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Salt Reference Case and Interfaces to R&D

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SFWD

Spent Fuel & Waste Disposition

Annual Working Group Meeting

UNLV-SEB – *Las Vegas, Nevada*

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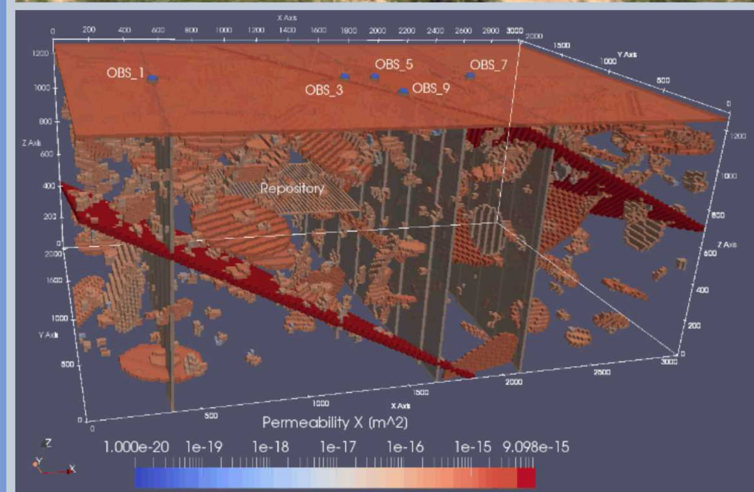


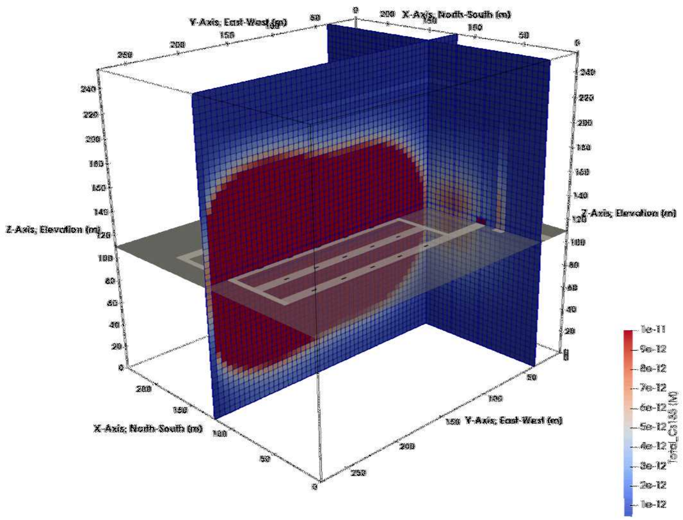
INTRODUCTION

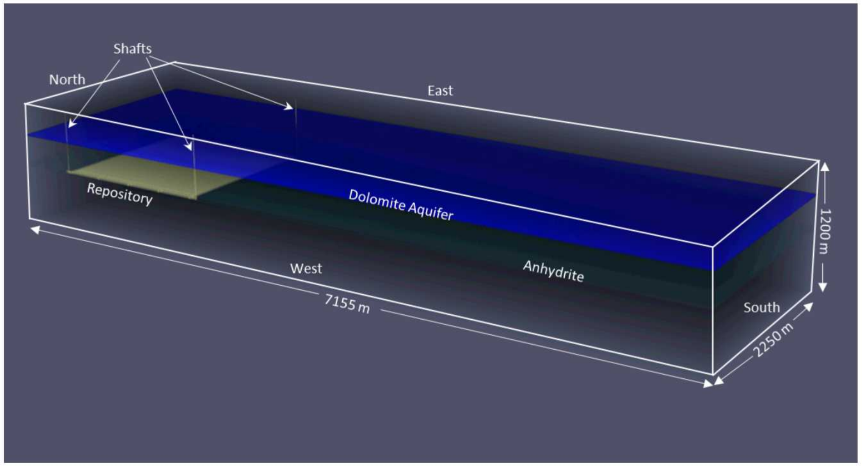
Interface to Salt R&D

- Objective of the Salt Reference Case
- Description
  - Waste packages / engineered barrier
  - Salt conceptual model
  - Grid & Numerical model development
- Results to Date

OBJECTIVES

- Provide the technical basis for disposal options in salt
- Increase confidence in the robustness of generic disposal concepts
- Develop the science and engineering tools needed to support salt disposal concept implementation
- Identify gaps in understanding





Site Description

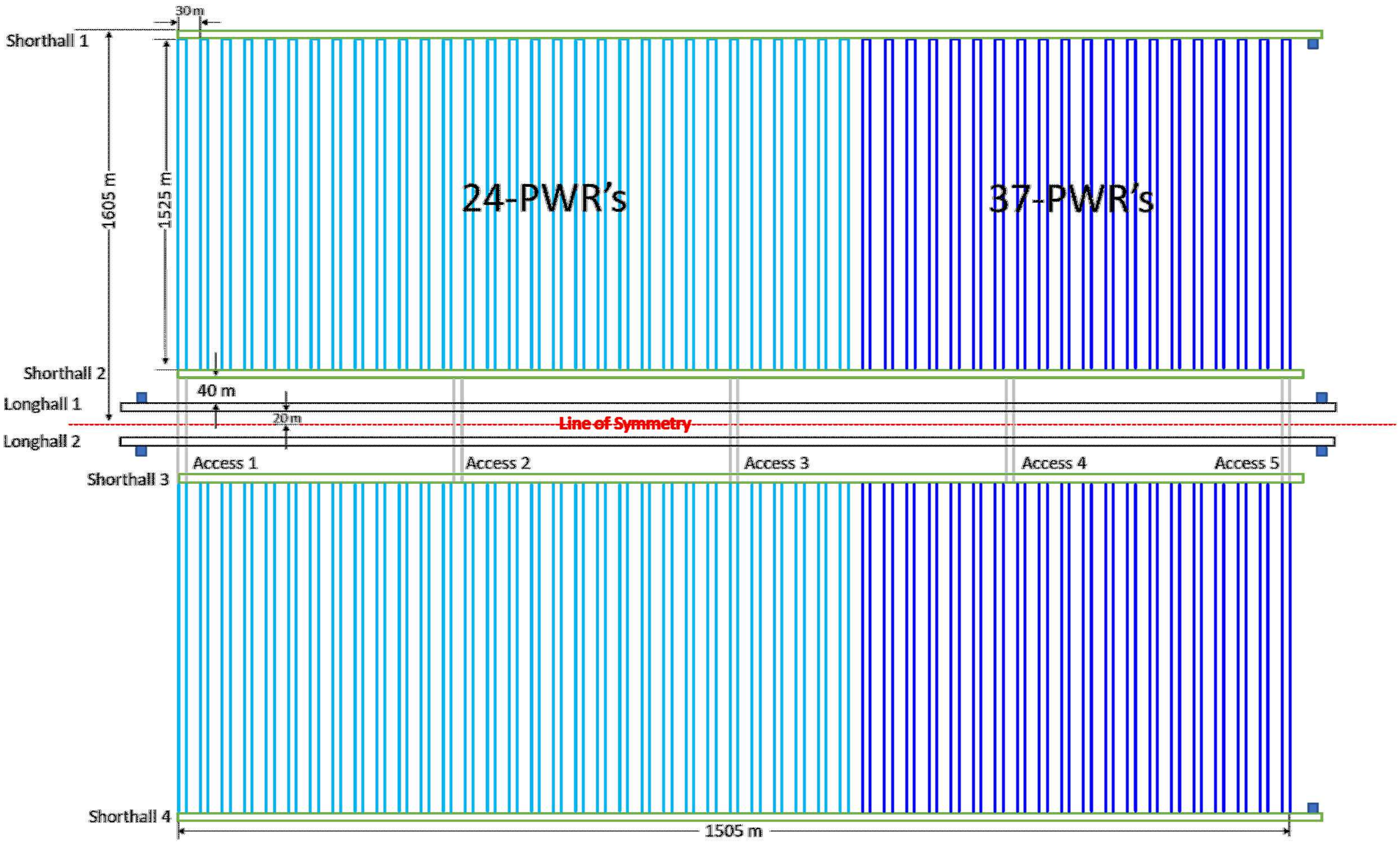
- Mined repository 600 m below the surface
  - 69,748 MTHM total emplacement, 24- & 38-PWR DPC's
  - Two models; 'site scale' and 'small scale'

Parameters	Reference Case Value	Site-Scale Simulated Value	Small-Scale Simulated Value
Waste Package (WP)			
WP center-to-center (m) [24-PWR's and 37-PWR's]	30.0	30.0	30.0
Inventory per 24-PWR WP (MTHM)	11.28 [c]	11.28 [c]	11.28 [c]
Inventory per 37-PWR WP (MTHM)	17.39 [c]	17.39 [c]	17.39 [c]
Number of 24-PWR WPs	3100	1550 / 3100 [b]	15
Number of 37-PWR WPs	2000	1000 / 2000 [b]	10
Emplacement Drift			
Drift diameter (m)	4.5 [a]	5.0 (on a side)	10.0 (*x*) / 5.75 (*z*)
Drift center-to-center spacing (m)	30 [a]	30	30
Number of WPs per drift	50 [a]	50	5
Drift seal length (m)	25	25	25
Drift length, including seals (m)	1525	1525	175
Repository			
Repository Depth (m)	600	600	600
Number of drifts	102	51 / 102 [b]	5
Number of shafts	Not specified	3 / 6 [b]	1
Shaft access size (m^2)	Not specified	5 x 10	5 x 5
Emplacement footprint (km^2)	4.88	2.44 / 4.88 [b]	0.023

[a] Hardin and Kalinina (2016, Section 3)
[b] half-symmetry domain / with reflection
[c] Harding et al. (2013, Table 4-2)

Description: Site Scale Design

- Repository Schematic Plan View



Package Inventory
3100, 24-PWR's
2000, 37-PWR's
69,748 MTHM

50 WP's / drift
5.0 m package length

Longhalls:
1625 x 10 m

Shorthalls:
1505 x 5 m

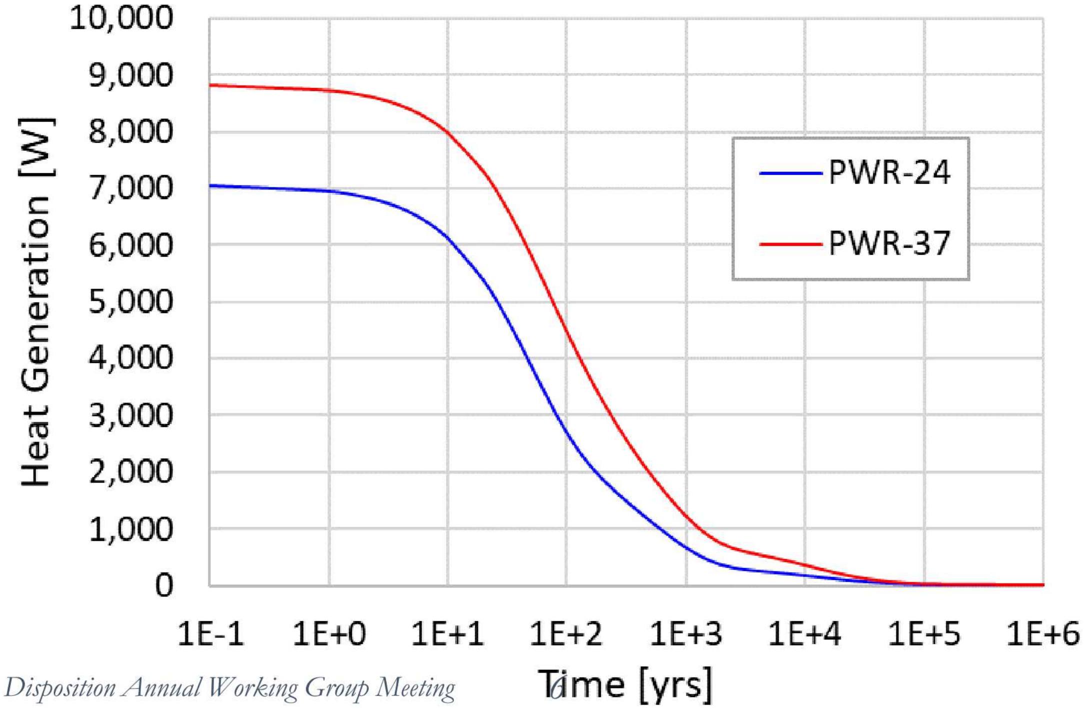
Drifts:
1525 x 5 m
25 m backfill on ends

Access Halls:
150 x 5 m

Shafts:
10 x 10 m

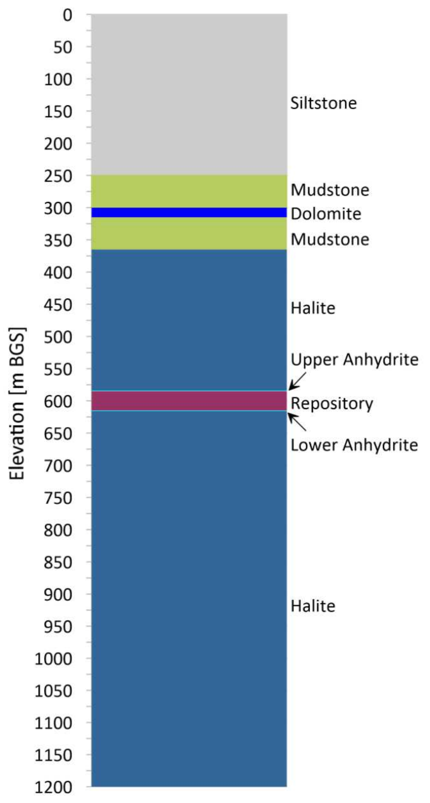
Description: DPC Waste Packages

- 24-PWR: 40-GWd/MTU, 50 yrs OoR, 7058 W
  - Start at t = 0
- 37-PWR: 60-GWd/MTU, 100 yrs OoR, 8810 W
  - Start at t = 50 yrs

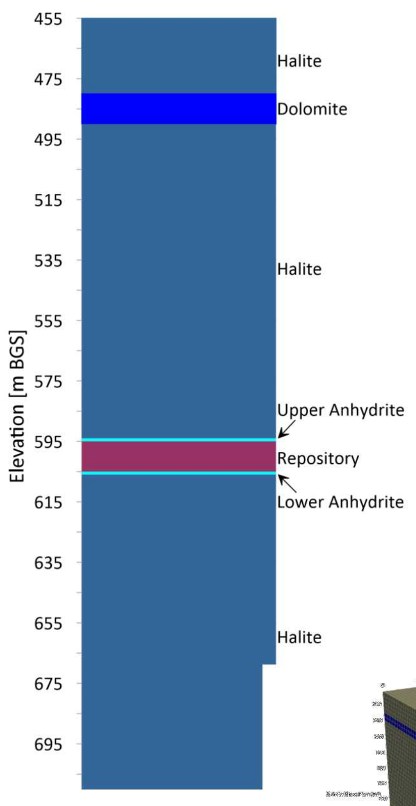


Conceptual Model

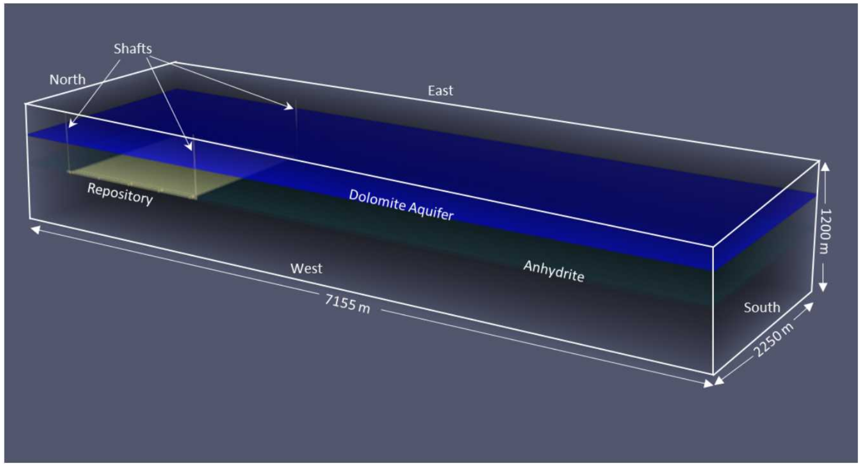
Repository Schematic: 3D View

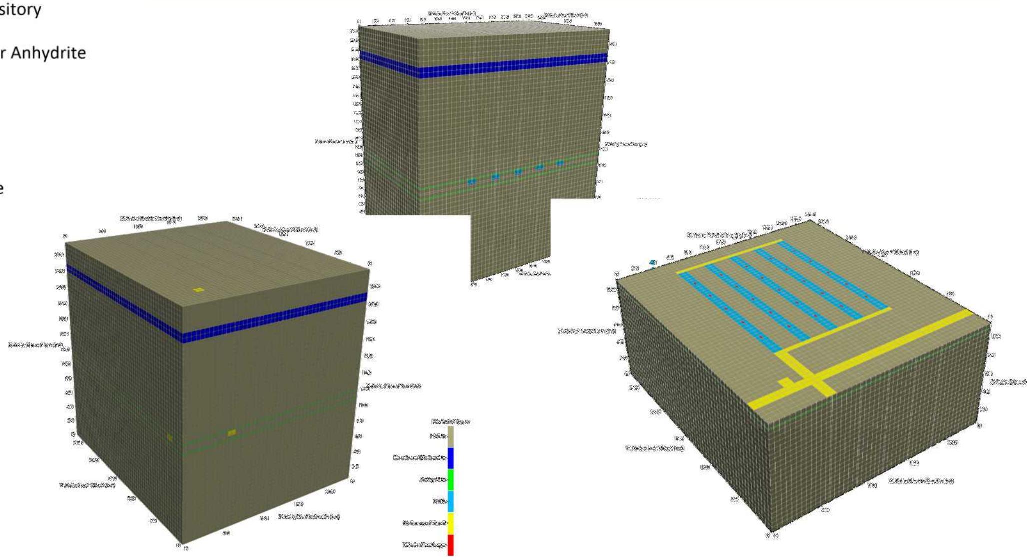


Site Scale Model



Small Scale Mode



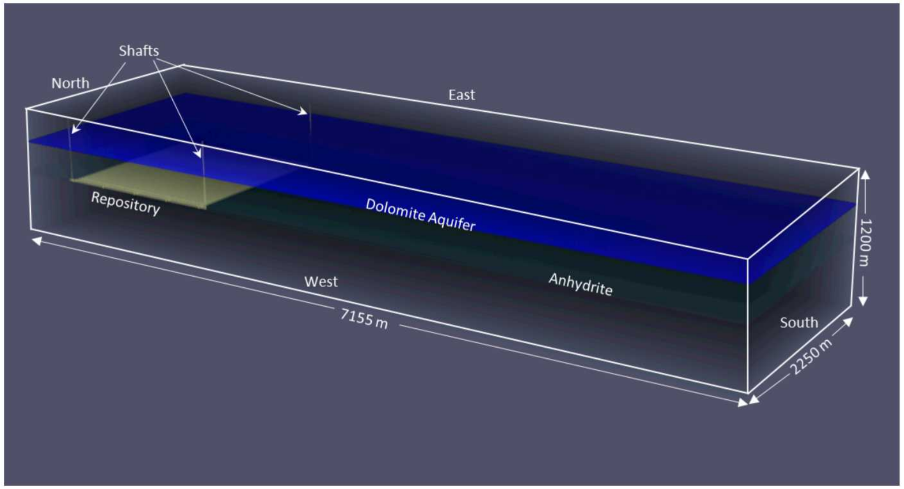


INTERFACE WITH SALT R&D – INITIAL CONDITIONS

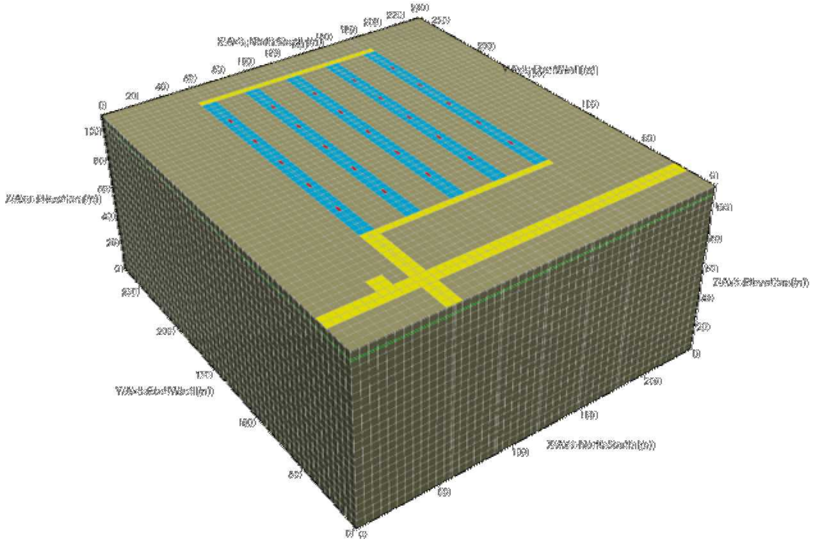
- Saturation
- Pressure
- DRZ
  - Extent
  - Physical parameters
- Backfill
  - Physical parameters

Grid and Numerical Model Development

- Site-Scale Model: 9,156,747 elements, 9,313,850 nodes
  - 5/3 m to 15 m
- Small-Scale Model: 53 x 55 x 54 = 157,410 structured grid cells
  - 5/3 m to 5 m



Site Scale Model



Small Scale Model

Parameters: R-S Model

- Geologic

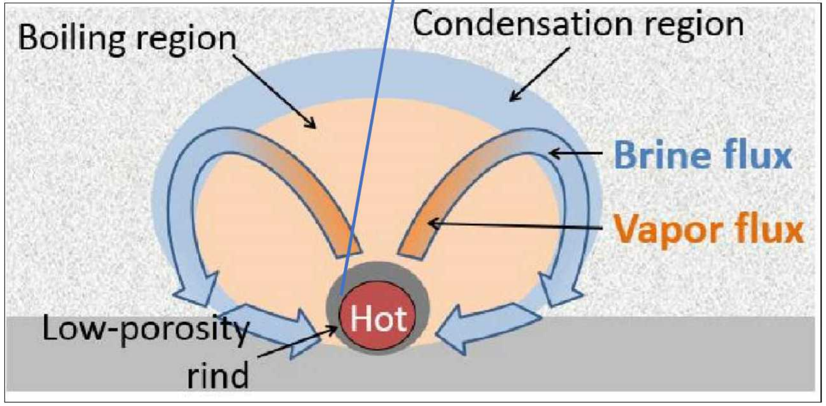
Model Region	Permeability (m^2)	Porosity □	Tortuosity □	Effective Diffusion Coefficient[1] (m^2/s)	Saturated Thermal Conductivity (W/m/K)	Heat Capacity (J/kg/K)	Grain Density (kg/m^3)
Halite	3.16×10^{-23}	0.01	1.0	1.0×10^{-11}	5.0	880	2180
Dolimite	1.00×10^{-13}	0.15	0.11	1.65×10^{-11}	1.4	920	2820
Anhydrite	1.26×10^{-19}	0.011	0.20	2.2×10^{-11}	1.4	890	2700
Backfill	1.00×10^{-18}	0.113	0.20	2.6×10^{-11}	1.4	880	2180
Waste Package	2.40×10^{-14}	0.50	1.0	5×10^{-10}	16.7	466	5000

[1] Effective diffusion coefficient = $D_w \phi \tau s$, where the free water diffusion coefficient (D_w) = 1×10^{-9} m^2/s (Li and Gregory 1974) and saturation (s) = 1

- Gradient, west to east: -0.0013 m/m
- Time scale: 50,000 yrs
- Initial
  - Radionuclide concentration: 10^{-20} mol/l
  - Temperature: 25 ^{o}C
  - Pressure: hydrostatic

INTERFACE WITH SALT R&D – TIME EVOLUTION

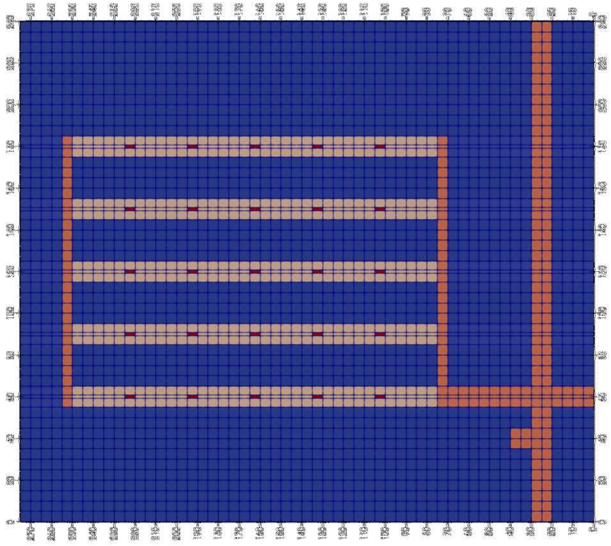
- Salt is "thermally activated"
  - High temperatures speed up creep closure
  - More brine available in hot salt
  - Salt more soluble in hot brine
- High temperatures lead to dry-out
  - Water driven off as vapor, forming salt crust
  - Near-package permeability reduced
  - Less corrosion in dry environment
- Coupled models (Δ porosity / permeability)
  - Creep, damage & healing
  - Precipitation & dissolution
  - Brine migration (rel. permeability)
    - Gas-filled fractures
    - Liquid-saturated far field

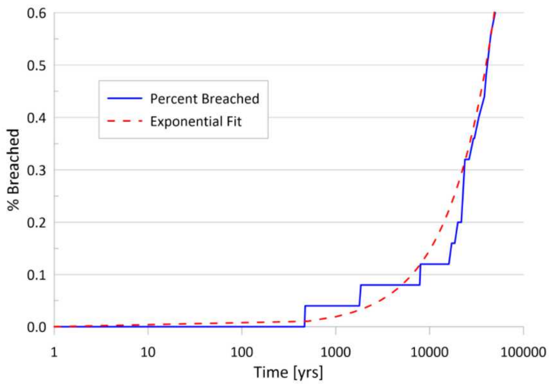


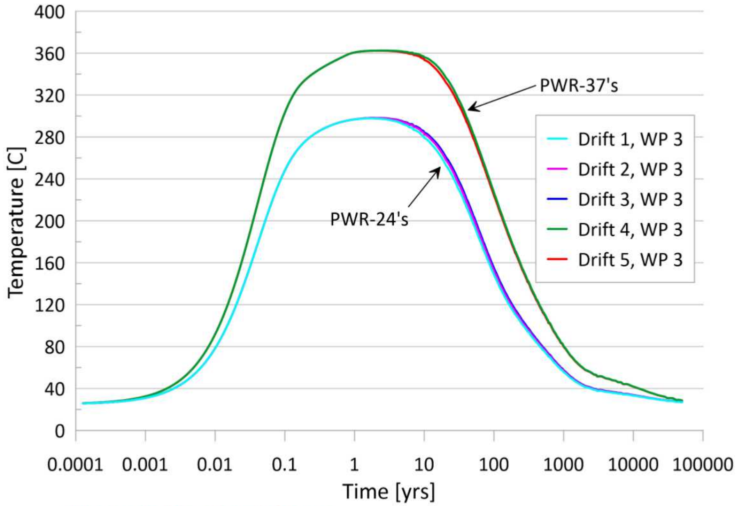
From: Kuhlman and Staufer, NWTRB April 2019

Results: Small-Scale Model

- Waste Packages







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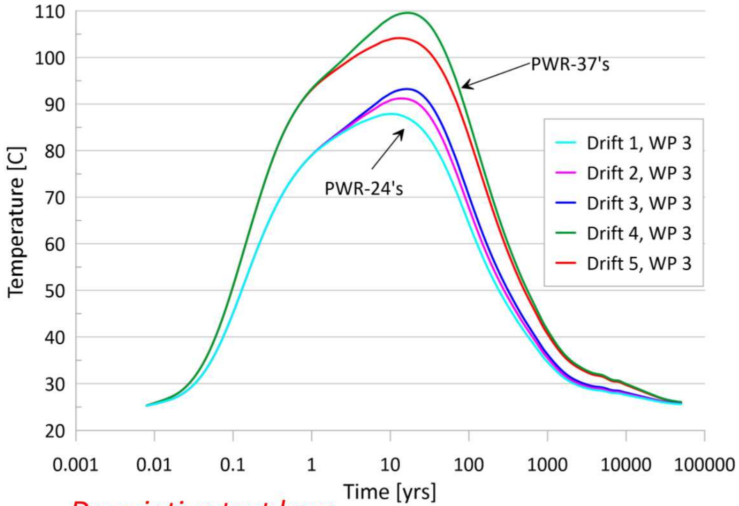

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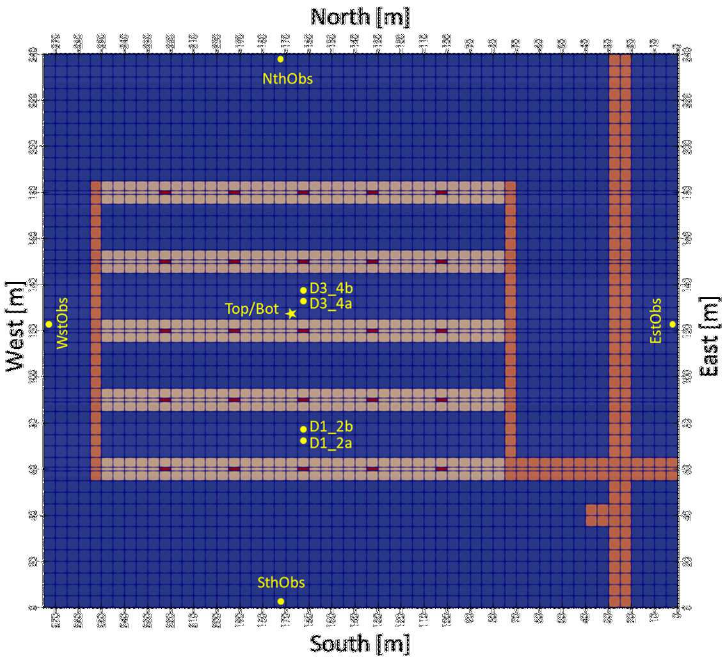
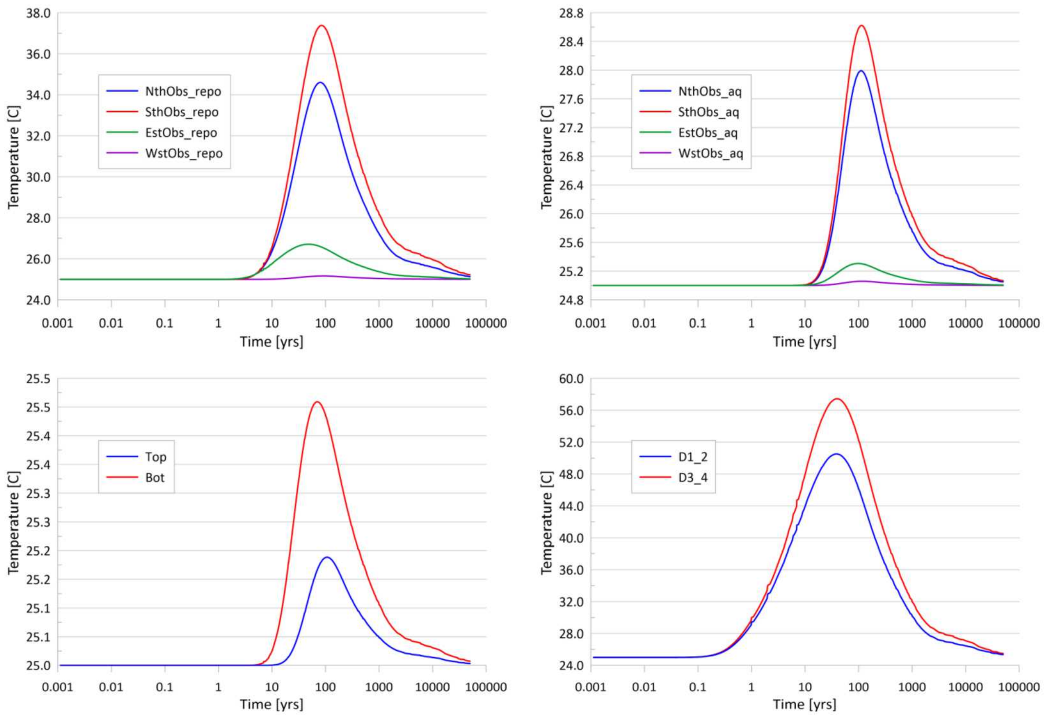
Results: Small-Scale Model

- Observation Points - Temperature

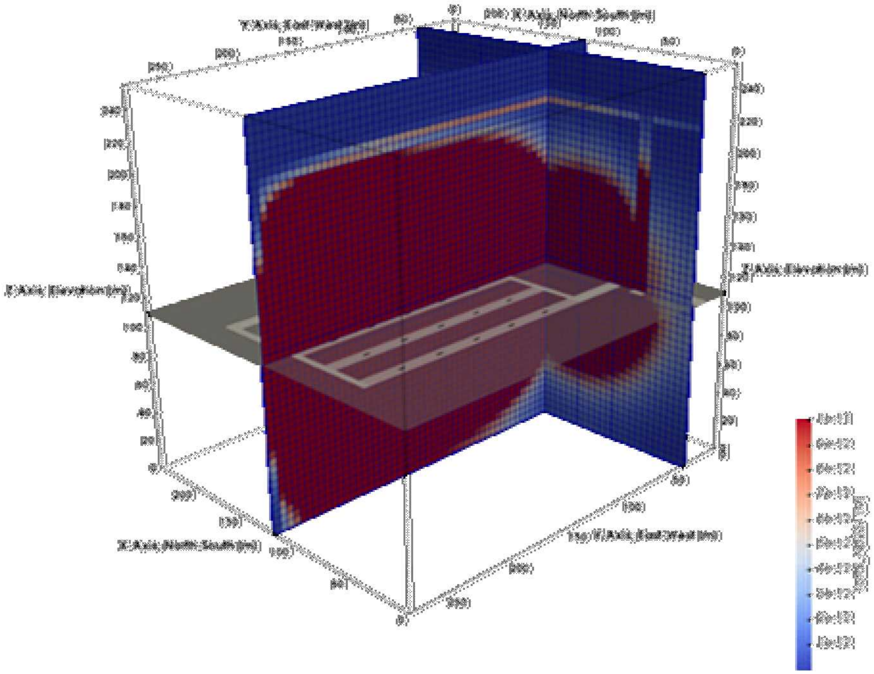


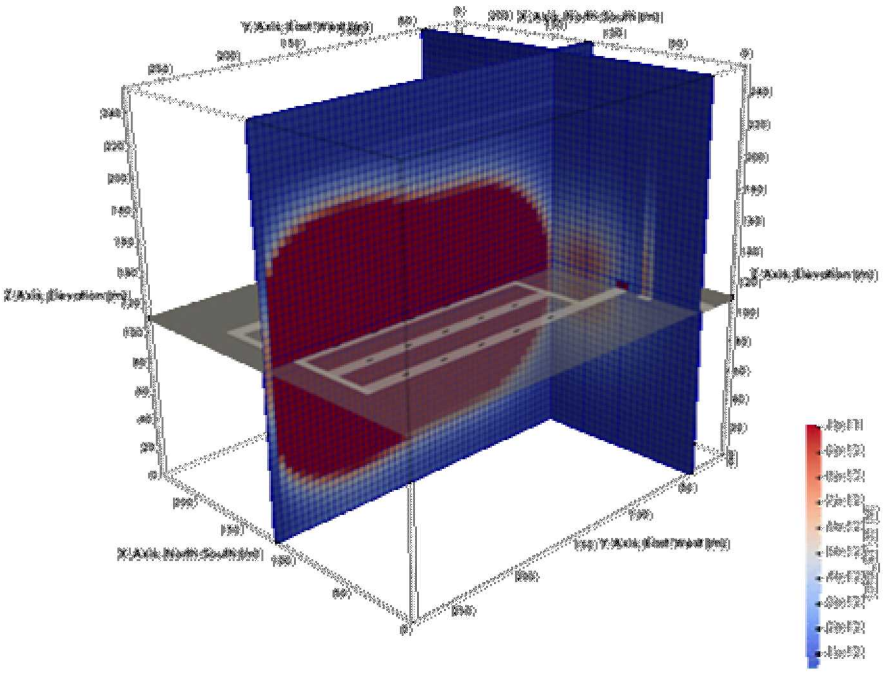


Need to update east-west-north-south designation.

Results: Small-Scale Model

- Transport: 50,000 yrs





Questions?

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REFRENCES

- Hardin and Kalinina, 2016
- Hardin et al. 2013
- Kuhlman, K.L., Stauffer, P.H., 2019, DOE Salt Research and WIPP Test, U.S. Nuclear Waste Technical Review Board Workshop, April 24-25, San Francisco, CA