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Variation of the Deep Borehole Reference Design for Disposal of Vitrified High Level Waste

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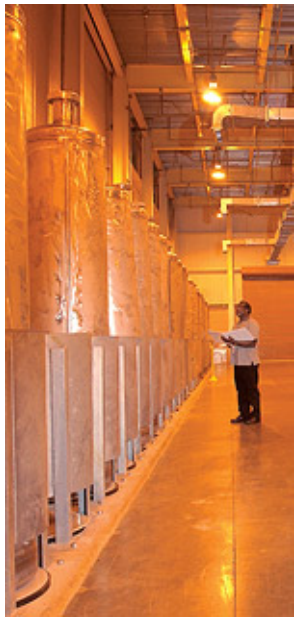
Vitrified High Level Waste: A Challenge for Deep Borehole Disposal



*Relative to the reference design, disposal vitrified HLW in deep boreholes will require:

- The redesign of treatment plants to accommodate smaller diameter glass logs.
- Approximately four times as many reduced volume canisters would have to be created and handled.
- Existing waste at West Valley and Savannah River would require reprocessing and repackaging into smaller canisters

Or could we modify the deep borehole design to accommodate the current canister design???

*U.S. Department of Energy (DOE), 2014, *Evaluation of Options for Permanent Geologic Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste in Support of a Comprehensive National Nuclear Fuel Cycle Strategy*, FCRD-USED-2013-000371, U.S. Department of Energy, Washington, DC.

Large Diameter Deep Boreholes

The Cannikin Example – 5 Megaton Spartan Missile Detonation

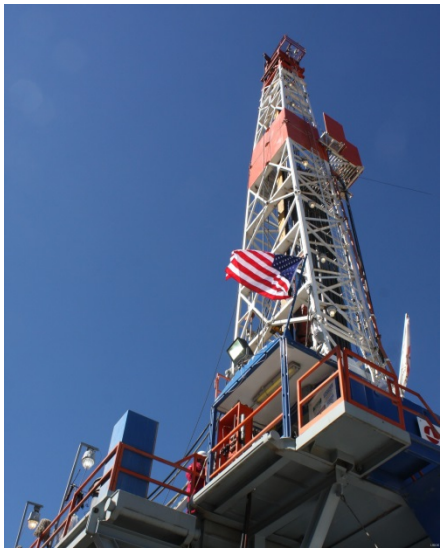
- First major project under the National Environmental Policy Act of 1969, which required the preparation of an "Official Environmental Impact Statement."
- Largest mined shaft in the United States with a single elevator to 6,000 feet.
- Deepest 90-inch hole—6,150 feet (1,875 meters)
- Cased hole using 54" casing
- Largest load lowered downhole—over 400 tons.
- Largest emplacement drill rig—1,000 ton mast.
- Drilled in hard rock (volcanics)
- Drilled without blow out preventer (BOP)

Deep Mine Shafts -Penna #3 shaft (LaRonde, Canada)

- Deepest single-lift shaft in the western hemisphere
- Depth: 2,259 meters
- Circular hole 5.5m diameter
- Drilled in hard rock (volcanics)

Large Diameter Deep Boreholes

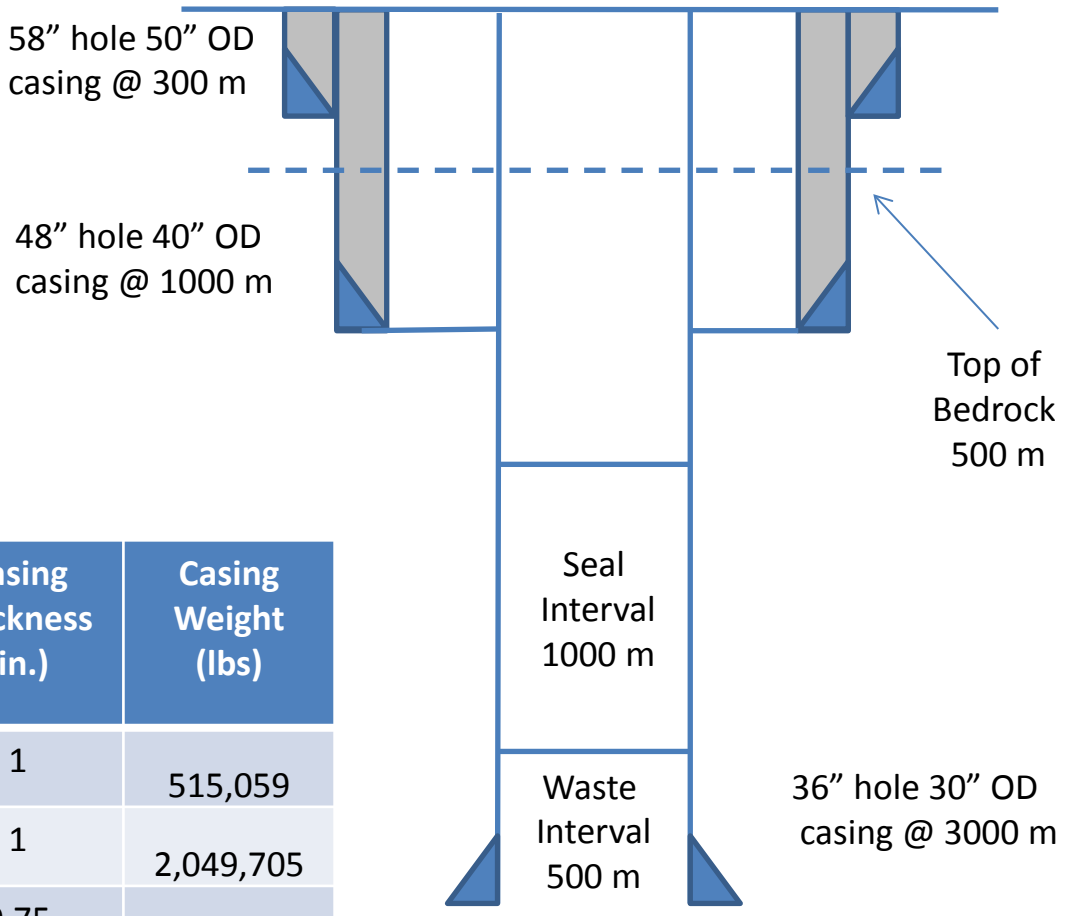
Beswick et al., 2014* propose the following design:



Depth (m)	Hole Diameter (in.)	Casing Diameter (in.)
0-500	60	54
500-1000	48	40
1500-2500	36	30
2500-5000	24 to 26	20

*Beswick A.J., Gibb, F.G., and Kravis, K.P. (2014) Deep borehole disposal of nuclear waste: engineering challenges. *Proceedings of the Institution of Civil Engineers,* 167, EN12. p.47-66.

Preliminary Large Diameter Deep Borehole Design For Vitrified HLW



Depth (m)	Hole Diameter (in.)	Casing Diameter (in.)	Casing Thickness (in.)	Casing Weight (lbs)
0-300	58	50	1	515,059
300-1000	48	40	1	2,049,705
1000-3000	36	30	0.75	2,306,102

Considerations for Very Large Borehole Design

- Proposed depth to bedrock is shallow relative to reference design (500-1000 m).
- The borehole redesign will likely require non-standard drilling equipment and techniques.
  - Largest available BOP is 30”
  - Hydraulic jacking system to lower casing
  - Large diameter bits (36” and greater)
- Characterization borehole becomes critical for the decision to proceed with drilling disposal borehole(s).
  - Stress state of rocks at depth
  - Over-pressured formations and well blow out risk
  - Establishing acceptable geochemical and hydrological conditions at 1500-3000 m.
- Can the current canisters (and canister designs) be emplaced in a deep borehole?
- Shallow borehole depths may necessitate an increased reliance on waste form and waste package performance.
- Very preliminary cost estimates suggest significant cost increase (50 million) in cost per borehole over the reference design.
- Current and Projected vitrified HLW can be disposed of in ~150 boreholes.

Questions/Comments/Discussion