharged to the temporary gantry shuttlecar and the traveling gantry shuttlecar then will return to the drift entrance to receive additional backfill.

The temporary storage gantry shuttlecar will use a conveyor belt to move the backfill to the stower. The stower will dump the backfill over the waste packages.