



U.S. DEPARTMENT OF
ENERGY

SAND2016-1252C
Nuclear Energy

Used Nuclear Fuel Disposition (UFD) R&D Campaign Overview

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Used Fuel Disposition R&D Campaign**

**2016 Waste Management Symposium
March 2016
Phoenix, AZ**

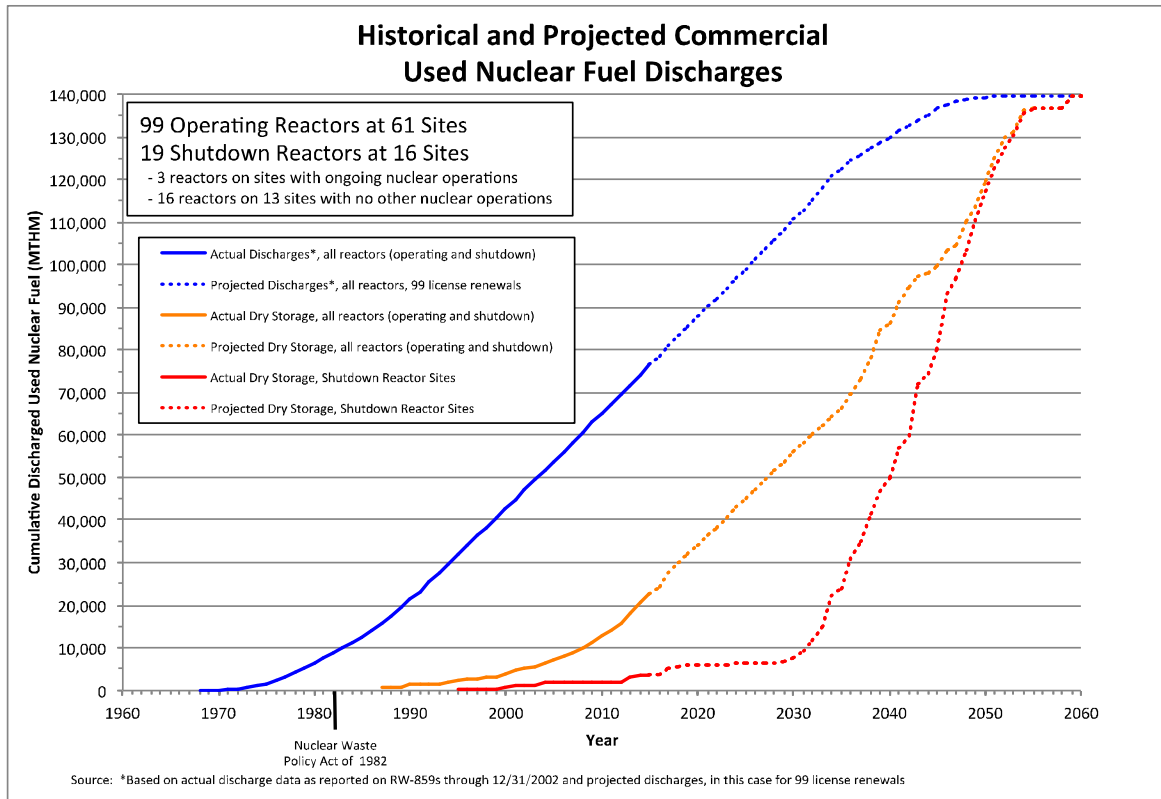


■ The Campaign Overview

- Mission
- Long-term Objectives (10-20 years)
- Organization of the Current R&D Portfolio
- Selected research highlights
- Conclusion

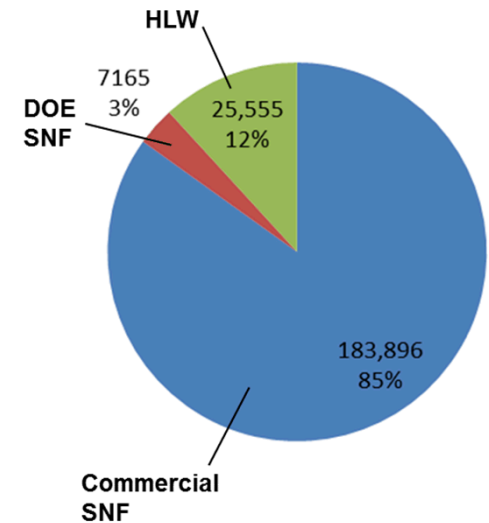


Historical and Projected Spent Nuclear Fuel (SNF) and High-Level Radioactive Waste (HLW) in the United States



Historical and Projected Commercial SNF Discharges

Projected Volumes of SNF and HLW in 2048



Volumes shown in m³, assuming constant rate of nuclear power generation and packaging of future commercial SNF in existing designs of dual-purpose canisters

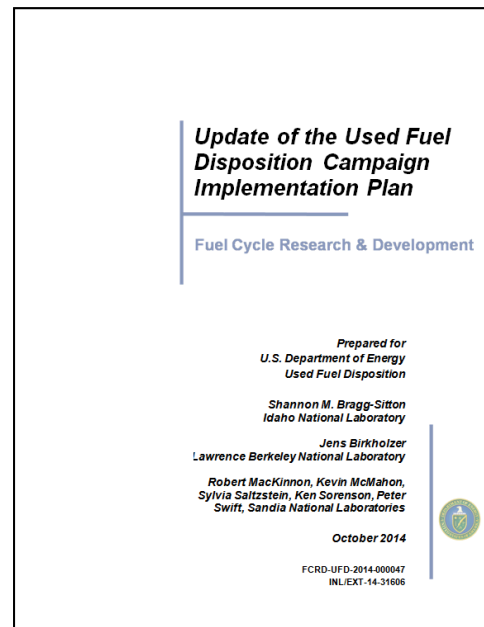


UFD Mission

Campaign Mission: to identify alternatives and conduct scientific research and technology development to enable storage, transportation and disposal of used nuclear fuel and wastes generated by existing and future nuclear fuel cycles

Campaign challenge: to provide a sound technical basis for supporting the current DOE strategy for managing the back end of the nuclear fuel cycle, including the identification and evaluation of safe and secure options for storage, transportation, and permanent disposal of radioactive wastes resulting from existing and future fuel cycles.

Update of the Used Fuel Disposition Campaign Implementation Plan
FCRD-UFD-2014-0000474, October 2014





UFD Campaign Strategic Focus: Storage and Transportation R&D

Prepare for extended storage and eventual large-scale transport of used nuclear fuel and high-level waste

■ **Develop the technical basis for:**

- Extended storage of used nuclear fuel
- Fuel retrievability and transportation after extended storage
- Transportation of high-burnup used nuclear fuel

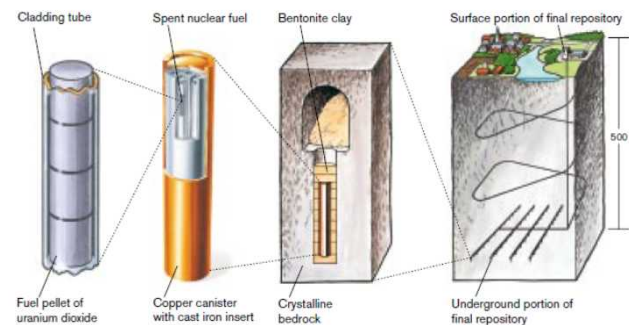
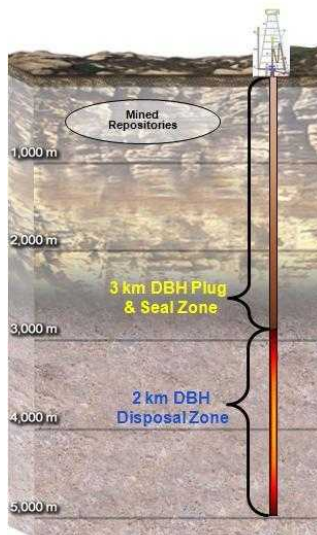
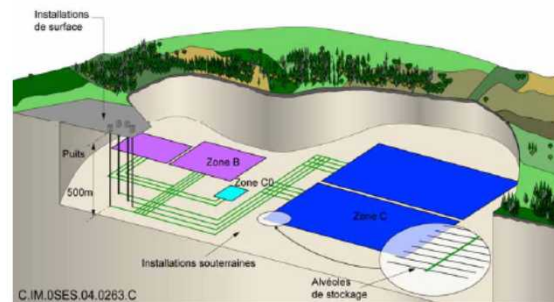
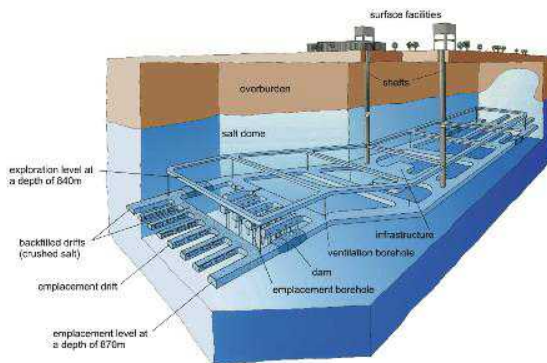




UFD Campaign Strategic Focus: Disposal R&D

Focus for Used Nuclear Fuel and High-Level Waste Disposal

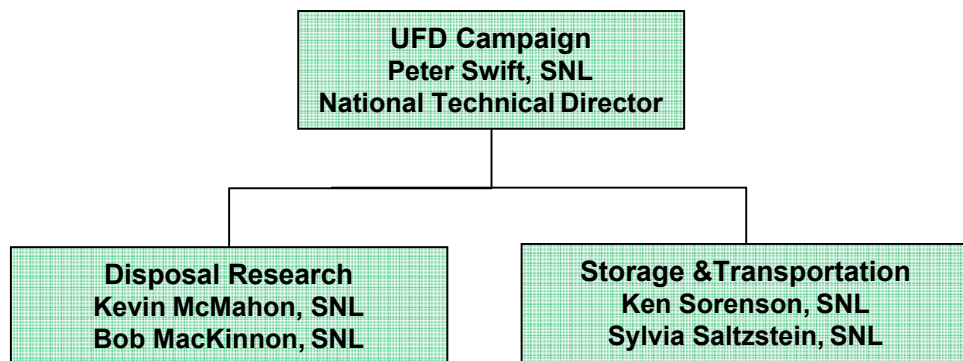
- Provide a sound technical basis for multiple viable disposal options in the US
- Increase confidence in the robustness of generic disposal concepts
- Develop the science and engineering tools needed to support disposal concept implementation





Organization of the Used Fuel Disposition Campaign R&D Portfolio

*UFD R&D is conducted at nine
national laboratories*



Host Rock Research: Argillite
Host Rock Research: Crystalline
Host Rock Research: Salt
Generic Disposal System Analysis
International Collaborations
Deep Borehole Disposal Field Test
Disposal of Dual Purpose Canisters
DOE HLW and SNF Research

Field Demonstration Support
Experiments
Analysis
Transportation
Security





Used Fuel Disposition Campaign External Collaborations

■ Collaboration among Fuel Cycle Technology Campaigns

- Full collaboration and shared resources with Nuclear Fuels Storage and Transportation Planning Project (NFST)
- Support for Fuel Cycle Options Campaign
- Close interactions with Material Recovery/Waste Form Campaign
 - Waste form modeling work transitioning from MR/WF to UFD in FY14

■ Collaboration with DOE-EM

- Canister concepts for deep borehole disposal

■ Industry (Advisory and Assistance Contracts)

- E.g., Areva; engineering services task for deep borehole field test

■ DOE/Industry Storage High-Burnup Data Project initiated FY13

- Dominion, Areva, Westinghouse

■ EPRI

- Extended Storage Collaboration Program (ESCP) (with NRC, utilities, vendors, and international organizations)

■ NEI

- Meetings to coordinate prioritization of funded activities



Used Fuel Disposition Campaign External Collaborations

■ International Collaborations

- Participation in international Underground Research Laboratories in Europe and Korea and in multi-national disposal research activities
- Bilateral agreements on storage and disposal R&D with Korea, Japan, China
- MOU for salt disposal R&D with Germany
- IAEA working groups in storage and transportation
- Collaboration with Germany and Japan on extended performance of bolts and seals for bolted storage casks and on SS canister stress corrosion cracking

■ DOE NE University Programs

- UFD R&D is affiliated with 22 active NEUP research projects (not including FY15 awards)
 - 11 projects in Storage R&D
 - 2 projects in Transportation R&D
 - 6 projects in Disposal R&D
 - 3 Integrated Research Projects in Storage R&D

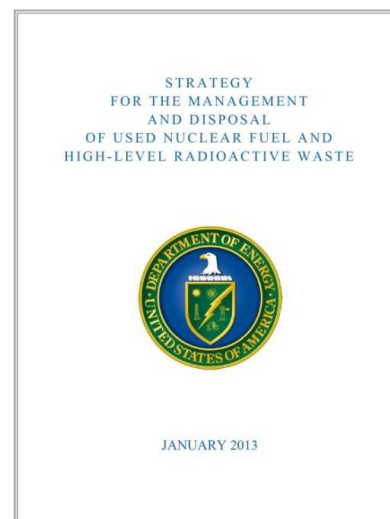
■ Other university collaborations (MIT, U. of Oklahoma, University of Sheffield UK)



Long-Term UFD R&D Campaign Objectives

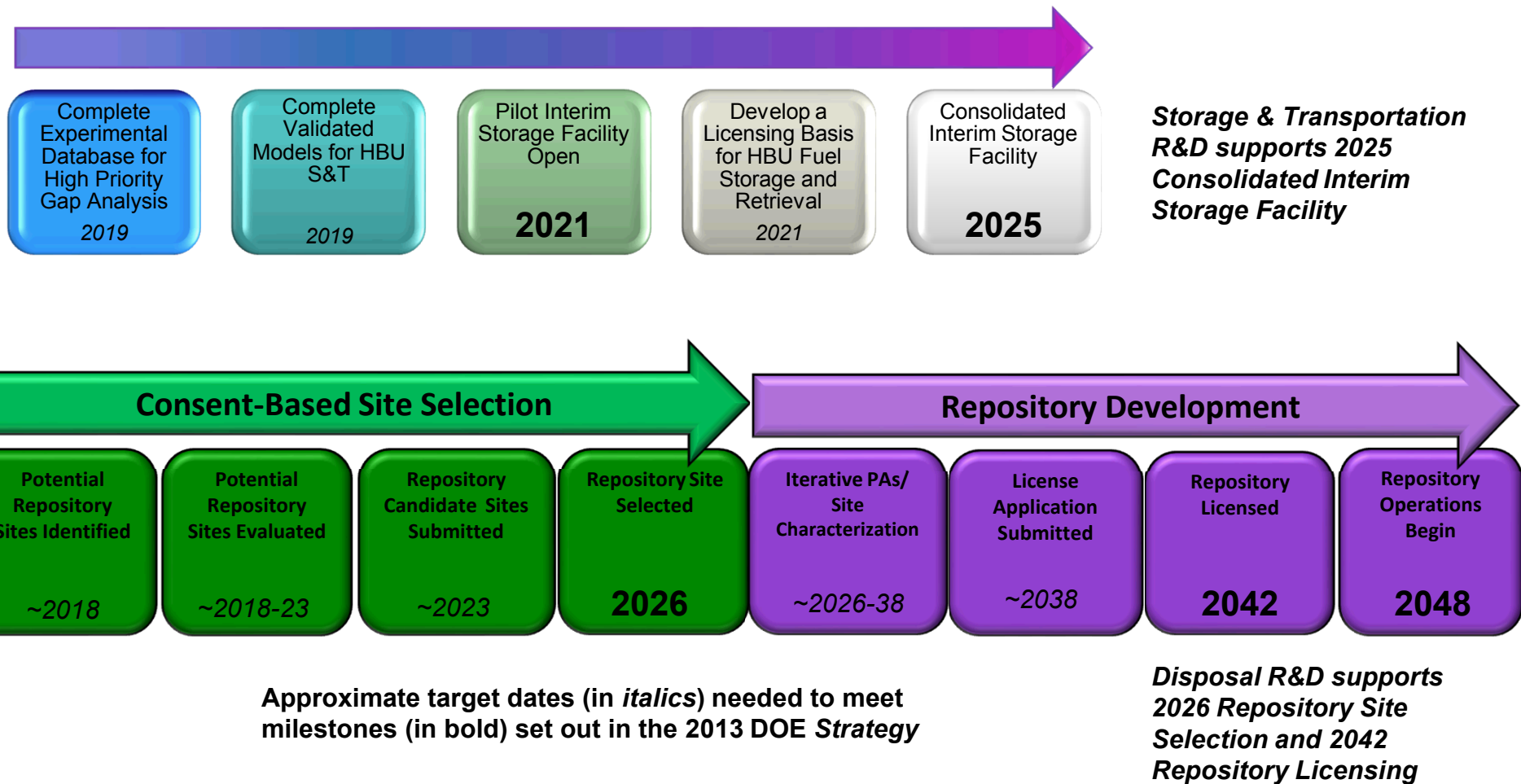
- Support the implementation of a full-scale NRC-licensed confirmatory storage demonstration facility, in collaboration with industry
- Develop the technical basis necessary to support eventual transportation of used nuclear fuel, including high-burnup fuel
- Support the Nuclear Fuel Storage and Transportation Planning Project with implementation of integrated storage, transportation, and disposal concepts

**Support the Administration's 2013
*Strategy for the Management and
Disposal of Used Nuclear Fuel and
High-Level Radioactive Waste***





R&D Path to Support DOE Waste Management Strategy





Three-Year UFD Campaign Objectives (2016-2019)

Storage and Transportation

- Support the high burn-up fuel full-scale storage demonstration project
- Develop understanding of how temperature and pressure affect cladding integrity in high-burnup UNF
 - Predictive modeling
 - Experimentation
- Develop understanding of how corrosion and stress corrosion cracking affect performance of stainless steel dry storage canisters
 - Material and environmental data; predictive modeling
- Characterize external loadings on UNF during normal conditions of transport

Disposal Research

- Field a deep borehole test
 - Initiate drilling in 2016, complete testing in 2019
- Complete evaluation of the direct disposal of dual-purpose canisters
- Develop experimental and modeling basis for understanding long-term performance of disposal systems in argillaceous rock, salt, crystalline rock, and deep boreholes
 - Leverage international disposal R&D
- Develop reference cases for generic disposal concepts



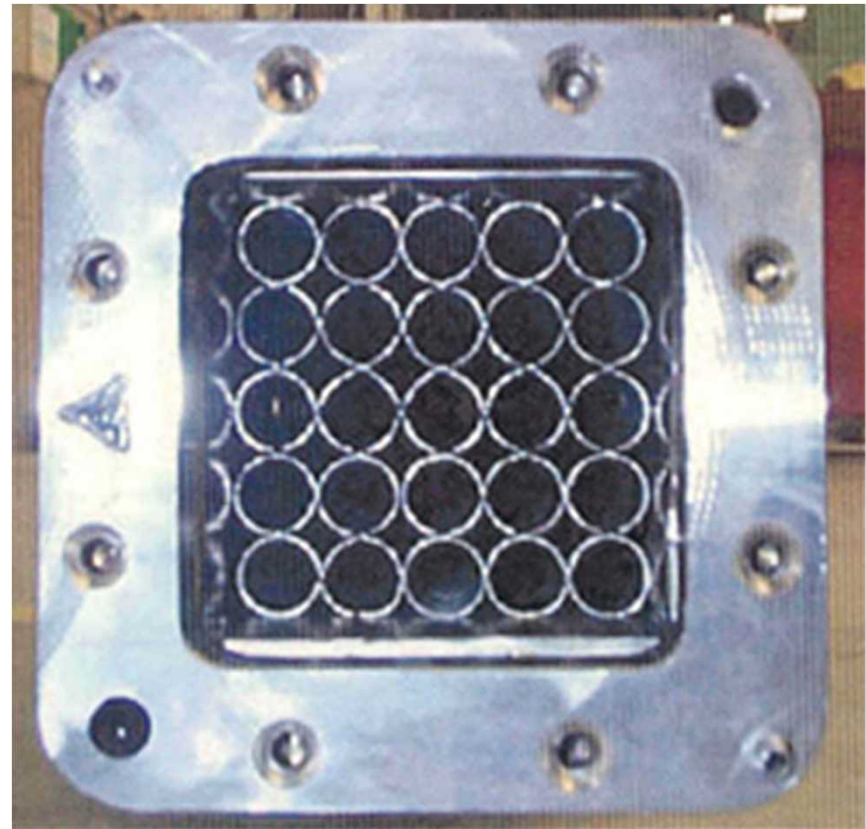
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Selected UFD Storage and Transportation R&D Research Highlights

High Burnup Confirmatory Data Project – Research Highlight

- Both INL and ORNL Transportation routes have been approved by NRC
- AREVA rods pulled January 2015
- Westinghouse rods pulled June 2015
 - Nine AREVA M5™ rods
 - Nine Westinghouse Zirlo™ rods
 - Four Westinghouse Low-tin Zircaloy-4 rods
 - Three Westinghouse standard Zircaloy-4 rods
- Draft Sister Rod Test Plan has been completed and shared with others
- License Amendment was submitted to the NRC by Dominion in August, 2015
- NRC has docketed the LAR and is continuing to review the document. Draft SER is expected summer of 2016



NAC LWT basket for shipping rods

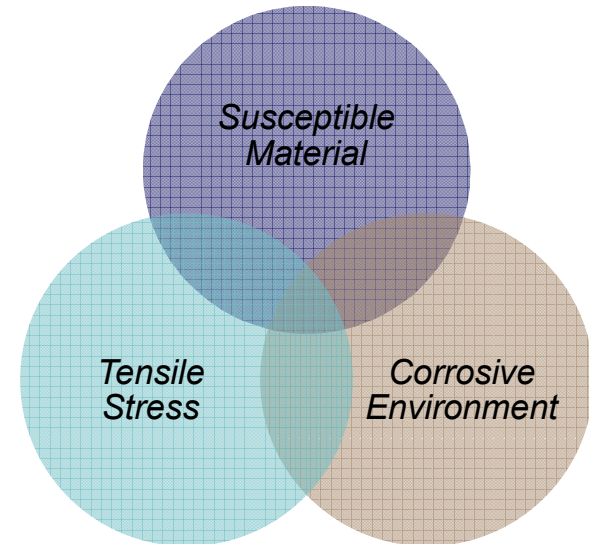


Storage and Transportation Research Highlight

Stress Corrosion Cracking of Stainless Steel Storage Canisters

Questions to be answered:

1. Will a chloride bearing environment form on the surface of the containers?
2. Is the material of construction for fielded interim storage containers susceptible?
3. Is there a sufficiently large tensile stress to support crack initiation and propagation in fielded interim storage containers?



Preliminary Observations:

Be prepared to inspect the canister surfaces

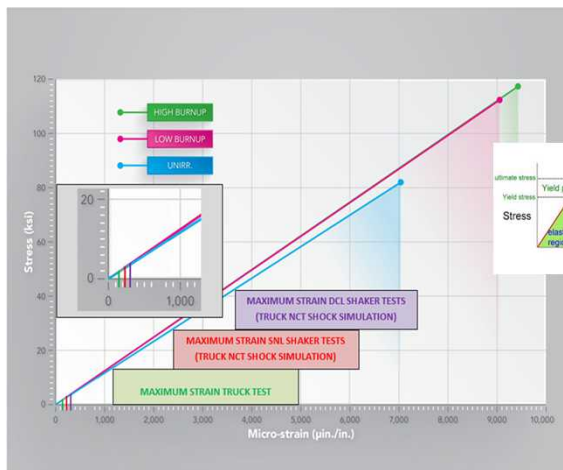


Storage and Transportation Highlight

Loading on Fuel Assemblies During Normal Conditions of Transport

Three series of tests using a surrogate PWR assembly

- Tests on a vertical acceleration shaker table at SNL
- Over-the-road truck test
- Tests on a commercial seismic shaker with six degrees of motion



Conclusions: strains during normal transport are far below yield and failure limits for cladding



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Selected UFD Disposal R&D Research Highlights



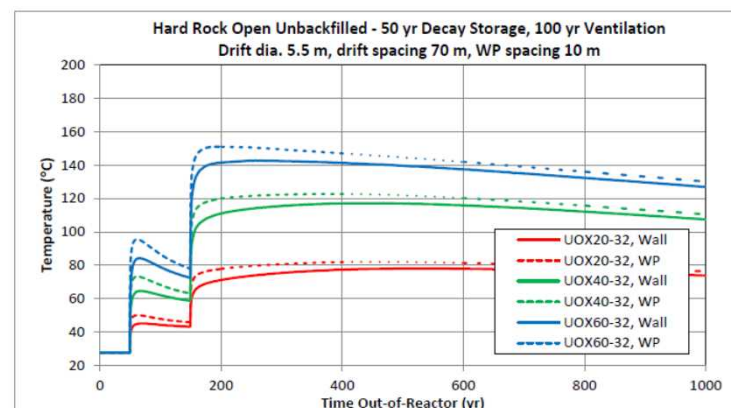
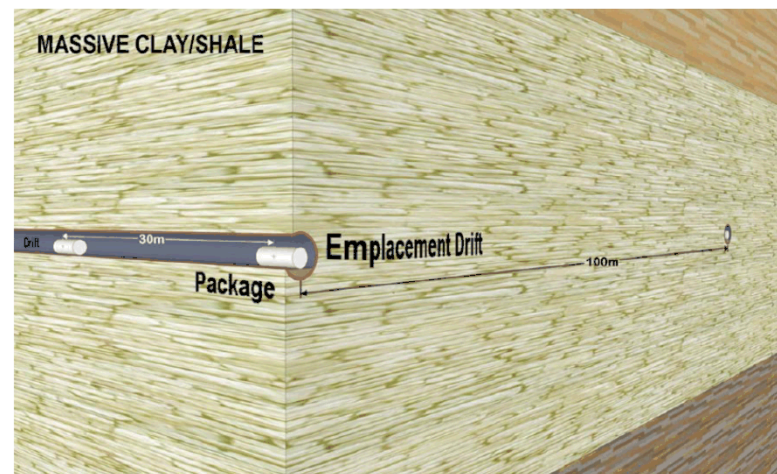
Disposal R&D Research Highlight

■ Evaluating Technical Feasibility of Direct Disposal of Dual Purpose Canisters (DPCs)

- Considerations
 - Operational challenges (size and mass)
 - Thermal management
 - Post-closure criticality control

■ Conclusions:

- Direct geologic disposal of some DPCs is feasible in some disposal concepts
 - Operational challenges can be met
 - Thermal management can be achieved through aging, ventilation, and spacing
 - Post-closure criticality control may need to be addressed individually for each DPC
- *DPC disposal is not an all-or-nothing choice*





Disposal R&D Research Highlight – Deep Borehole Concept:

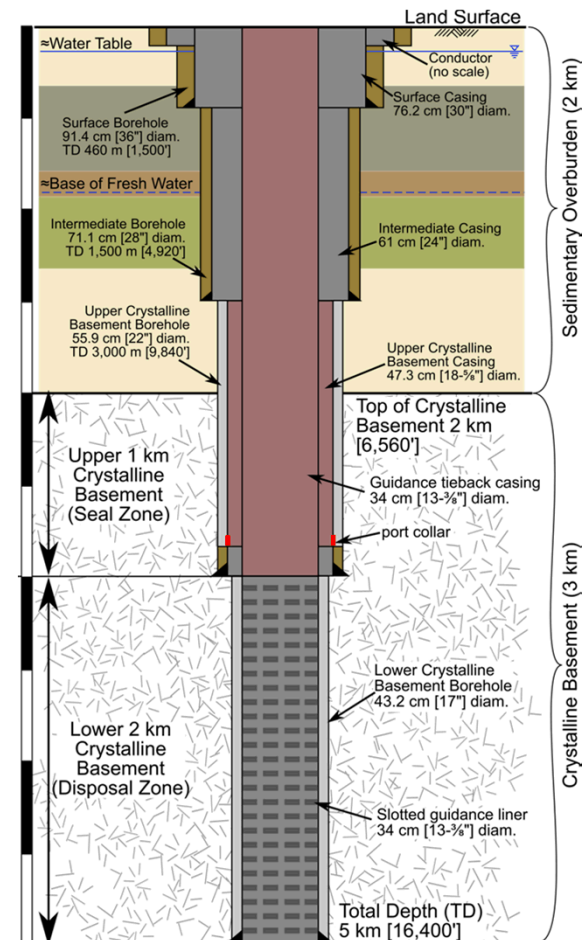
Improving Scientific Understanding with a Field Experiment

- DOE's proposed Deep Borehole field test is the next logical step in evaluating the DBH concept and is part of the Department's cross cut in subsurface research.

- No radioactive waste will be used during the field test.

- The DBH Field Test will:

- Demonstrate the feasibility of characterizing and engineering deep boreholes
- Demonstrate safe processes and operations for safe waste emplacement downhole





Disposal R&D Research Highlight – Deep Borehole Concept:

- **Request for Information solicited input and interest from States, local communities, individuals, private groups, academia, or any other stakeholders who were willing to host a DBH Field Test**
 - Posted to via Federal Business Opportunities (FedBizOps, www.fbo.gov) on October 24, 2014
 - Responses received on December 8, 2014 (45 days)
- **Sources Sought and Draft RFP**
 - Posted on FedBizOps on April 7, 2015
 - Feedback received on May 5, 2015
- **Final RFP (Solicitation Number DE-SOL-0008071)**
 - Pre-solicitation notice posted on June 22, 2015
 - Final RFP posted on FedBizOps on July 9, 2015
 - Proposals due September 9, 2015
- **DBFT Contract awarded to Battelle Team on January 5, 2016**



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