

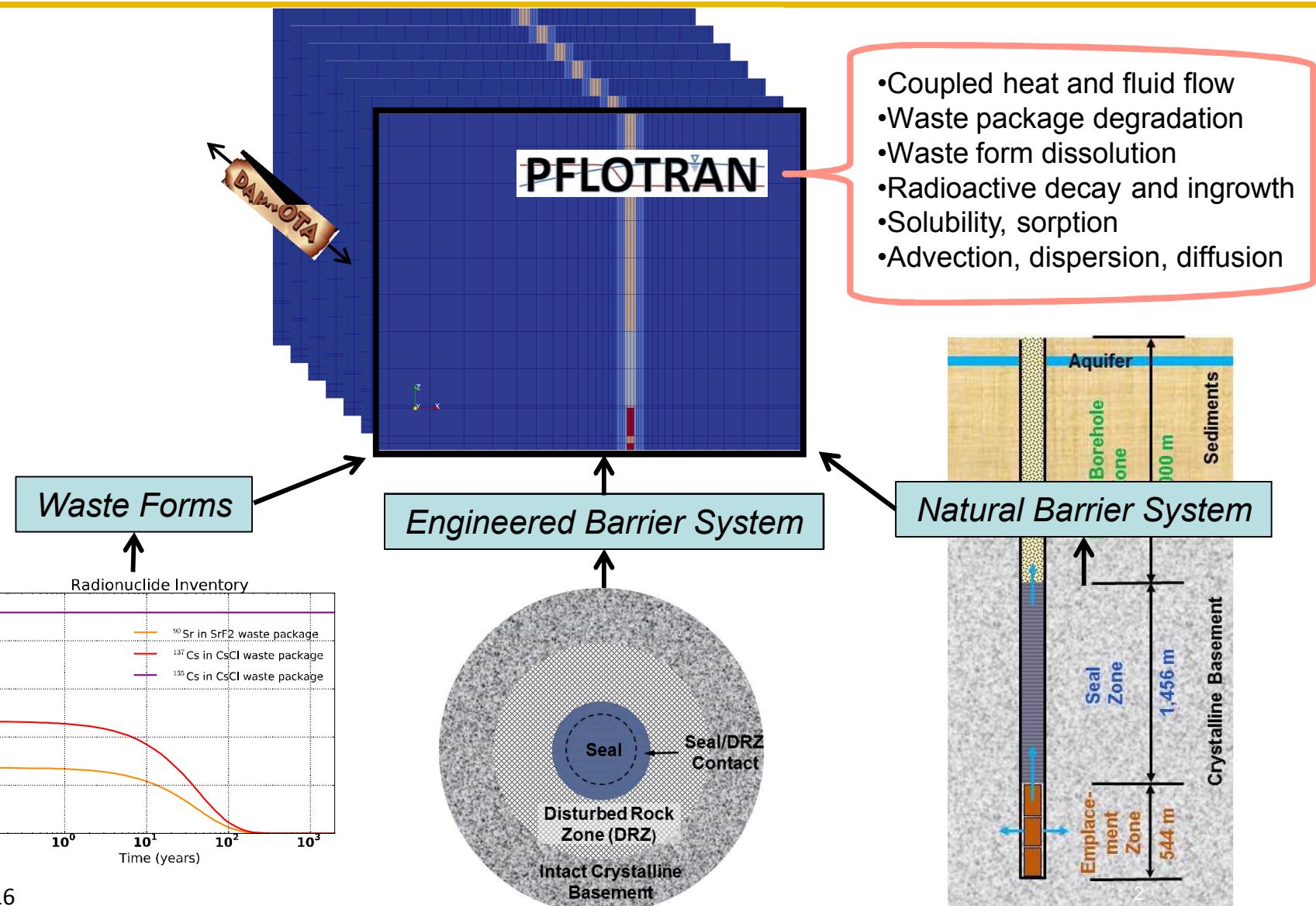
Used Fuel Disposition Campaign

Deep Borehole Disposal: Preliminary Performance Assessment

**Emily Stein, Geoff Freeze, Kris Kuhlman,
Glenn Hammond, Jenn Frederick
Sandia National Laboratories**

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Performance Assessment



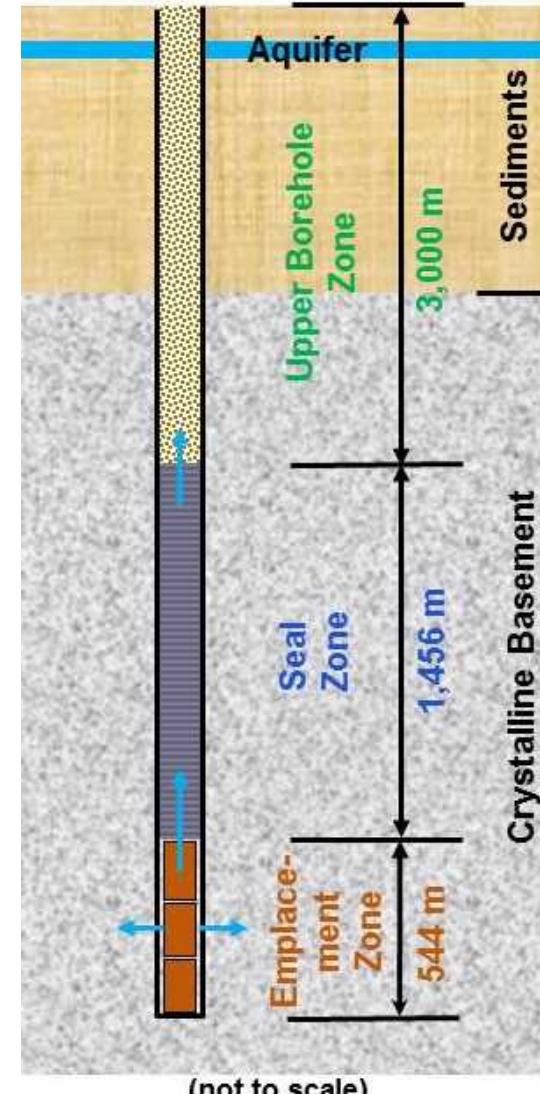
Natural Barrier System

■ Sediments (not simulated)

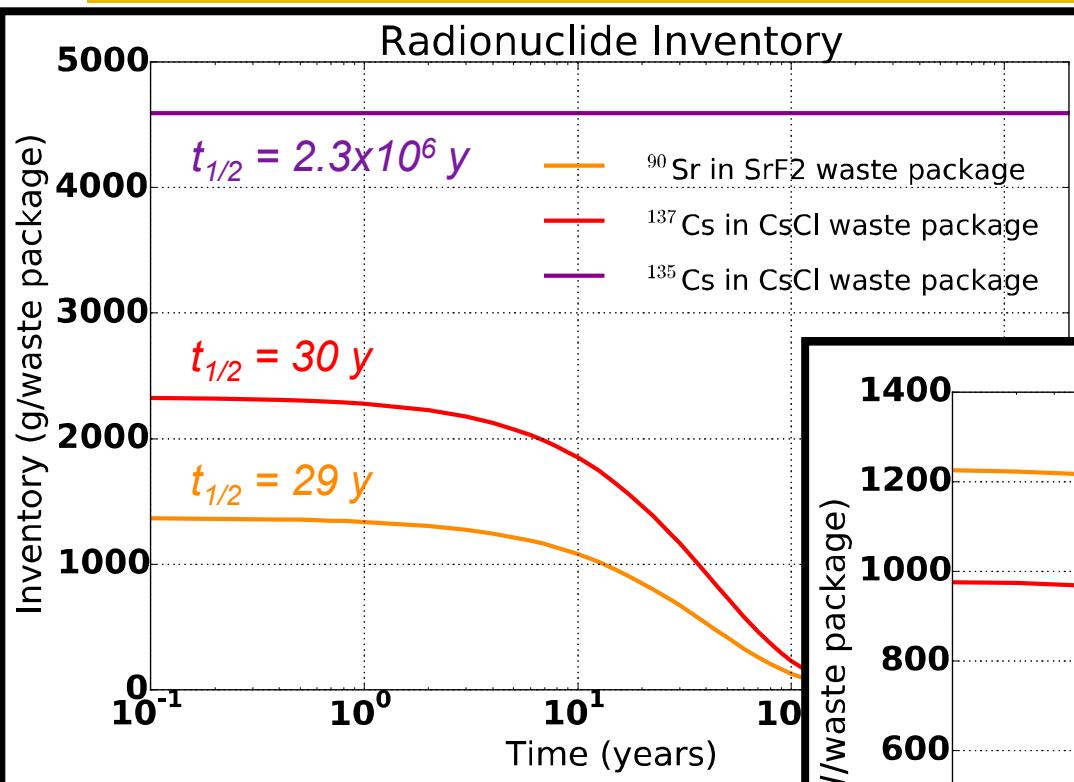
- ~2000-m thick
- Flat-lying sedimentary sequence

■ Crystalline Basement

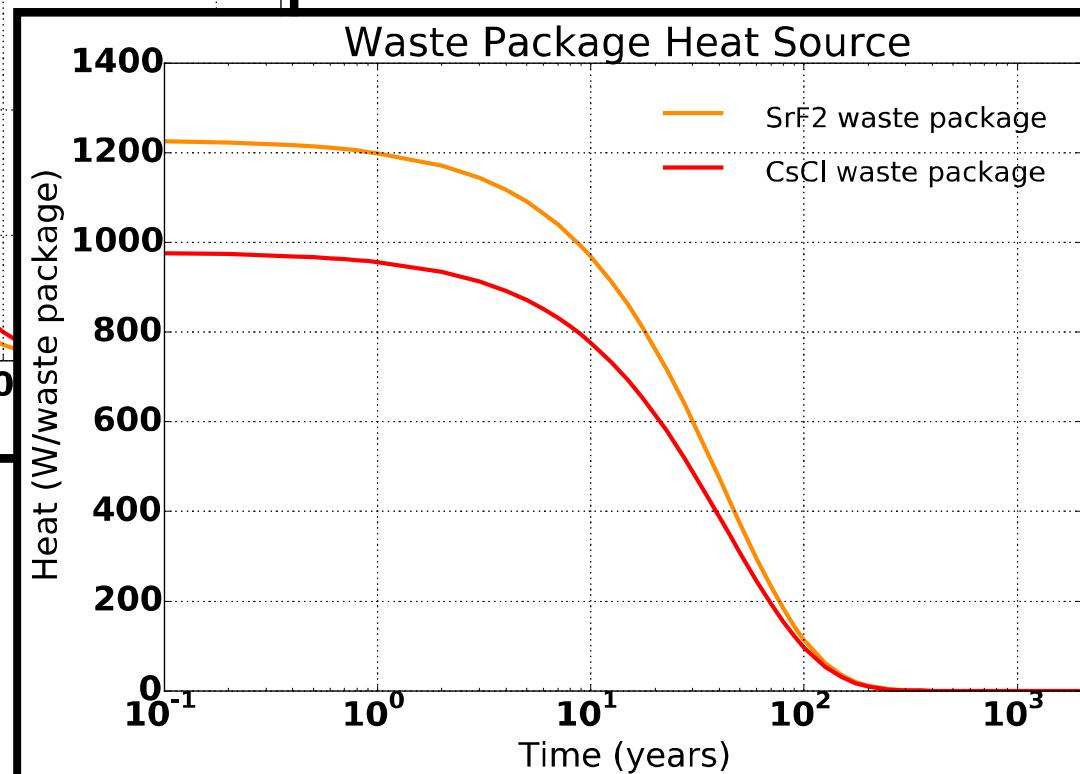
- Hydraulically isolated due to:
 - *Depth*
 - *Low permeability*
- Sparsely fractured granite
 - $k = 10^{-18} \text{ m}^2$, $\phi = 0.01$
 - $\kappa = 2.5 \text{ W}/(\text{m}^\circ\text{K})$
 - $C_p = 880 \text{ J}/(\text{kg}^\circ\text{K})$
- $\text{Sr } K_d = 0.4 \text{ L/kg}$; $\text{Cs } K_d = 5 \text{ L/kg}$
- Modeled as homogeneous medium



Waste Inventory



- 1335 CsCl capsules
- 601 SrF_2 capsules
- 18 capsules per waste package

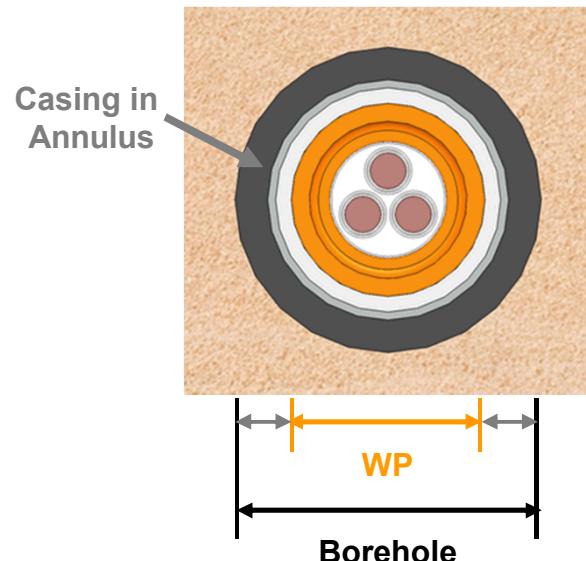
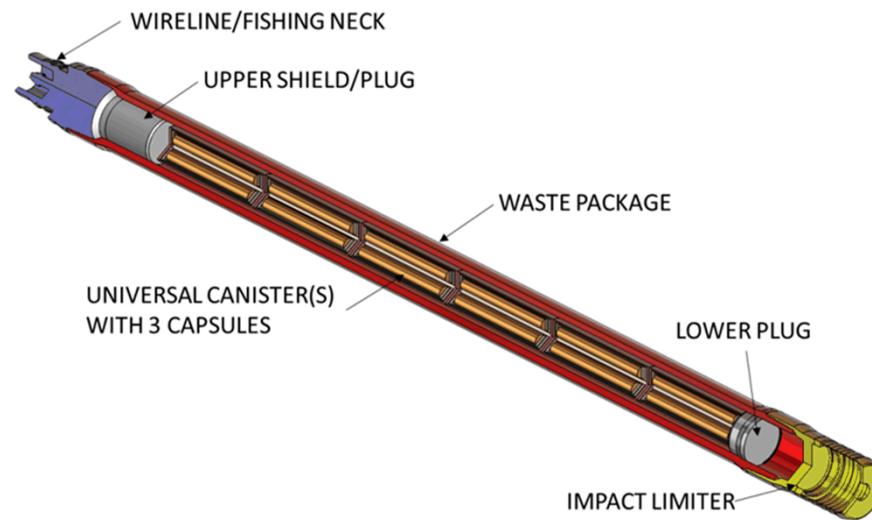


- Instantaneous degradation
- Unlimited solubility

Engineered Barrier System: Waste Package

■ Waste Package (WP)

- 108 WPs (~ 74 Cs, ~ 34 Sr)
- WP O.D. = 19.1 cm (7.5 in)
- WP length = 4.76 m
- Breach at 1 year
- $k = 10^{-16} \text{ m}^2$, $\phi = 0.5$
- No sorption



■ Annulus

- O.D. = 31.1 cm (12.25 in)
- Contains:
 - *Steel casing (not simulated)*
 - *Brine ($k = 10^{-12} \text{ m}^2$, $\phi = 0.99$)*
 - *(or Cement: $k = 10^{-16} \text{ m}^2$, $\phi = 0.15$)*
- No sorption

Engineered Barrier System: Plugs, Seal, DRZ

■ Disturbed Rock Zone (DRZ)

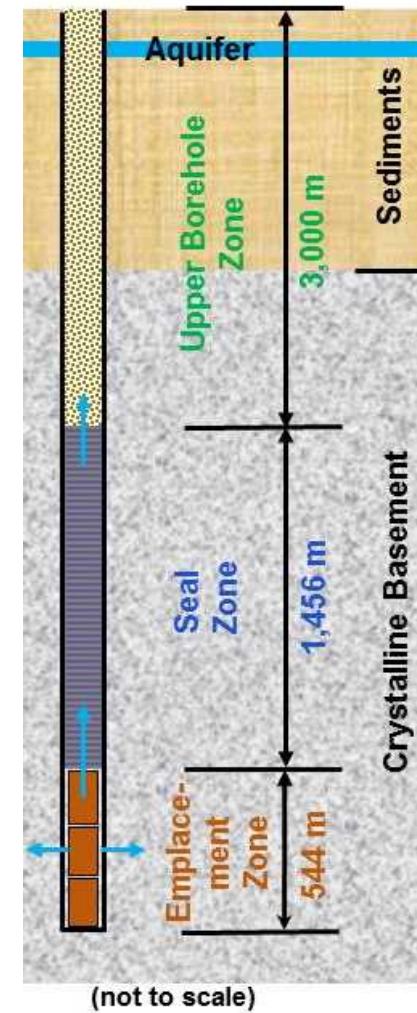
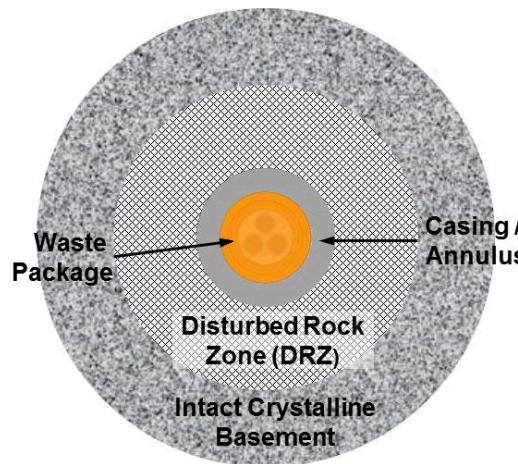
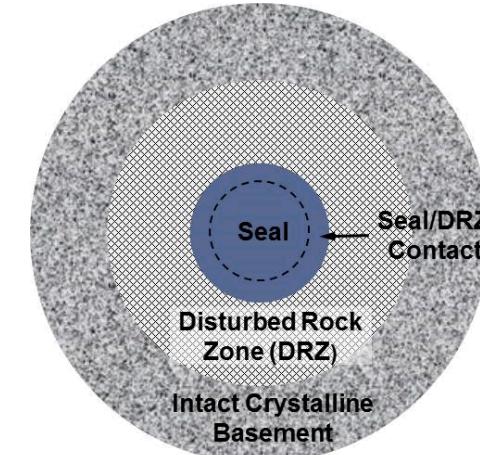
- Length of the borehole
- $k = 10^{-16} \text{ m}^2$, $\phi = 0.01$

■ Bentonite Seal

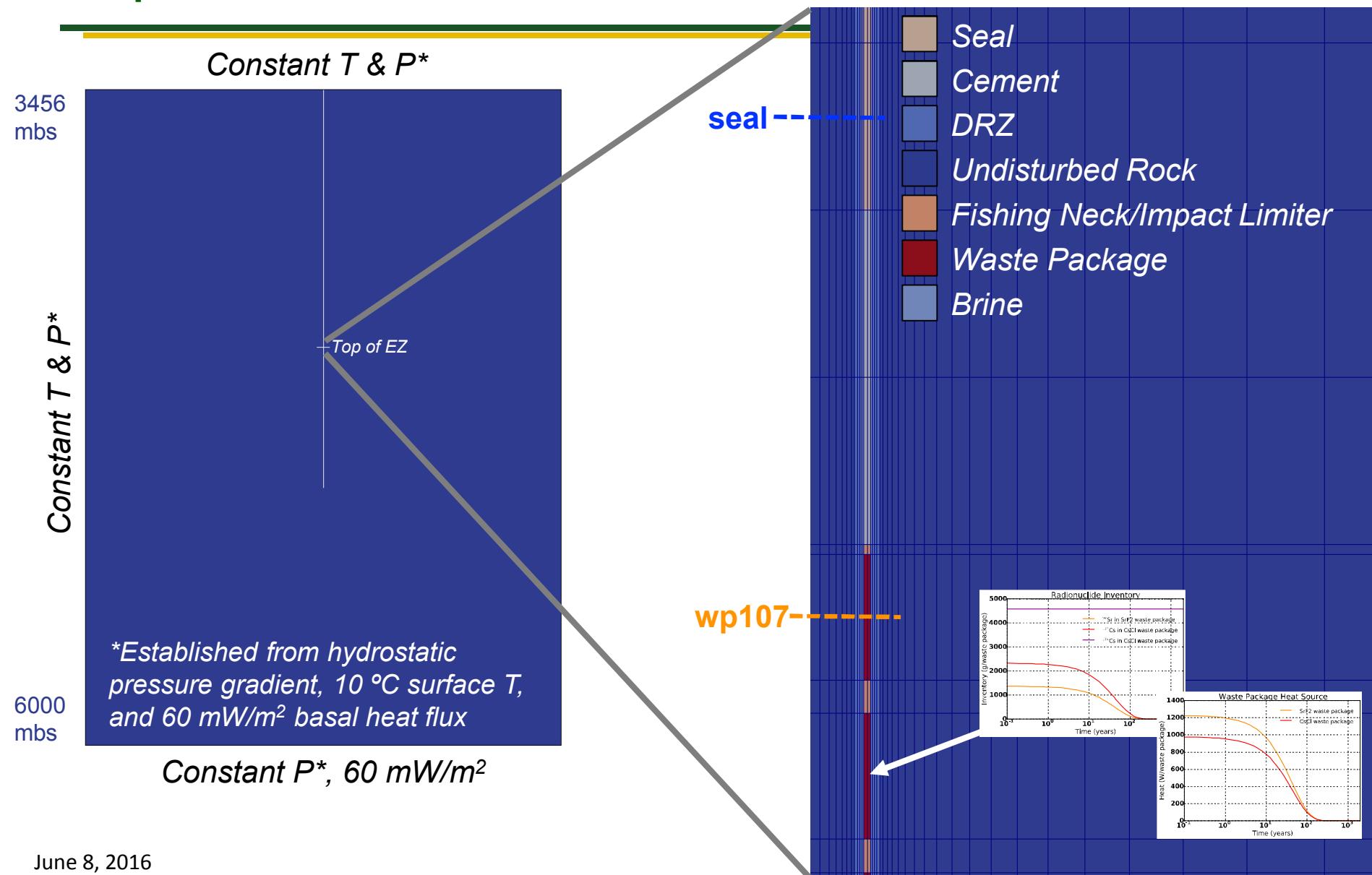
- Extends to 3000 m below surface
- $k = 10^{-16} \text{ m}^2$, $\phi = 0.2$
- $\text{Sr } K_d = 50 \text{ L/kg}$; $\text{Cs } K_d = 120 \text{ L/kg}$

■ Cement Plugs

- 3 plugs, above:
 - 40th WP
 - 80th WP
 - 108th WP
- 10 m height
- $k = 10^{-16} \text{ m}^2$, $\phi = 0.15$
- No sorption

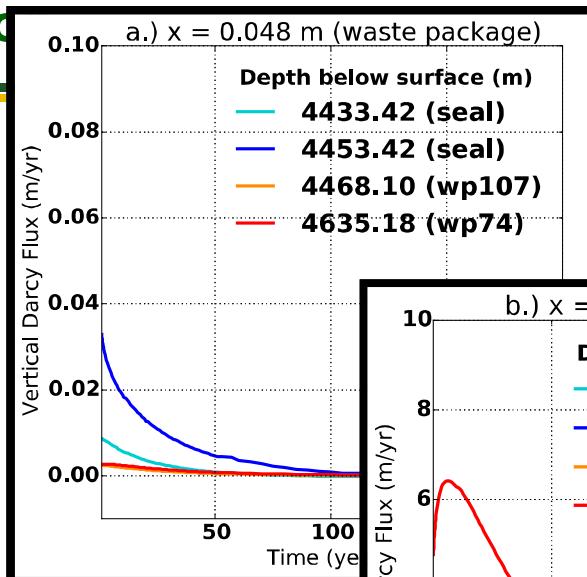


2-D Radial Domain



Used Fuel Disposition

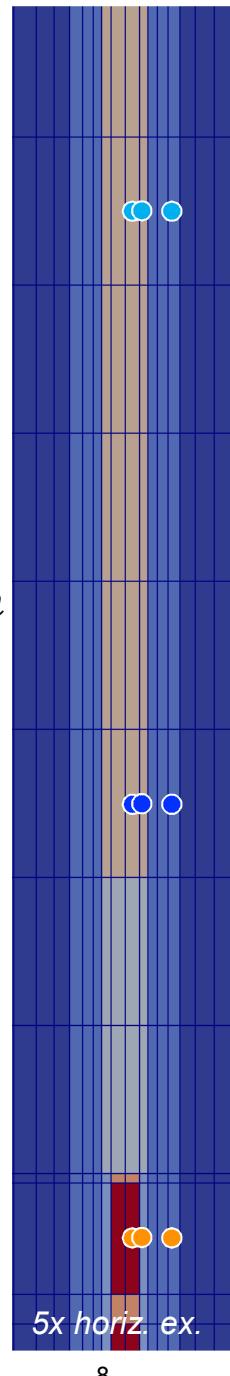
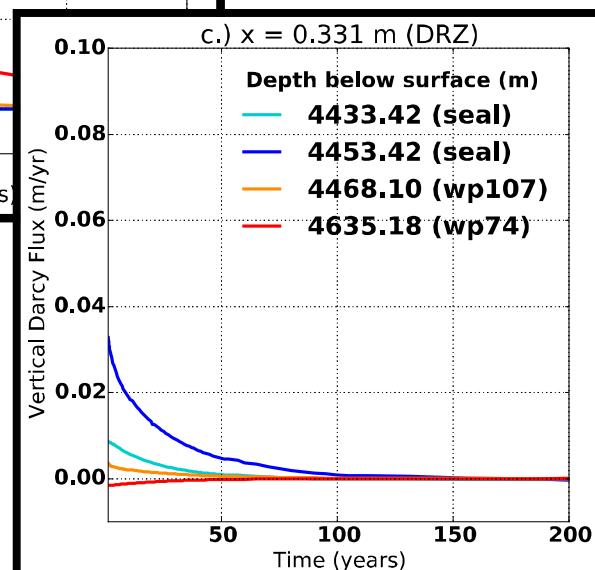
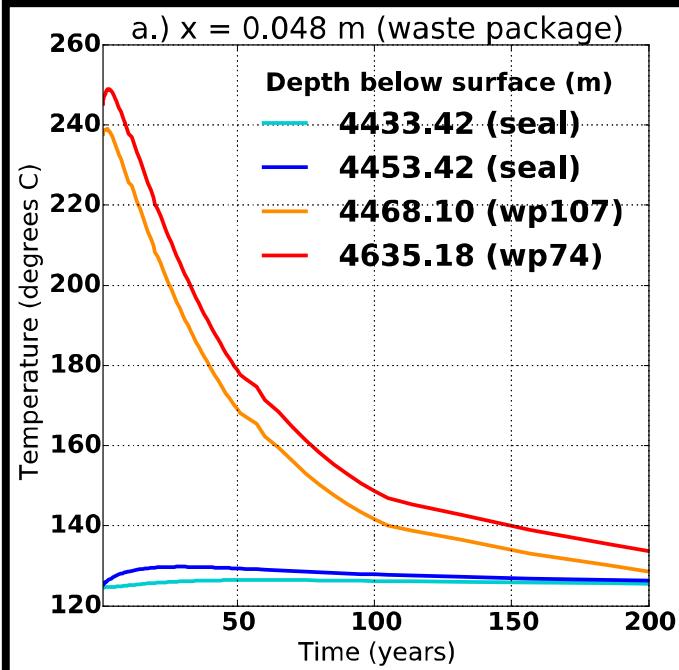
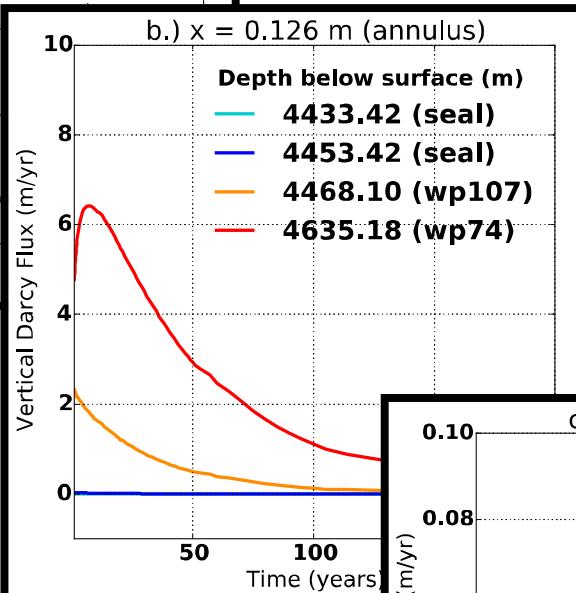
Temperature and Darcy Flux



- T peaks ~5 yrs
- q peaks ~10 yrs
- H_2O in DRZ moves <50 m

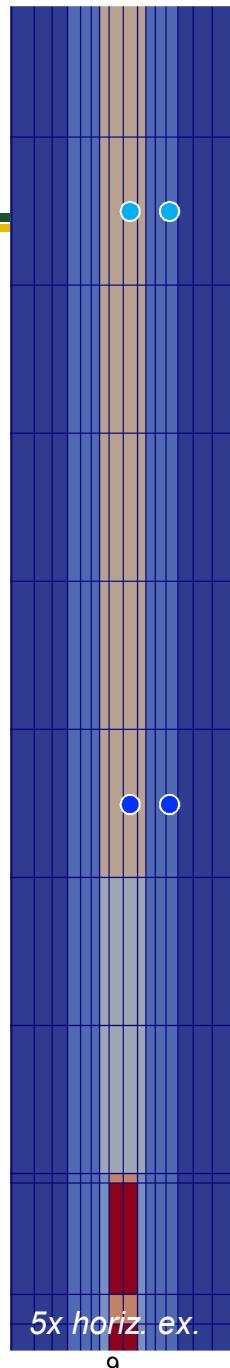
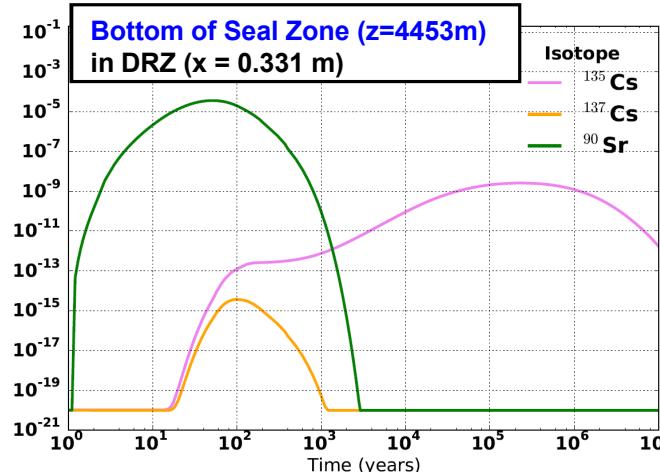
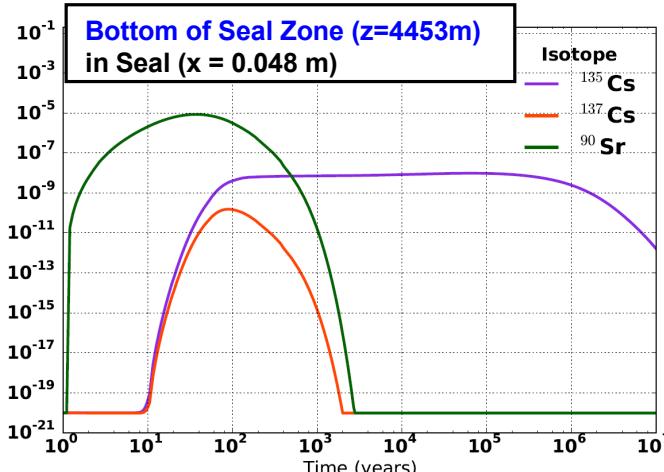
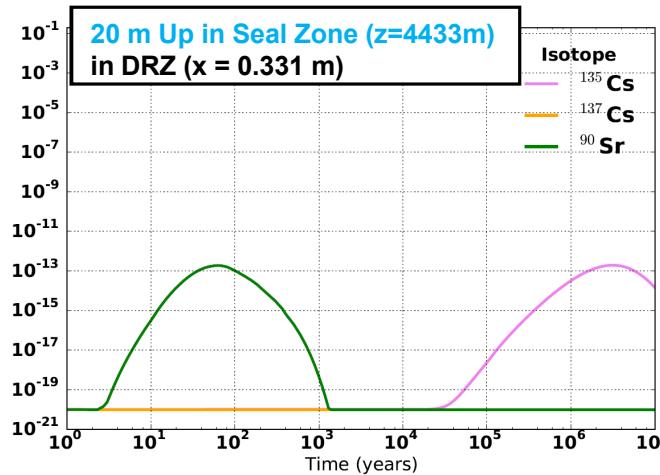
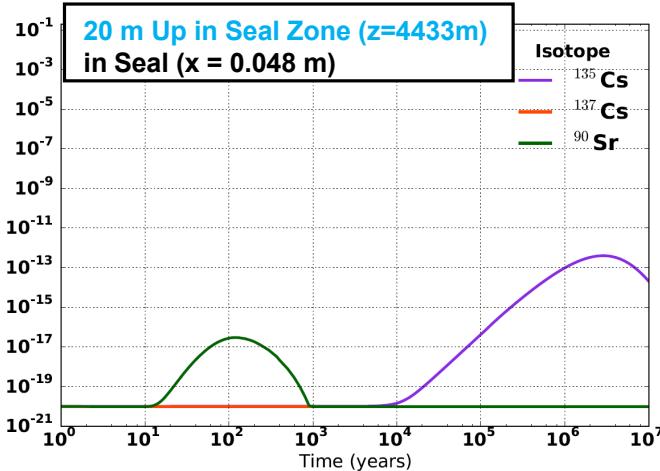


$$\frac{0.01 \frac{m}{y} * 50y}{0.01} = 50 \text{ m}$$

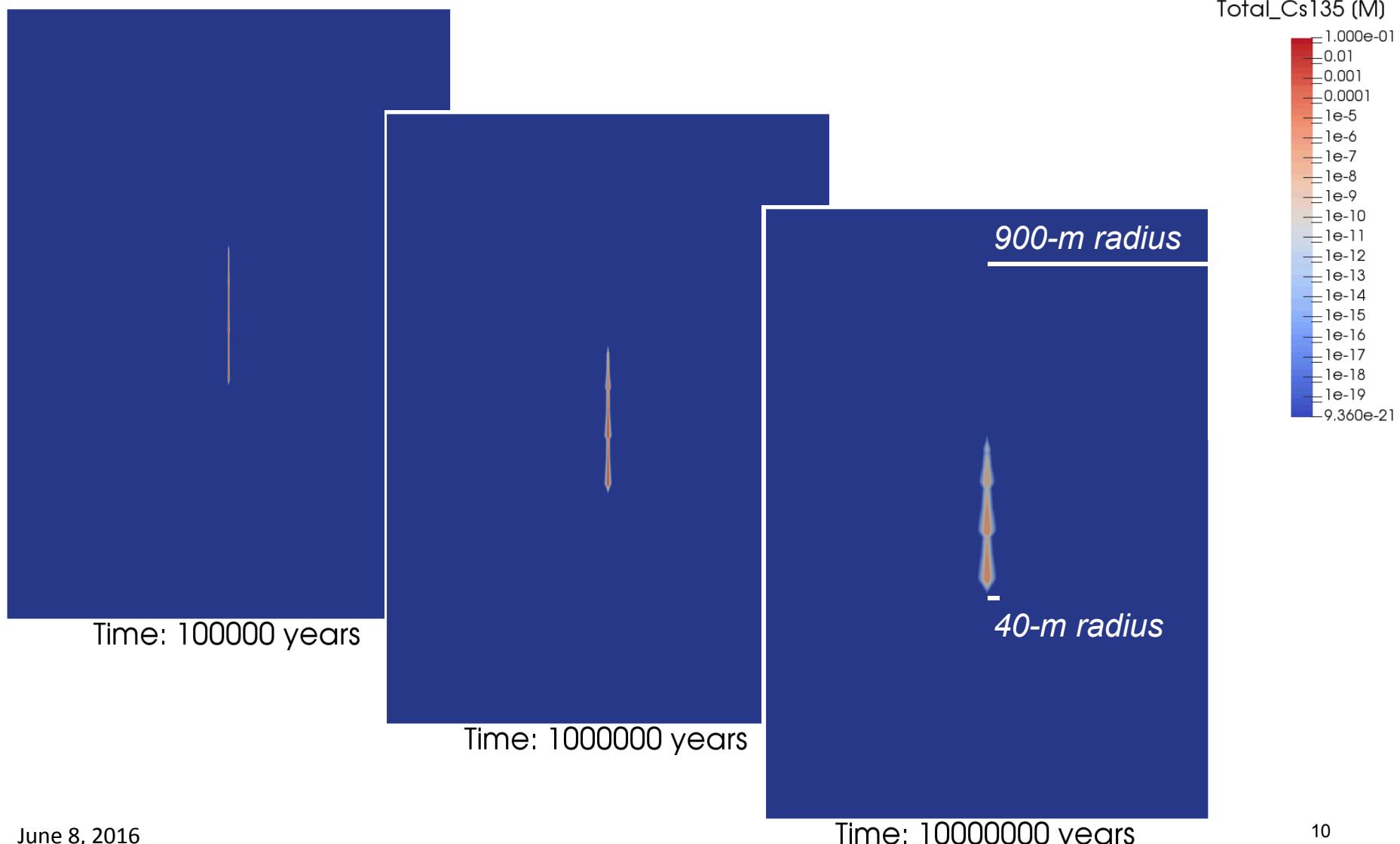


Radionuclide Transport

- ^{90}Sr : early arrival from top of EZ, less sorption in SZ, short half-life
- ^{137}Cs : later arrival from bottom of EZ, more sorption in SZ, short half-life
- ^{135}Cs : later arrival from bottom of EZ, more sorption in SZ, long half-life



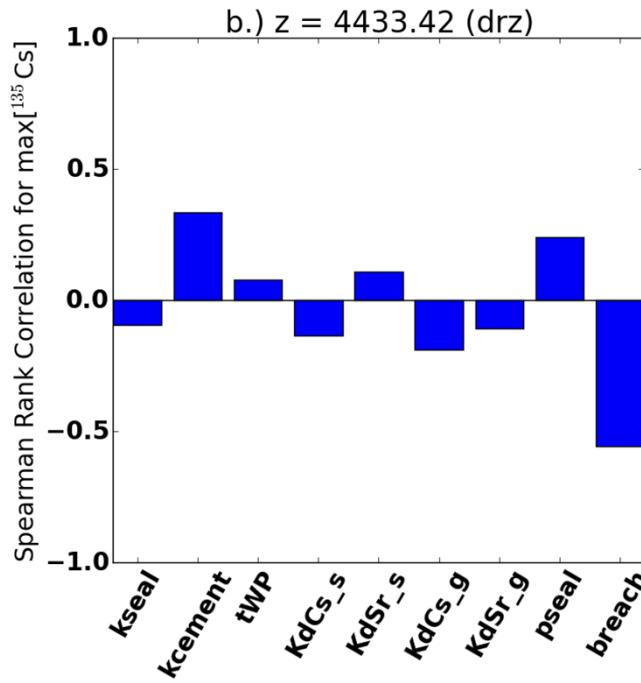
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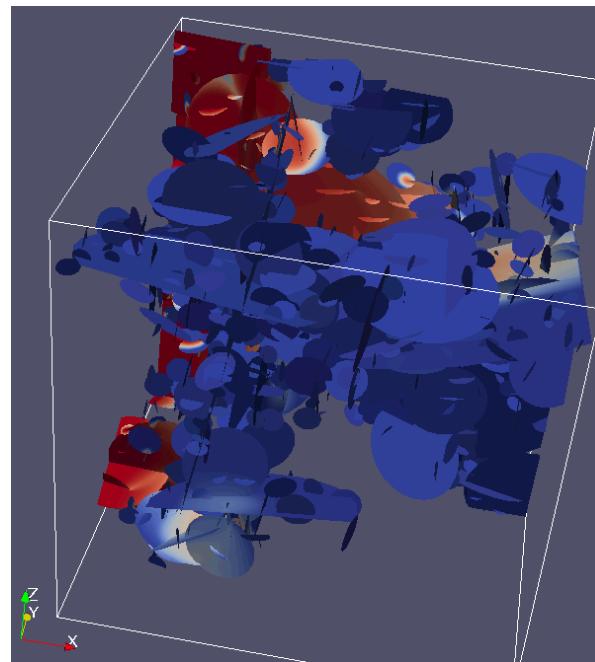
Summary and Next Steps:

- Preliminary results from post-closure PA calculations suggest minimal radionuclide releases beyond the disposal zone and zero dose at biosphere.
- Soon to be implemented PA model enhancements include:

Uncertainty and Sensitivity



High Permeability Pathways



Salinity-Dependent Density

