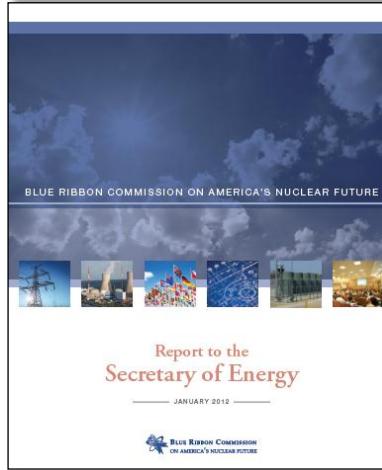


Exceptional service in the national interest



DRAFT

Current Status of the United States Radioactive Waste Disposal Program

Peter Swift

National Technical Director

U.S. Department of Energy Used Nuclear Fuel Disposition Campaign

Presented to the Scientific Visit on Crystalline Rock Repository Development, Prague, Czech Republic

24 September 2012



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Outline

- Current Status of the U.S. Radioactive Waste Disposal Program
- The Waste Isolation Pilot Plant (WIPP) for Transuranic Waste
- The High-Level Radioactive Waste Disposal Program
- Ongoing Research and Development Activities in the U.S.

Status of the U.S. Repository Program

- “Yucca Mountain is not a workable option” (DOE licensing motion, March 3, 2010)
 - “the Secretary’s judgment here is not that Yucca Mountain is unsafe or that there are flaws in the LA, but rather that it is not a workable option and that alternatives will better serve the public interest.” (DOE filing to NRC Licensing Board, May 27, 2010, footnote 102)
- The Nuclear Waste Policy Act remains in effect and Yucca Mountain remains the only disposal option for commercial used fuel and high-level waste without legislation
- Yucca Mountain license hearings remain suspended pending court action
 - August 3, 2012 ruling by the US Court of Appeals for the District of Columbia delays a decision until after December 14, 2012, pending Congressional action
- All current DOE activities related to disposal of used nuclear fuel and high-level radioactive waste have moved to the DOE Office of Nuclear Energy
- The Waste Isolation Pilot Plant (WIPP) is in operation for transuranic waste, managed by the DOE Office of Environmental Management

Recommendations from the Blue Ribbon Commission on America's Nuclear Future

- BRC's Report to the Secretary of Energy published January 2012
 - A new, consent-based approach to siting future nuclear waste management facilities.
 - A new organization dedicated solely to implementing the waste management program and empowered with the authority and resources to succeed.
 - Access to the funds nuclear utility ratepayers are providing for the purpose of nuclear waste management.
 - Prompt efforts to develop one or more geologic disposal facilities.
 - Prompt efforts to develop one or more consolidated storage facilities.
 - Prompt efforts to prepare for the eventual large-scale transport of spent nuclear fuel and high-level waste to consolidated storage and disposal facilities when such facilities become available.
 - Support for continued U.S. innovation in nuclear energy technology and for workforce development.
 - Active U.S. leadership in international efforts to address safety, waste management, non-proliferation, and security concerns.
- The DOE is working to address these recommendations

Waste Isolation Pilot Plant

Geologic Disposal of Transuranic Waste



- Site Selection – 1975
- Certified by the EPA – 1998
- First Waste Receipt – March 26, 1999
- First Recertification – March 2006
- Second Recertification – November 2010
- More than 10,000 shipments to date
 - ~83,000 m³ emplaced, projected inventory of ~150,000 m³
 - allowable capacity of ~175,000 m³
- Disposal operations continue: 2012 → 2033?

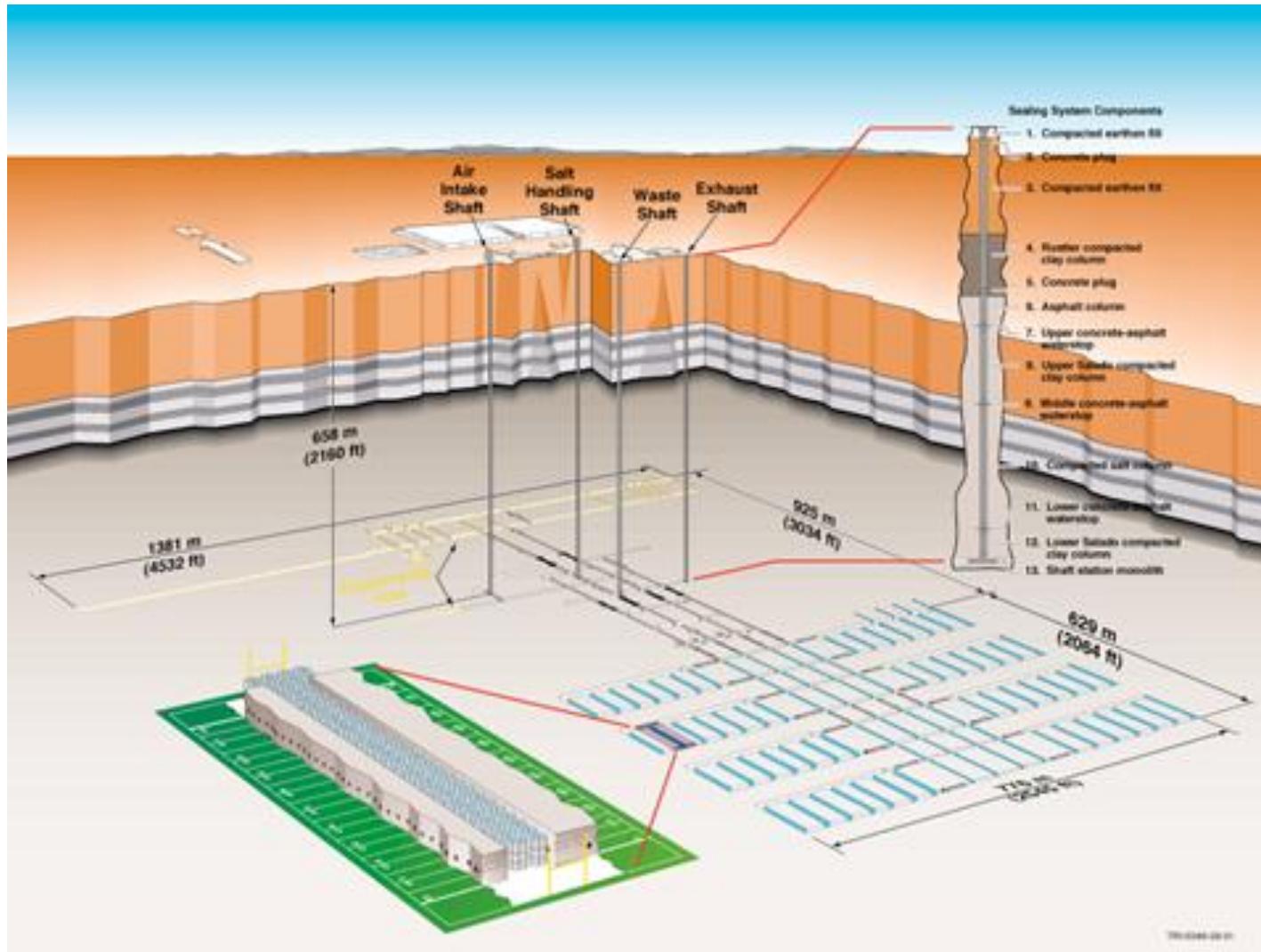


WIPP Transuranic Waste

- Derived from defense-related activities
 - Laboratory and industrial trash contaminated with transuranic radionuclides
 - Primarily alpha-emitting radionuclides, relatively little gamma emission and low thermal power



WIPP Design

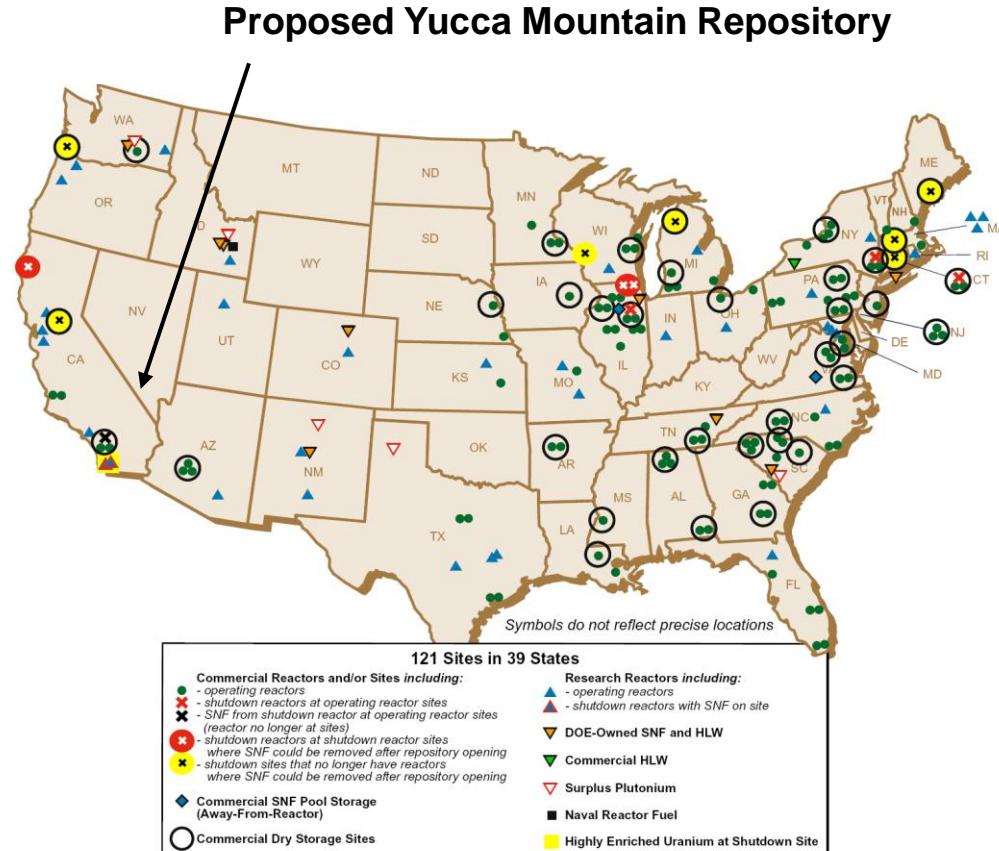


The Yucca Mountain Mission

Current locations of spent nuclear fuel (SNF) and high-level radioactive waste (HLW) destined for geologic disposal:
121 sites in 39 states

United States Department of Energy (DOE) Office of Civilian Radioactive Waste Management (OCRWM) Mission:

To manage and dispose of high-level radioactive waste and spent nuclear fuel in a manner that protects health, safety, and the environment; enhances national and energy security; and merits public confidence.



Waste for Yucca Mountain



Commercial Spent Nuclear Fuel:
63,000 MTHM (~7500 waste packages)



DOE & Naval Spent Nuclear Fuel:
2,333 MTHM
(~400 naval waste packages)
(DSNF packaged with HLW)



DOE & Commercial High-Level Waste:
4,667 MTHM
(~3000 waste packages of co-disposed DSNF and HLW)

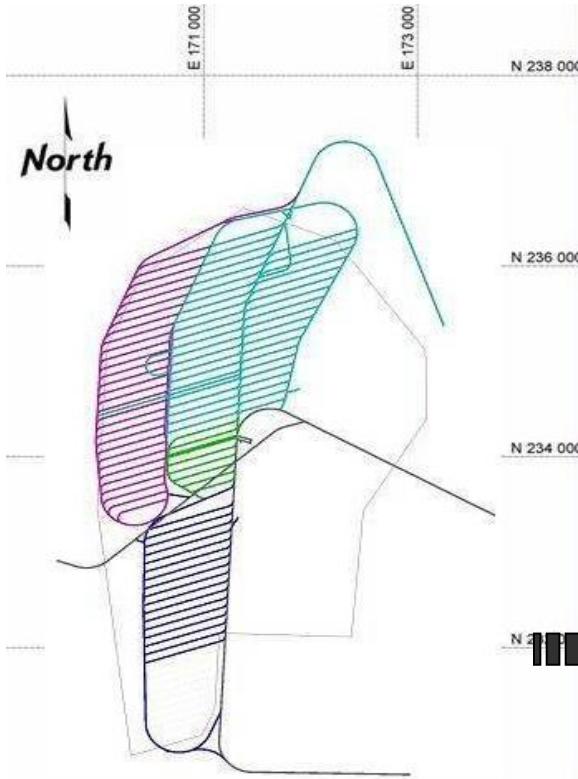


DSNF: Defense Spent Nuclear Fuel
HLW: High Level Radioactive Waste
MTHM: Metric Tons Heavy Metal

Yucca Mountain Exploratory Studies Facility



Yucca Mountain Subsurface Design



Emplacement drifts

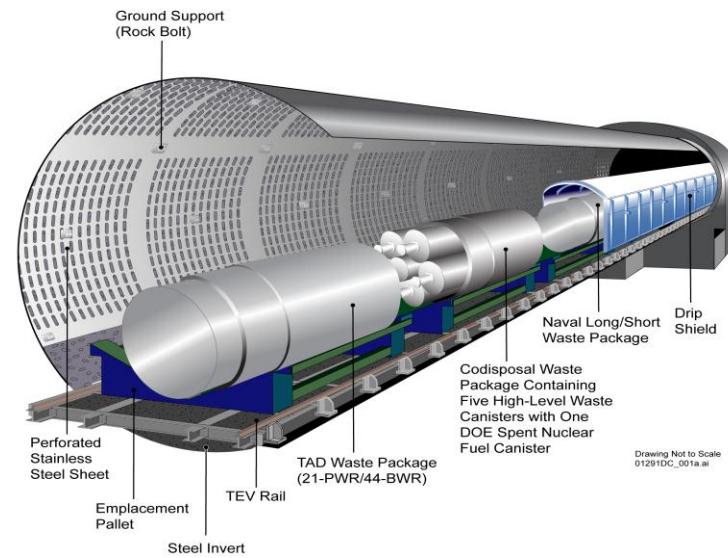
5.5 m diameter
approx. 100 drifts, 600-800 m long

Waste packages

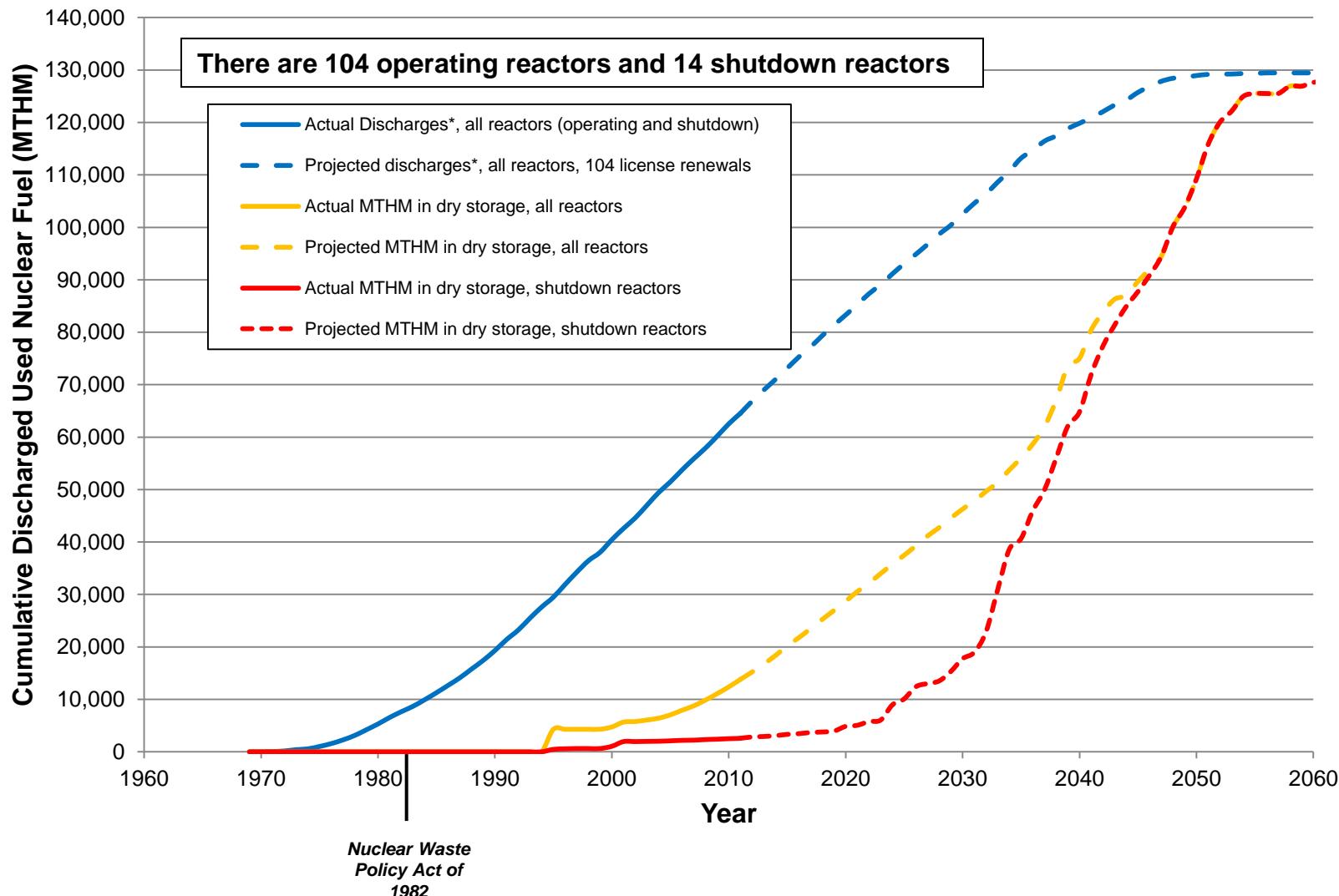
~11,000 packages
~ 5 m long, 2 m diameter
outer layer 2.5 cm Alloy 22 (Ni-Cr-Mo-V)
inner layer 5 cm stainless steel
Internal TAD (transportation, aging, and disposal) canisters
for commercial spent fuel, 2.5 cm stainless steel

Drip shields

free-standing 1.5 cm Ti shell



Historical and Projected Commercial Spent Nuclear Fuel Discharges in the United States



Source: Based on actual discharge data as reported through 12/31/02, and projected discharges, in this case for 104 license renewals

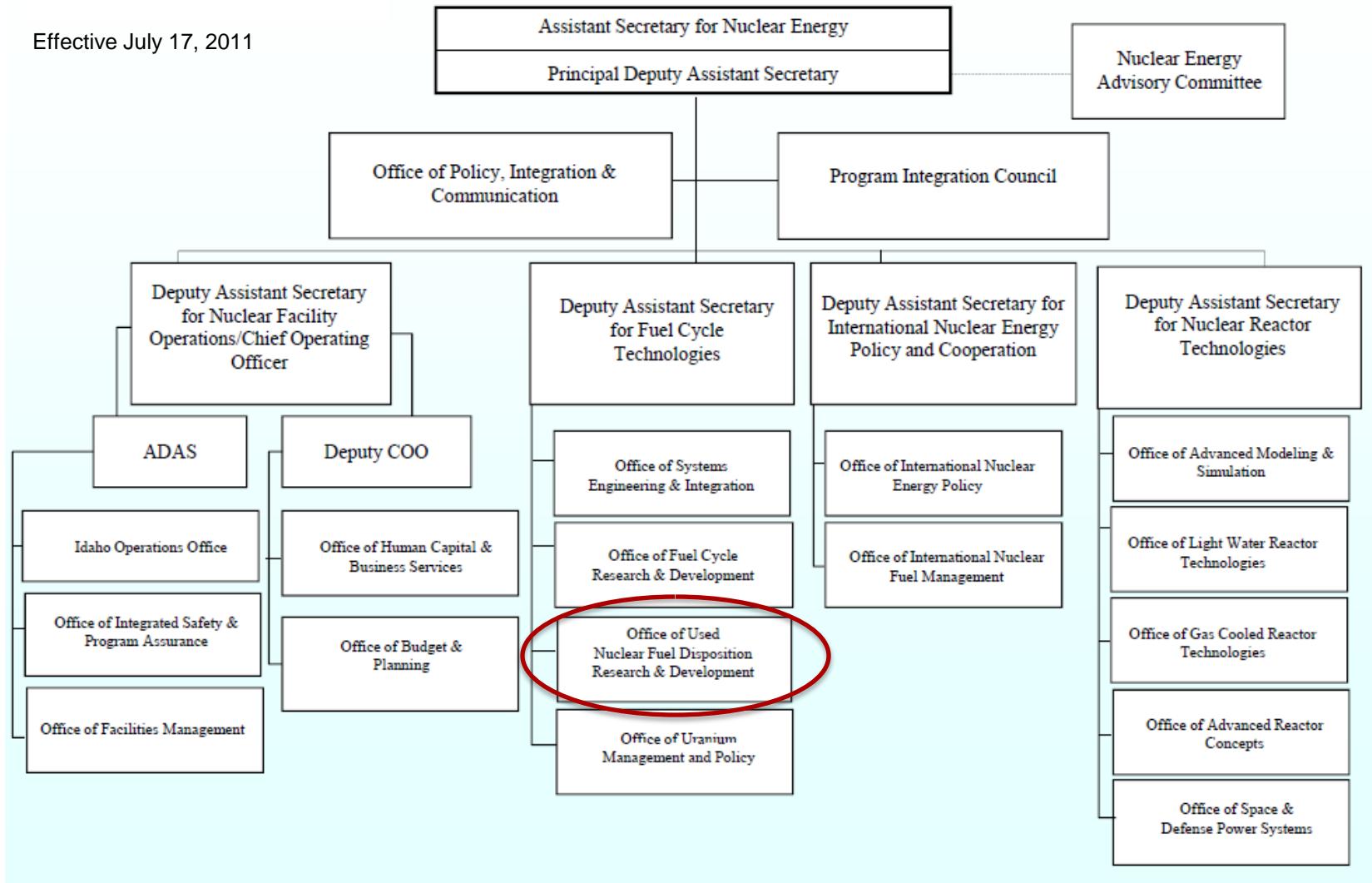
The US Repository Program After Yucca Mountain



- With the suspension of Yucca Mountain licensing and termination of funding for the DOE Office Civilian Radioactive Waste Management, the national mission for management and disposal of used nuclear fuel and high-level radioactive waste has moved to the DOE Office of Nuclear Energy Office of Used Fuel Disposition (NE-53)
 - R&D within NE-53 is performed by the “Used Fuel Disposition Campaign”
 - The mission of the Used Fuel Disposition Campaign is 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.

DOE NE Organizational Chart

Effective July 17, 2011



UFD Campaign 2009-Present

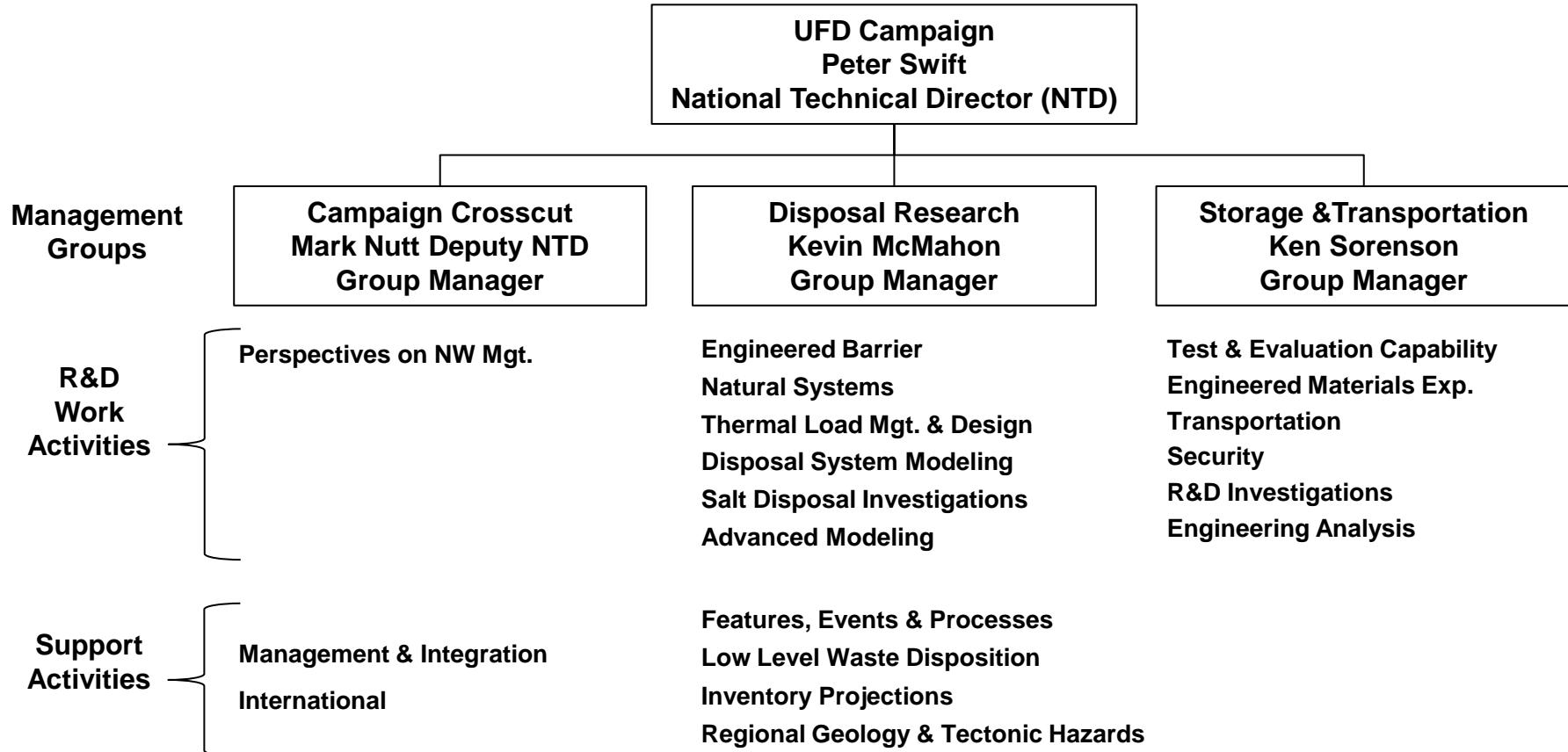
- FY09 Planning meeting at Argonne National Laboratory, June 2009
- FY10 R&D
 - Disposal R&D, modest level of effort on Storage R&D, no Transportation R&D
- FY11 R&D
 - Nine national laboratories participating in UFD
 - Significant R&D program in Storage, including Transportation
 - Disposal R&D not site specific
- FY12 R&D
 - Increase in work scope following Congressional appropriations in December 2012, some elements of FY12 work scope not established until fourth quarter
 - Programmatic uncertainties remain regarding national policy and Yucca Mountain litigation.
- FY13 R&D work scope planning in progress

UDF Campaign R&D Participants...

9 US National Laboratories



Organization of R&D in the Used Fuel Disposition Campaign

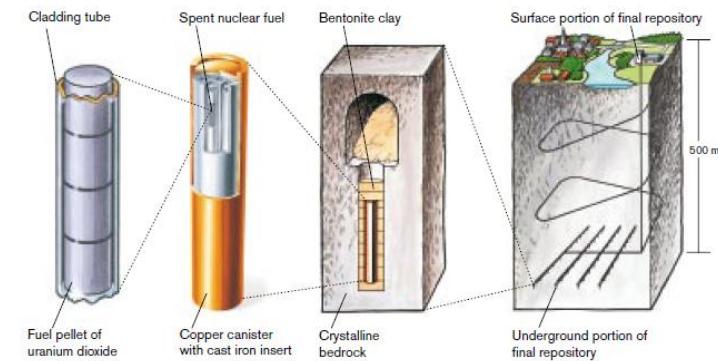
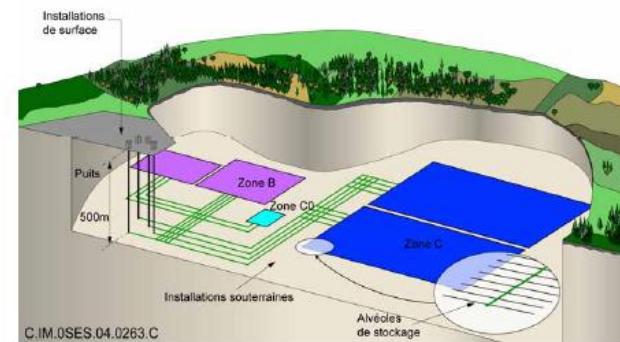
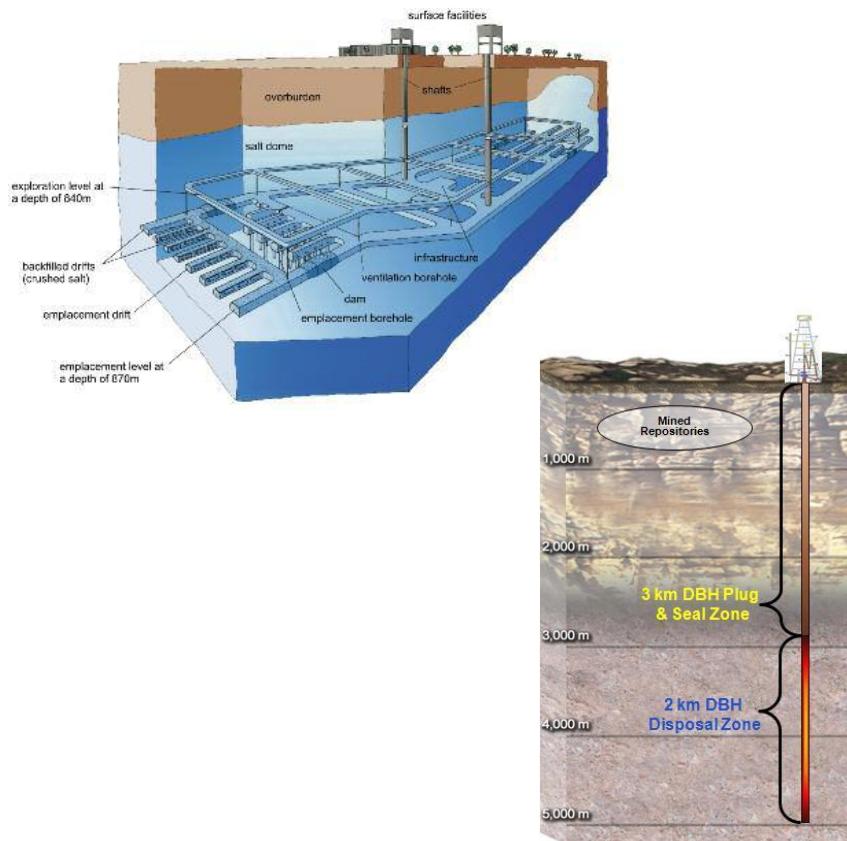


Generic Disposal R&D

- The Nuclear Waste Policy Act precludes any and all site-specific repository investigations at locations other than Yucca Mountain
- All disposal research must be generic at this stage
- What can generic R&D accomplish?
 - Provide a sound technical basis for the assertion that the US has multiple viable disposal options that will be available when national policy is ready
 - Identify and research the generic sources of uncertainty that will challenge the viability of disposal concepts
 - Increase confidence in the robustness of generic disposal concepts to reduce the impact of unavoidable site-specific complexity
 - Develop the science and engineering tools required to address the goals above, through collaborations within NE and DOE, and with universities, industry, and international programs

U.S. Disposal R&D Focuses on Four Options

- Three mined repository options (granitic rocks, clay/shale, and salt)
- One geologic disposal alternative: deep boreholes in crystalline rocks



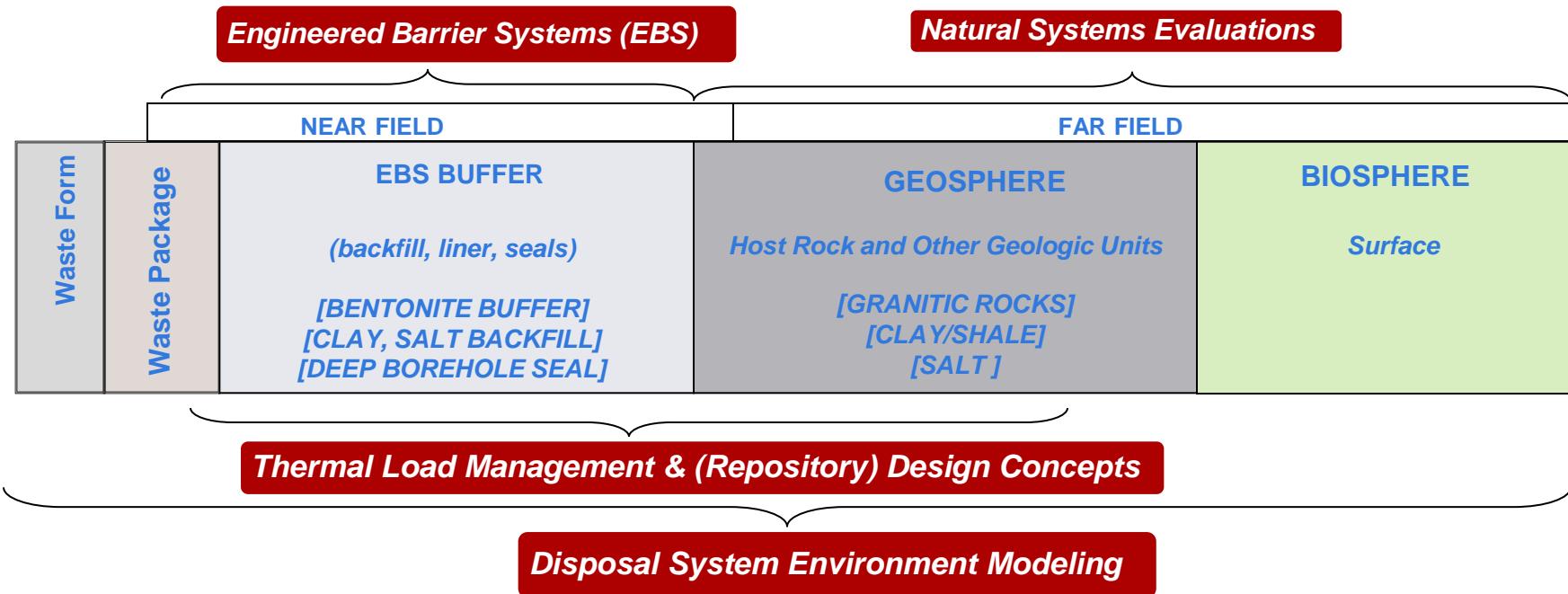
How Did the UFD Identify Disposal R&D Needs?



- *Used Fuel Disposition Campaign Disposal Research and Development Roadmap*
 - “an initial evaluation of prioritization of R&D opportunities that could be pursued by the campaign”
 - Completed March 2011
 - Used to inform prioritization decisions for disposal research in FY12 and beyond
- Update in progress

http://www.ne.doe.gov/FuelCycle/neFuelCycle_UsedNuclearFuelDispositionReports.html

UFD Disposal Research Activities

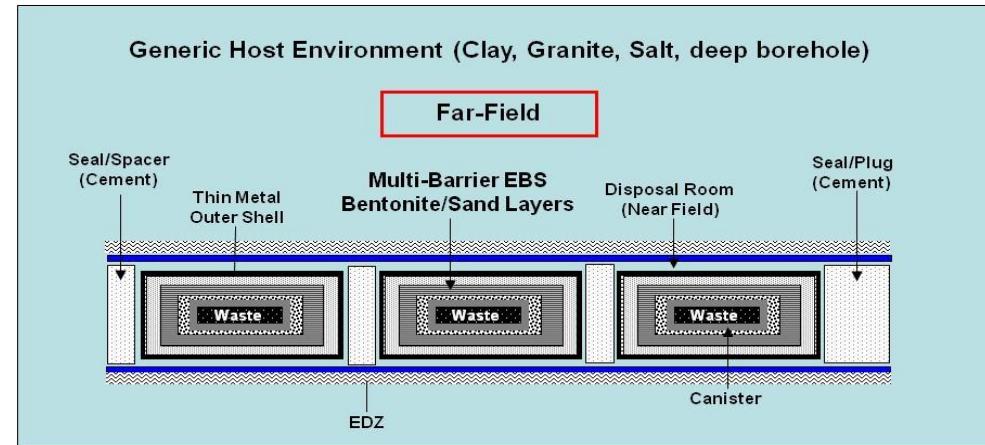


SUPPORT, ANALYSIS & EXPERIMENTAL ACTIVITIES

<i>Engineered Materials Performance</i>	<i>(corrosion, degradation studies)</i>
<i>Features, Events & Processes</i>	<i>(how R&D is organized and prioritized)</i>
<i>Low Level Waste Disposition Issues</i>	<i>(part of total nuclear waste consideration)</i>
<i>Inventory Projections</i>	<i>(LLW/HLW, used fuel, open → closed fuel cycles)</i>

Generic Engineered Barrier Systems R&D

EBS and materials evaluation for multiple disposal environments (clay/shale, granitic rocks, salt, deep borehole)



Representative activities

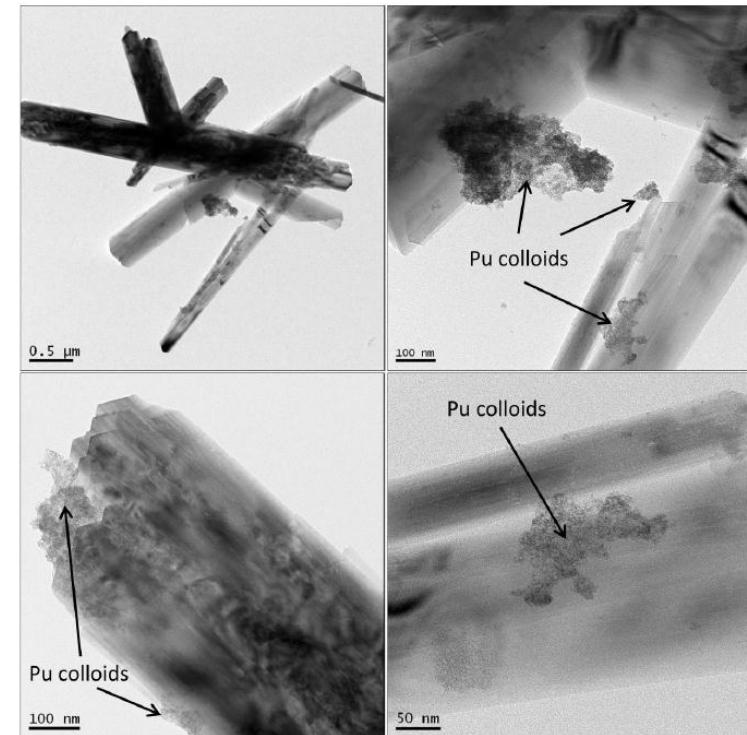
- Evaluation of EBS configurations and material properties: backfill and sealing material (clay and cement)
- Evaluation of clay / metal interactions at elevated temperatures and pressures: literature review, clay phase characterization, and experiments
- Expand THM constitutive and reactive diffusive transport modeling in bentonite
- Laboratory-scale crushed-salt consolidation experiments and modeling

Generic Natural Systems Evaluation R&D

Evaluation of key natural system attributes of multiple disposal system concepts to evaluate impacts on waste immobilization and isolation

Representative activities

- Regional geologic characterization
- Discrete fracture network simulation
- Effects of spatial heterogeneity in Kd on radionuclide transport
- Experimental work on Pu colloid behavior in the presence of goethite
- Geomechanical modeling of excavation damage zone in clay/shale and salt
- Experimental work on saturated and unsaturated flow through clay
- Experimental work related to direct disposal of e-chem salt in a salt repository



•TEM of intrinsic Pu(IV) nano-colloids sorbed to goethite at 25° C for 103 days

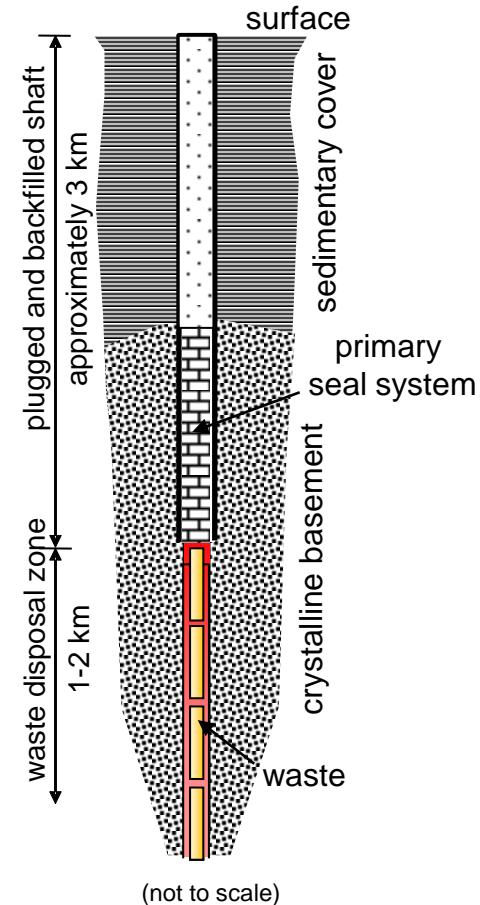
Generic Disposal

System-Level Modeling R&D

Develop models to evaluate performance of multiple generic disposal systems

Representative activities

- Implement configuration management for the generic performance assessment (PA) models
- Document technical basis for treatment of Features, Events, and Processes for each generic PA model
- Develop preliminary generic PA models for repositories in clay/shale, granitic rock, salt, and deep borehole settings
 - Highly simplified geometries
 - Isothermal behavior except for deep borehole



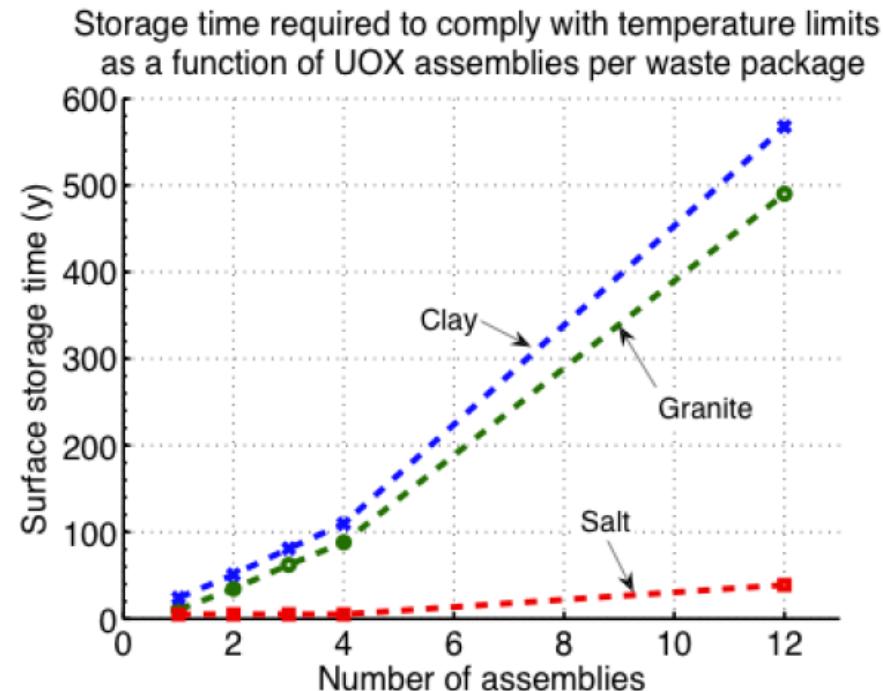
Source: modified from Brady et al., 2009,
Deep Borehole Disposal of High-Level
Radioactive Waste, SAND2009-4401

Thermal Load Management & Design Concepts R&D

Thermal modeling and testing to evaluate thermal loading options for multiple disposal concepts and alternative waste forms

Representative activities

- Develop representative design concepts for repositories in clay/shale, granite, salt, and deep borehole settings.
- Identify waste streams for thermal analysis
- Complete thermal loading analyses in representative design concepts for selected waste streams



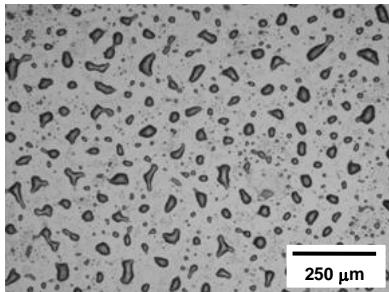
Minimum decay storage durations to limit peak PWR waste package surface temperature to 100° C (granite, clay) or 200° C (salt). (Hardin et al., 2011, Generic Repository Design Concepts and Thermal Analysis (FY11), FCRD-USED-2011-000143)

Engineered Materials Performance R&D

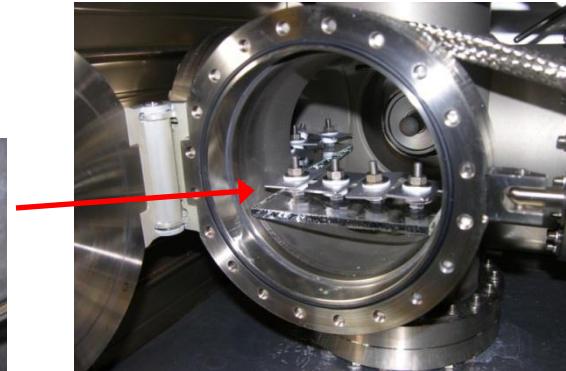
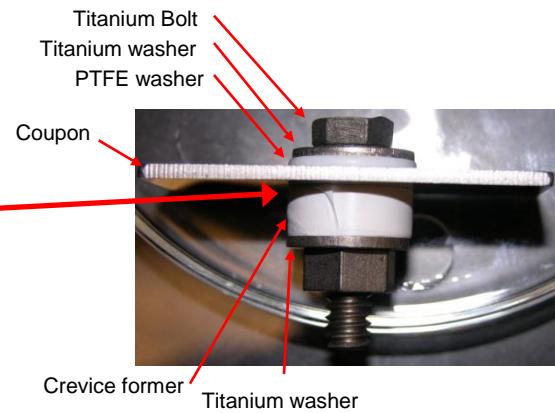
Experiments and model development for long-term performance of engineered materials in storage and repository environments

Representative activities (limited to repository environments in FY11, expanded to include storage in FY12)

- Ongoing experiments (YMP initiated, continuing):
 - Immersion: Sampled after 9 months of exposure (12/10). Analysis of samples underway
 - Deliquescence: Corrosion initiation experiments with 2-, 3-, and 4-salt assemblages completed
 - Dependence of extent of corrosion on quantity of salt present is now being investigated
- Literature survey/gap analysis for material performance in repository environments has been initiated



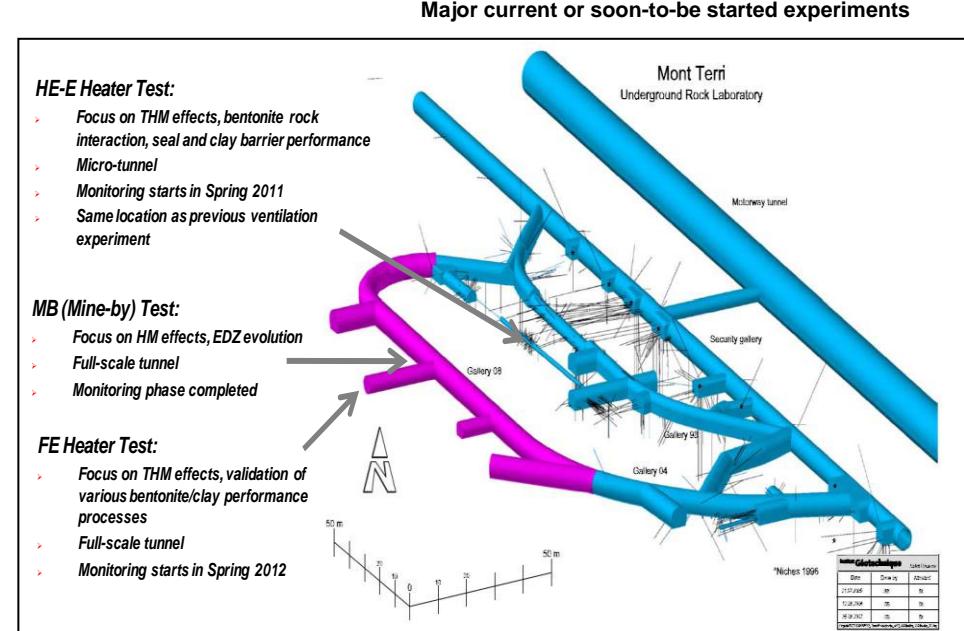
Salt mixture on an Alloy 22 Coupon



T, RH-Controlled Environmental Chamber

UFD Campaign International Activities

Primary new goal for Disposal R&D in FY12: Establish formal collaborative R&D arrangements ongoing international programs
Ongoing collaborations continue in multiple areas, including storage, transportation, and disposal



Mont Terri: International underground research laboratory (URL) in clay in Switzerland

Joining the URL will give DOE access to data from all Mont Terri R&D, also the opportunity to conduct new experiments

Colloid Formation and Migration Project

Colloid research at Grimsel granite URL in Switzerland

DECOVALEX: (Development of Coupled Models and their Validation against Experiments)

DOE has participated in the past, new phase of project begins Spring 2012

KAERI Underground Research Tunnel (KURT)

R&D plan for experiments beginning in FY13

Questions?