

Used Fuel Disposition R&D Campaign

Overview of Defense Repository Safety Analysis R&D

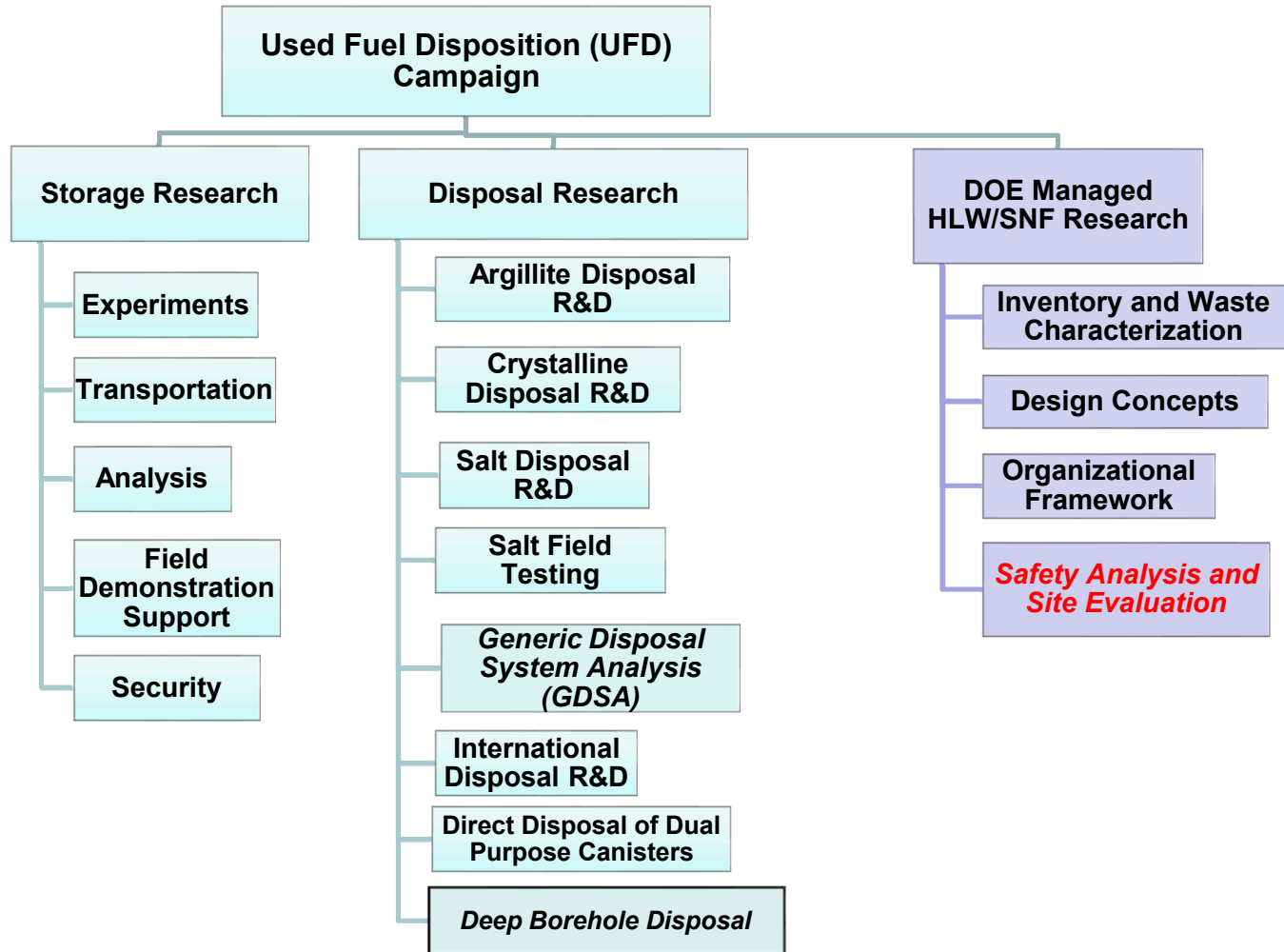
S. David Sevougian
Sandia National Laboratories

2016 UFDC Annual Working Group Meeting
Defense Repository Session, June 9, 2016
Las Vegas, NV

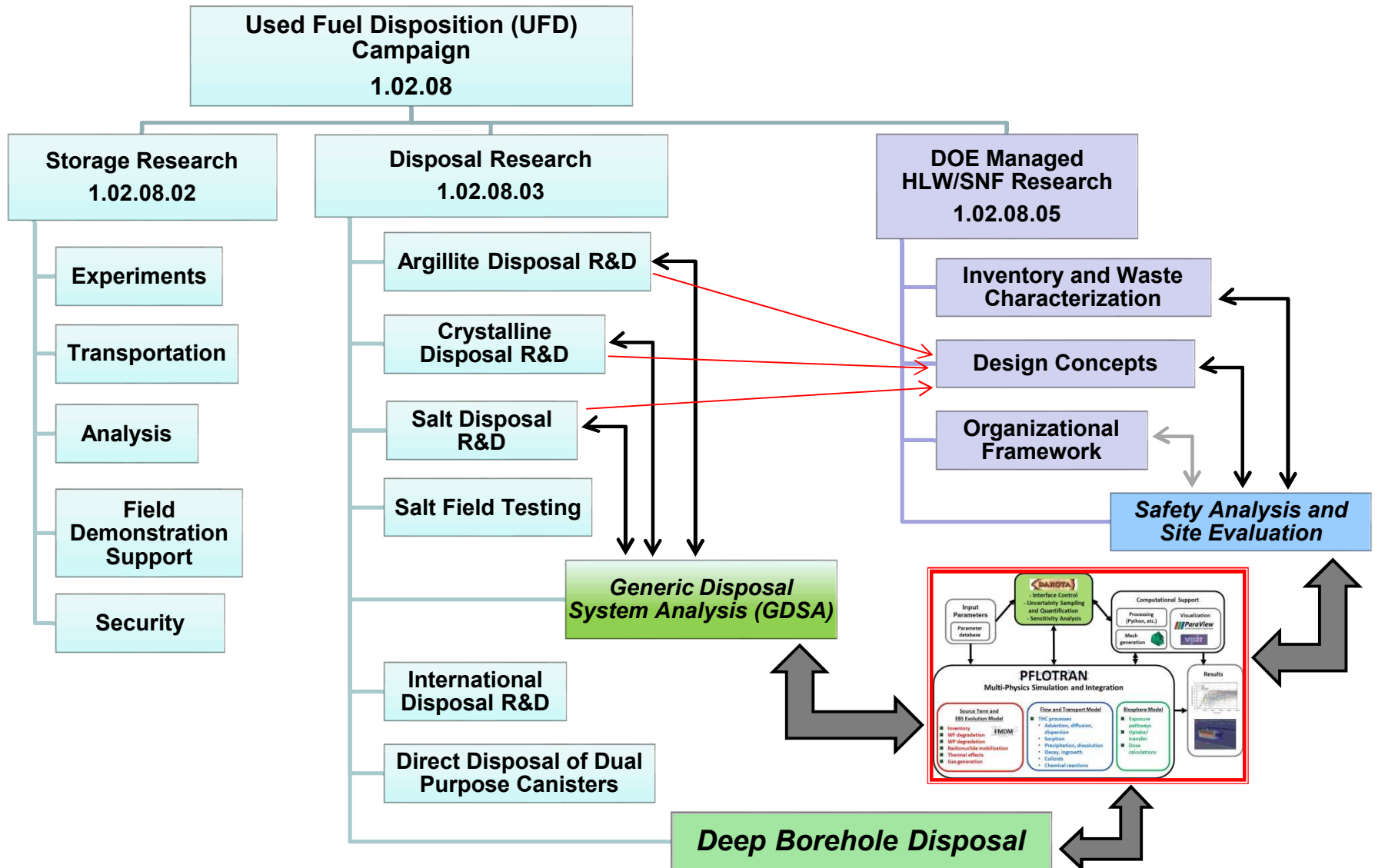
Outline

- **Work breakdown structure of Safety Analysis WBS**
- **GDSA Framework as an integration tool**
- **Overview of six ongoing Safety Analysis work packages**

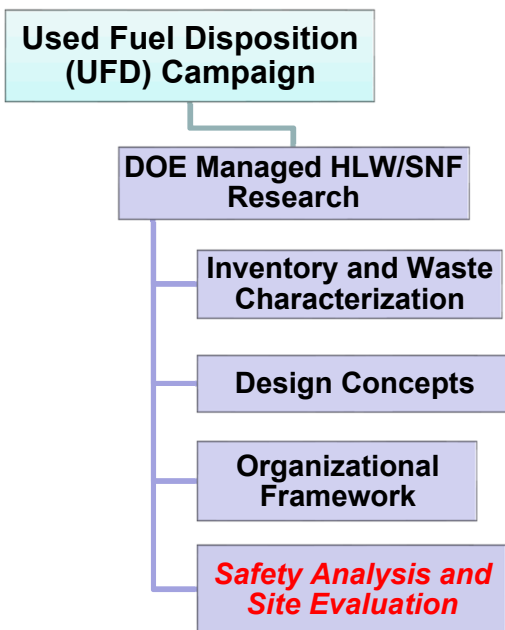
Work Structure for the R&D Program



Model Integration Linkages



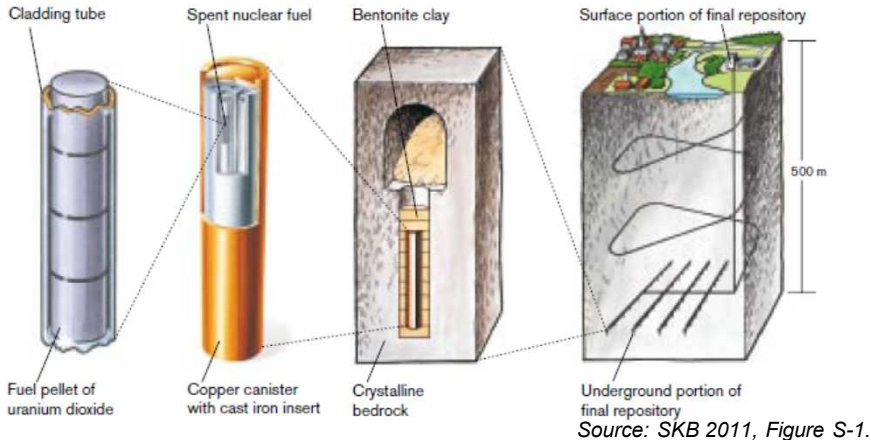
Safety Analysis Work Packages



- **WP 1 (SNL): Complete Reference Cases for each Geologic Medium** (some are deferred)
- **WP 2 (SNL): FEPs Analysis**
- **WP 3 (LANL): FEPs Analysis (aka. the Colloid Synthesis Report)**
- **WP 4 (SNL): Define Generic Performance/Safety Objectives** (deferred pending funding)
- **WP 5 (SNL): Evaluate Alternative EBS Concepts**
- **WP 6 (SNL): Total System Performance Assessment**
- **WP 7 (SNL): Document Preliminary Technical Site Evaluation Plan** (deferred pending funding)
- **WP 8 (LANL): Preliminary Regional Geology Evaluation**

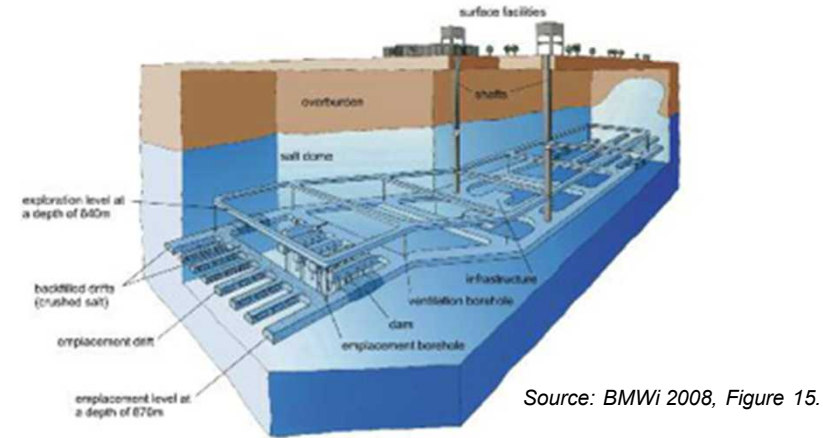
WP 1 (SNL): Complete Reference Cases for each Geologic Medium

Mined repository in granite or other hard rock



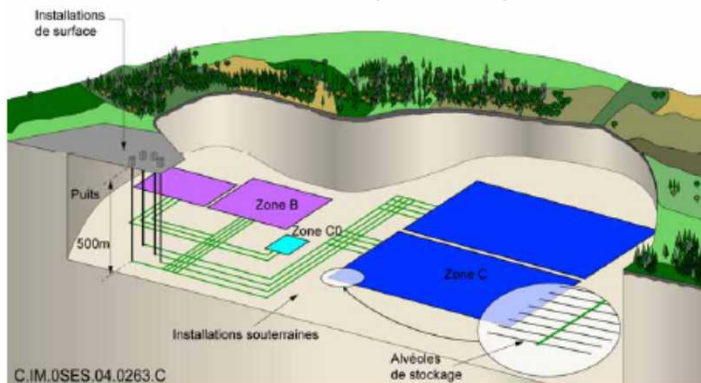
(primary focus of FY16, in conjunction with GDSA work)

Mined repository in bedded salt



(some work in FY15; hope to update for FY16)

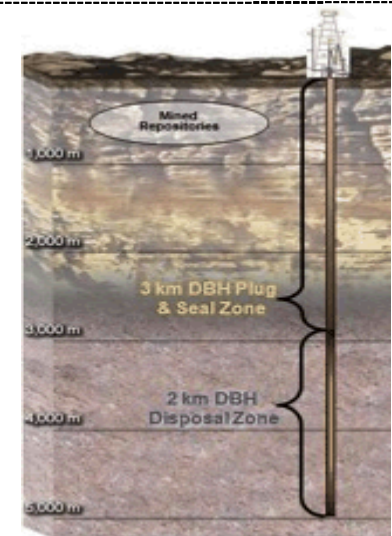
Mined repository in clay/shale



(deferred due to funding cut) Source: ANDRA 2005b.

Deep borehole in crystalline basement rock

(R&D conducted
under DBFT WPs)



WP 1: Reference Cases (continued)

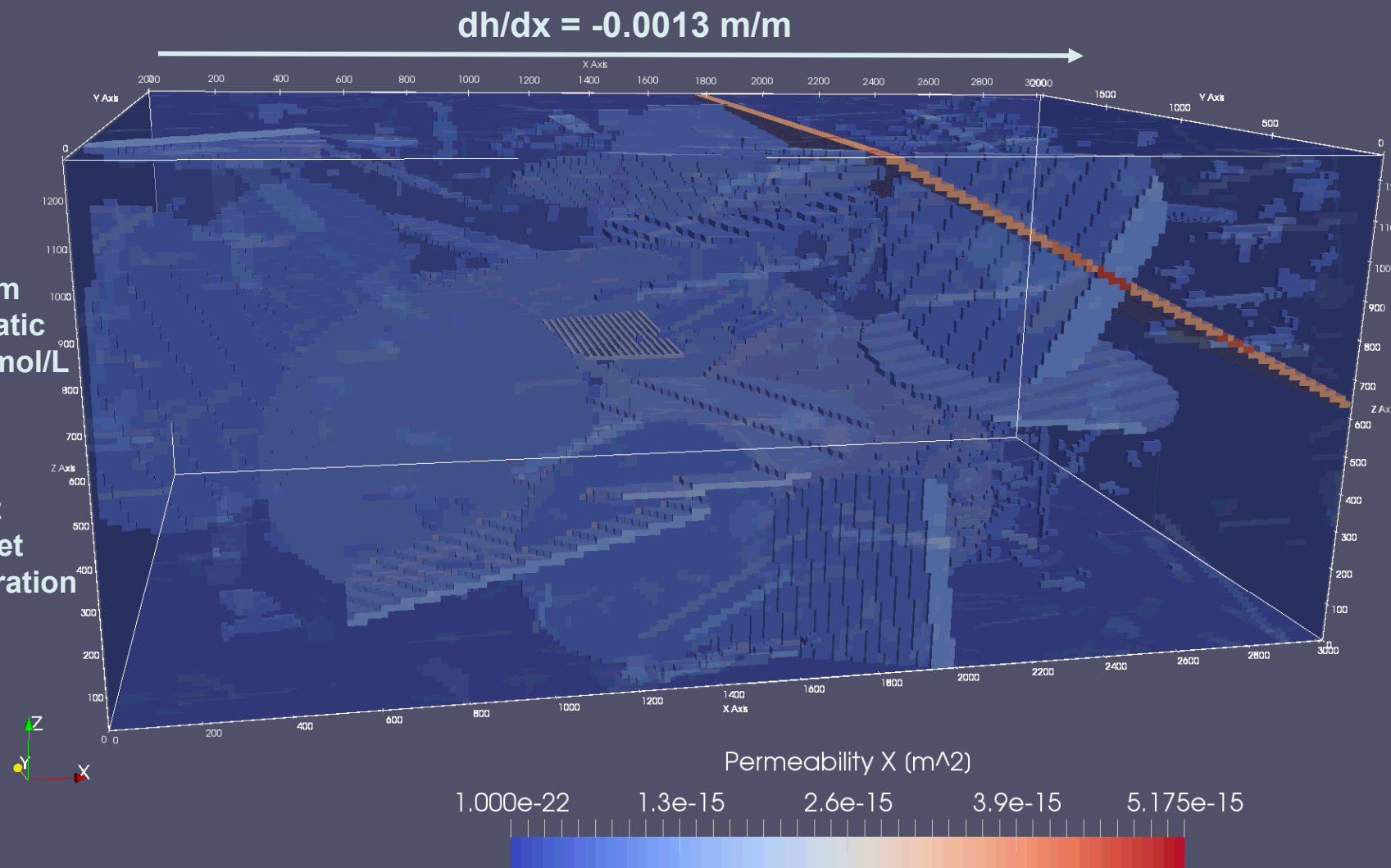
Fractured Crystalline (Granite)

Initial

- T: ~ 25 °C/km
- P: Hydrostatic
- [C]: $1e-20$ mol/L

Boundary

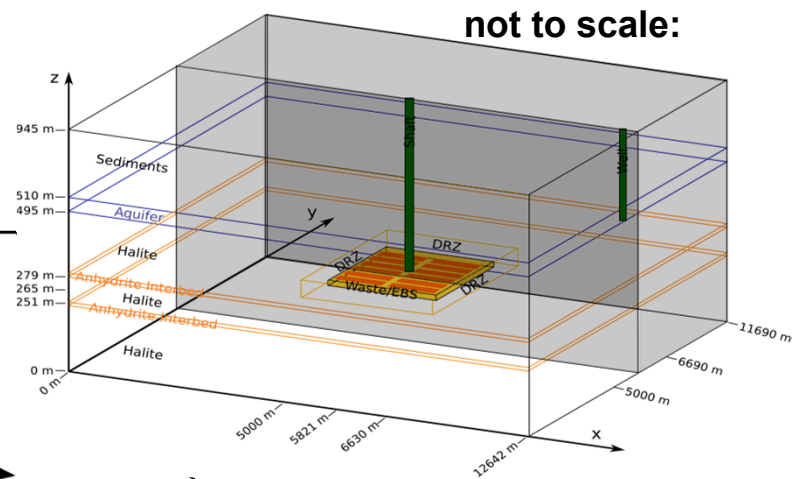
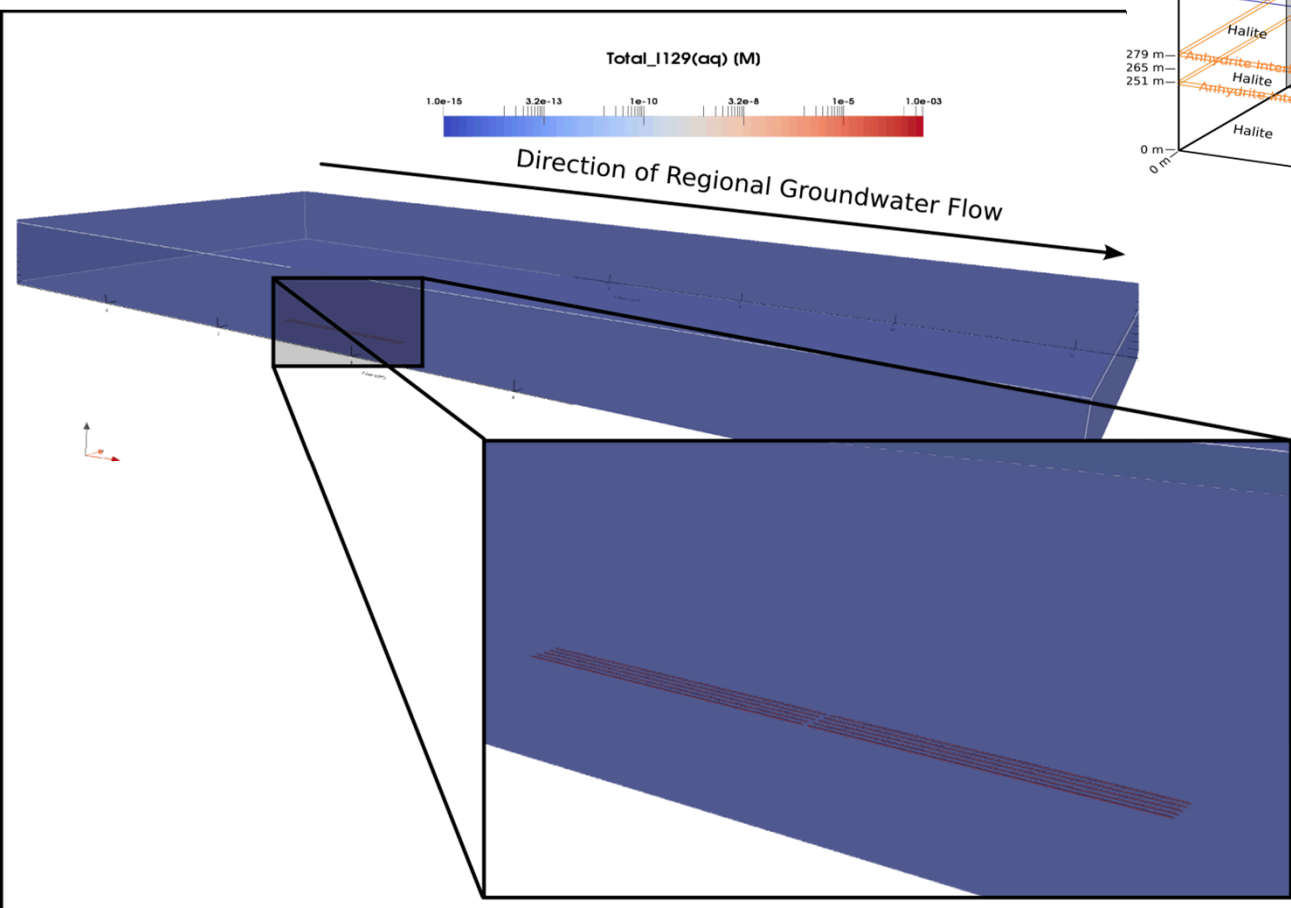
- T: Dirichlet
- P: Dirichlet
- [C]: Dirichlet
(0-concentration
gradient)



WP 1: Reference Cases (continued)

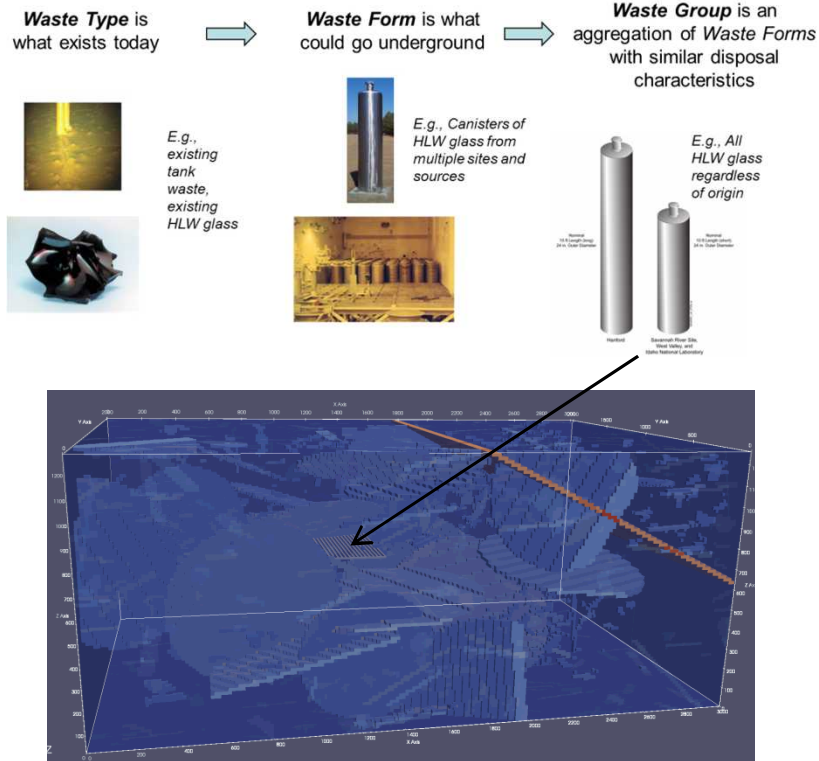
Bedded Salt

- Hanford HLW only in current salt host rock simulations
- 3 canisters per WP



WP 2 (SNL): FEPs Analysis

- Preliminary screening to be based on FEPs matrix approach being developed in collaboration with Germans
- FEPs screening is a function of host rock and waste characteristics:



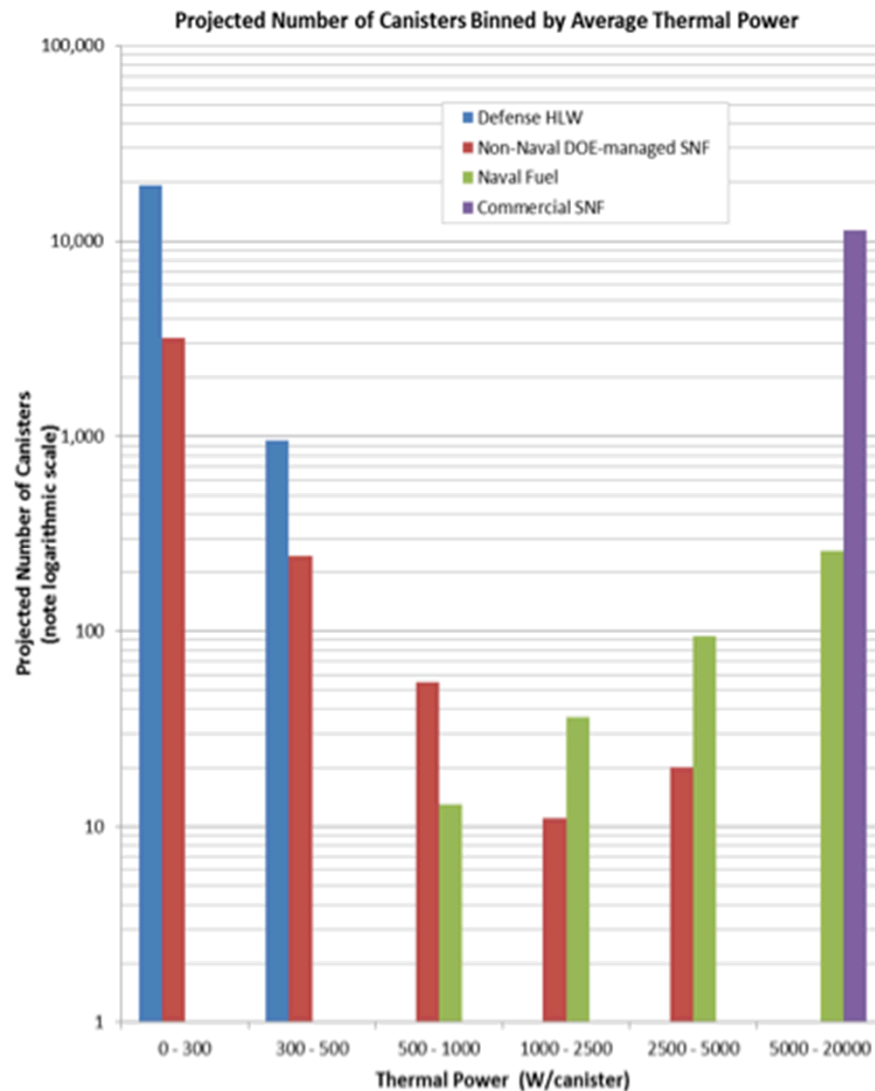
Features / Components	Characteristics, Processes, and Events	Characteristics	Processes											Events					
			Mechanical and Thermal-Mechanical	Hydrological and Thermal-Hydrologic	Chemical and Thermal-Chemical	Biological and Thermal-Biological	Transport and Thermal-Transport	Thermal	Radiological	Long-Term Geologic	Climatic	Human Activities (Long Timescale)	Other	Nuclear Criticality	Early Failure	Seismic	Igneous	Human Activities (Short Timescale)	Other
Glossary / Definitions		CP	TM	TH	TC	TB	TT	TL	RA	LG	CL	HP	OP	NC	EF	SM	IG	HE	OE
Waste and Engineered Features																			
(WF) Waste Form and Cladding																			
(01) SNF and Cladding																			
(02) Vitrified HLW																			
(05) Other HLW																			
(06) Metal Parts from Reprocessing																			
(WP) Waste Package and Internals																			
(01) SNF																			
(02) Vitrified HLW																			
(05) Other HLW																			
(06) Metal Parts																			
(BB) Buffer/Backfill																			
(01) Waste Package Buffer																			
(02) Drift/Tunnel Backfill																			
(MW) Emplacement Drifts/Rooms and Mine Workings																			
(01) Open Excavations																			
(02) Drift/Tunnel Support																			
(03) Liners																			
(SP) Seals/Plugs																			
(01) Drift/Tunnel Seals																			
(02) Shaft Seals																			
(03) Borehole Plugs																			
Geosphere Features																			
(HR) Host Rock																			
(01) Disturbed Rock Zone (DRZ)																			
(02) Emplacement Unit(s)																			
(03) Other Host Rock Units																			
(OU) Other Geologic Units																			
(01) Overlying / Adjacent Units (including Caprock, Aquifers)																			
(02) Underlying Units																			
Surface Features																			
(BP) Biosphere																			
(01) Natural Surface and Near-Surface Environment																			
(02) Flora and Fauna																			
(03) Humans																			
(04) Food and Drinking Water																			
(05) Dwellings and Other Man-Made Surface Features/Materials																			
System Features																			
(RS) Repository System																			
(01) Assessment Basis																			
(02) Preclosure/Operational																			
(03) Other Global																			

Thermal Characteristics of HLW and SNF Affect Disposal Strategies

■ Repository designs and operational concepts can be engineered to address waste-form thermal characteristics:

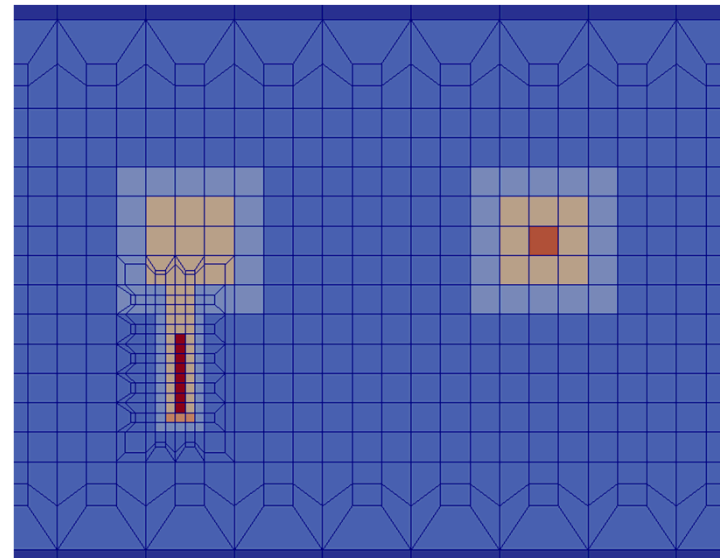
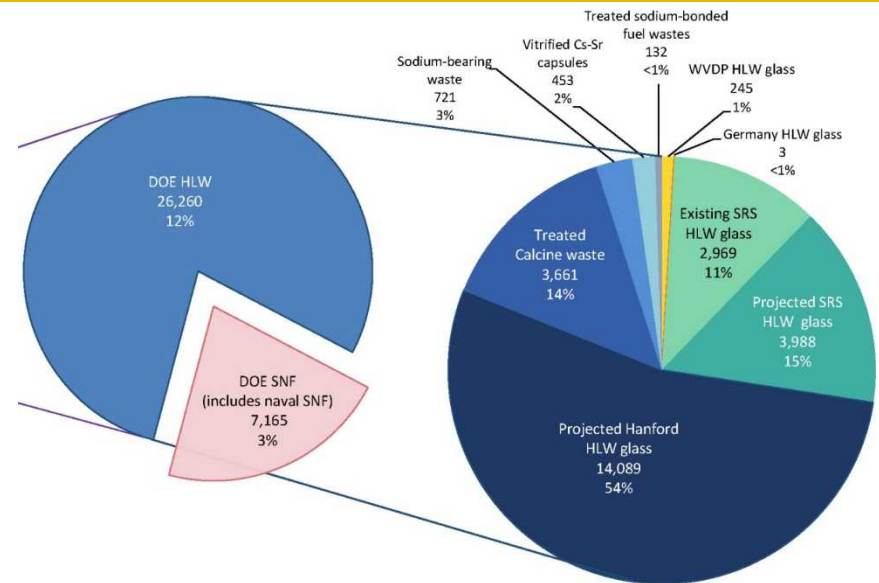
- All Defense HLW is relatively cold: less than 500 W per canister
- Most DOE-managed SNF is relatively cold: less than 1000 W per canister
- All commercial SNF has comparatively high thermal output
- Some naval SNF is comparable in thermal power to commercial SNF

■ Initial R&D will limit EBS/repository designs to canisters of approximately less than 1000 W



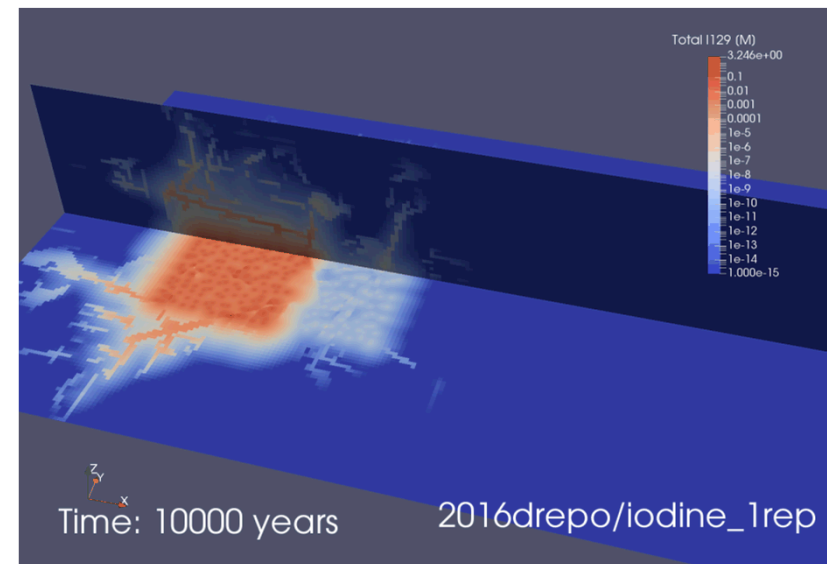
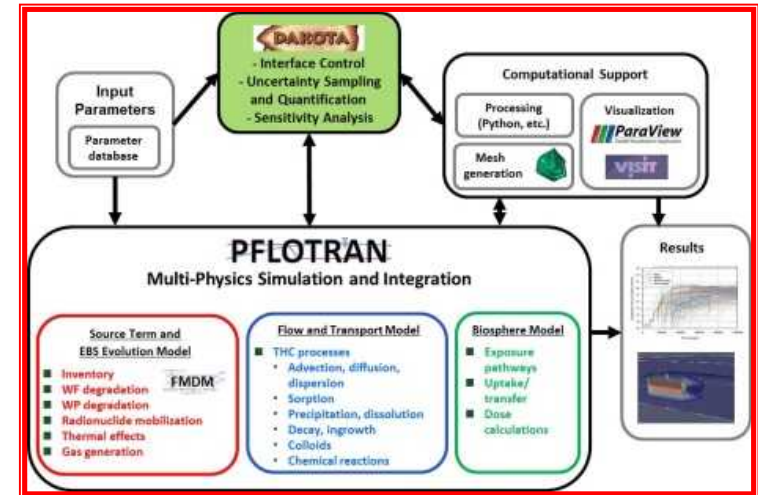
WP5 (SNL): Evaluate Alternative EBS Concepts

- Developed in collaboration with WBS 1.02.08.05.02 “Preliminary Design Concepts” (Matteo)
- For FY16, considering two primary waste types: DOE SNF (all types, but dominated by N-reactor fuel) and DOE HLW (both SRS and Hanford)
- Considering both single-canister vertical emplacement (SNF) and multi-canister horizontal emplacement (HLW), in separate areas of the repository
- Representing thermal variability:
 - 7 different “thermal bins”, distributed spatially, for DOE SNF
 - SRS glass and Hanford glass have different average thermal outputs



WP6 (SNL): Total System Performance Assessment

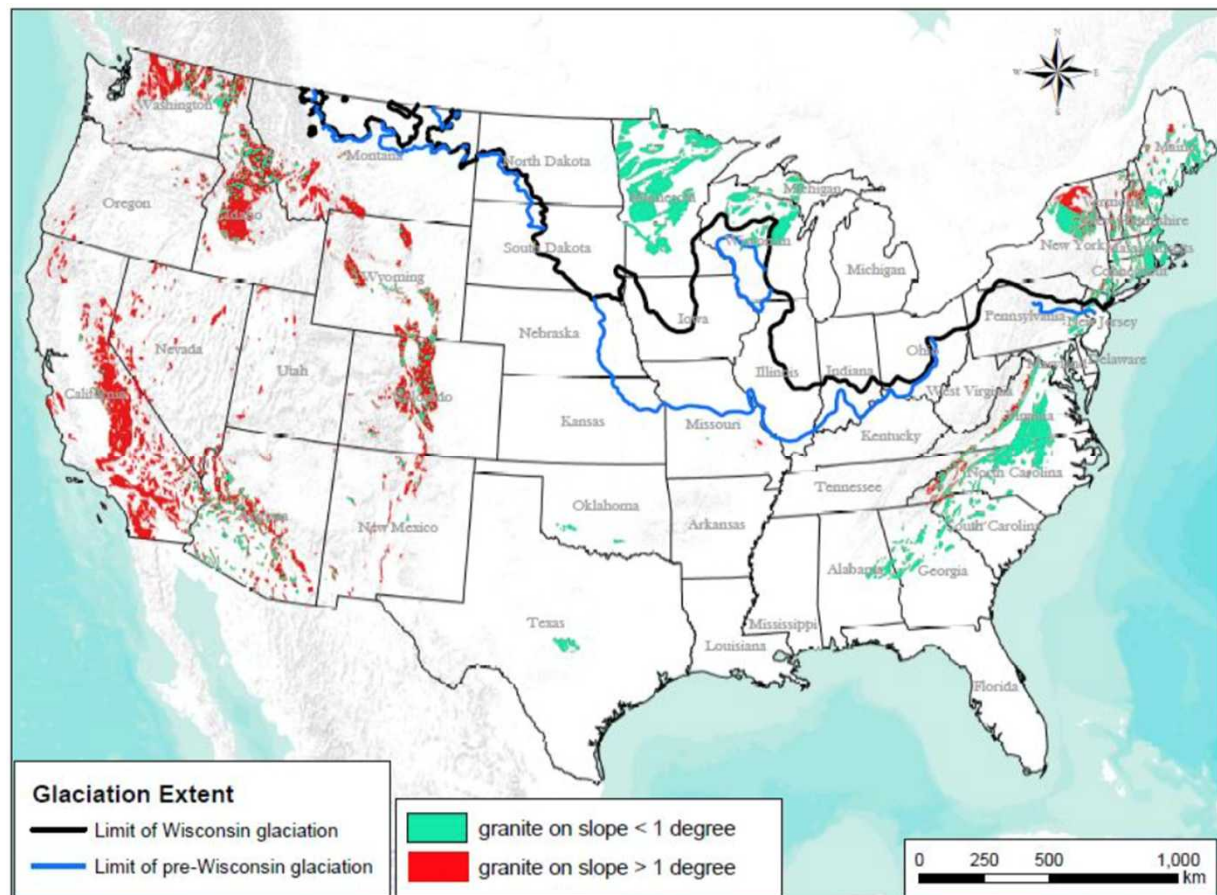
- M2 milestone in Nov 2016: “*Status of Progress Made Toward Safety Analysis and Technical Site Evaluations for DOE Managed HLW and SNF*”
- Simulations conducted with the GDSA-PFLOTRAN Framework (heat, fluid, and mass transport)
- Granite host-rock natural barrier system is the same as in GDSA commercial SNF simulations
- Waste characteristics, packaging, degradation rates, and repository layout are specific to a defense-waste repository
- Preliminary simulations and example UA/SA for the granite defense repository reference case



WP8 (LANL): Regional Geology Evaluations

- Comparisons of granitic terrane and fracture features at Forsmark, Sweden—used as a basis for the UFD reference case—to granitic provinces in North America
- Maps of water table elevations (thickness of unsaturated zone)

*Crystalline
rock outcrop*



Agenda

Used Fuel Disposition (UFD) Campaign

DOE Managed HLW/SNF Research

Inventory and Waste
Characterization

Design Concepts

Organizational
Framework

*Safety Analysis and
Site Evaluation*

Session 3: *Safety Analysis and Organization/Procedural Frameworks*

10:10 – 10:30: Overview of D-Repo Safety Analysis R&D – **Sevougian**

10:30 – 10:50: Regional Geology Investigations – **Perry**

10:50 – 11:20: D-Repo Repository Reference Case and Preliminary PA Simulations – **Stein**

11:20 – 11:35: Draft Program Plan: Organizational and Procedural Frameworks – **Swift**

11:35 – 11:50: Wrap-up and Brainstorming on Future Directions – **All**

Back-Up Slides

Summary of D-Repo Milestones

■ Inventory and Waste Characterization

- M2: The On-line Waste Library (OWL): Usage and Status Report (SNL, 9/23/2016)
- M4: Inventory Input Report (SRNL, 7/29/2016)

■ Preliminary Design Concepts

- M2: Status of Progress Made Toward Preliminary Design Concepts for the Inventory in Select Media for DOE Managed HLW/SNF (SNL, 9/30/2016)
- M4: Decay Heat of Selected Defense Waste Materials (SRNL, 7/29/2016)

■ Organizational and Procedural Frameworks

- M2: Draft Program Plan for the Permanent Disposal of High-Level Radioactive Waste and Spent Nuclear Fuel from Defense and Department of Energy Research and Development Activities (SNL, 7/29/2016)
- M2: Generic Organizational and Procedural Framework for DOE Managed HLW and SNF Licensing (SNL, 9/16/2016)

■ Safety Analysis and Technical Site Evaluations

- M2: Status of Progress Made Toward Safety Analysis and Technical Site Evaluations for DOE Managed HLW and SNF (SNL, 11/3/2016, i.e., in FY17)
- M4: Preliminary Regional Site Evaluations for Disposal of DOE-Managed HLW and SNF (LANL, 9/16/2016)