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Handling and Emplacement Options for Deep Borehole Disposal Conceptual Design

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Outline

Background

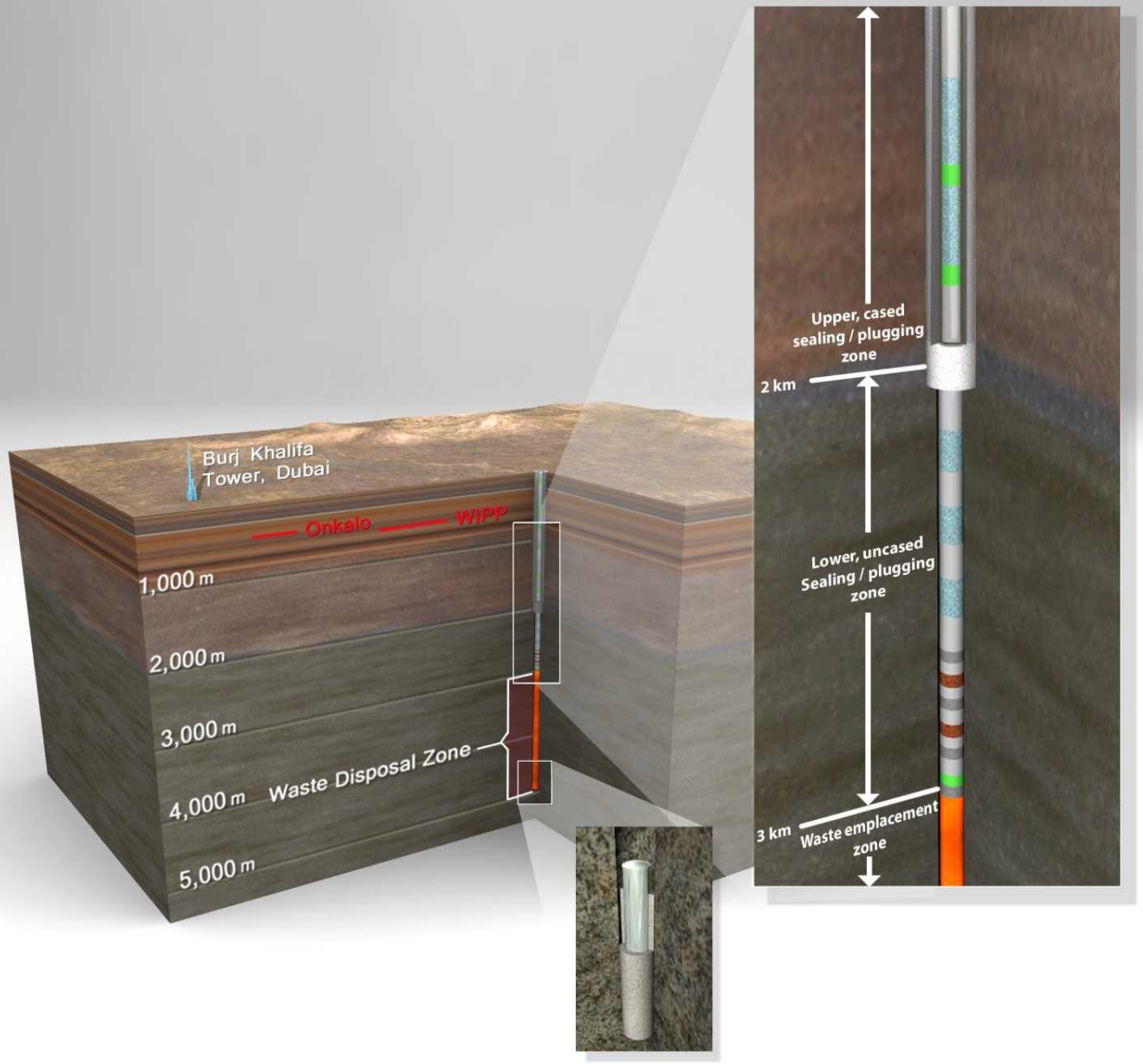
- Overview of Deep Borehole Disposal Concept
- Viability and Safety of Deep Borehole Disposal
- 2011 Reference Design for Deep Borehole Disposal

Focus on Waste Handling and Emplacement

- Handling and Emplacement Scope
- Waste Characteristics and Waste Form
- 2011 Reference Design for Waste Handling & Emplacement
- 2011 Reference Design in pictures
- Updating 2011 Reference for Handling and Emplacement

Overview of the Deep Borehole Disposal Concept

- Disposal of radioactive waste in a borehole or an array of boreholes in crystalline basement rock to about 5,000 m depth
- Waste, in disposal overpacks, placed in the lower 2,000 m of the borehole
- Upper 3,000 m of borehole sealed with compacted bentonite clay, cement plugs and other nonporous materials
- Concept being developed for Used Nuclear Fuel (UNF) and High-Level Waste (HLW)



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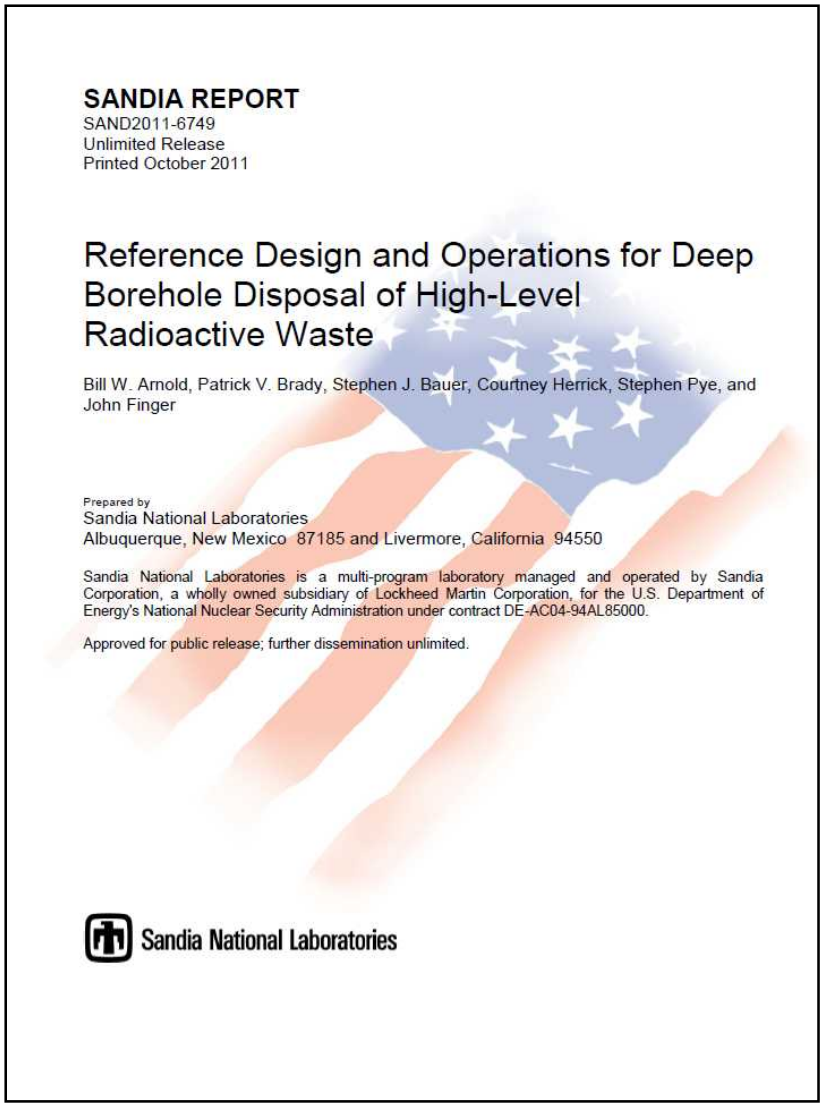
Viability and Safety of Deep Borehole Disposal Concept

- Strong evidence that the groundwaters in deep crystalline basement are very isolated from shallow fresh groundwaters
- Solubility of radionuclides is limited by geochemically reducing conditions at depth
- Much deeper than normal human activities, including drilling in crystalline rocks
- Crystalline basement rocks are common in many stable continental regions
- Existing drilling technology permits dependable construction at acceptable cost

2011 Reference Design for Deep Borehole Disposal Concept

- **2011 Reference Design for a *simple and off-the-shelf* waste disposal system that provides:**
  - **reference for performance assessment**
  - **reference for costing**
- **But, lacks high-resolution details**



SANDIA REPORT
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Reference Design and Operations for Deep Borehole Disposal of High-Level Radioactive Waste

Bill W. Arnold, Patrick V. Brady, Stephen J. Bauer, Courtney Herrick, Stephen Pye, and John Finger

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FOCUS ON:
WASTE HANDLING AND EMPLACEMENT

Scope of Waste Handling and Emplacement

- Equipment and activities for above-grade handling and borehole emplacement of disposal overpacks to about 5 km depth

- Handling and Emplacement for 3 purposes:
  - Anticipated disposal of UNF and HLW
  - The Deep Borehole Field Test
  - Possible disposal of Cs & Sr capsules from Hanford

Waste Characteristics and Waste Form

- **Waste characteristics:**
  - **Radiologically hot – 1,000's rem/hour contact dose**
  - **Thermally hot**
    - **~ 500 w per meter length of UNF**
    - **200 – 400 w per meter for Cs Sr capsules**

- **Waste form:**
  - **Waste canister, inside a disposal overpack**
  - **Disposal overpack:**
    - **~ 11 inches x ~17.7 feet**
    - **~ 2 metric tones (4,400 lb.) dry weight**

2011 Reference Design for Waste Handling and Emplacement

- **2011 reference design for waste handling and emplacement based on:**
  - **Woodward-Clyde Study (1983)**
  - **Spent Fuel Test-Climax at the Nevada Test Site (1978-1983)**

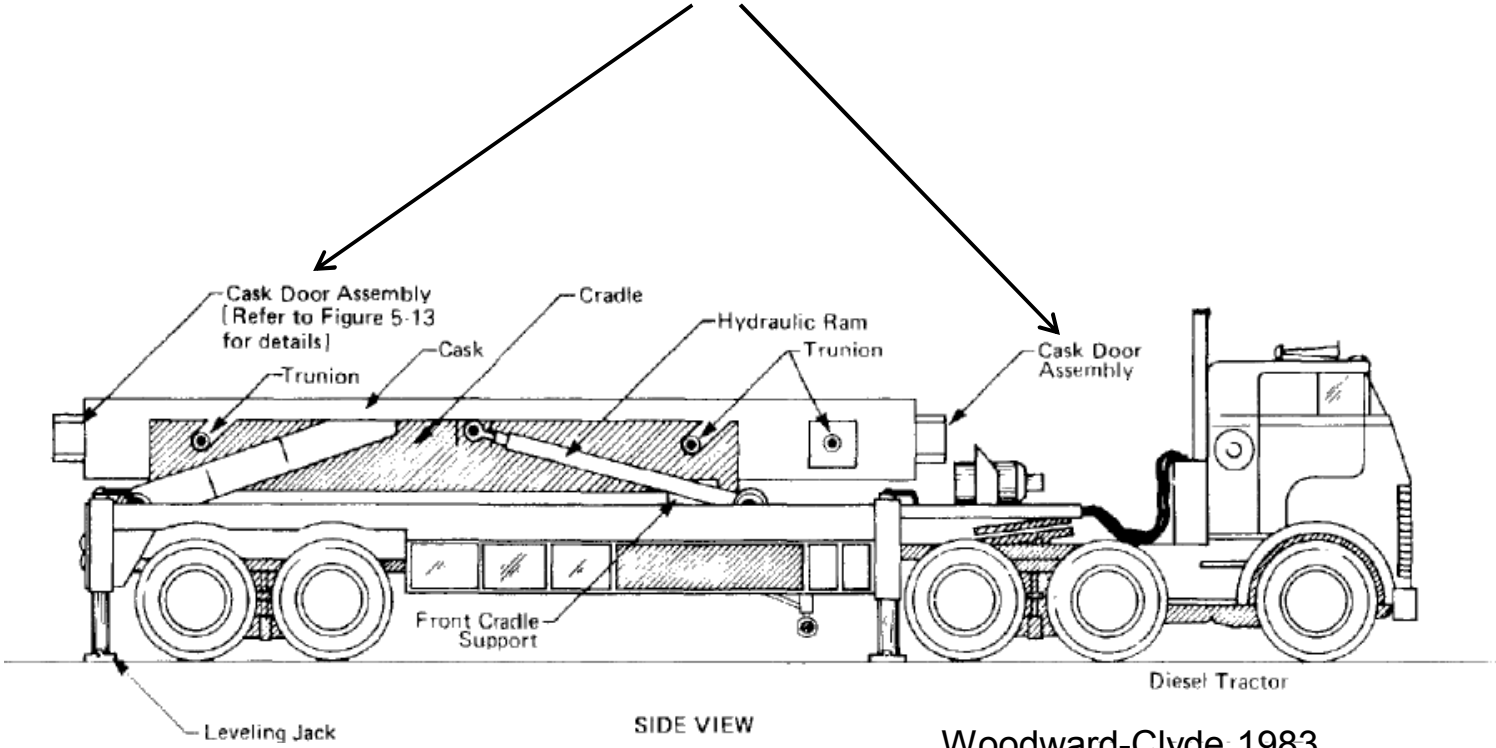
- **Woodward-Clyde - conceptual design of deep borehole disposal system – never tested**
- **Climax Study – Operational test where 11 UNF canisters were transferred to vertical storage holes, in the Climax Mine at 1365 ft depth on NTS, UNF canisters retrieved after 3 years**

2011 Reference Design for Waste Handling and Emplacement

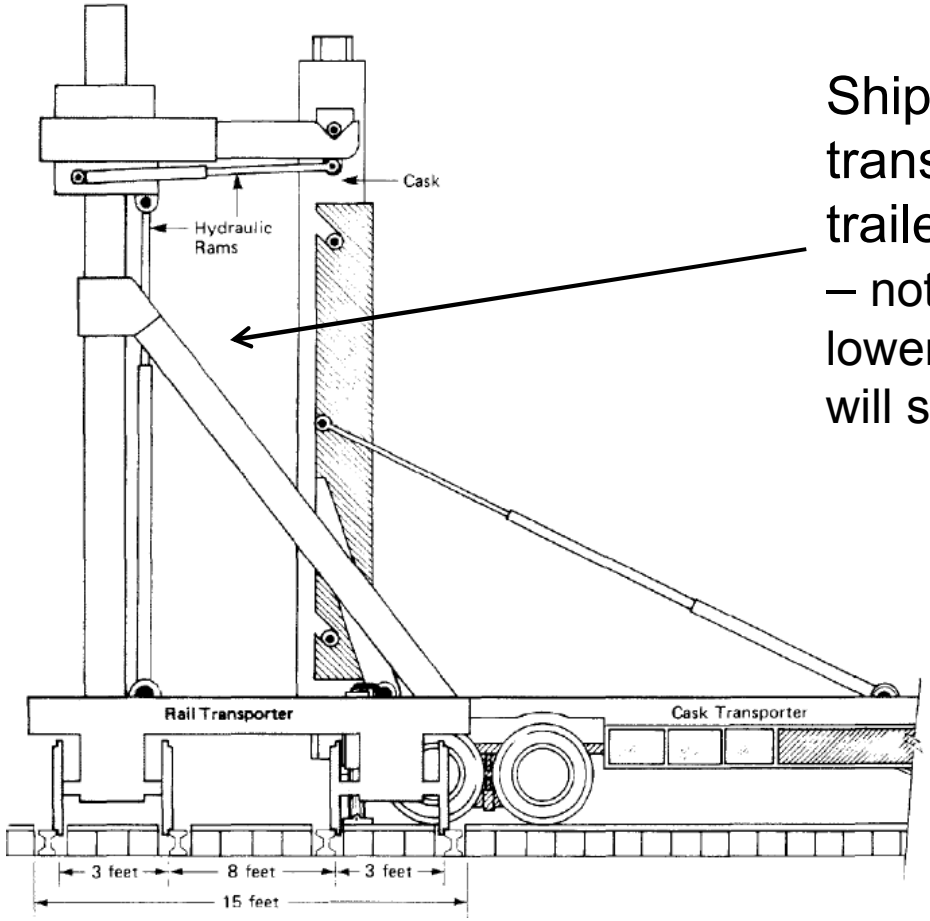
- Disposal overpack arrives by tractor trailer in Type B cask
- Surface handling rotates Type B shipping cask vertically and Type B cask is moved to special rail car
- Special rail car moves Type B shipping cask over borehole
- Disposal overpack lowered through Type B shipping cask into shielded remote handling area on top of borehole
- Disposal overpacks assembled into strings of 40 packages
- String of 40 disposal overpacks lowered by drill pipe to the disposal zone

2011 REFERENCE DESIGN IN PICTURES

Shipping cask on flatbed trailer – note lid on each end of the shipping cask



Woodward-Clyde 1983



Shipping cask being transferred from flatbed trailer to special rail car – note double rail tracks in lower left – double tracks will straddle borehole

Woodward-Clyde 1983

Climax Test with shipping cask turned vertically - note shielded lid on bottom of shipping cask (~1980)

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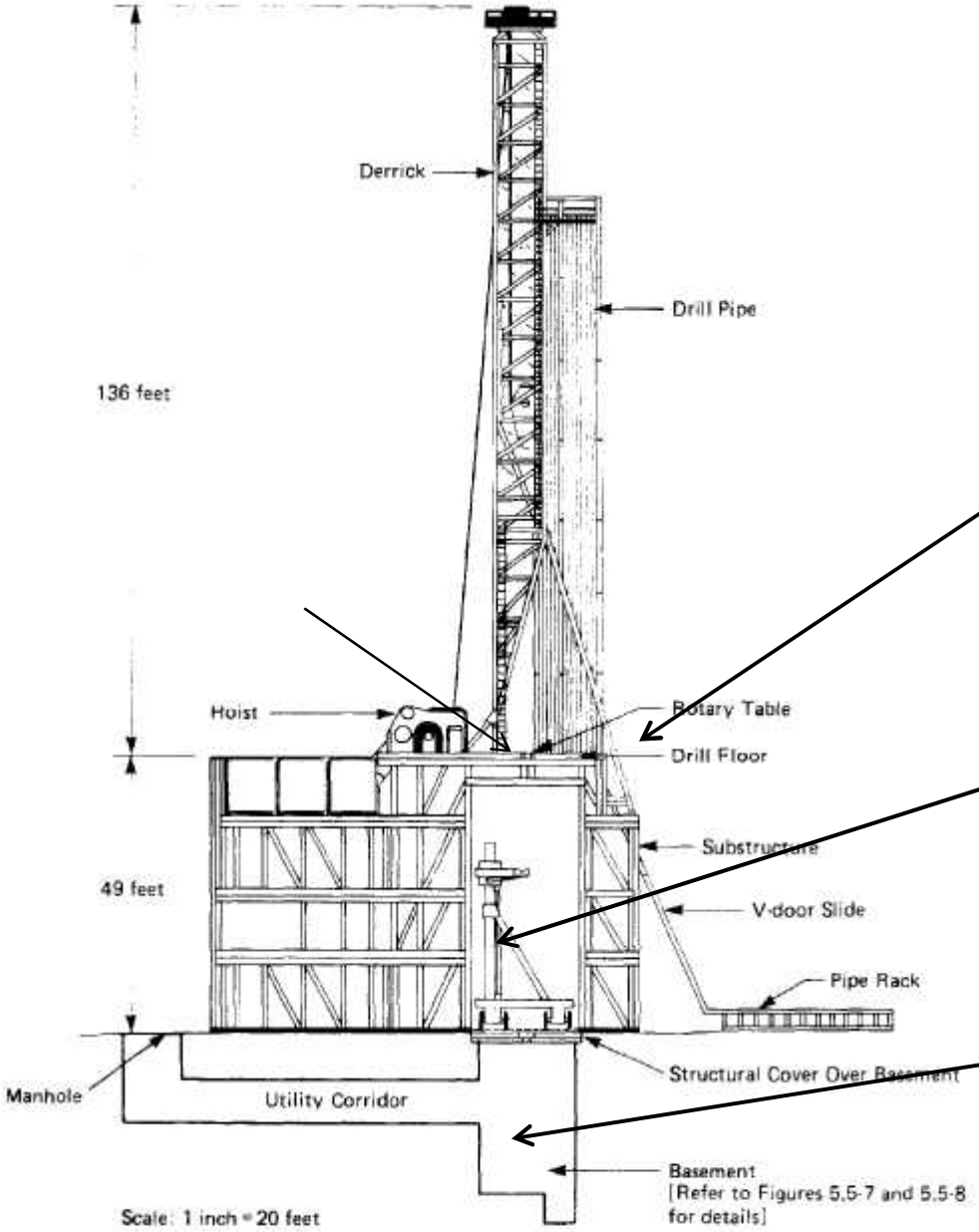


Emplacement rig floor is 49 ft above grade

Shipping cask on rail car over borehole

Shielded remote handling area (basement)

Woodward-Clyde 1983

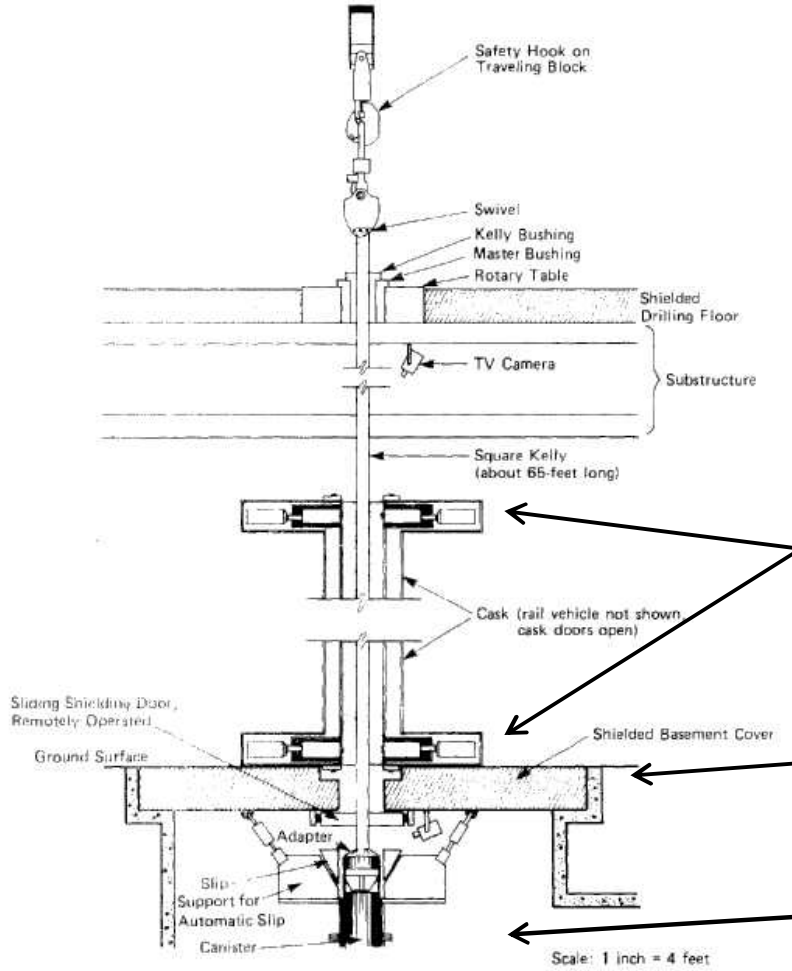


FIGURE 5-21
SCHEMATIC OF EMPLACEMENT FACILITY EQUIPMENT

Woodward-Clyde 1983

Equipment for transferring disposal overpack from shipping cask to shielded remote handling area over borehole

Lid on each end of shipping cask allows disposal overpack to be lowered into handling area

At grade, shielded floor

Shielded remote handling area (basement)

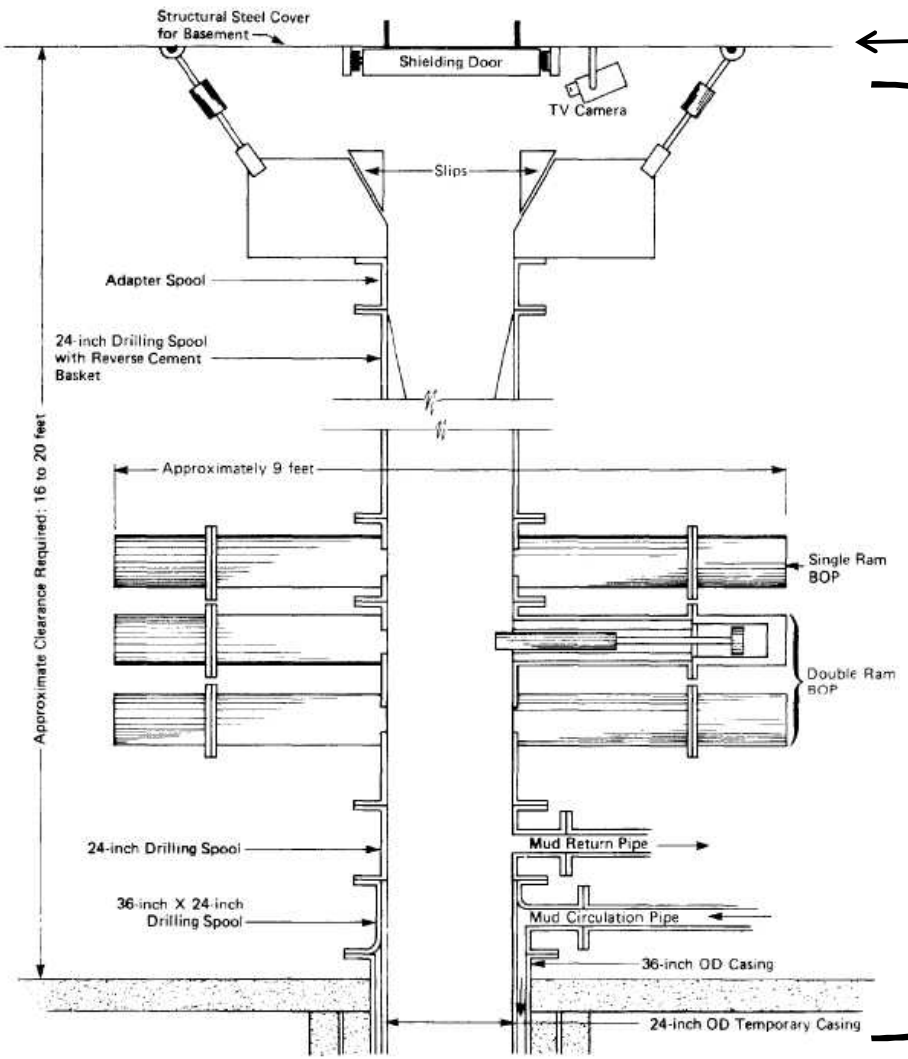


FIGURE 5-16

DETAIL OF EQUIPMENT IN BASEMENT

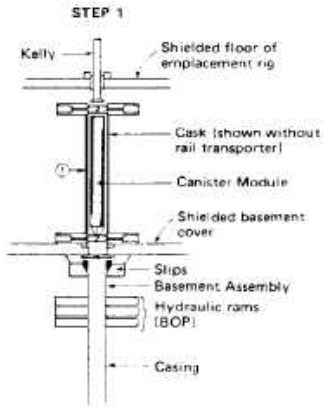
← At grade, shielded floor

Equipment in shielded remote handling area (basement) for assembling and holding strings of 40 disposal overpacks

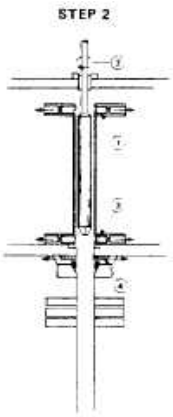
Woodward-Clyde 1983

13 steps to add one disposal overpack to the string of overpacks in shielded remote handling area – note string may hang in hole for 40 days to assemble string of 40 overpacks

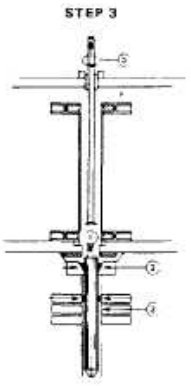
Woodward-Clyde 1983



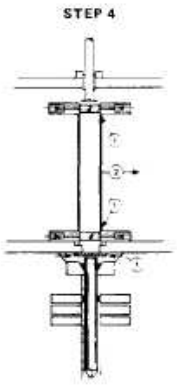
Cask containing waste module arrives on rail transporter and is positioned over the repository hole.



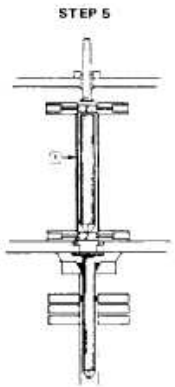
① Open upper shielding door of cask.
② Thread kelly to canister module.
③ Lift up attached canister module and open lower shielding door of cask.
④ Open basement shielding door.



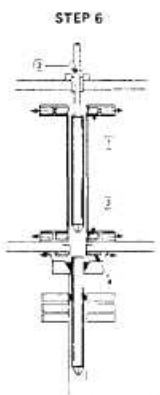
① Lower canister into basement assembly.
② Set slips and hydraulic rams to hold canister module.
③ Unscrew kelly and raise.



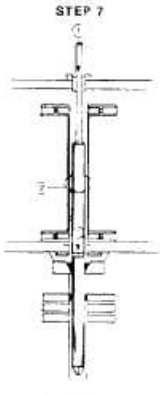
① Close basement shielding door and upper and lower cask doors.
② Move empty cask off the hole.



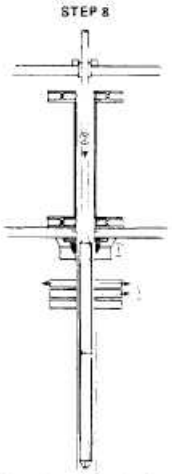
Cask containing another waste module arrives on rail transporter and is positioned over the hole.



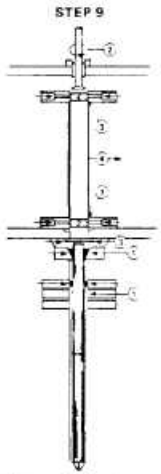
① Open upper shielding door of cask.
② Thread kelly to canister module.
③ Lift up attached canister module and open lower shielding door of cask.
④ Open basement shielding door.



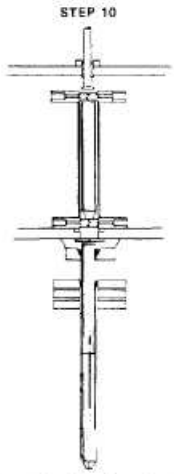
① Lower and position upper canister module over lower module.
② Screw canister modules together.



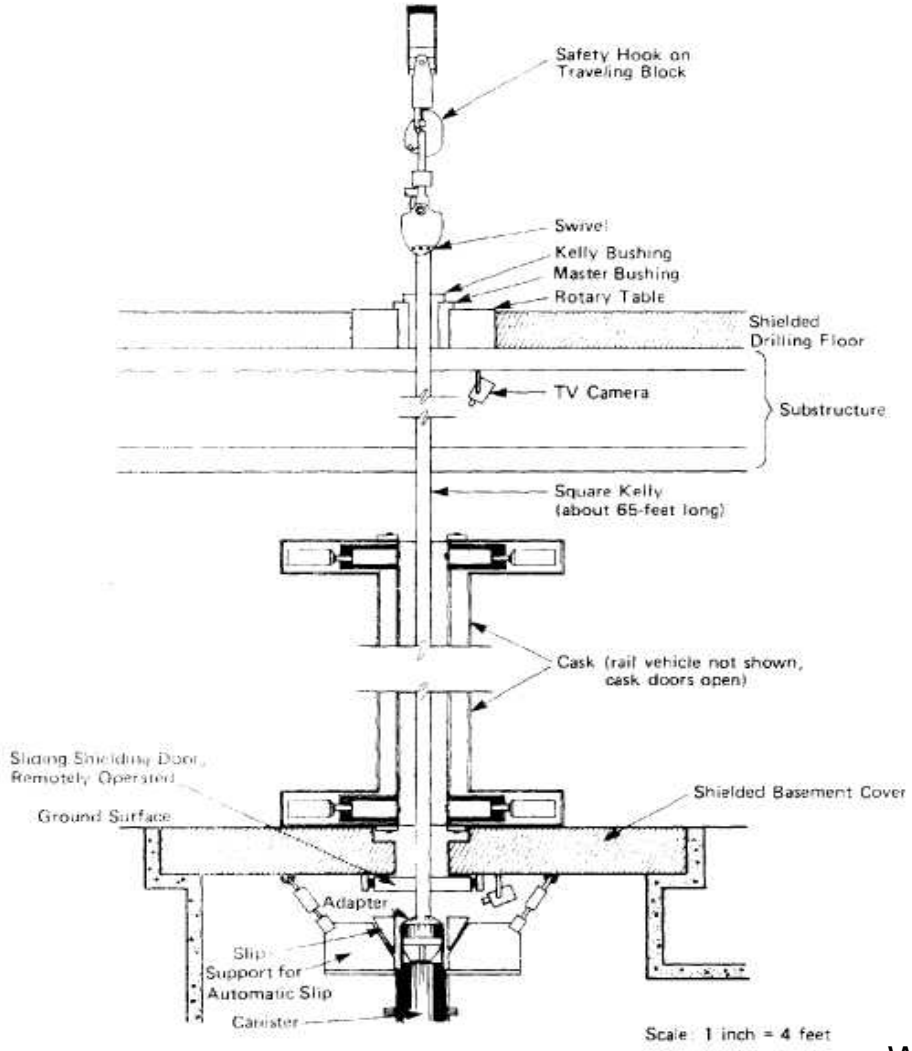
① Release slips and hydraulic rams.
② Lower upper canister module into basement assembly.



① Set slips and hydraulic rams.
② Unscrew kelly and raise.
③ Close basement shielding door and upper and lower cask doors.
④ Move empty off the hole.



Repeat steps 5 to 9 until waste module string is complete.



4½” drill pipe used to lower string of disposal overpacks to 5 km

Woodward-Clyde 1983

UPDATING REFERENCE DESIGN FOR HANDLING AND EMPLACEMENT

Handling

“Handling” includes the equipment and activities from receipt of the Type B shipping cask, to having disposal overpack vertically in borehole, ready to lower

Each disposal overpack:

- **~ 11 inches x ~17.7 feet**
- **~ 2 metric tones (4,400 lb.) dry weight**
- **Radiologically and thermally hot**

Handling Question 1

Type B shipping casks with a lid on each end, that can hold a 17 ft long disposal overpack, do not exist

Options:

- **Design, license, fabricate new Type B cask, or**
- **Transfer from Type B to onsite cask with 2 lids, or**
- **Free-air transfer from Type B into shielding remote handling area (basement)?**

Evaluation Criteria for all Handling and Emplacement Questions

1. Safety
2. Cost

Handling Question 2

Use (1) special railroad car and double tracks or (2) wheeled stack loader with cradle above borehole, to move Type B shipping cask over borehole?

Ability to carry 20 ft long Type B that weights 65,000 lb?

Handling Question 3A

- Lower waste overpacks in strings of 40, or lower single waste overpacks? (assume 400 overpacks per borehole)

- Strings of 40:
  - Remote handling equipment needed to build strings
  - Each string hangs in hole for ~ 40 days
  - Up to 39 overpacks hanging in hole
  - String is heavy (176,000 lb. plus factor of safety)
  - Limits emplacement options (due to weight)
  - Difficult for 660 ft rigid string to pass deviations in bore
  - 10 trips to TD and 100 km total travel distance

Handling Question 3B

- Lower waste overpacks in strings of 40, or lower single waste overpacks? (assume 400 overpacks per borehole)

- Single overpack:
  - No remote handling equipment to build strings
  - Only one overpack ever hangs in hole
  - Much lower weight (4,400 lb. plus factor of safety)
  - Many options for emplacement (e.g., wireline)
  - Easier for 17 ft string to pass deviations in bore
  - 400 trips to TD and 4000 km total travel distance

Emplacement

- "Emplacement" includes the equipment and activities necessary to lower waste overpacks to TD

- 11" OD waste overpack inside 12.5" ID guide casing
- Each waste overpack: ~ 2 metric tonnes (4,400 lb.)
- Chloride brine
- 170 C
- 10,000 psi downhole pressure

Emplacement Question 1

- Determine system for lowering waste overpacks:
  - Drill stem
  - Coiled Tubing
  - Slickline
  - Wireline
  - Self-emplacement
- How to emplace the disposal overpacks depends, in part, on what is being lowered (singles or strings of 40)

THANK YOU

BACKUP SLIDES

Tri-City Herald

February 25, 2015

By Annette Cary

Energy secretary: Some Hanford waste might go down deep boreholes

The cesium and strontium capsules stored at Hanford might be disposed of sooner if a demonstration project proposed for deep borehole disposal of radioactive waste is successful.

Energy Secretary Ernest Moniz discussed that possibility Wednesday at a House Science, Space and Technology committee hearing under questioning from Rep. Dan Newhouse, R-Wash.

Hanford has 1,936 capsules filled with strontium and cesium removed from the high-level waste tanks at Hanford in 1972 to reduce the temperature of the waste inside those tanks.

The capsules, which contain about a third of the total radioactivity at Hanford, are stored in an underwater pool in central part of the reservation. They had been planned to be sent to a proposed repository at Yucca Mountain, Nev., before the Obama administration stopped work on that facility.

Now a permanent federal repository for high-level waste is not expected to be available before 2048, but some DOE officials have proposed options that could dispose of some waste sooner.

- Conceptual Design FY15
- Final Design FY16
- Fabrication FY17
- Field Test FY18-19

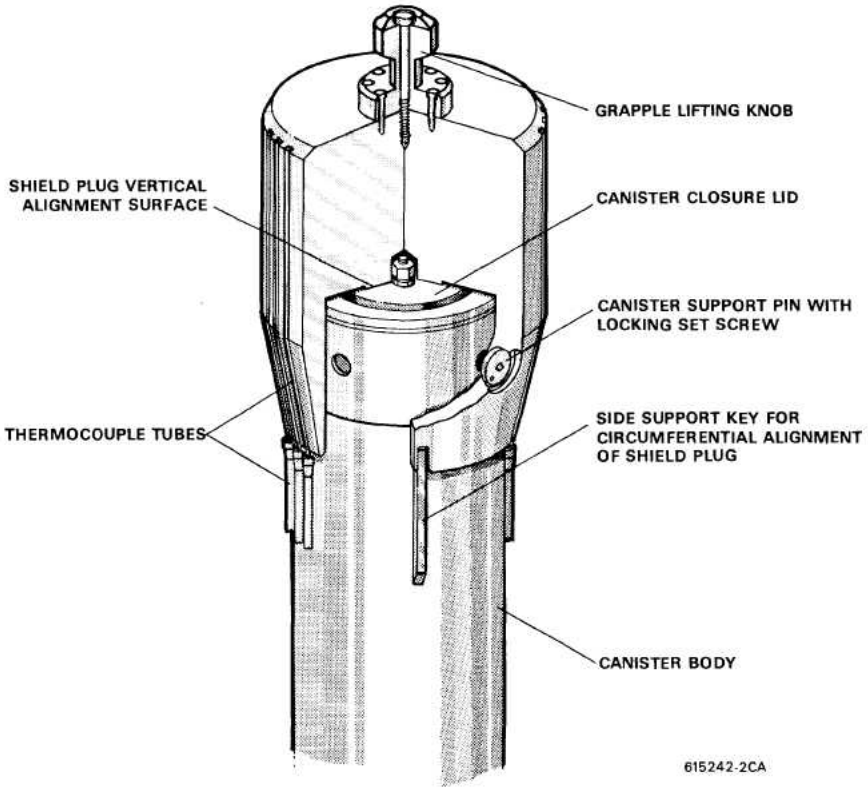


Figure 6.2-2. Canister/Shield Plug Mating Arrangement

Safety Assessment Document for … CLIMAX GRANITE STOCK, January, 1980)

Shielding plug is fabricated from carbon steel plate nominally 12 inches thick, welded to the bottom of the main body of the plug is an externally tapered (10° from centerline) skirt extension approximately 10 inches long and with an internal diameter of 14.50 inches. (p 6-9 *Safety Assessment Document for the SPENT REACTOR FUEL GEOLOGIC STORAGE TEST IN THE CLIMAX GRANITE STOCK at the Nevada Test Site*, January, 1980)).