Used Fuel Disposition Campaign

Handling & Emplacement Options Study for Deep Borehole

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Objective of Study

- **Develop conceptual design options for handling & emplacement of waste packages in 5 km deep boreholes**
- ***Handling*:**
  - Begins with onsite receipt of shipping cask containing a waste package
  - Ends with waste package locked in a receiving collar over the borehole
  - Includes equipment and activities
- ***Emplacement:***
  - Begins with waste package locked in the receiving collar
  - Ends when waste package is safely released in emplacement interval
  - Includes equipment and activities

Near-Orbit Activities

- **This study will influence other FY15 activities, including:**
  - *Disposal Waste Package Specifications*
  - *Shielding and Transportation Analysis*
  - *Emplacement Mode Hazard Identification and Analysis*
- **This study will be used:**
  - To brief subject-matter experts for the multi-attribute utility analysis
  - Subject-matter experts will recommend options to be presented in the FY15 Conceptual Design Report

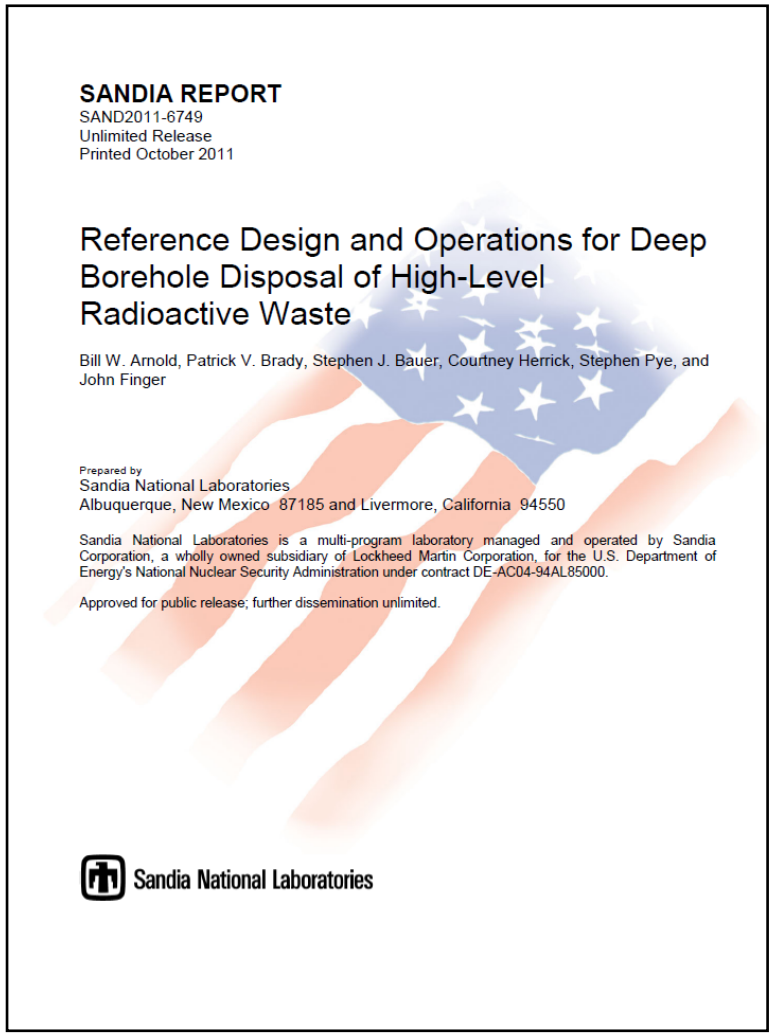
Waste Forms

- **Primarily for U.S. DOE-title wastes including:**
  - Compact HLW such as Hanford's Cs-137 and Sr-90 capsules
  - Bulk HLW such as granular calcine waste from reprocessing at Idaho
  - Used Nuclear Fuel

- **Waste characteristics:**
  - Radiologically hot – up to 1,000's rem/hour contact dose
  - Thermally hot - up to 400 w per meter for Cs Sr capsules

Began Options Study with 2011 Reference Design

- ***2011 Reference Design for a simple and off-the-shelf waste disposal system that provides:***
  - ***reference for performance assessment***
  - ***reference for costing***



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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2011 Reference Design for Handling and Emplacement Systems

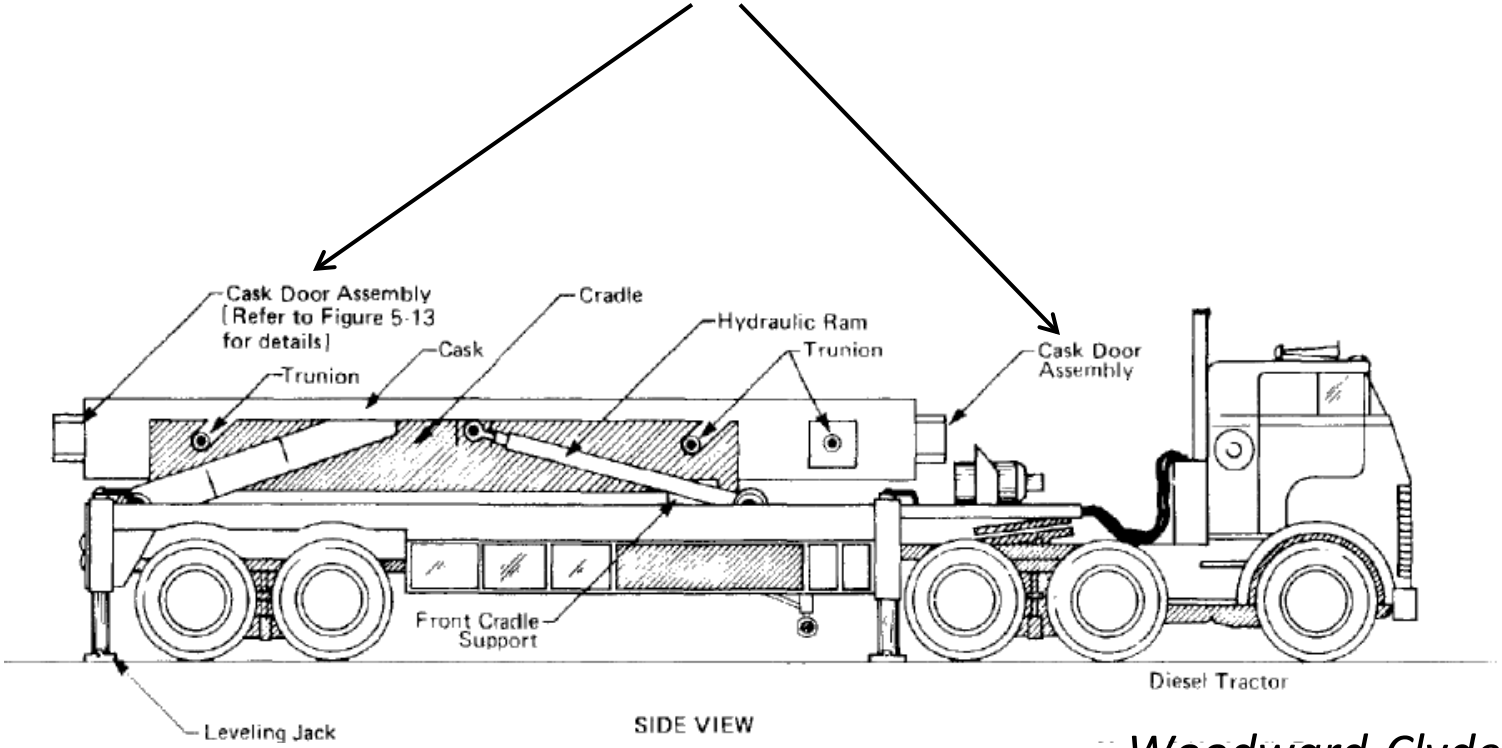
- 2011 reference design for waste handling and emplacement based on Woodward-Clyde Study (1983)
- Woodward-Clyde (1983) draws on “Climax Spent Fuel Test” (1978-1983) – Operational test where 11 UNF canisters were transferred to vertical storage holes, in the Climax Mine at 1365 ft depth on Nevada Test Site, UNF canisters retrieved after 3 years

2011 Reference Design for Handling and Emplacement System

- Waste package arrives by tractor trailer in Type B shipping cask
- Purpose-built Type B cask has doors at both ends
- Special rail car moves Type B shipping cask over borehole
- Waste package lowered through Type B shipping cask into shielded remote handling area on top of borehole
- Waste packages assembled into strings of 40 packages
- String of 40 waste packages lowered by drill pipe to the disposal zone

Shipping Cask in 2011 Reference Design

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



Woodward-Clyde 1983

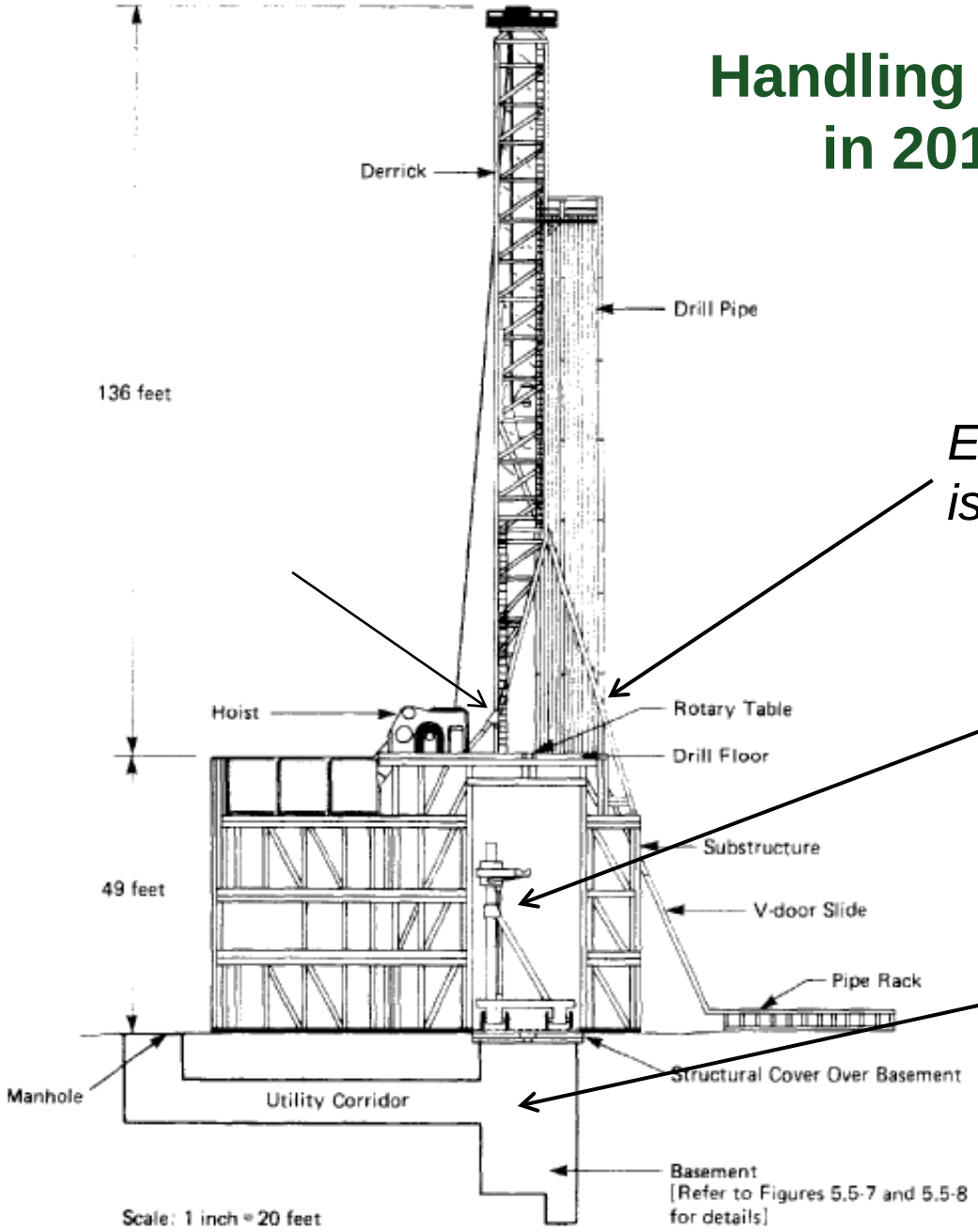
Shipping Cask in Climax Study (1978-1983)

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

Lowering Waste Through Shipping Cask in Climax Study (1978-1983)

Waste package being lowered through shipping cask into borehole, leading to Climax Mine

Handling & Emplacement System in 2011 Reference Design



Emplacement rig floor is 49 ft above grade

Shipping cask on rail car over borehole

Shielded remote handling area (basement)

Woodward-Clyde 1983

Emplacement System in 2011 Reference Design

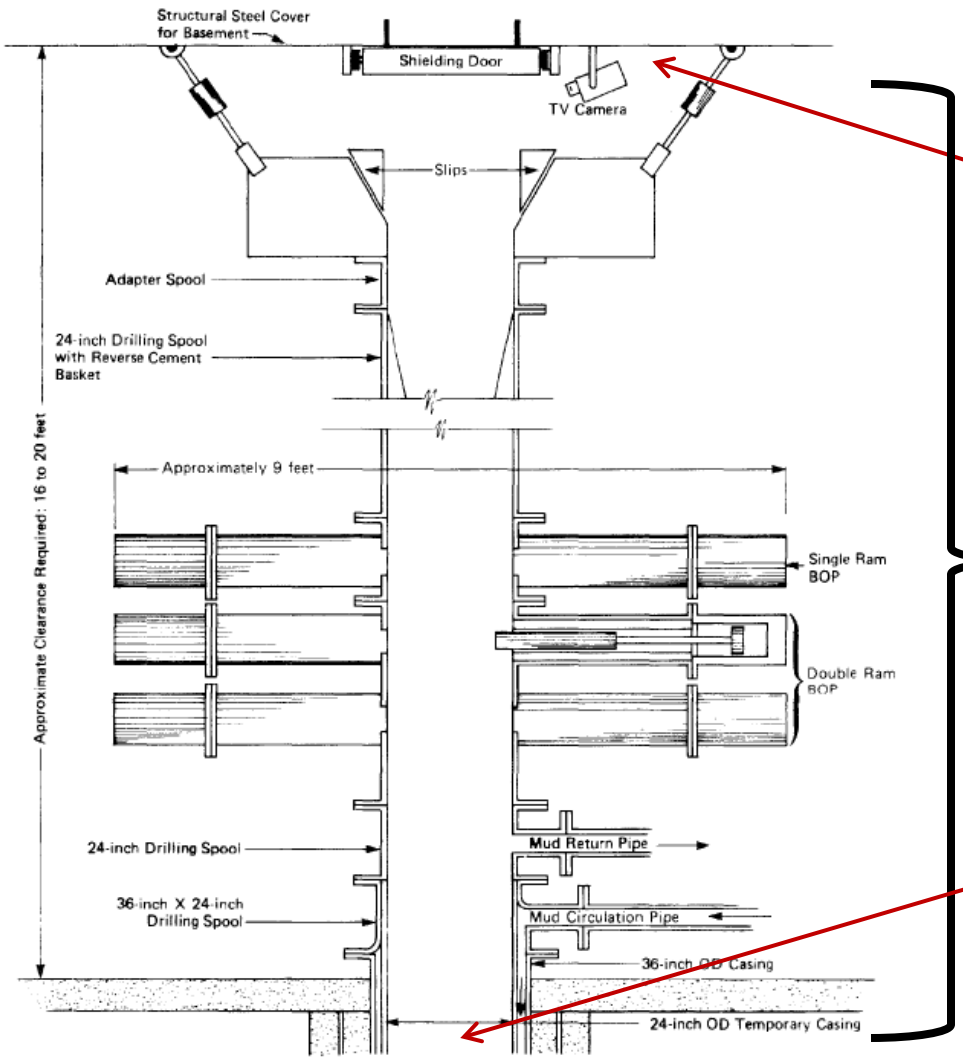


FIGURE 5-16

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

Emplacement borehole

Woodward-Clyde 1983

Remaining Presentation on Conceptual Design Options

Current Conceptual Design Options

1. **Drill-String Emplacement of Strings of 40 Waste Packages**
   - Undated version of 2011 reference system
   - Remotely assembling 40 packages into string, lower string with drill pipe

2. **Wireline Emplacement of Single Waste Packages**
   - Lower single waste packages using wireline

- **Same Waste Package for both options**
- **Developing conceptual designs of waste packages**

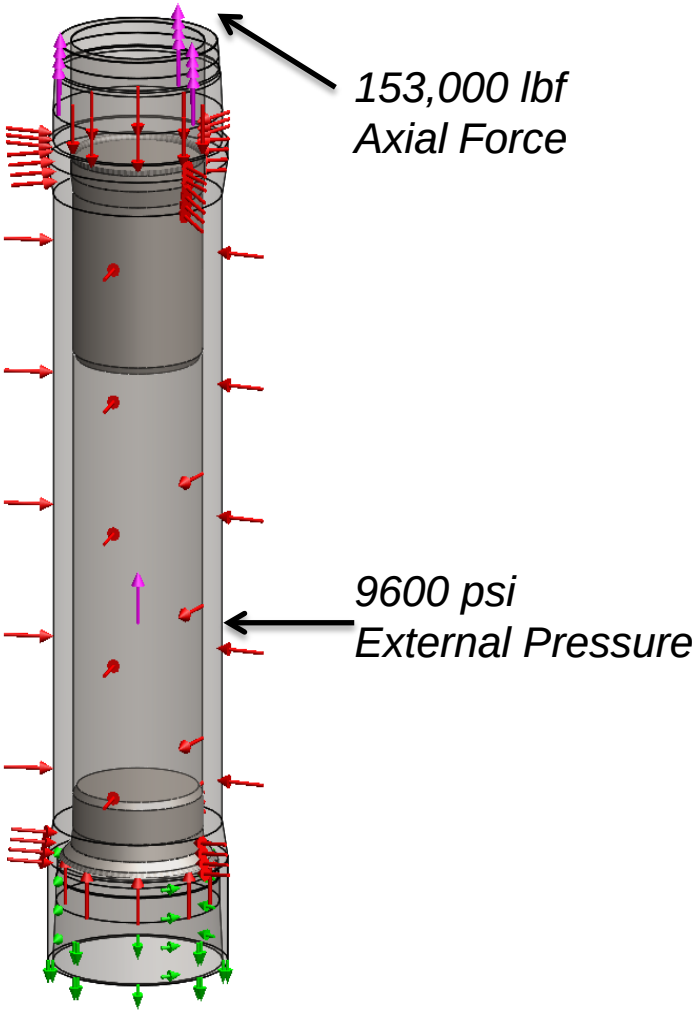
Waste Package Design Requirements

- Internal temperature: 480°F (250°C) or higher
- External temperature at 5 km: 338° F (170°C)
- Internal length: 17 ft (5 m)
- Maximum diameter: 11 in (28 cm)
- Exterior flush and free of sharp steps
- 12 inch shield on upper end

- Hydrostatic pressure at 5 km: 10,000 psi (65 MPa)
- Axial stress: 153,000 lb (70 MT) (weight of 40 packages)

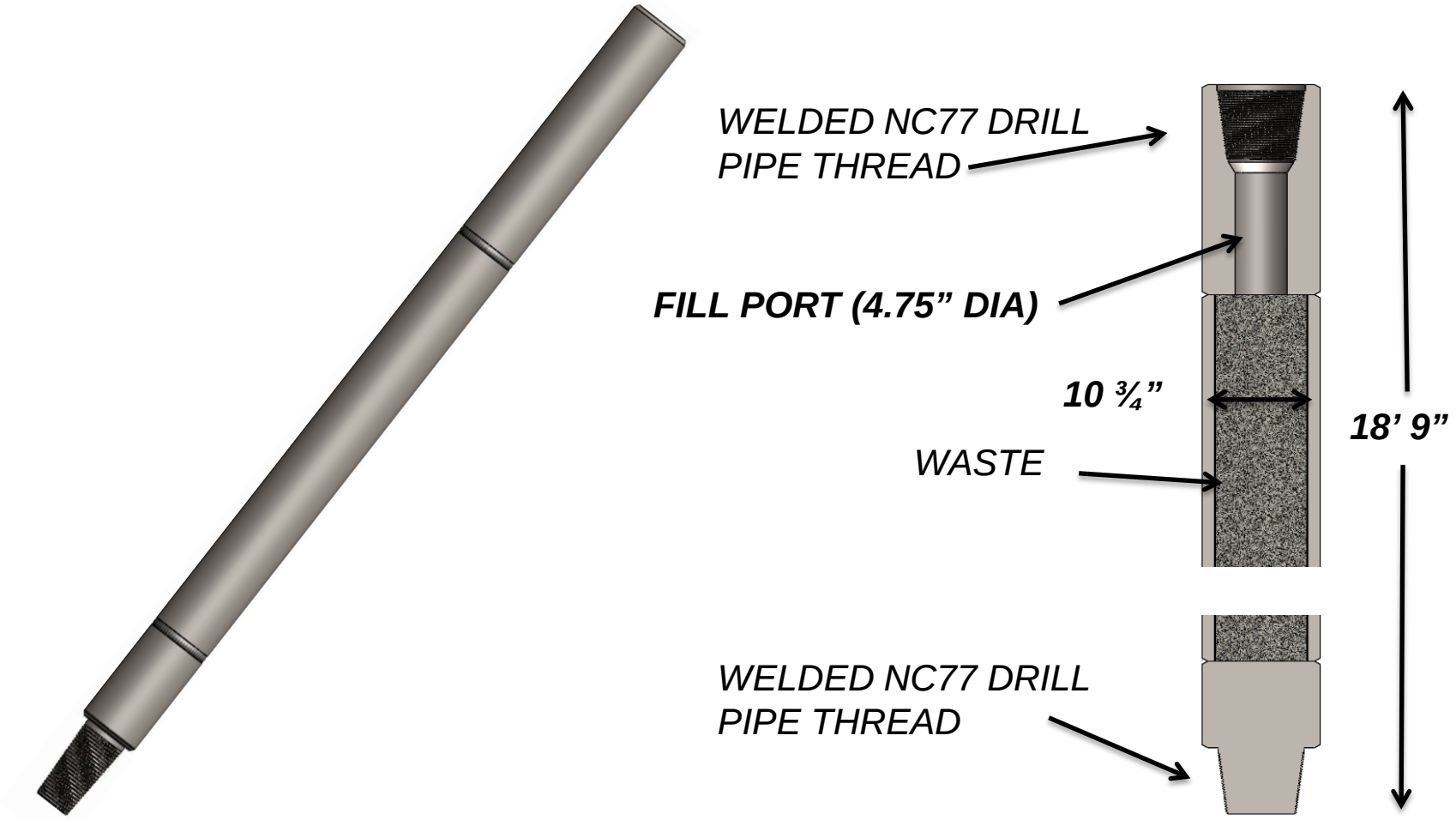
- Factor of Safety of 2.0

Waste Package Stress Analysis



Waste Package Design Analysis by Jiann Su SNL 6916

Example Waste Package Conceptual Design for Granular HLW

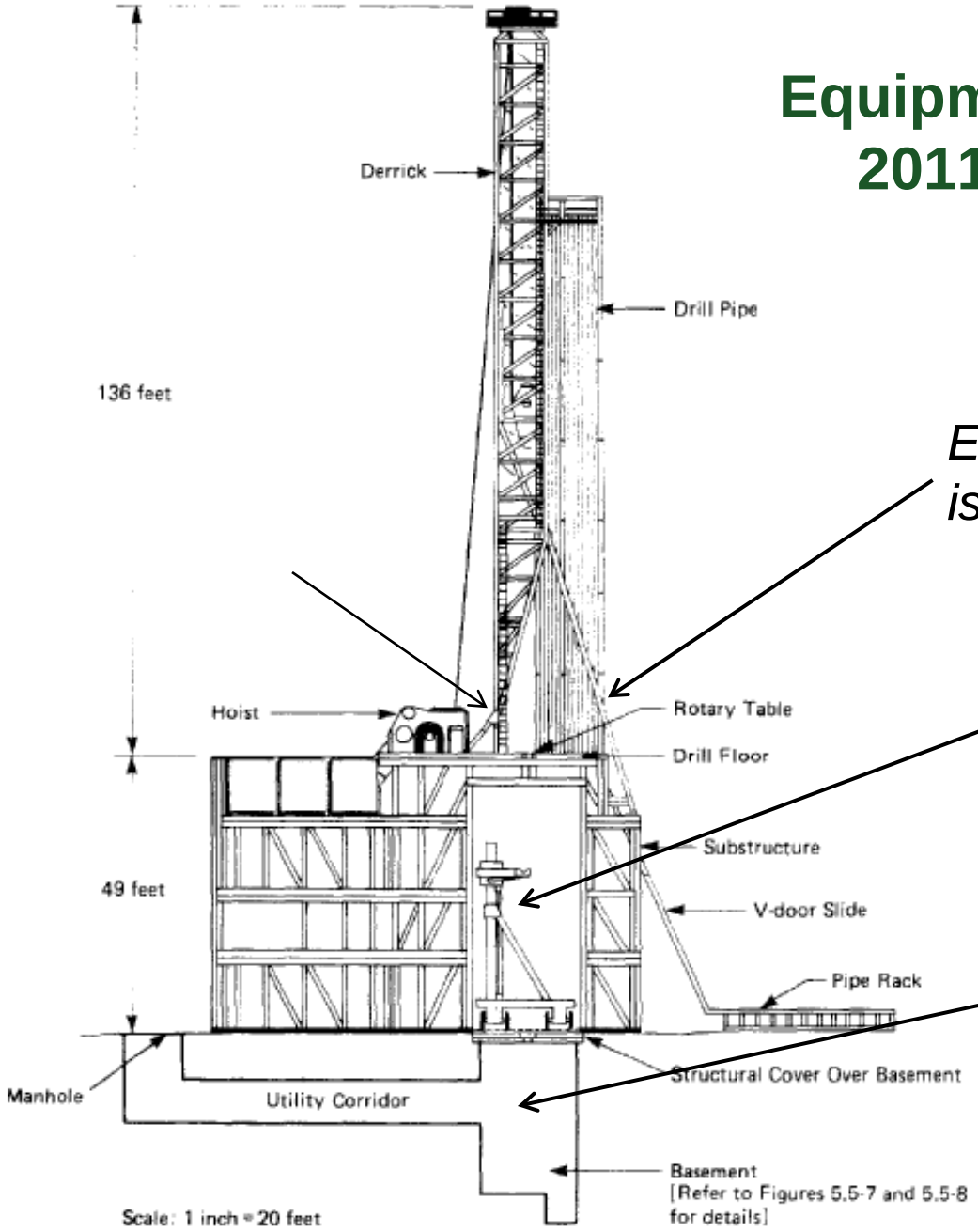


Drill-String Emplacement Option

Equipment for Drill-String Emplacement

1. **Shielded, Remote Handling Basement**
   - Subgrade, shielded room wrapped around borehole
   - 25 to 30 ft deep below grade
   - Triple blow-out preventer, power slips, mud handling, cameras, lights, etc.
   - Receiving collar over borehole, ~ at grade
2. **Emplacement Rig**
   - Rig floor 30 ft above grade
   - 1,000,000 lb capacity (string of 40 packages + 5 km drill pipe + FoS)
3. **Transfer Carrier – rail mounted carrier to move waste package over borehole**
4. **Control room – for command and remotely-controlled operations**
5. **Ancillary Surface Equipment – generators, mud handling, cementing, shelter, toilets, etc.**

Equipment Layout Similar to 2011 Reference Design



Emplacement rig floor is 49 ft above grade

Shipping cask on rail car over borehole

Shielded remote handling area (basement)

Woodward-Clyde 1983

Handling Steps for Drill-String Emplacement

- Waste package arrives in purpose-built Type B shipping cask on a flatbed trailer
- Radiological surveyed & “reciept” paperwork
- Remove impact limiters
- Use crane to bring shipping cask vertical
- Place shipping cask on transfer carrier
- Move cask to borehole, lower onto receiving collar
- Secure to receiving collar

Removing Impact Limiters

Removal of typical impact limiters (photo courtesy of Waste Control Specialists)

Emplacement Steps for Drill-String Emplacement

- Remotely open upper door on shipping cask
- Attach drill pipe to threaded connection on waste package
- Slightly lift waste package
- Remotely open the lower door on the shipping cask
- Lower first waste package into basement with drill string
- Grip package with power slips and elevator ram (redundancy)
- Remove drill pipe and shipping cask

- *Optimistically assume one package per day*

Emplacement Steps for Drill-String Emplacement

- Bring second waste package
- Remotely open upper door on shipping cask, attach drill pipe to threaded connection, lift slightly, remotely open the lower door on the shipping cask
- Lower waste package into basement with drill string
- Screw second waste package to first waste package
- Release power slips and elevator ram
- Lower both waste packages by one-package length
- Grip upper package with power slips and elevator ram
- Remove drill pipe and shipping cask

Emplacement Steps for Drill-String Emplacement

- Repeat 38 times, until string of 40 packages is hanging in hole
- String is 220 m (715 ft) long, weighs ~153,000 lb
- Use drill pipe to lower the string of waste packages to disposal zone
- Use both slips and pipe ram to hold each string of drill pipe, when adding next string of pipe (redundancy)
- If using 90 ft stands of pipe - repeat 172 times
- Assuming 7 minutes per 90 ft stand of drill pipe, ~ 20 hours to emplace the string and ~20 hours to trip out
- Set cement bridge plug

Wireline Emplacement Option

Equipment for Wireline Emplacement

1. **Blow-out Preventer Shielding Room**
   - Double BOP at ground level, with mud handling and cameras
   - Build shielded room wrapped around and over BOP
   - Shielding room ~ 10 ft tall
   - Receiving collar over borehole ~ 10 ft above grade
2. **Boom-Type Crane – to hold wireline sheave over the borehole**
3. **Wireline Hoist – Standard wireline truck with 20,000 ft of 0.488” diameter, double-armored 7-conductor electric wireline**
4. **Ancillary Surface Equipment – generators, mud handling, cementing, shelter, toilets, etc.**

Handling Steps for Wireline Emplacement

- Similar to steps for drill pipe emplacement – but there is no transfer carrier
- Crane lifts shipping cask from flatbed, and places on receiving collar
- Secure to receiving collar

Emplacement Steps for Wireline Emplacement

- Remotely open upper door on shipping cask
- Attach wireline cable head to waste package
- Slightly lift waste package
- Remotely open the lower door on the shipping cask
- Lower waste package to emplacement interval (~ 3 hours)
- Electrically release waste package
- Remove wireline and shipping cask
- After 40 packages are emplaced, set cement bridge plug

Summary

- **Reviewed 2011 reference design for handling & emplacement**
- **Discussed design criterial for waste package**
- **Presented example of conceptual design of waste package**
- **Described two conceptual design options:**
  1. Drill-String Emplacement of Strings of 40 Waste Packages
  2. Wireline Emplacement of Single Waste Packages
- **Summarized equipment needed for each option**
- **Summarized handling & emplacement steps for each option**