Depleted Uranium Disposition Option: Beneficial Disposal in a High-Level-Waste Geologic Repository

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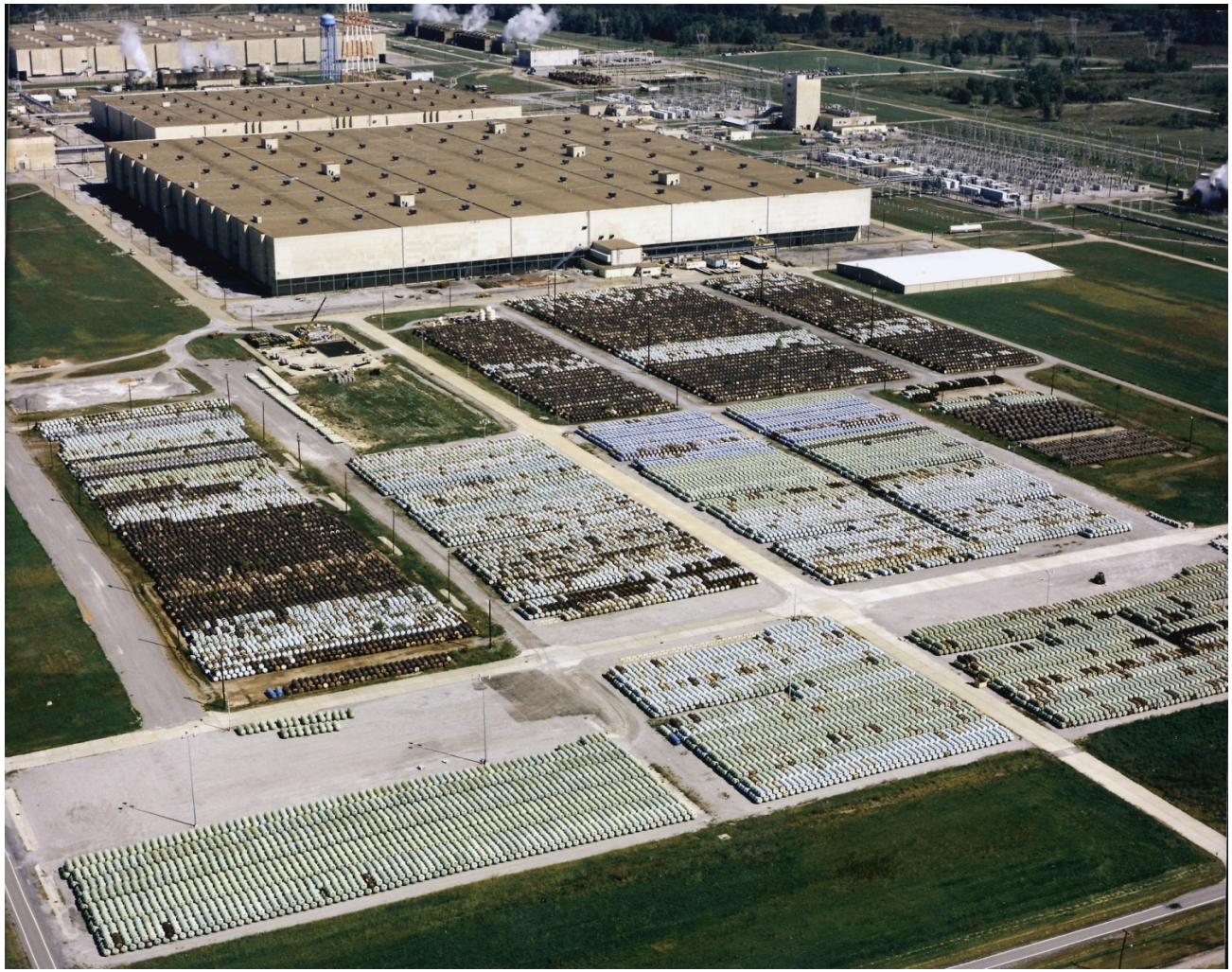
Presented to
The American Nuclear Society 2005 Annual Meeting
San Diego, California
June 5–9, 2005

DUF_6 Stored at Paducah Gaseous Diffusion Plant



Depleted Uranium (DU) Disposition Status

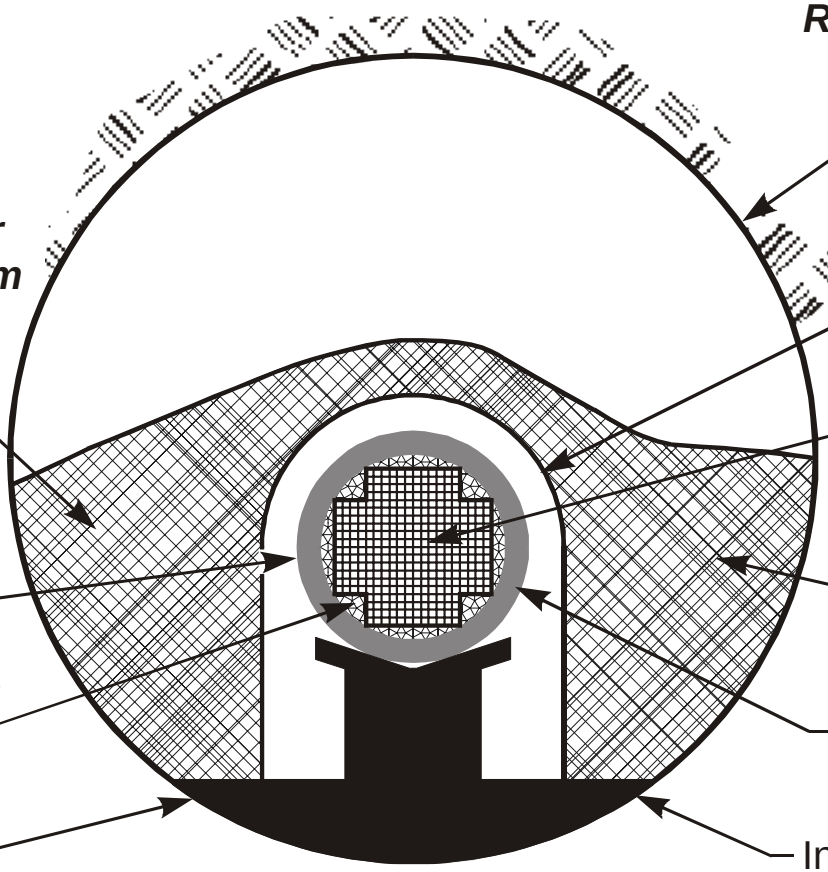
- Current cylinder management activities cost $~15M/year
- The objective of DOE's contract (total value $562M) with Uranium Disposition Services LLC is to convert DUF_6 to a ". . . Stable form acceptable for transportation, beneficial use/reuse, and/or disposal." Storage is not an option
- The Record of Decision (ROD) (July 2004) for Construction and Operation of DUF_6 Conversion Facility at Paducah, Kentucky, says " . . . DOE plans to decide the specific disposal location(s) for the depleted U_3O_8 conversion product after additional National Environmental Protection Agency review."

Current DUO_3 Disposal at EnviroCare

Drums of Envirocare that have been roughly placed in the Disposal Embankment with grout or CLSM (Control Low Strength Material).

Unloading DUO_3 drums from Gondola at Envirocare's Clive Facility.

Potential DU Dioxide Applications in a Geologic Repository



DU Oxide Functions in a Geologic Repository

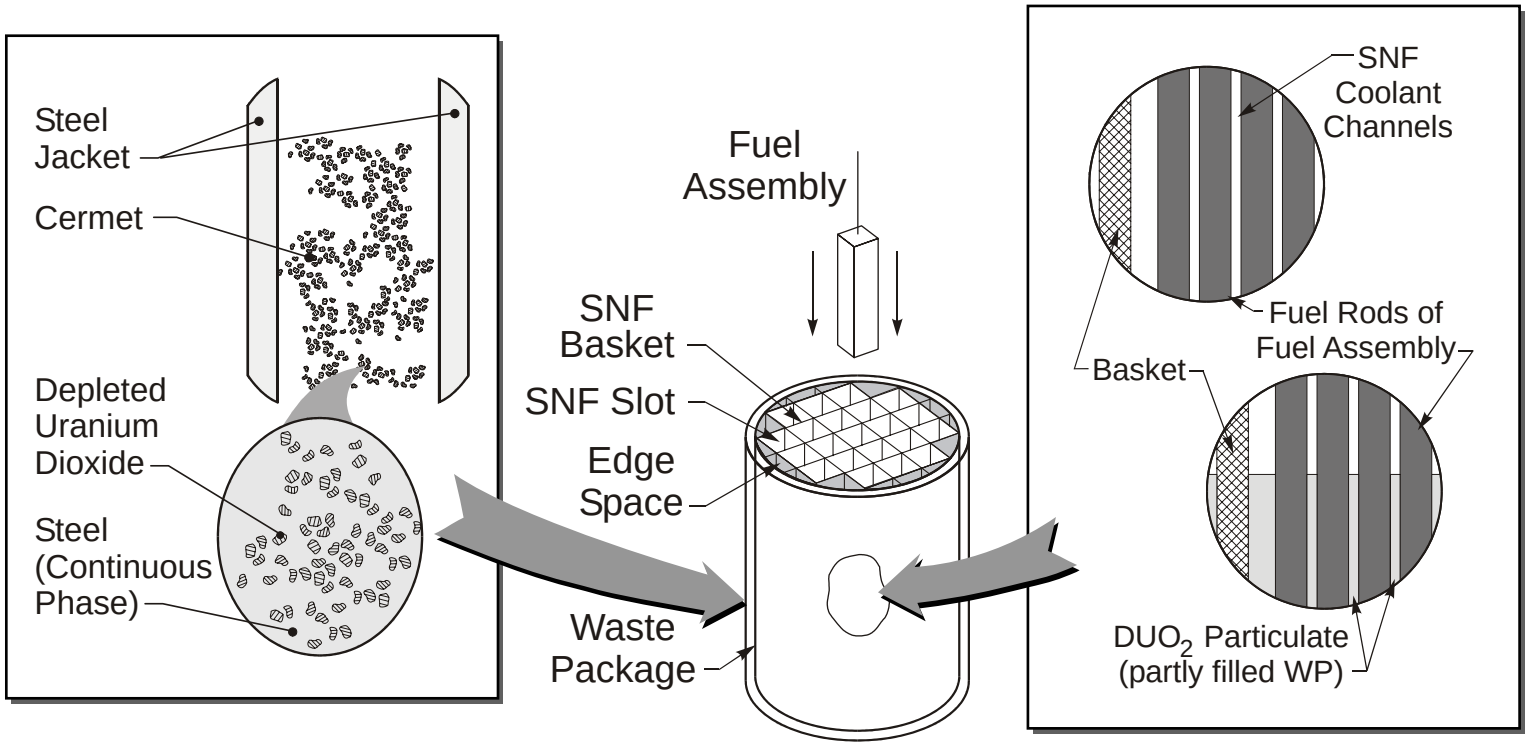
- *Nuclear criticality*. The DU reduces the probability of nuclear criticality over geological time by isotopic dilution of spent nuclear fuel (SNF) enriched uranium with the DU
- *Chemically reducing conditions*. The DUO_2 fill helps maintain chemically reducing conditions near the SNF as the waste package (WP) degrades—slowing long-term SNF degradation
- *Physical isolation*. Backfill eliminates the low probability risk of transport of radioactivity via lava flow through disposal drifts

DU Oxide Functions in a Geologic Repository (continued)

- *Reduced groundwater flow*. The DUO_2 fill may reduce groundwater flow through the degraded WP and thus reduce radionuclide transport from the WP. The DUO_2 evolves in air or oxidizing groundwater to hydrated higher uranium oxides that have lower densities than do the initial UO_2 particulates. The growth of hydrated uranium oxides blocks flow channels and slows water flow through the WP

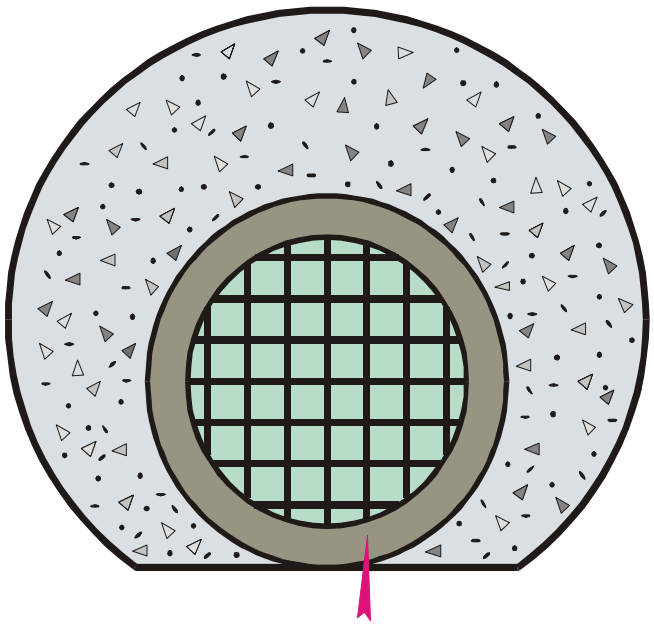
- *Adsorption and filtering*. DU oxides in all applications may slow the migration of radionuclides in groundwater by (1) ion-exchange and absorption of selected radionuclides and (2) filtering of radioactive colloids from groundwater

Depleted Uranium can be Added to the Repository in Different Forms

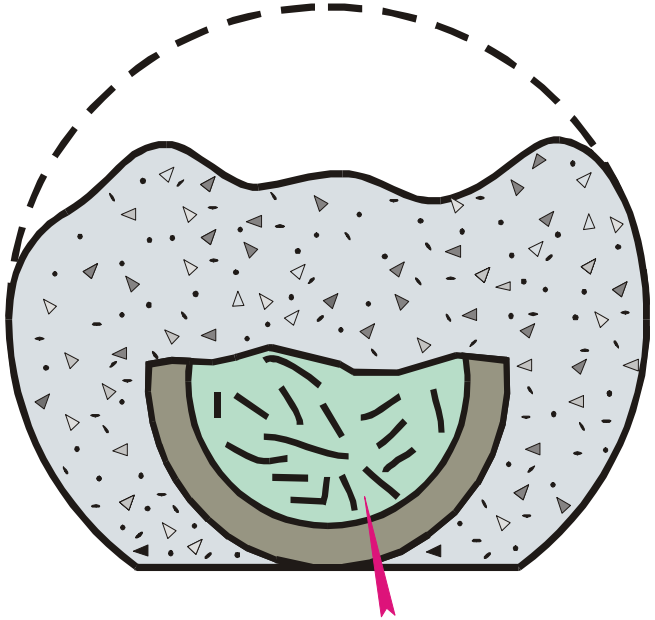


Cermet Cask ***Spent Nuclear Fuel Cask*** ***Particulate Fill***

Package Fill Prevents Early Collapse of WP by Providing Internal Support

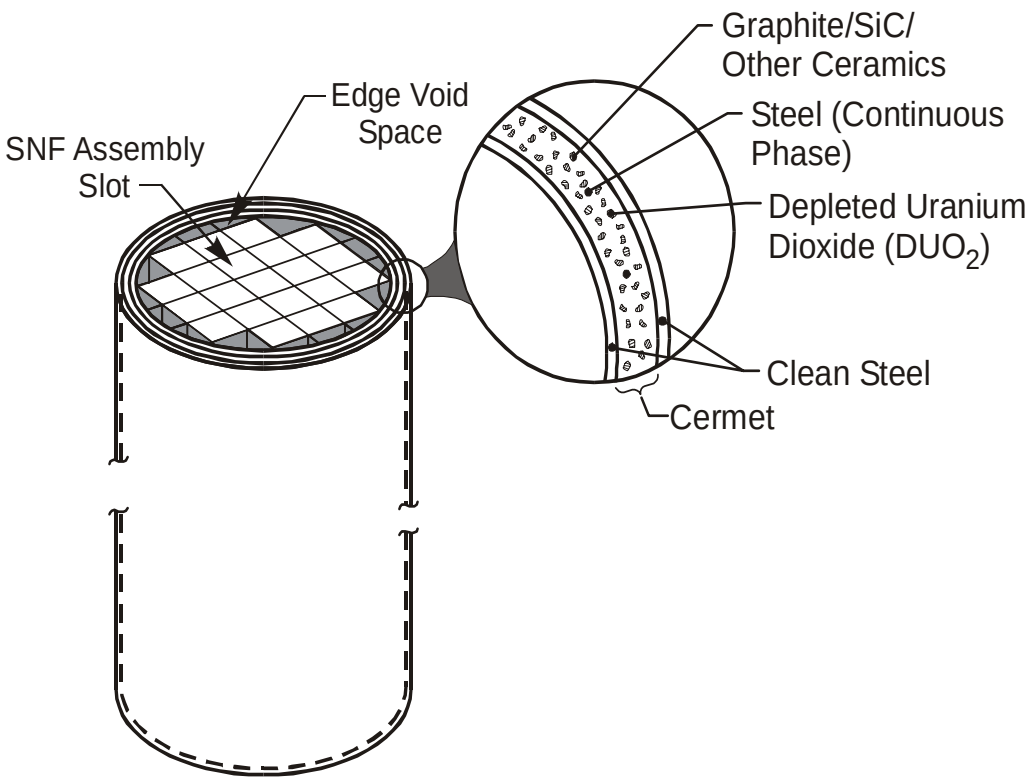


Intact Waste Package or Waste Package with Fill (High Resistance to Collapse)



Failed Waste Package (Collapse With No Internal Support)

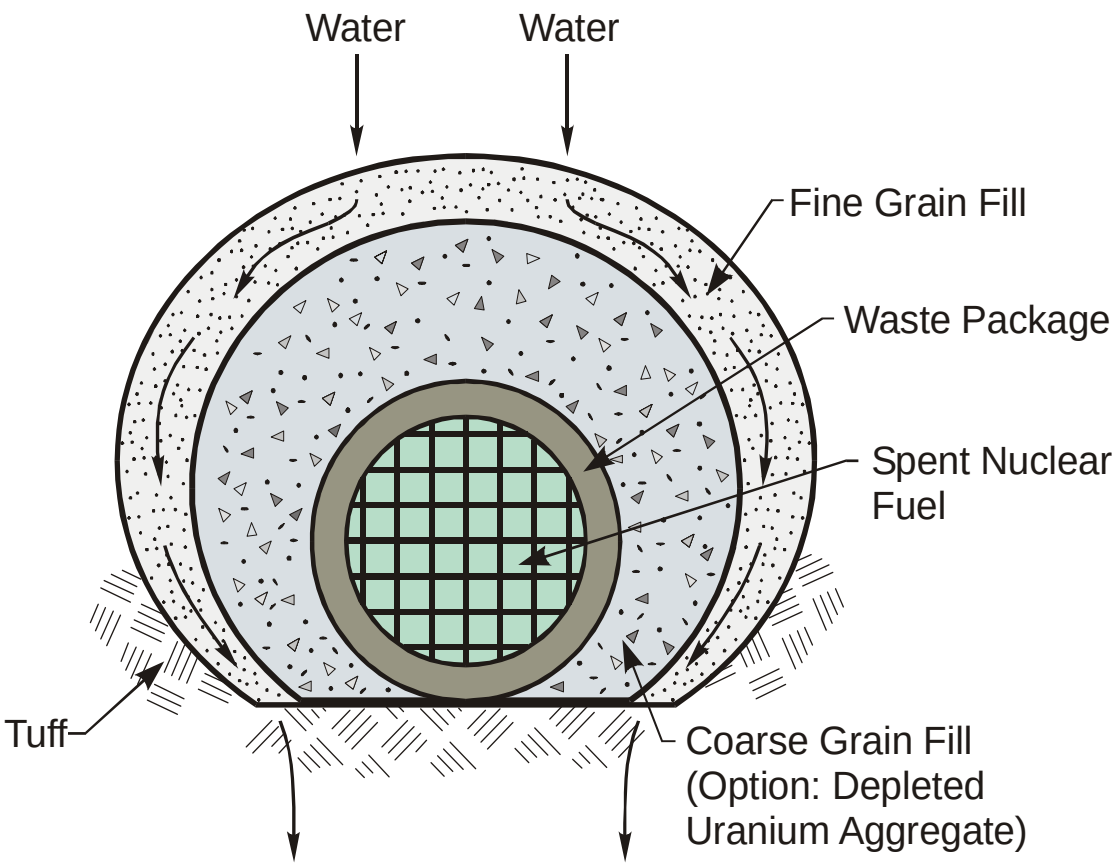
DU-Steel Cermet Casks



Functions

- Radiation Shielding
  - Gamma: High-Density DUO_2/Other
  - Neutron Moderation/Absorption
    - Oxygen in DUO_2
    - Carbon in SiC and Graphite
- Assault Protection: Multilayer Cermet (Traditional Armor)
  - Ceramic (Al_2O_3, DUO_2, SiC, Other)
  - Metal
- Safeguards and Theft
  - Large Mass
  - Vault Construction: Multilayer Cermet
- Decay Heat Removal
  - High Conductivity Steel Matrix

Depleted Uranium Oxides can be a Component of a Richards Barrier



- **Barrier diverts water around the WP**
- **DU aggregate in coarse fill**
- **DU not exposed to water until Richards barrier failure**
- **DU exposed to oxidizing air**
- **Potential benefits**
  - **DU disposal**
  - **Local chemical control**
  - **Criticality**

Options from a DU Disposal Perspective

1. Reuse of DU, e.g., as a shielding material in SNF and high-level waste casks
2. Disposal in a shallow land burial site, e.g., Envirocare or Nevada Test Site
3. Disposal in a deep mine
4. Disposal at Yucca Mountain (YM)

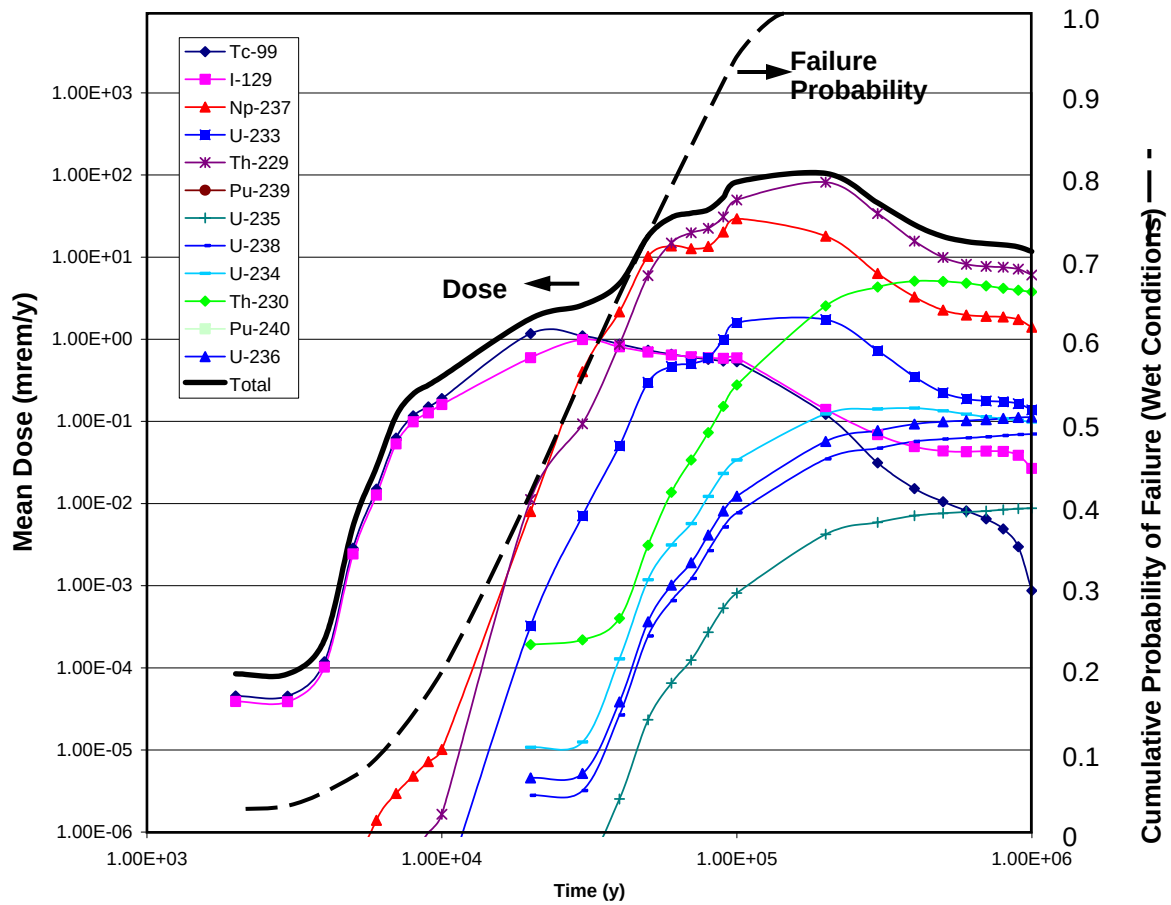
Perhaps YM would prefer to be Option #1 and use DU oxides as a chemical barrier to radionuclide release?

Conclusion

- Disposing of DU using one or more of the methods proposed appears to offer sufficient advantages to warrant further considerations

BACKGROUND

Site Boundary Dose Calculations Assuming Initial Failure of WPs and Drip Shields



(Ref. Scientific and Technical Priorities at Yucca Mountain, EPRI Report No. 1003335, December 2003).

Concerns About Considering Emplacing DU Oxides in a Geologic Repository

- It could jeopardize the proposed YM licensing application
  - Unlike nuclear reactors, repositories will be constructed progressively over the lifetime of the facility. Consequently, it is expected that the design of a repository will change as new technologies become available. It is expected that licensing amendments will reflect these changes
- Space is limited for disposal of SNF. Addition of DU oxides would exacerbate the problem
  - The need for expanded spacing of WPs due to SNF decay heat does not exist for DU. Consequently, DU containers could be much more tightly placed
- There might be unacceptable radiation dose at the site boundary because of DU
  - Within a 10^6 year timeframe, the calculated radiation dose at the YM site boundary at 20 km is less than that for SNF. All doses are below the Environmental Protection Agency limit

Depleted Uranium Disposal Costs

- Near surface (e.g., EnviroCare)[1]: ~$100M
- Deep mine[2]: ~$1500M
- Yucca Mountain[3]: ~$200M

References

1. "Technology Assessment Report for the Long-Term Management of Depleted Uranium Hexafluoride," UCRL-ID-120372, Lawrence Livermore National Laboratory (June 1995)
2. "Summary of the Cost Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride," UCRL-ID-127650, Lawrence Livermore National Laboratory (September 1997)
3. D. C. Sassani, "Disposal of Depleted Uranium at Yucca Mountain: An Assessment of Costs and Direct Impacts to Potential Repository Performance," DU White Paper, Engineered Barrier Systems Operations, CRWMS M&O PAO (July 22, 1999)