U.S. Department of Energy
Office of Civilian Radioactive Waste Management

YUCCA MOUNTAIN PROJECT

Repository Design Status

Presented to:
Nuclear Waste Technical Review Board Panel on the Engineered System

Presented by:
Paul Harrington
Office of Repository Development
U. S. Department of Energy

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Las Vegas, Nevada

Introduction

- **Presentation on design solutions with preliminary preclosure safety analysis results**
- **Design details to be added for License Application**
- **Preliminary preclosure safety analysis based upon April 2003 design**
- **Surface facilities changes implement Cogema expertise**
- **Subsurface facility layout and ground support changes**
- **Waste package design detail changes**

Preclosure Safety Analysis Approach

- **Internal and external hazards analyses identify hazards**
- **Categorization analyses estimate frequency of event sequences**
- **Consequence analyses estimate doses to public and workers from event sequences**
- **Classification analyses identify structures, systems, and components that are important to safety**
- **Nuclear safety design basis document captures design requirements**

Preclosure Safety Analysis Event Sequences

- **Category 1 - expected to occur one or more times before permanent closure**
- **Category 2 - at least one chance in 10,000 of occurring before permanent closure**

Preclosure Safety Analysis Status

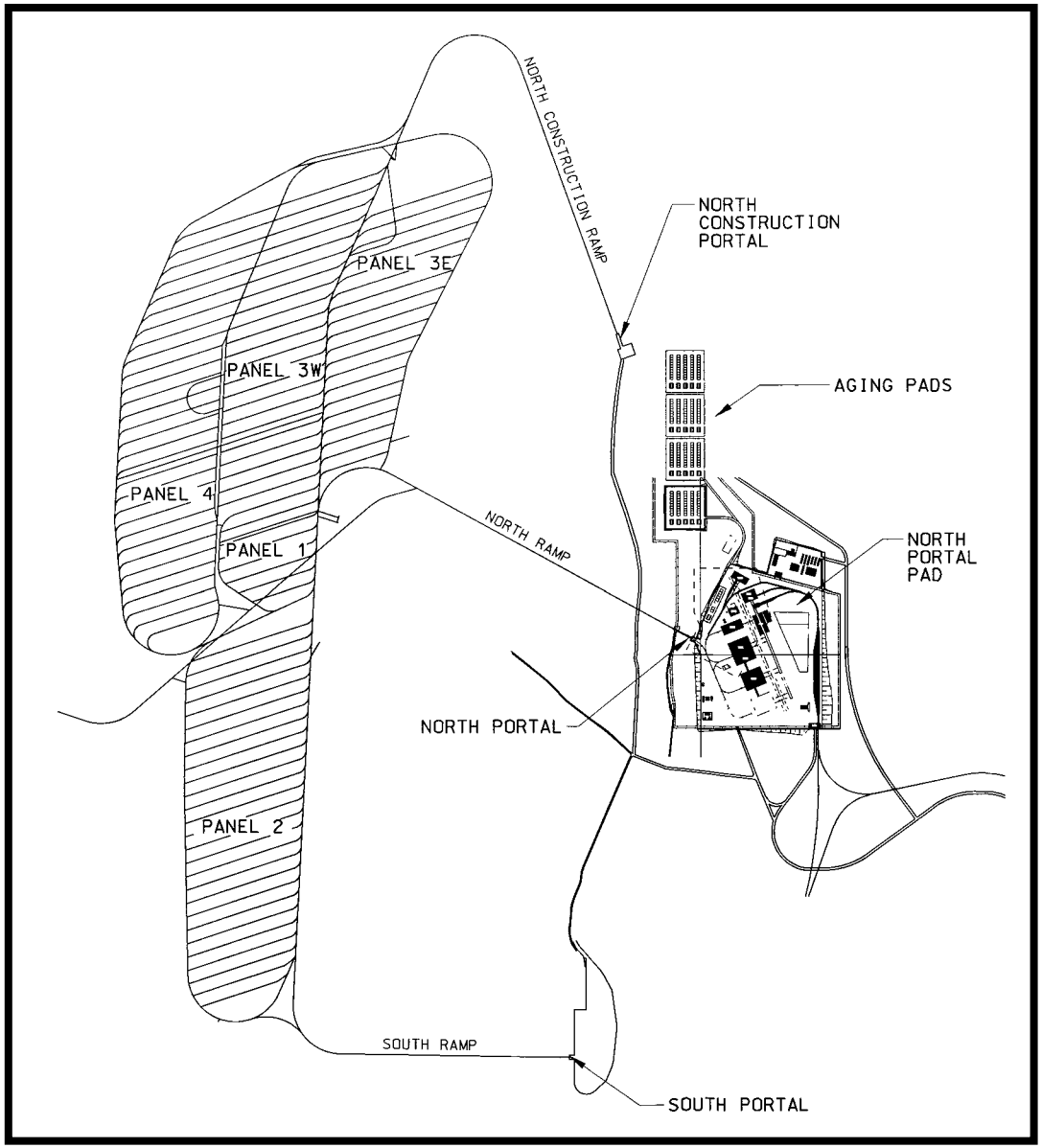
- **Preliminary preclosure safety analysis of design as of April 2003 is complete**
- **Results of preliminary preclosure safety analysis will influence License Application design**
- **Preclosure safety analysis process will be repeated for License Application design**
- **Identified event sequences and dose consequences are expected to be substantially similar for License Application design**

Surface Facilities

Surface Facilities

- **Design input from Cogema using extensive process experience from La Hague facility**
- **Design adapted for Yucca Mountain requirements**
- **Recent design changes**
  - **Transportation Cask Receipt Facility with buffer area**
  - **Canister Handling Facility**
  - **Integrated Dry Transfer Facility with remediation capability**
  - **Second Dry Transfer Facility to be built later**
  - **Processing is primarily dry with small pool for remediation**
  - **Rail-based transportation system**

Site Plan



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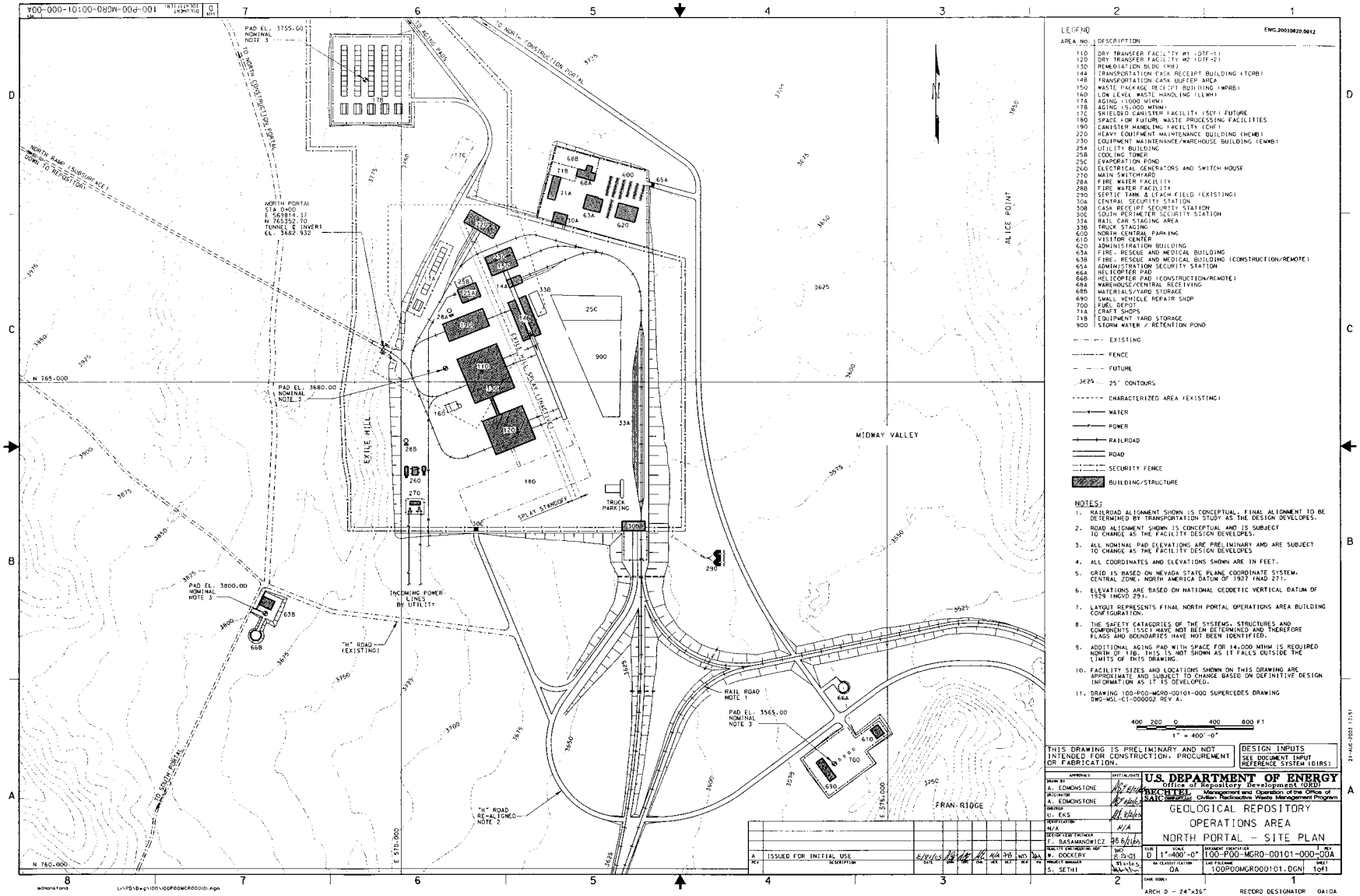
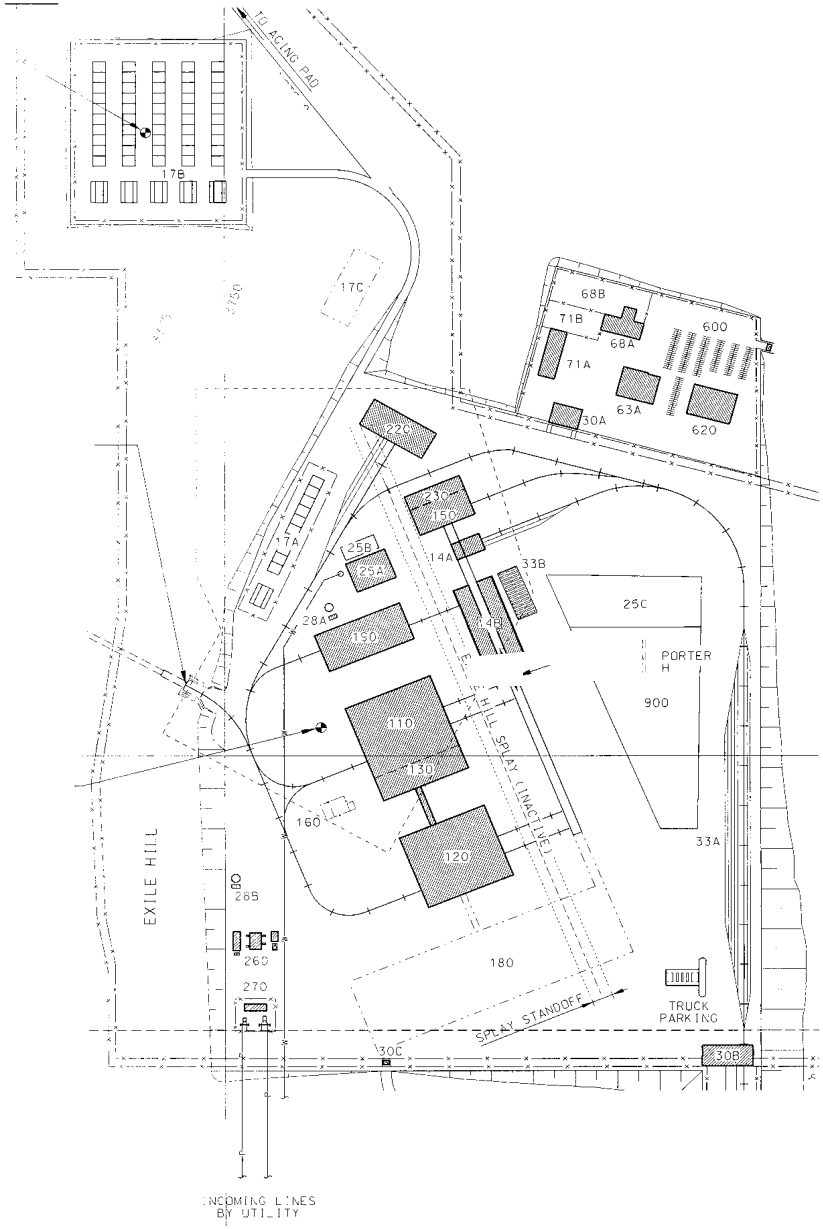
Surface Facilities



North Portal Plan



AREA No.	DESCRIPTION
110	DRY TRANSFER FACILITY #1 (DTF-1)
120	DRY TRANSFER FACILITY #2 (DTF-2)
130	REMEDIATION BLDG (RB)
14A	TRANSPORTATION CASK RECEIPT BUILDING (TCRB)
14B	TRANSPORTATION CASK BUFFER AREA
150	WASTE PACKAGE RECEIPT BUILDING (WPRB)
160	LOW LEVEL WASTE HANDLING (LLWH)
17A	AGING (1000 MTHM)
17B	AGING (5,000 MTHM)
17C	SHIELDED CANISTER FACILITY (SCF) FUTURE
180	SPACE FOR FUTURE WASTE PROCESSING FACILITIES
190	CANISTER HANDLING FACILITY (CHF)
220	HEAVY EQUIPMENT MAINTENANCE BUILDING (HEMB)
230	EQUIPMENT MAINTENANCE/WAREHOUSE BUILDING (EMWB)
25A	UTILITY BUILDING
25B	COOLING TOWER
25C	EVAPORATION POND
260	ELECTRICAL GENERATORS AND SWITCH HOUSE
270	MAIN SWITCHYARD
28A	FIRE WATER FACILITY
28B	FIRE WATER FACILITY
290	SEPTIC TANK & LEACH FIELD (EXISTING)
30A	CENTRAL SECURITY STATION
30B	CASK RECEIPT SECURITY STATION
30C	SOUTH PERIMETER SECURITY STATION
33A	RAIL CAR STAGING AREA
33B	TRUCK STAGING
600	NORTH CENTRAL PARKING
610	VISITOR CENTER
620	ADMINISTRATION BUILDING
63A	FIRE, RESCUE AND MEDICAL BUILDING
63B	FIRE, RESCUE AND MEDICAL BUILDING (CONSTRUCTION/REMOTE)
65A	ADMINISTRATION SECURITY STATION
66A	HELICOPTER PAD
66B	HELICOPTER PAD (CONSTRUCTION/REMOTE)
68A	WAREHOUSE/CENTRAL RECEIVING
68B	MATERIALS/YARD STORAGE
690	SMALL VEHICLE REPAIR SHOP
700	FUEL DEPOT
71A	CRAFT SHOPS
71B	EQUIPMENT YARD STORAGE
900	STORM WATER / RETENTION POND

EXISTING
FENCE
FUTURE
3625 25' CONTOURS
CHARACTERIZED AREA (EXISTING)
WATER
POWER
RAILROAD
ROAD
SECURITY FENCE
BUILDING/STRUCTURE

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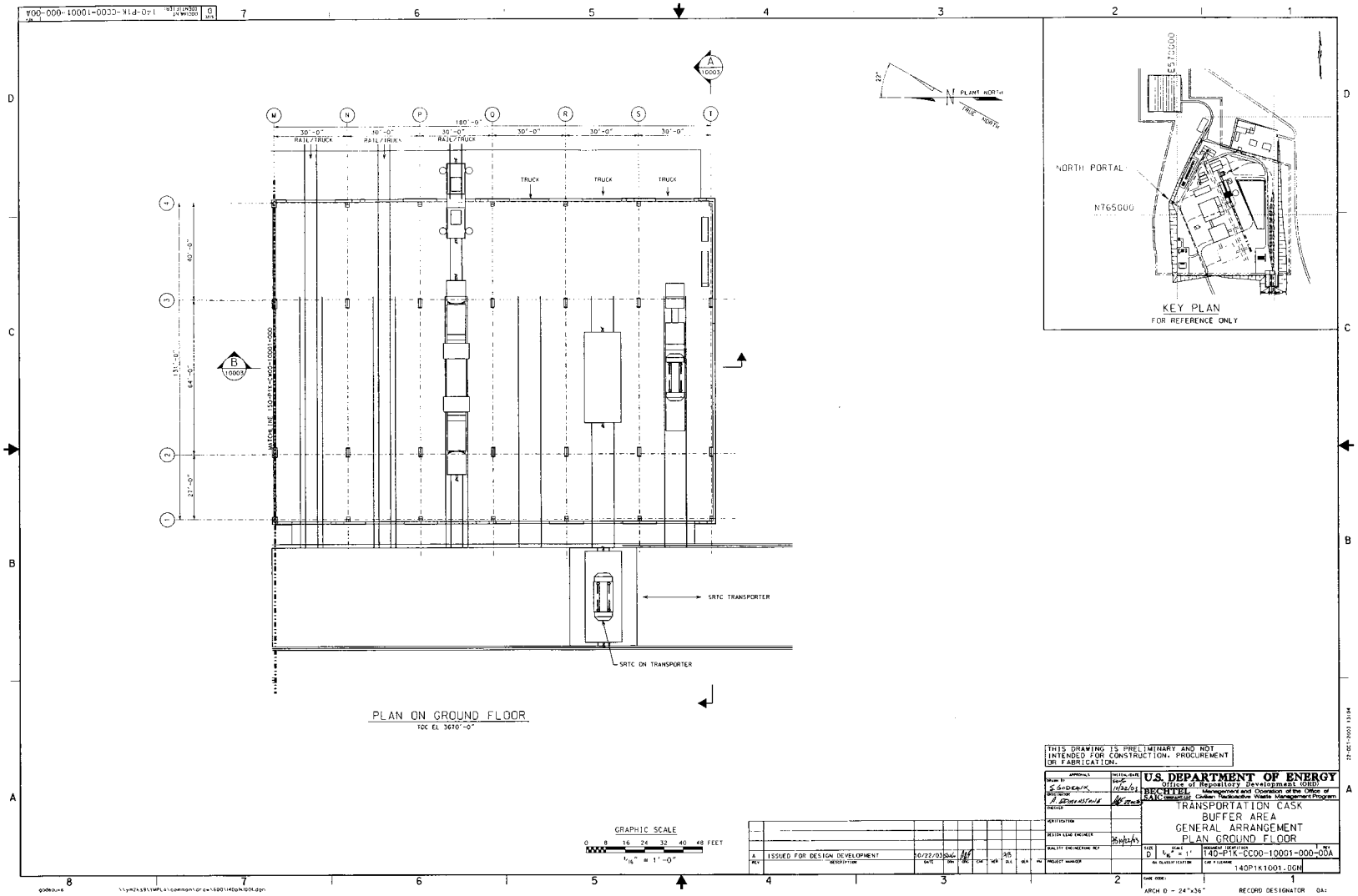
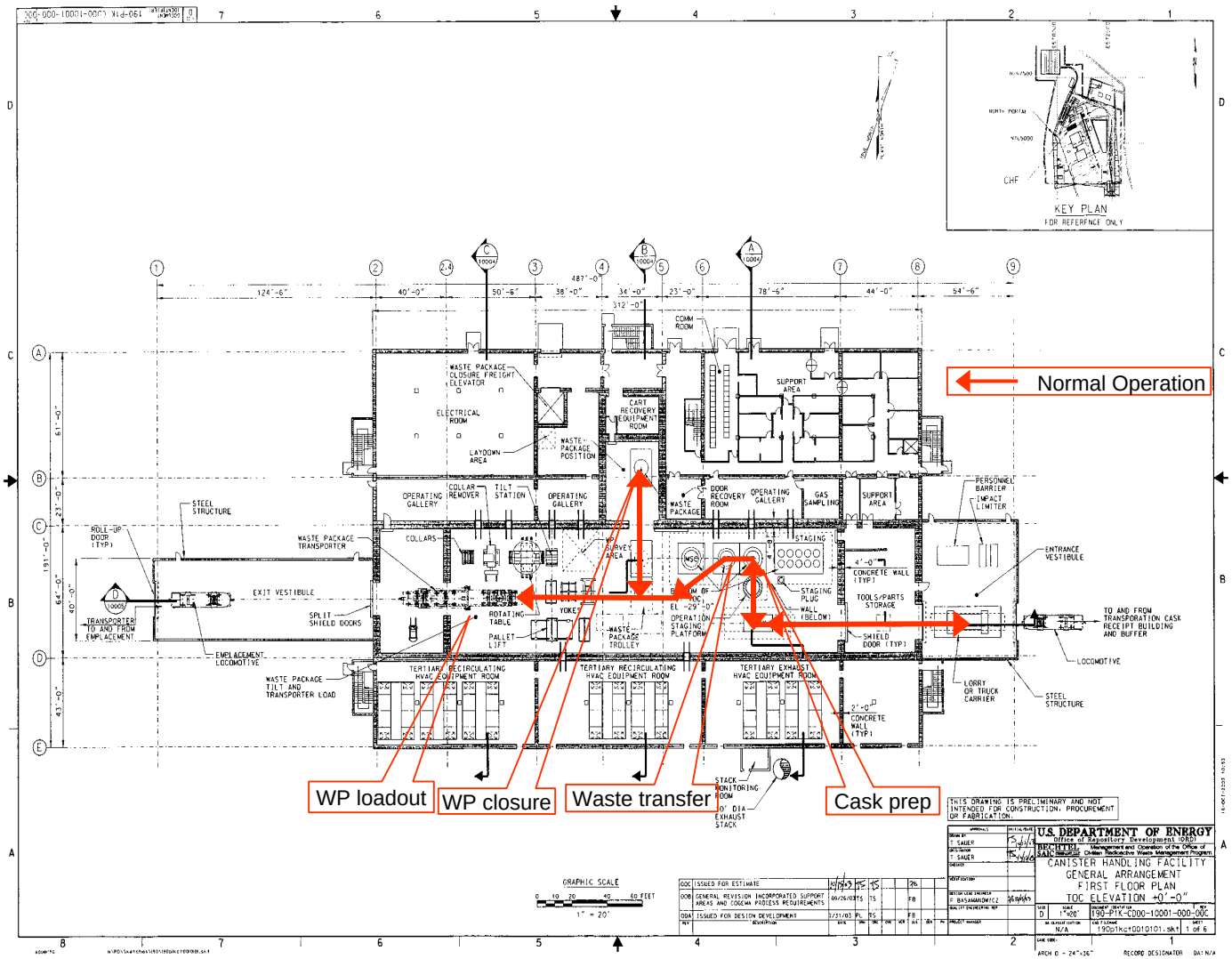
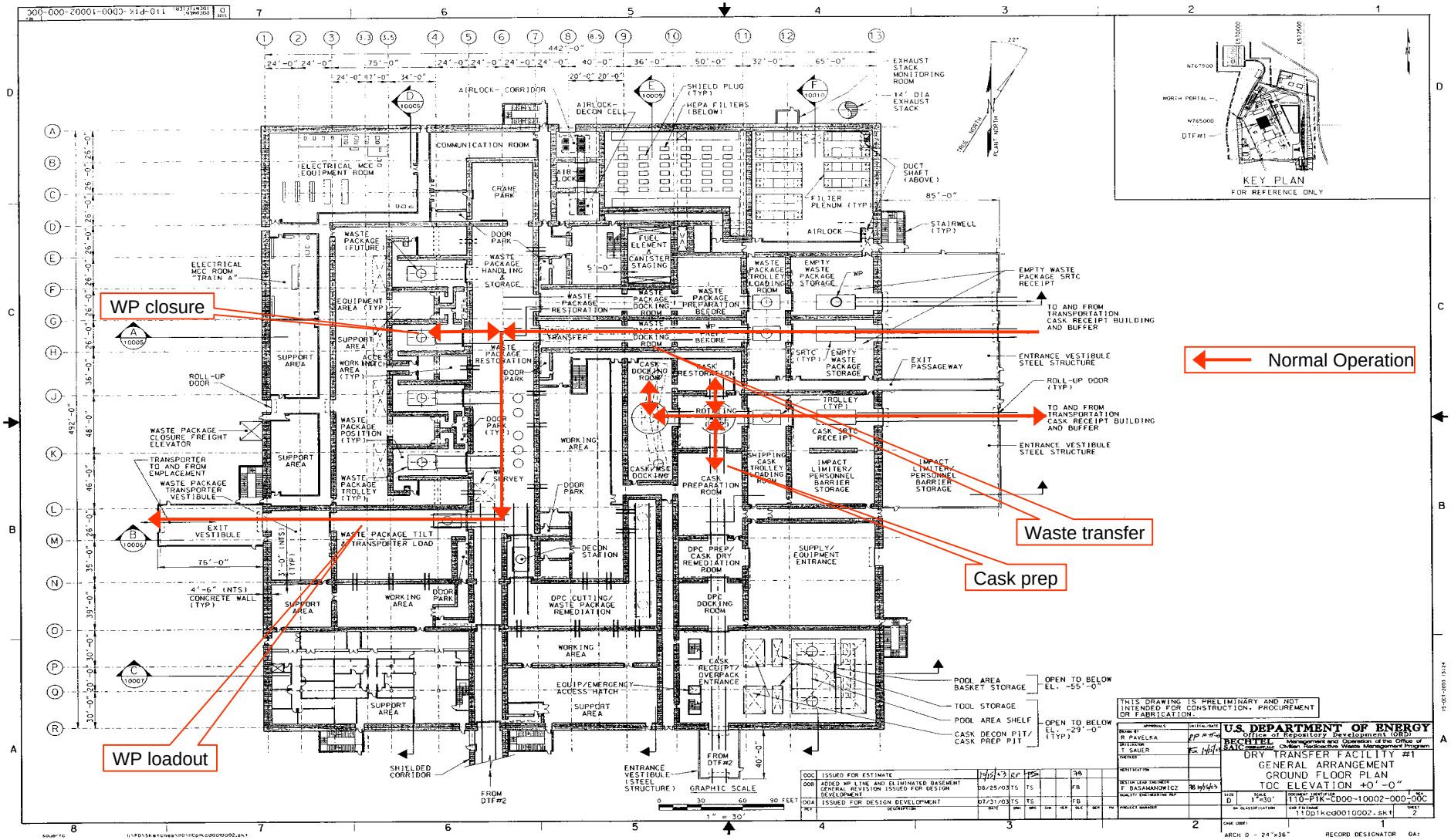
Transportation Cask Receipt Facility



Canister Handling Facility

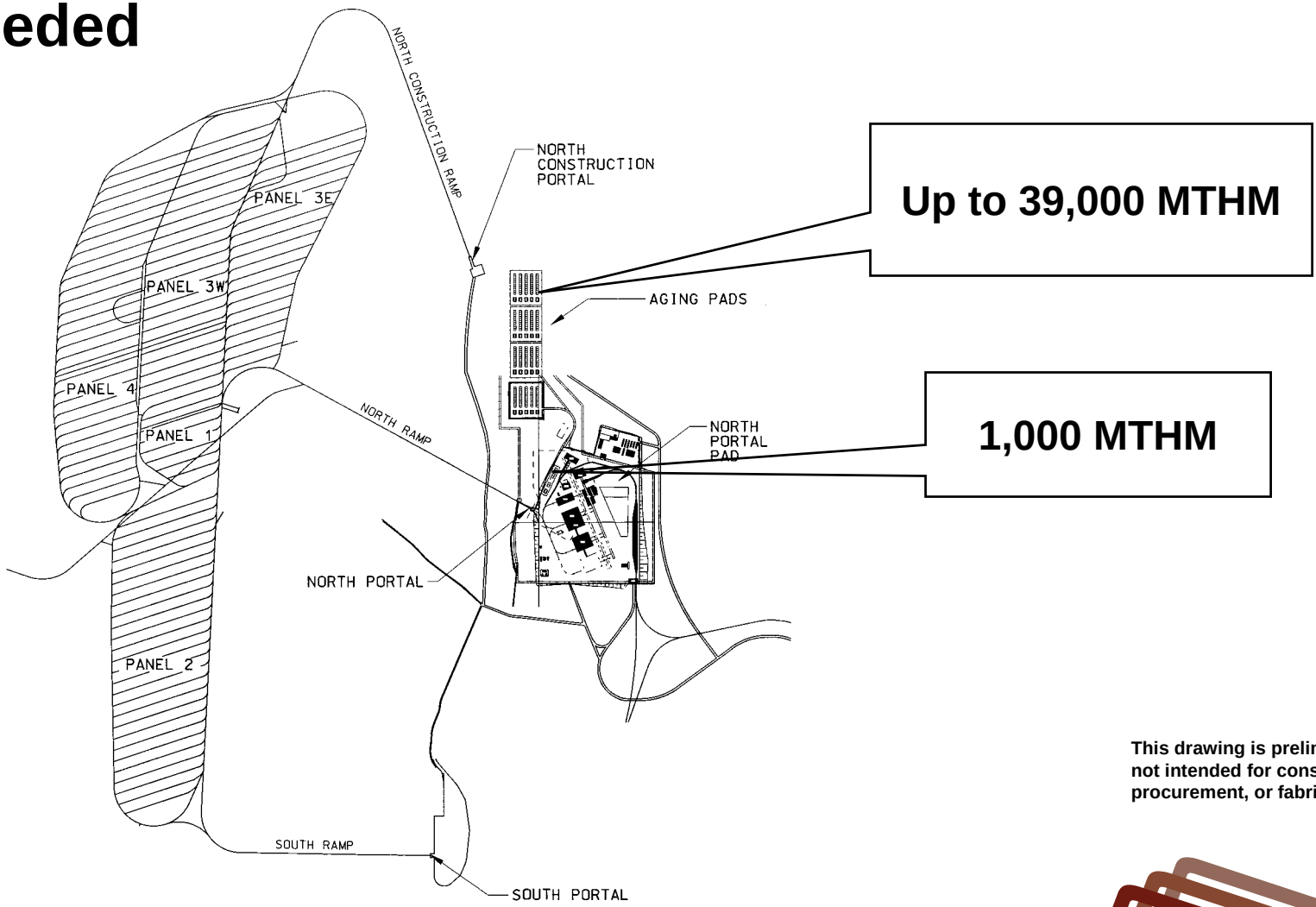


Dry Transfer Facility 1/ Remediation



Site Aging

Up to 40,000 metric tons of heavy metal capacity, built as needed



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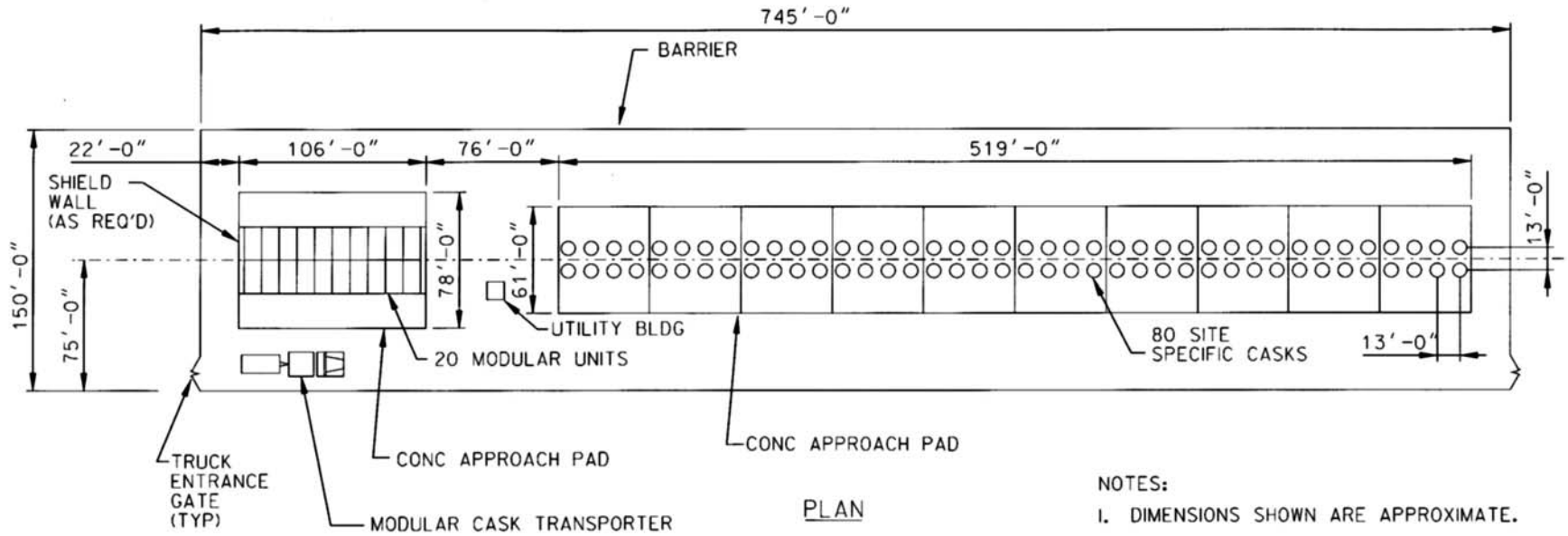
North Portal Aging Facility

1000 metric tons of heavy metal capacity



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Surface Facilities Phased Implementation

- **Allows for the implementation of a small initial disposal capability**
  - **Increases confidence to meet 2010 initial operation**
  - **Remediation integral with fuel handling facility for more efficient processing and movement inside a single facility**
  - **Adopt lessons learned approach**
- **Provides maximum flexibility to adjust to future changes in:**
  - **Funding**
  - **Schedule**
  - **Incoming waste stream**

Surface Facilities Construction Sequence

- **Phase 1**
  - **Transportation Cask Receipt Facility**
  - **Canister Handling Facility**
  - **Dry Transfer Facility 1**
  - **Aging - 6,000 metric tons of heavy metal, initial**
  - **Balance of Plant Facilities, partial**
- **Phase 2**
  - **Dry Transfer Facility 2**
  - **Aging - up to 40,000 metric tons of heavy metal, total**
  - **Balance of Plant, complete**

Surface Facilities Preliminary Preclosure Safety Analysis Results

- No Category 1 or 2 external event sequences
- Two Category 1 internal event sequences involving drop or collision of commercial spent nuclear fuel assemblies in a Dry Transfer Facility
- 31 Category 2 internal event sequences for cask, canister, and assembly handling (drops or collisions) in the surface facilities
- No Category 1 or 2 event sequences for 1,000 metric tons of heavy metal Waste Aging Facility
- Canister Handling Facility and up to 40,000 metric tons of heavy metal aging not addressed

Surface Facilities
Dose Consequences

- **Sum of offsite doses from normal operations and frequency-weighted Category 1 event sequence doses are below regulatory limits**
- **Sum of worker doses from normal operations and Category 1 event sequences are below regulatory limits**
- **Category 2 offsite doses are below regulatory limits**

Classification Analyses

- **Structures, systems, and components that are credited for prevention or mitigation of Category 1 or Category 2 event sequences are important to safety and are classified as Safety Category**
- **Natural or engineered barriers that are important to meeting 10 CFR 63.113 performance objectives are important to waste isolation and are classified as Safety Category**
- **Structures, systems, and components that are not important to safety or waste isolation are classified as Non-Safety Category**

Surface Facilities Structures, Systems, and Components Classification Results

- **Structures in which spent fuel assemblies, canisters, or casks without impact limiters are handled are important to safety**
- **Important to safety subsystems in the Cask Receipt and Return System include cask receipt, cask preparation, and the cask buffer subsystems**
- **Important to safety systems in the Dry Transfer Facilities include cask preparation, waste package, DOE canister, and spent nuclear fuel/high-level radioactive waste transfer systems**
- **Other important to safety systems include the transportation cask, waste packages, remediation system, emplacement and retrieval system, and the aging system**

Aircraft Hazard Evaluation

- **Hazards**
  - **Military flights within the Nevada Test and Training Range and Nevada Test Site**
  - **Commercial, general aviation, and military flights 8 miles or more away in the Beatty corridor**
- **Approach: Screen out hazard due to low probability**
  - **Methods similar to NUREG-0800**
  - **Flight counts from Federal Aviation Administration**
  - **Flight counts from Nevada Test and Training Range instrumentation**
  - **Crash rates from historical data by type of aircraft**

Aircraft Hazard Evaluation

(Continued)

- **Initial study screened out hazard for 100-year operation and 1,000 metric tons of heavy metal aging pad**
- **Planned changes in use of the Nevada Test Site airspace by the Air Force require reevaluating the aircraft crash hazard**

Surface Facilities As Low As Is Reasonably Achievable and Worker Safety

- As low as is reasonably achievable design goals - 500 mrem/yr for rad worker
- As low as is reasonably achievable design guide
  - Minimize manual operations in radiation and contaminated areas
  - Increase the reliability of processes and equipment used
  - Increase the distance from the radiation source term and/or shield the radiation source
  - Engineer effective contamination controls into the design
  - Decrease exposure times
- Examples of as low as is reasonably achievable implementation
  - Remote operations for high radiation activities
  - Shield walls and limited personnel access during operations

Subsurface Facilities

Subsurface Facility

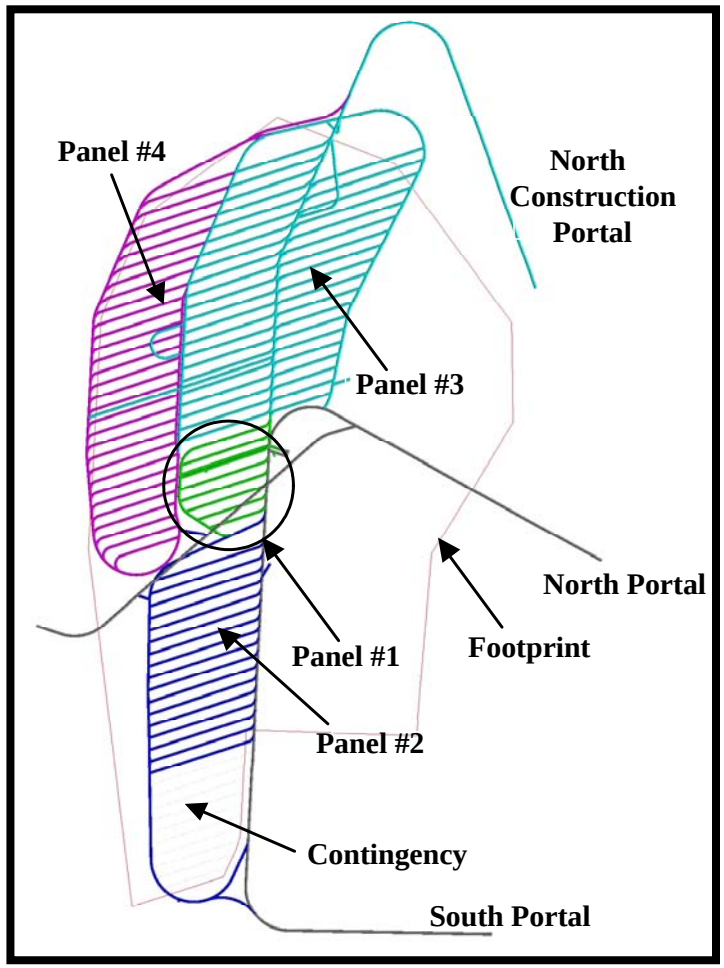
- **Thermal goals**
  - **Limit cladding temperature to 350°C**
  - **Limit preclosure drift wall temperature to 96°C**
  - **Limit postclosure drift wall temperature to 200°C**
  - **Allow for pillar drainage (a portion of the drift pillar temperature will remain below the boiling point of water)**
  - **The ventilation system must provide 15 m^3/s per emplacement drift for a period of 50 years after final emplacement to meet the thermal goals**
- **Waste packages emplaced 0.1 m end to end**

Subsurface Design Changes

- **Recent design changes**
  - **Revised panel layouts and ventilation system**
  - **Revised ground support**
  - **Returned to rail system for waste package transporter**
  - **Increased radius of emplacement drift turnouts**
  - **Moved ventilation control doors to outer end of turnouts**

Subsurface Configuration

- **Panel numbers represent the proposed emplacement sequence**
- **Sequence:**
  - **Panel 1, Phase 1 for 2010**
    - **Develop at least 3 emplacement drifts**
  - **Panel 1, Phase 2**
    - **Complete Panel 1 drifts (8 total)**
  - **Panel 2**
    - **17 drifts total (excludes contingency)**
- **Total emplacement length available is approximately 41 miles (65 km)**
- **Available contingency of 11 - 13.5 percent for the 70,000 metric tons of heavy metal case**



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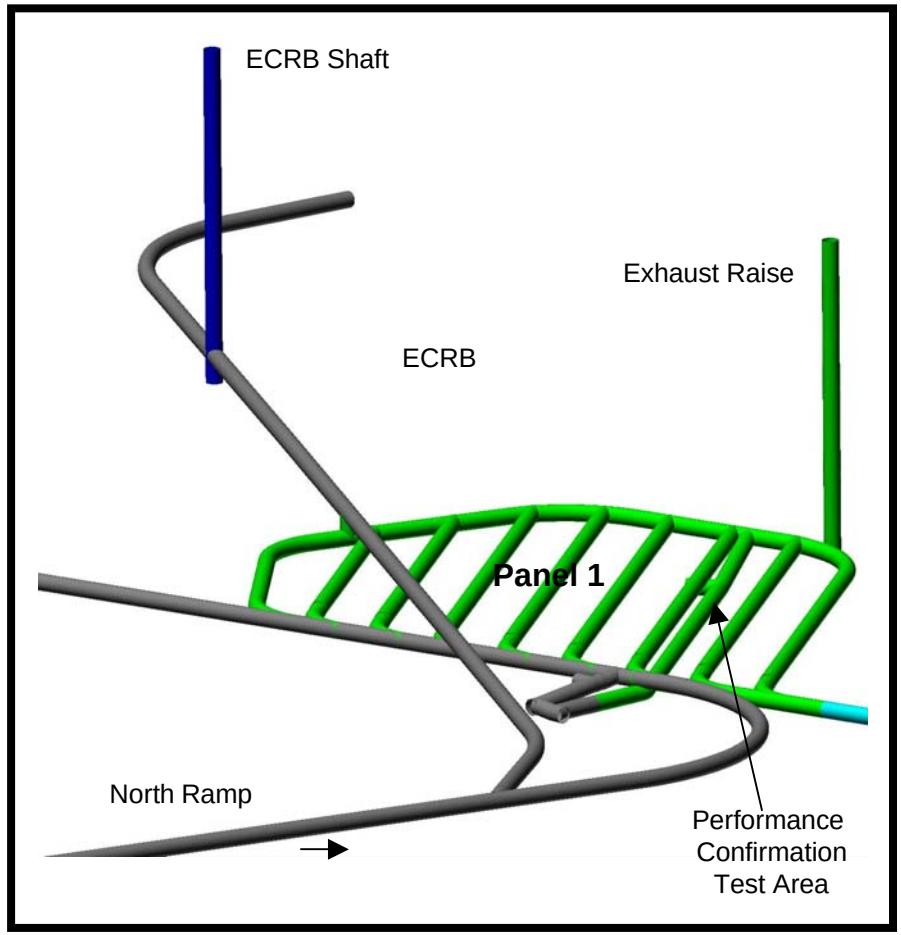
Panel 1

- **Panel 1 consists of eight emplacement drifts**
- **Approximately 4,100 m (13,000 ft) of useable emplacement drift**
- **Panel 1 is located approximately half in the lower lithophysal and half in the middle non-lithophysal**
- **Panel 1 will be ventilated using the North Ramp and the exhaust raise**
- **A portion of Panel 1 will be used as a test area for performance confirmation**



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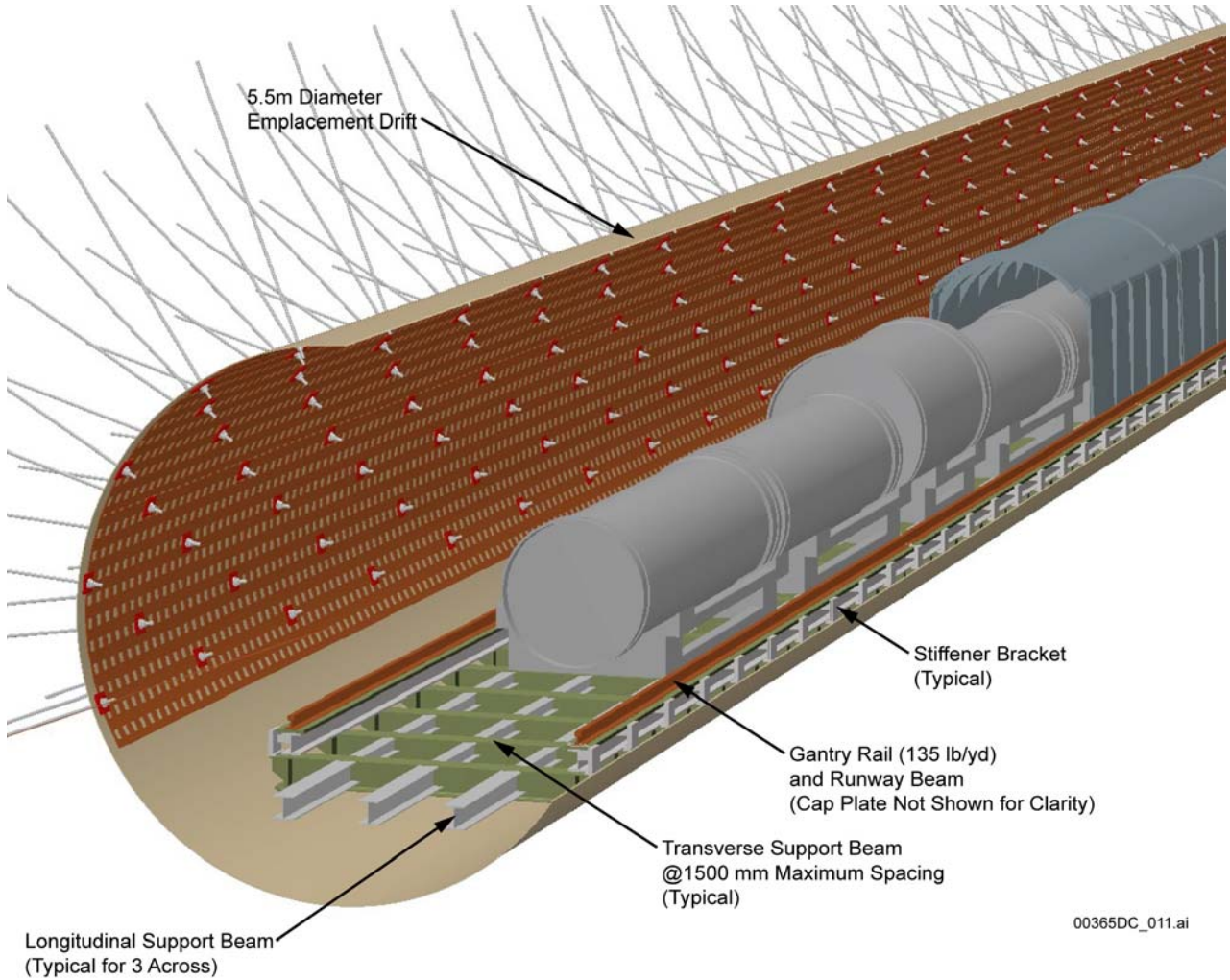
Emplacement Drift Isometric



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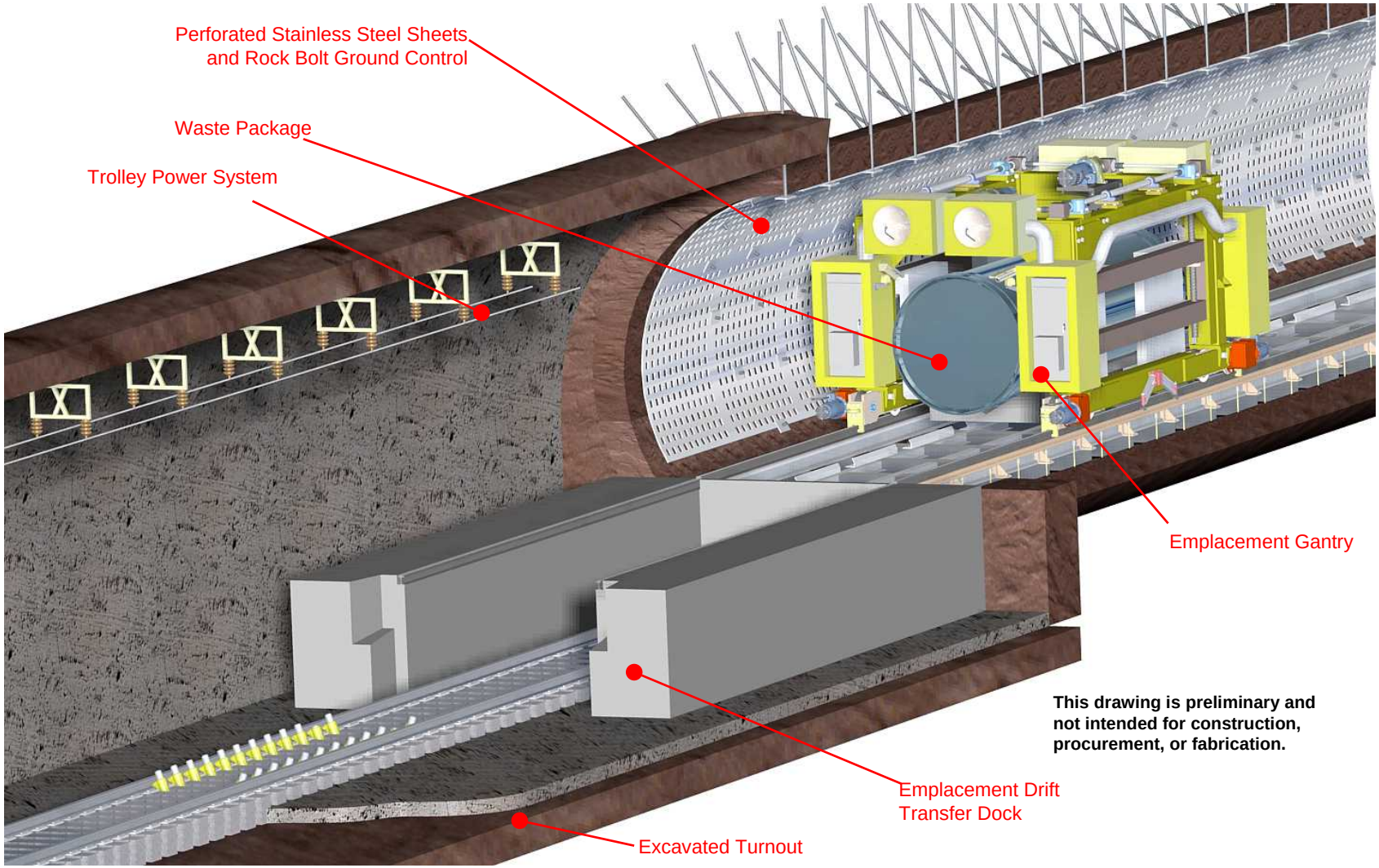
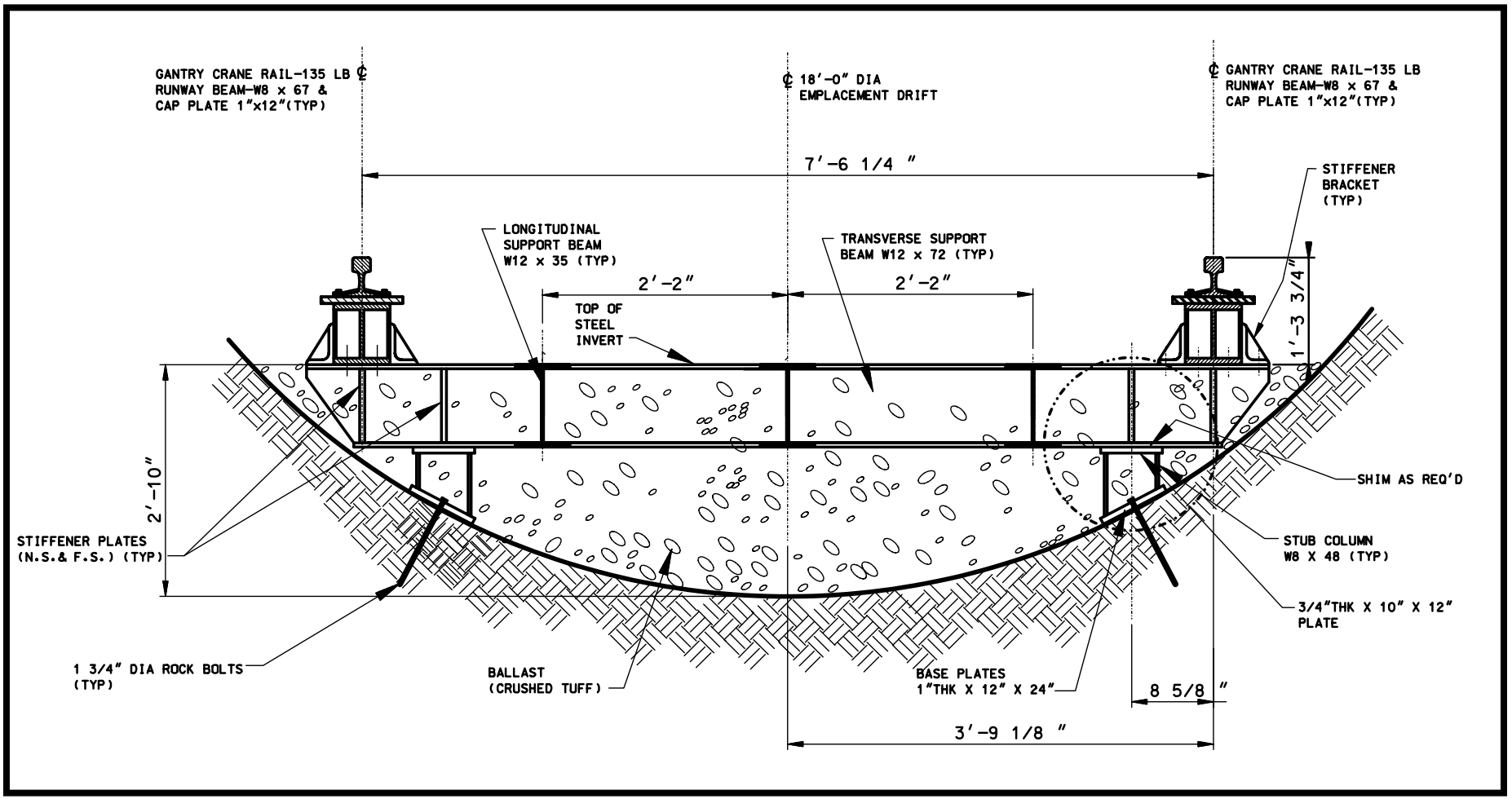
Emplacement Drift Entrance



Emplacement Drift Invert



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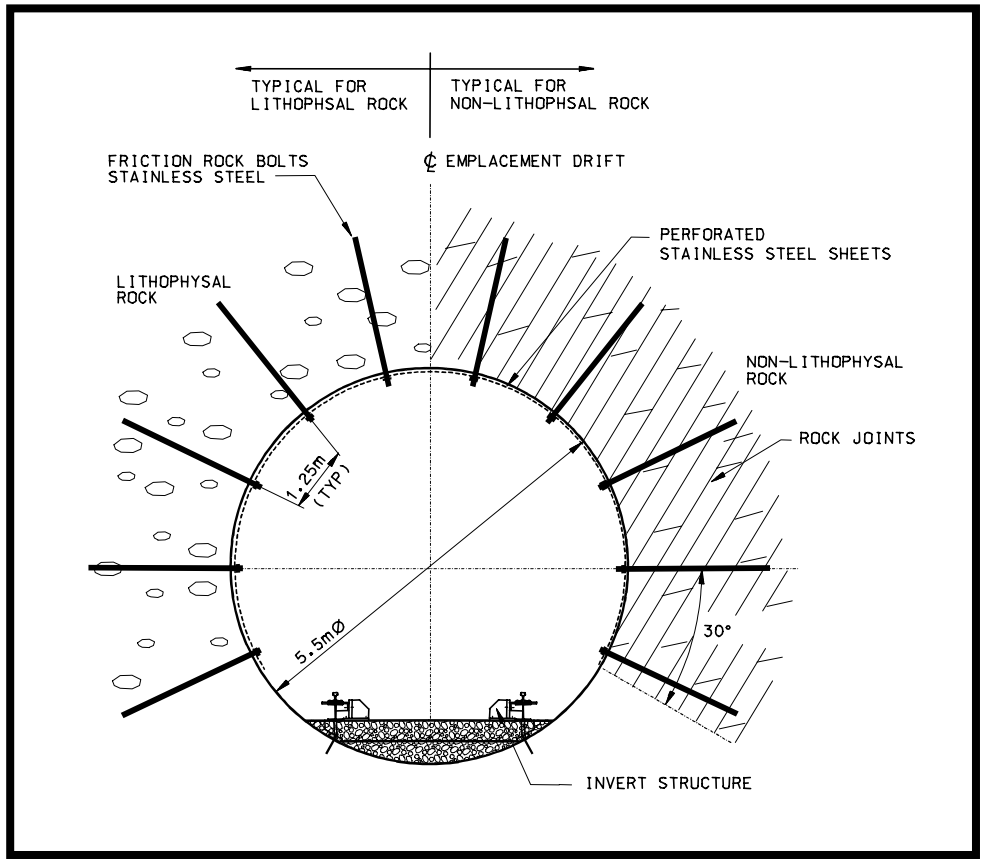
Emplacement Drift Invert

(Continued)

- **Emplacement drift invert includes steel structure and ballast material**
- **Carbon steel invert structure**
  - **Supports emplacement gantry rail system**
  - **Supports waste packages and drip shields during the preclosure period**
- **Ballast material**
  - **Crushed tuff, well graded from 2 inch minus to no more than 5 percent fines, compacted to 95 percent of its maximum dry density**
  - **Provides an engineered barrier to diffuse the potential radionuclide flow from the waste packages**
  - **Supports waste packages and drip shields during the postclosure period**

Ground Support for Emplacement Drifts

- Friction rock bolts 3 m long, spaced at 1.25 m
- Thin (3 mm thick) perforated sheets, installed in a 240° arc around the drift periphery along entire drift length
- Bolts and sheets made of stainless steel to ensure their longevity
- Suitable for various ground conditions
- Capable of preventing rock fall



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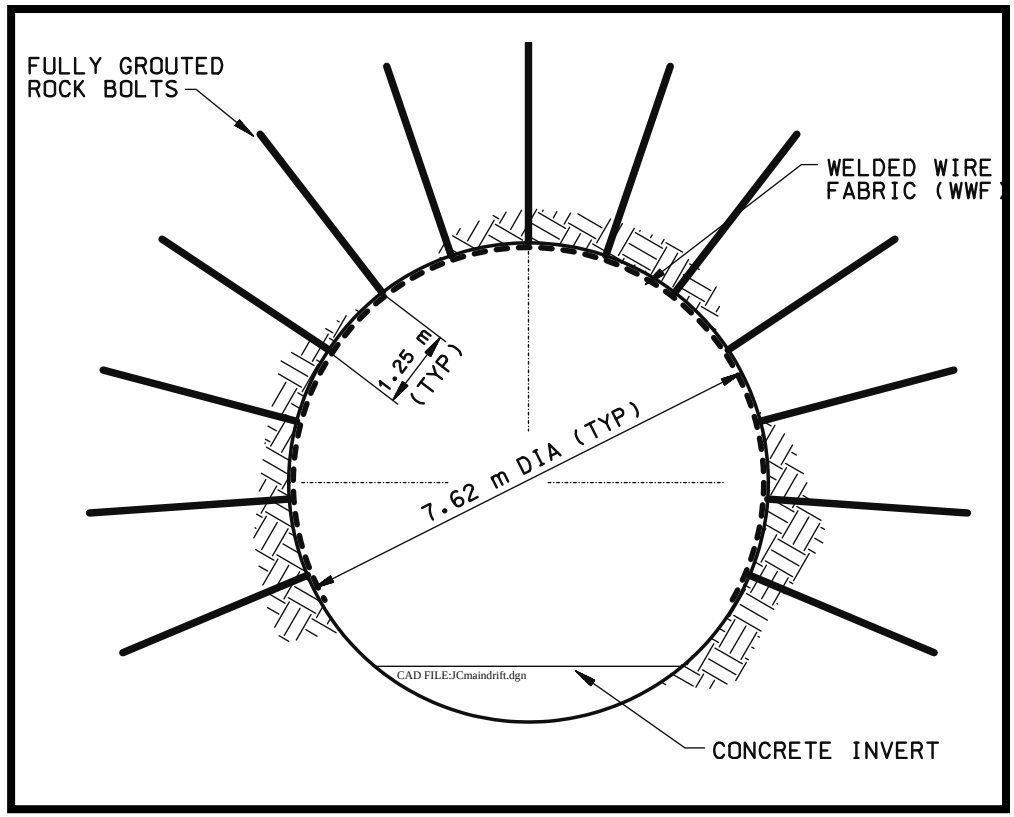
Ground Support for Non-Emplacement Openings

- **Access and exhaust mains; ramps**
  - Fully grouted rock bolts, typically spaced at 1.25 m
  - Welded wire fabric installed from springline to springline or below springline for raveling control
  - Materials made of carbon steel
- **Turnouts and intersections**
  - Fully grouted rock bolts
  - Wire mesh
  - Shotcrete (100 mm thick)
  - Lattice girders if required in wide spans
- **Shafts**
  - Rock bolts
  - Shotcrete or concrete (100 mm thick)



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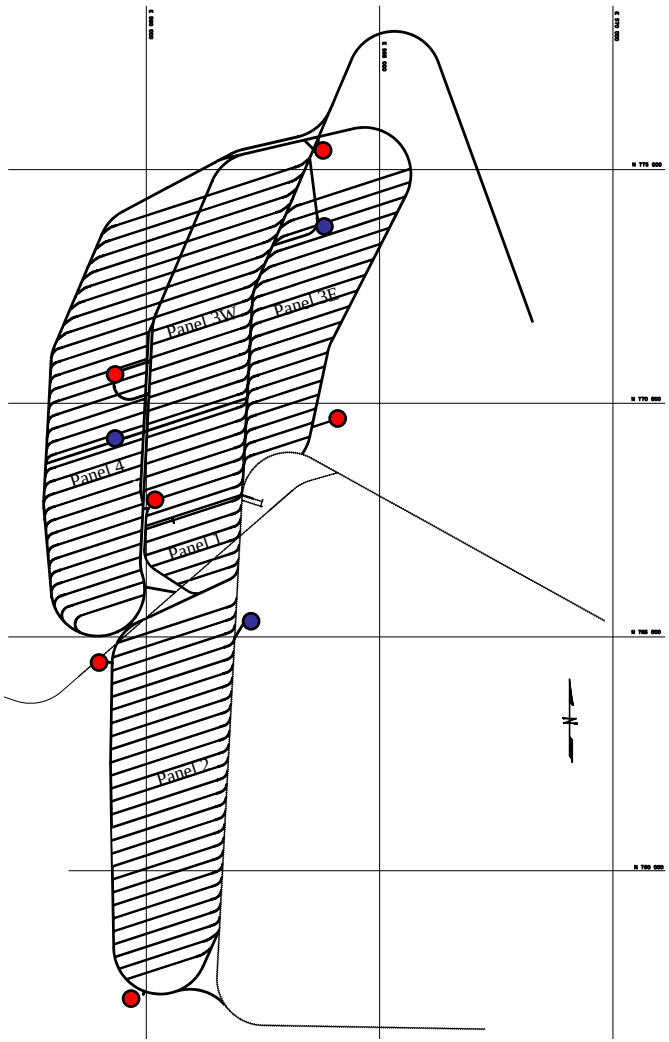
Forced Ventilation



- **Main Intakes:**
  - 3 shafts and 3 ramps
  - Total intake airflow rate: 1,700 m^3/s at 15 m^3/s per emplacement drift (includes leakage)
- **Main Exhausts:**
  - 6 shafts or raises
  - Total exhaust airflow rate: 1,900 m^3/s at 17 m^3/s per emplacement drift (includes leakage)
  - – Intake shaft
  - – Exhaust shaft or raise

Notes: Exhaust airflow greater than intake airflow to account for thermal expansion of air.

Estimated airflow rates are for emplacement drifts only.

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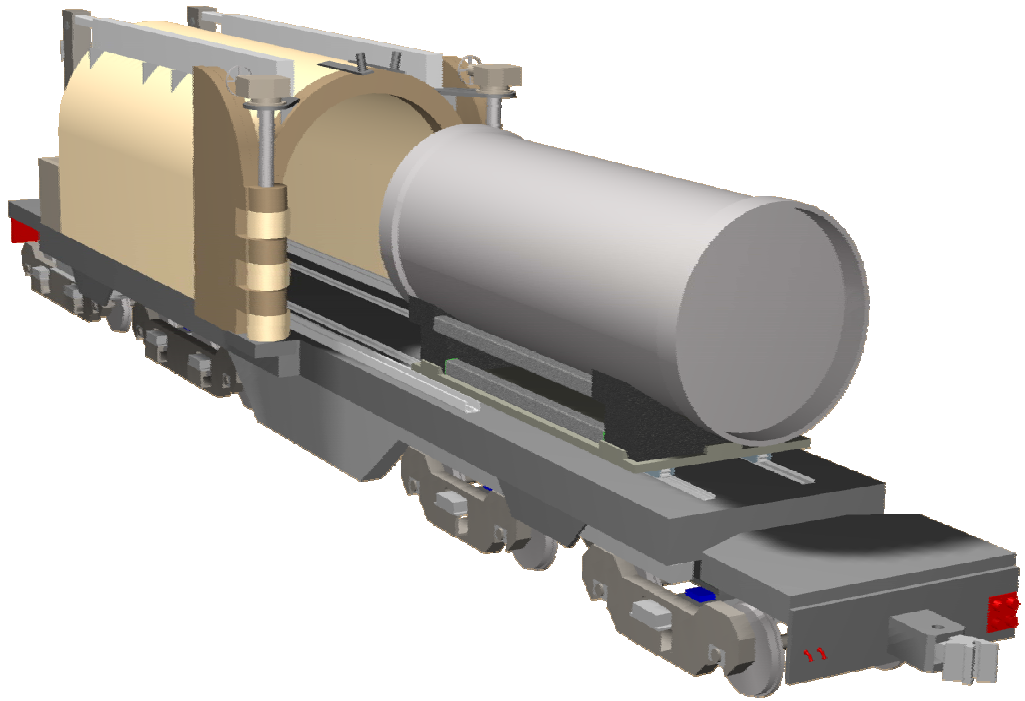
Waste Package Transporter

- Transports individual waste package on pallets from the surface facilities to the emplacement drifts
- Weight:
  - 350 tons loaded
  - 265 tons unloaded
- 5.0 mph maximum operating speed
- Two locomotives move transporter underground, one backs transporter into drift
- All manual and remote control operations are through the transport locomotives



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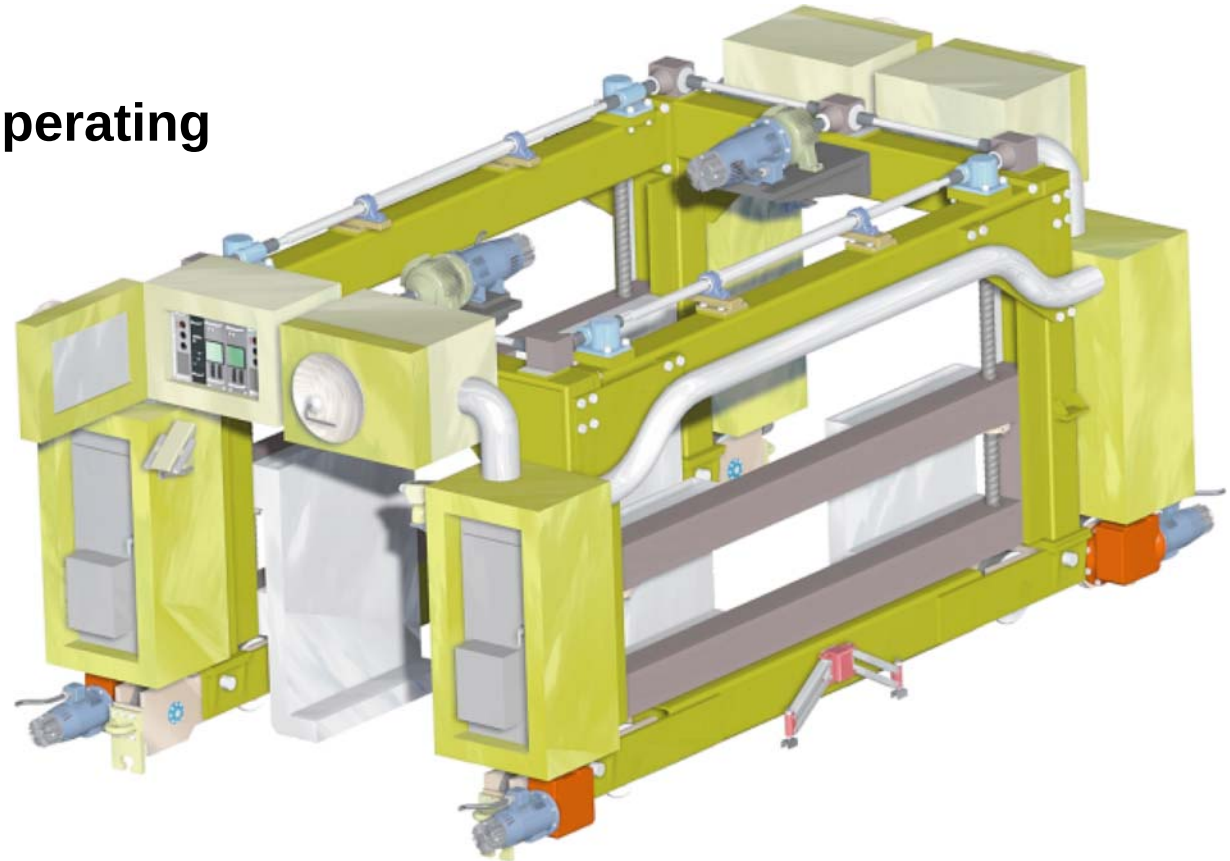
Emplacement Gantry

- **Moves and emplaces waste packages on pallets within emplacement drift**
- **40-60 tons weight**
- **1.7 mph maximum operating speed**
- **Remote controlled**



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Subsurface Facility Preliminary Preclosure Safety Analysis and Classification Results

- There are no Category 1 or Category 2 event sequences in the subsurface facilities
- Structures, systems, and components that prevent Category 1 or Category 2 event sequences are important to safety
- The following structures, systems, and components are important to safety because they are credited with prevention:
  - Waste package
  - Waste package transporter
  - Emplacement gantry

Subsurface Facilities Preliminary Classification Results

- **The following features are important to waste isolation because they are important to meeting 10 CFR 63.113 performance objectives**
  - **Subsurface facility**
  - **Drift inverts**
  - **Drip shields**
  - **Saturated zone (between repository and accessible environment)**
  - **Unsaturated zone (above and below the repository)**
  - **Waste packages**
  - **Commercial and naval spent nuclear fuel cladding**
  - **Waste form**

Subsurface Facilities As Low As Is Reasonably Achievable and Worker Safety

- **Unshielded waste packages are transported in a shielded transporter**
- **Drift turnouts are designed to reduce the dose rates in the access mains**
- **Emplacement drift ventilation control doors also provide personnel access control**
- **Differential pressure between emplacement and development areas**

Waste Package

Waste Package Design Process

- **Design for preclosure**
  - **Waste package is designed such that breach is beyond Category 2 for postulated event sequences to support the Preclosure Safety Analysis**
  - **The following postulated event sequences will be evaluated:**
    - **Object falls onto the waste package**
    - **Waste package drops, dynamic events, swingdowns, tipovers, etc.**
    - **Vibratory ground motions**
    - **Parametric fires**
    - **Preclosure design-basis rock fall**

Waste Package Design Process
(Continued)

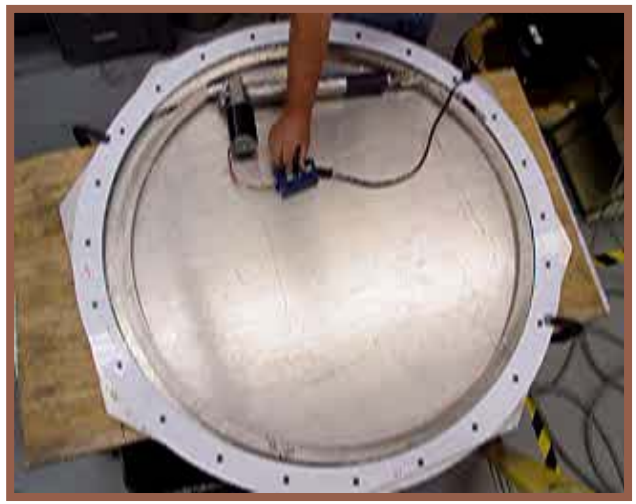
- **Analyze for postclosure**
  - **Analyze postulated events (drip shield installed) and provide information to support model abstractions for total system performance assessment, including assessment of corrosion potential**
    - **Damage from rock fall**
    - **Damage from vibratory ground motion**
    - **Weld flaw distribution**
    - **Waste package and weld area stress state**

Waste Package Design Changes

- **Recent design detail changes**
  - **Replaced the extended outer lid with a flat lid**
  - **Replaced induction annealing with either laser peening or low-plasticity burnishing as the outer lid closure weld stress mitigation technique**
  - **Changed the middle lid weld configuration from a full penetration weld to a fillet weld and deleted the stress mitigation step**
  - **Reduced the stainless steel inner lid thickness from 3 to 4 inches to 2 inches and changed the closure method from a full penetration weld to a spread ring with seal welds**
  - **Replaced the split trunnion collar design with a one-piece twist-on design**
  - **Changed the gap between the inner vessel and outer corrosion barrier to accommodate differential thermal expansion**

Waste Package Mockups

- **FY 2000 waste package mock-up (based on site recommendation design)**
  - **Fabricated a quarter-length test mock-up to investigate the feasibility of fabrication**
  - **Performed residual stress measurements before and after mock-up welding**
  - **Demonstrate machine welding and non-destructive evaluation techniques**
  - **Used in several development studies**
- **Spread ring mock-up**
  - **Mock-up of the single spread ring design and engagement tool was constructed**
  - **Operated successfully**



Waste Package Development Studies

- **Development studies serve several purposes:**
  - **Provide information and rationale for design and fabrication issues**
  - **Support analyses and model reports that are developed for total system performance assessment**
- **The following studies have been completed:**
  - **Weld Flaw Distribution**
  - **Induction Annealing**
  - **Laser Peening - Depth of Compressive Stress**
  - **Controlled Plasticity Burnishing - Depth of Compressive Stress**
  - **Residual Stress Measurement Analyses**
  - **Neutron Diffraction Analyses**

Waste Package Development Studies
(Continued)

- **The following studies are planned or continue in FY 04**
  - **Weld Material and Base Material Variability Study**
  - **Laser Peening and Controlled Plasticity Burnishing Corrosion Study**
  - **Fracture Toughness Study**
  - **Welding Interpass Temperature Study**

Waste Package Prototype Program

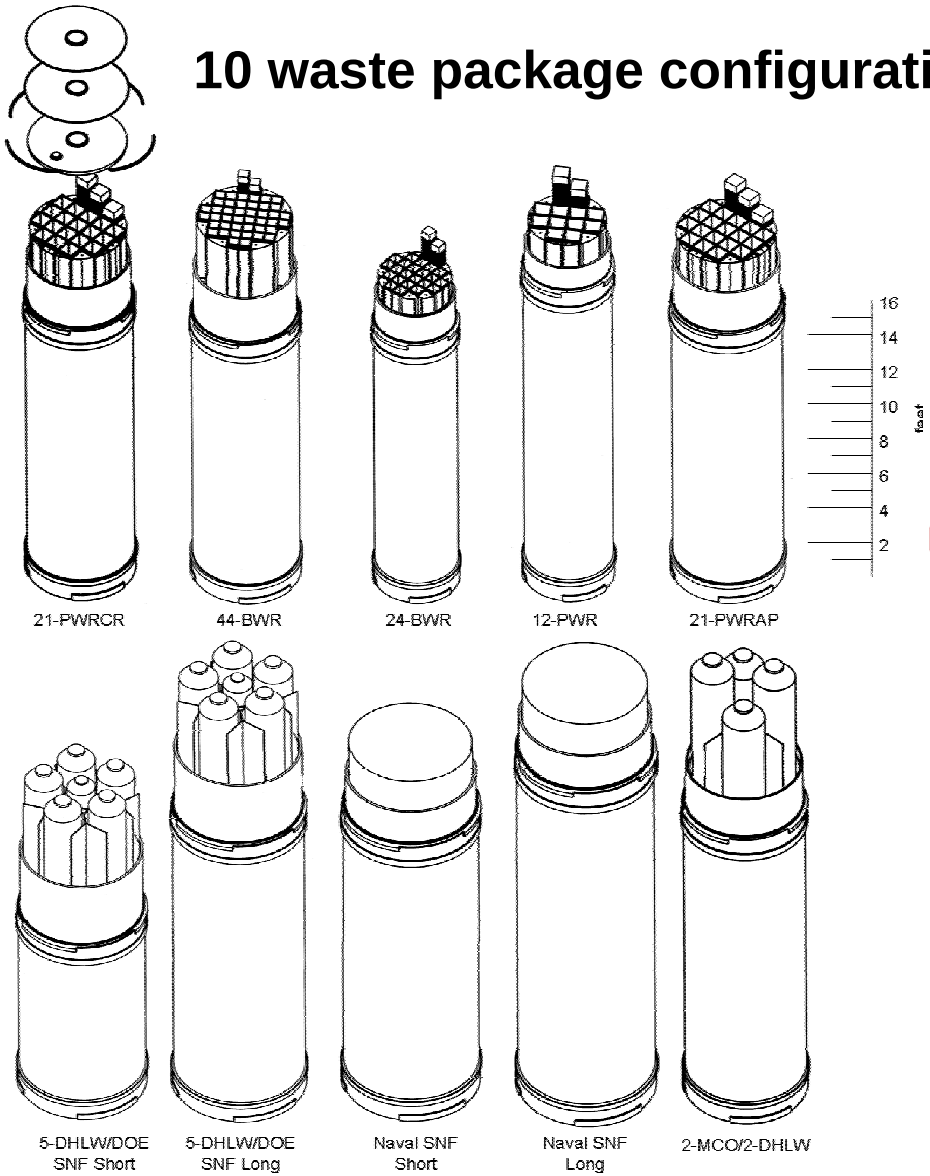
- **Prototyping is an integral part of design**
- **Prototyping will demonstrate the fabrication processes before manufacture of the production units**
  - **Ensures that waste packages can be manufactured as designed**
- **Prototypes will be used to:**
  - **Verify the closure processes and systems**
  - **Demonstrate waste package handling processes**
  - **Train operators for start-up and operations**

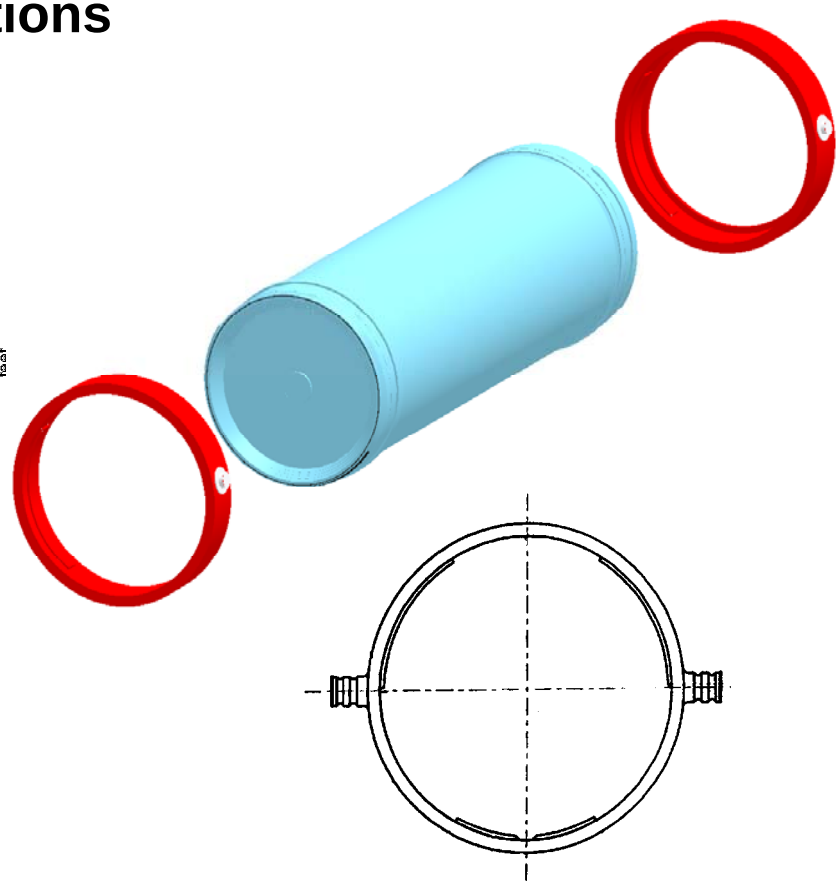
Waste Package Prototype Program
(Continued)

- **15 waste package prototypes have been planned, scheduled, and budgeted**
- **Prototypes will be produced over a six-year period from calendar year 2003 through 2008**
- **Request for proposal for the first waste package prototype procurement issued in July 2003**
  - **21 element pressurized water reactor waste package with absorber plates, full scale, includes all internals**
  - **Manufactured in strict compliance with all current design requirements including application of the American Society of Mechanical Engineers Section III Code N-Stamp**
- **Award of fixed-price contract is in process**

Waste Package Configurations

10 waste package configurations





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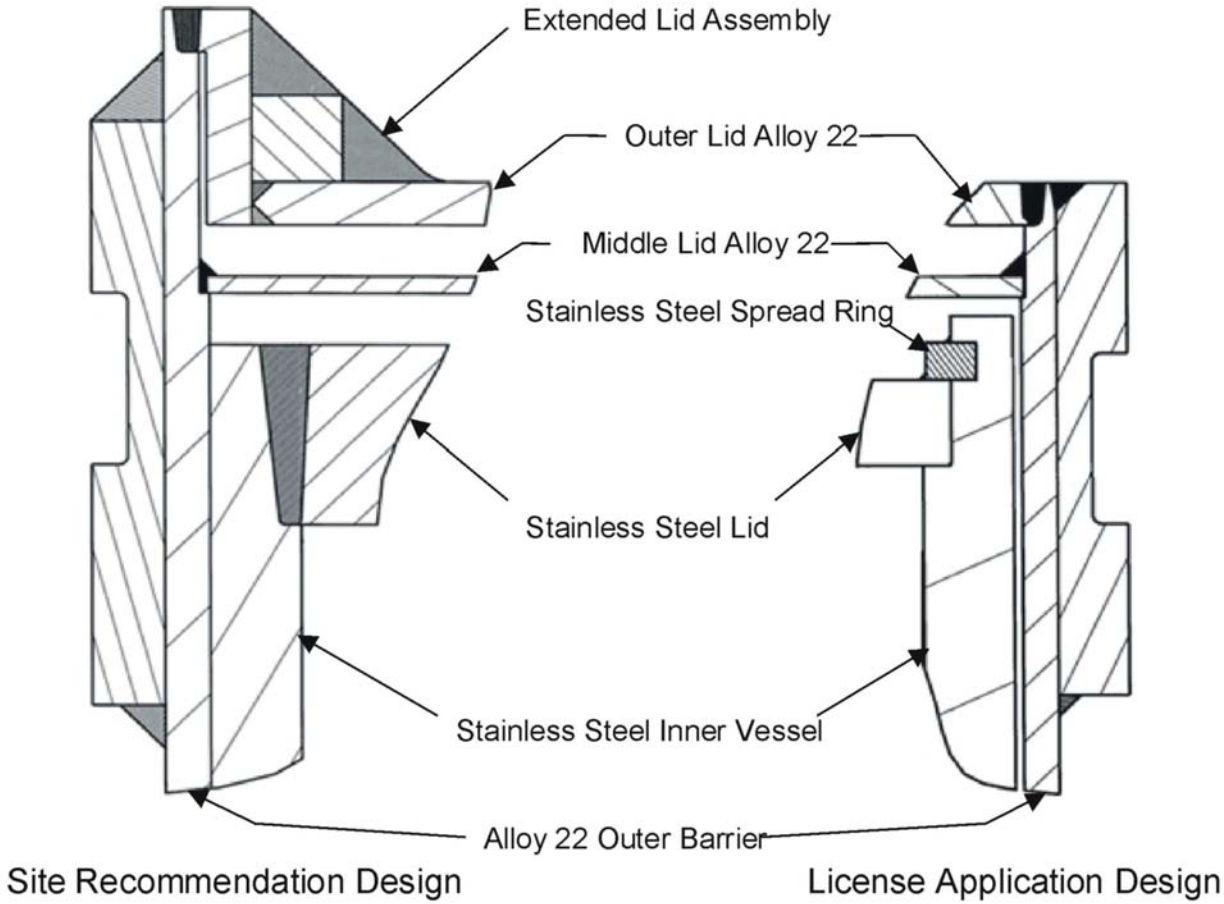
Waste Package Closure Details



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Drip Shield Design Process

- **Analyze for postclosure**
  - **Analyze postulated events and provide information to support model abstractions for total system performance assessment**
  - **Postulated events include:**
    - **Rock fall**
    - **Vibratory ground motion**

Drip Shield Design Changes

- **Potential drip shield design detail changes not yet adopted**
  - **Increased distance from drip shield to waste package to prevent drip shield contact with the waste package in the event of rock fall**
  - **Increased stiffness for bending loads and stresses along the bulkheads**
  - **Added longitudinal stiffener beams between the bulkheads along the axial direction, to provide additional strength for bending loads along axial length**
  - **Simplified handling and interlocking features**
- **Material selection remains unchanged**

Drip Shield Illustration

This drawing is preliminary and not intended for construction, procurement, or fabrication.

Waste Package Preliminary Preclosure Safety Analysis Results

- **Preclosure safety considerations**
  - **The waste package design considers both Category 1 and Category 2 event sequences as defined by preclosure safety analysis**
  - **Waste package breach is therefore beyond Category 2**

Waste Package Preliminary Classification Results

- **The following structure, system, and component is important to safety:**
  - **Waste package**
- **The following features are important to waste isolation:**
  - **Waste package**
  - **Drip shield**

Summary

- **Preliminary preclosure safety analysis indicated April 2003 design would be able to meet regulatory performance objectives**
- **Structures, systems, and components which are important to safety have been identified**
- **Engineered features which are important to waste isolation have been identified**
- **Complete design development to support License Application**
- **Preclosure safety analysis to be updated based upon final License Application design**
- **No new event sequences are anticipated, so ability of License Application design to meet regulatory performance objectives is expected**