

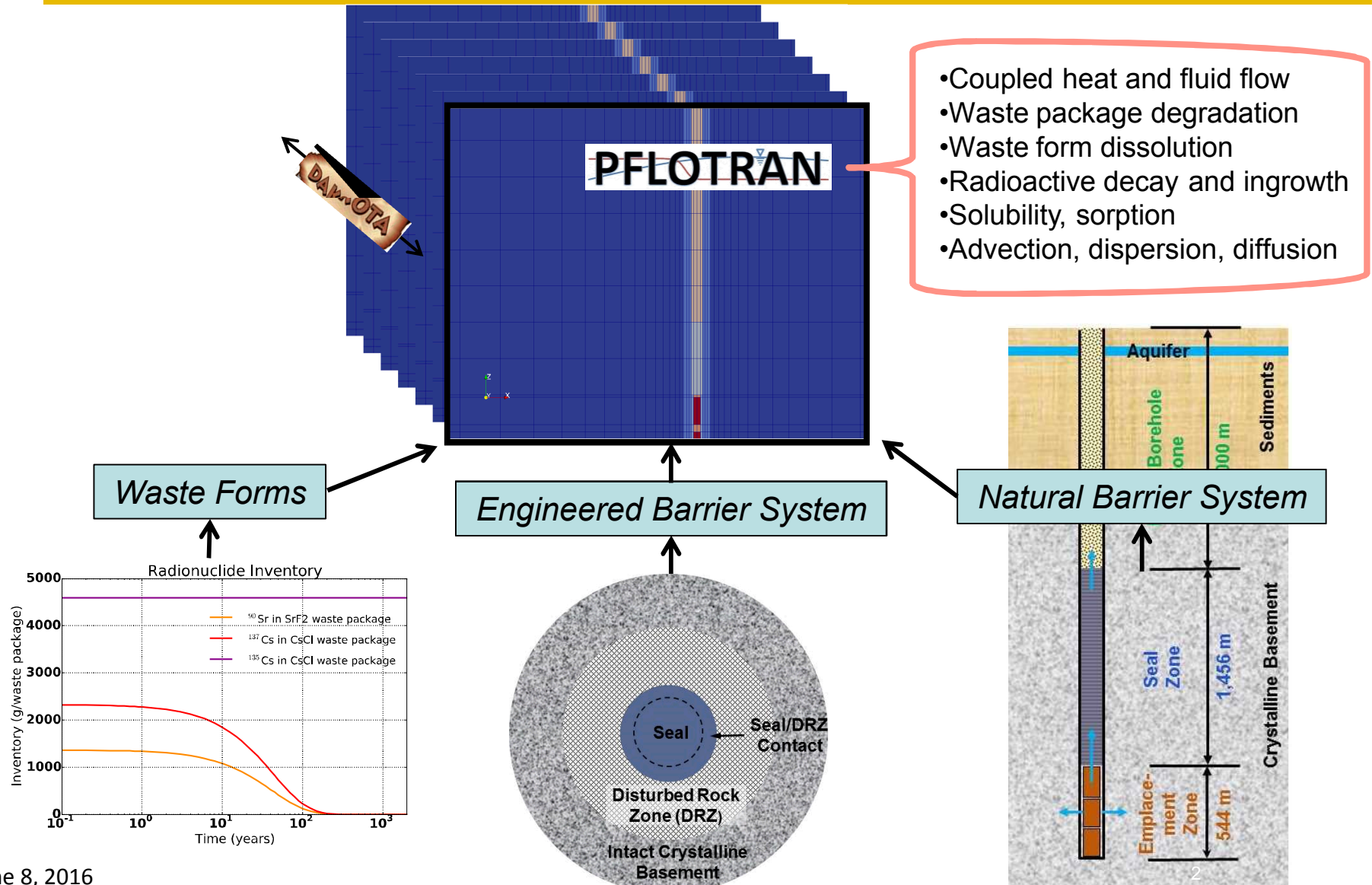
# Used Fuel Disposition Campaign

## Deep Borehole Disposal: Preliminary Performance Assessment

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Deep Borehole Session, June 8, 2016  
Las Vegas, NV**

# Performance Assessment



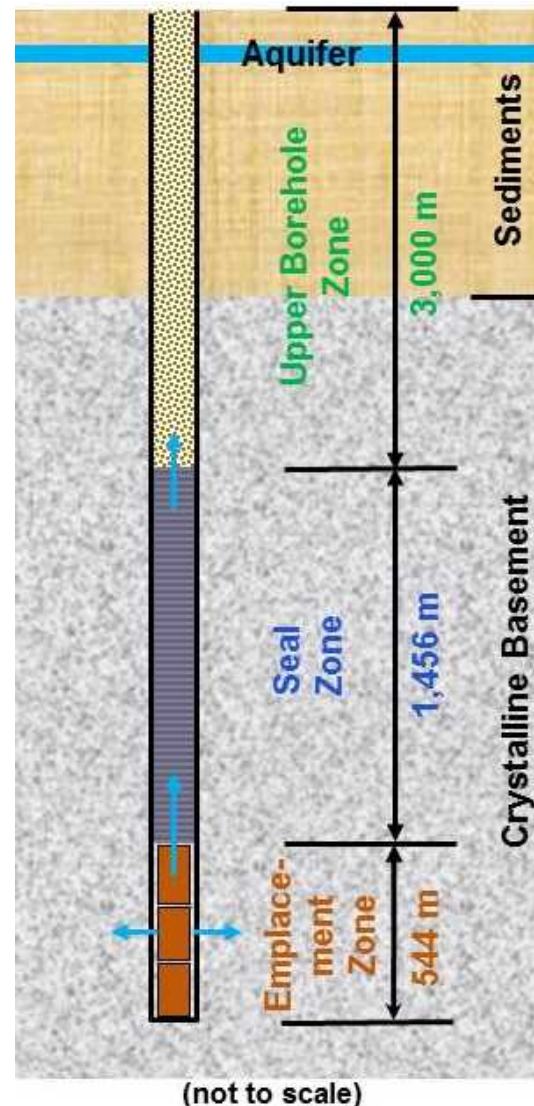
# Natural Barrier System

## ■ Sediments (not simulated)

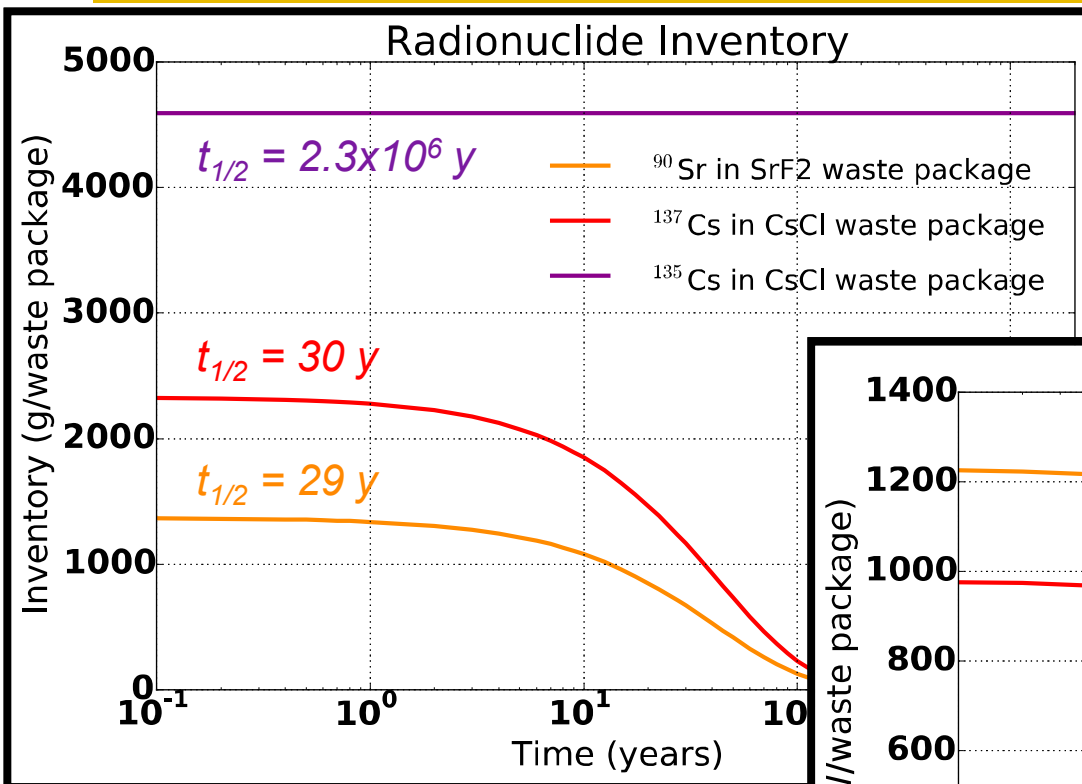
- ~2000-m thick
- Flat-lying sedimentary sequence

## ■ Crystalline Basement

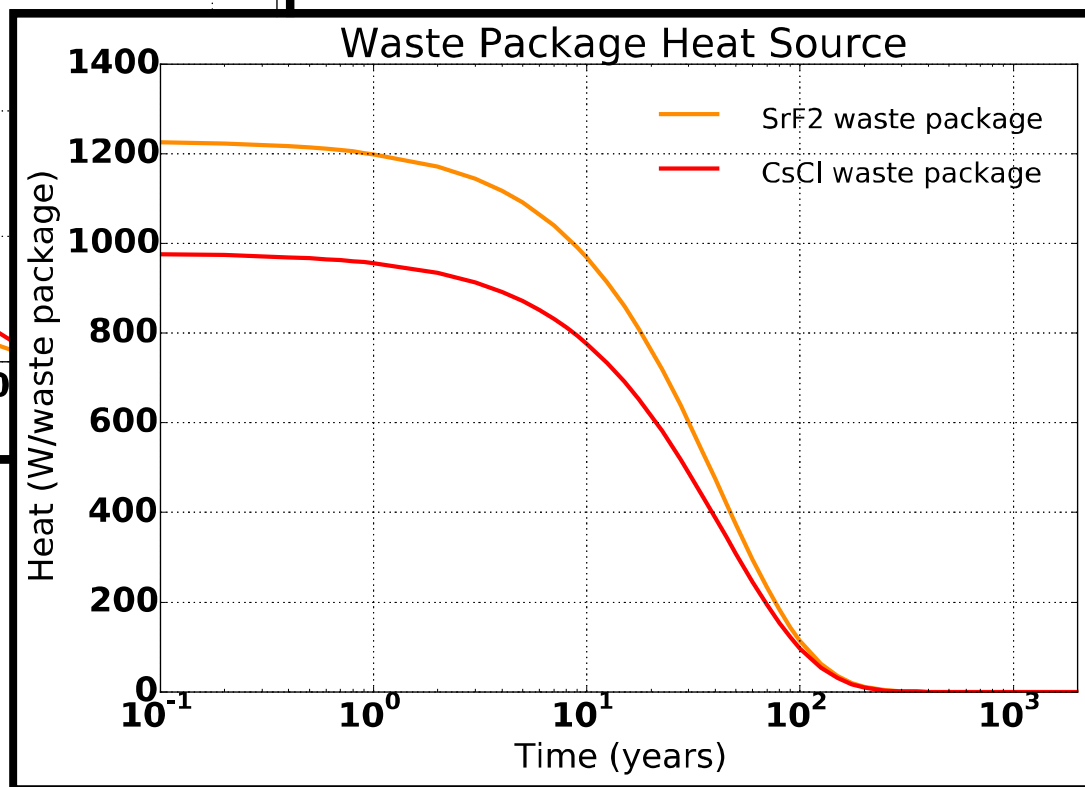
- Hydraulically isolated due to:
  - *Depth*
  - *Low permeability*
- Sparsely fractured granite
  - $k = 10^{-18} \text{ m}^2$ ,  $\Phi = 0.01$
  - $\kappa = 2.5 \text{ W/(m}^\circ\text{K)}$
  - $C_p = 880 \text{ J/(kg}^\circ\text{K)}$
- $\text{Sr } K_d = 0.4 \text{ L/kg}$ ;  $\text{Cs } K_d = 5 \text{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



# Waste Inventory



- **1335 CsCl capsules**
- **601  $\text{SrF}_2$  capsules**
- **18 capsules per waste package**

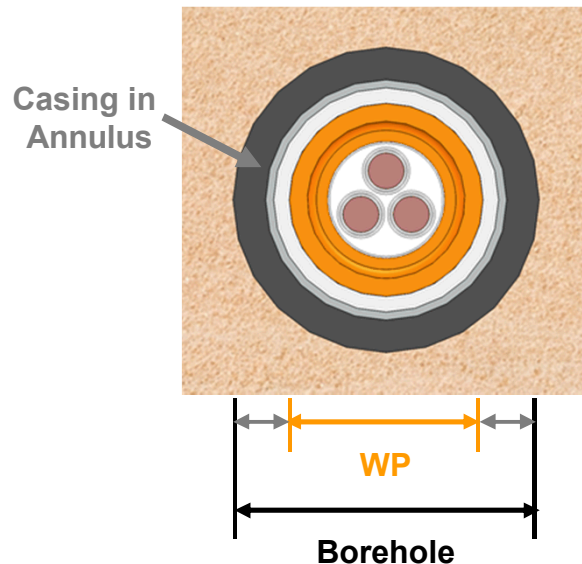
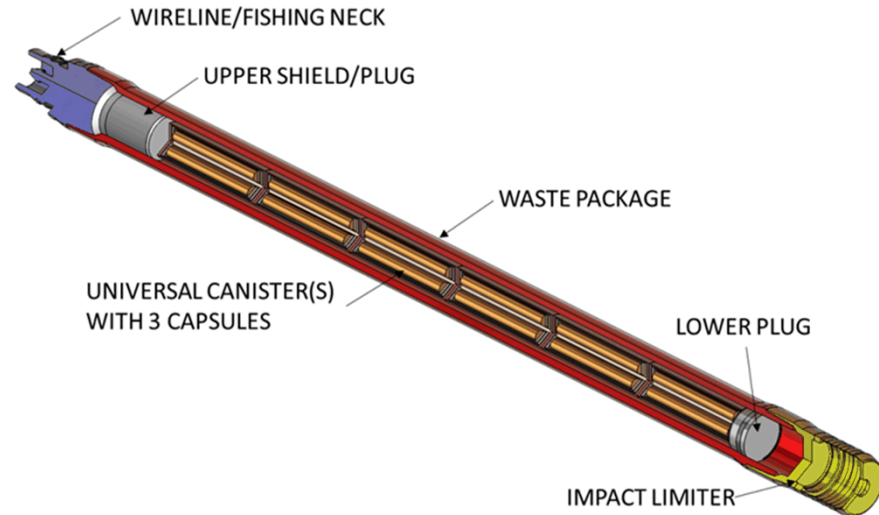


- **Instantaneous degradation**
- **Unlimited solubility**

# 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)

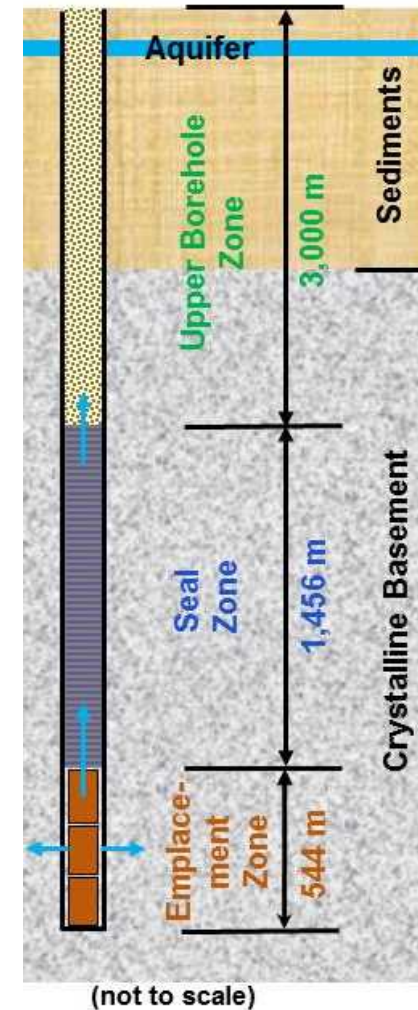
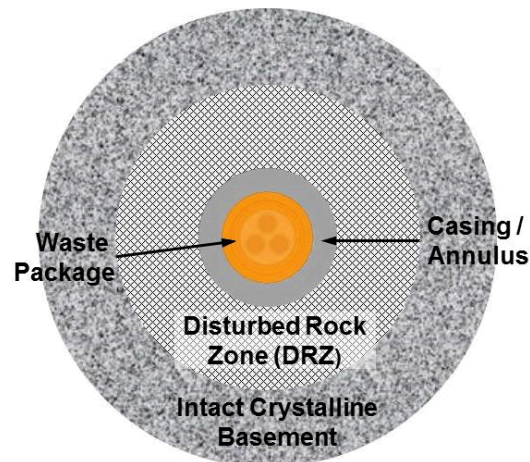
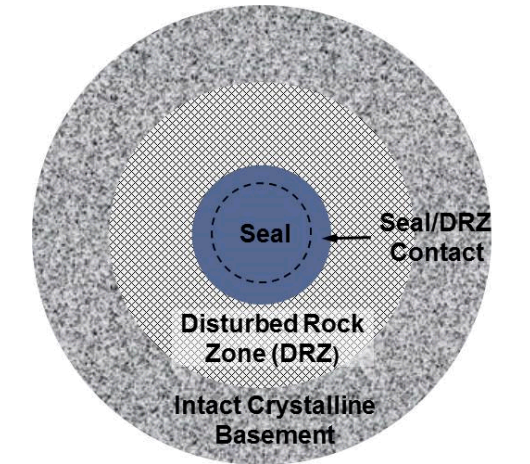
- Length of the borehole
- $k = 10^{-16} \text{ m}^2$ ,  $\phi = 0.01$

## ■ Bentonite Seal

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

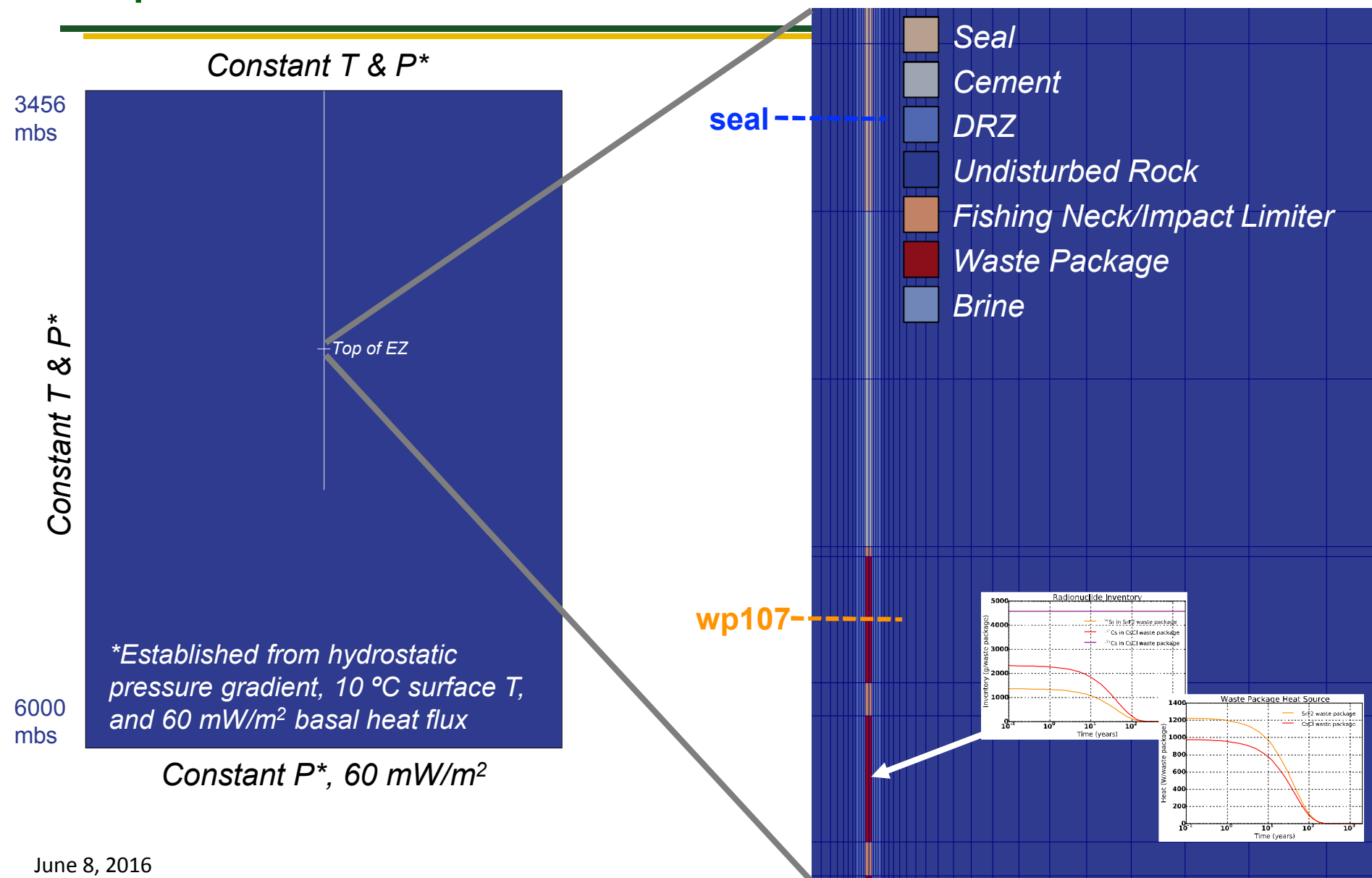
## ■ Cement Plugs

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



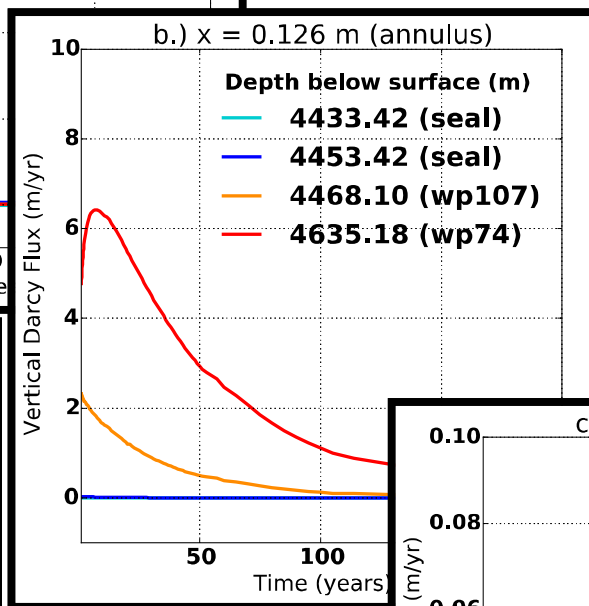
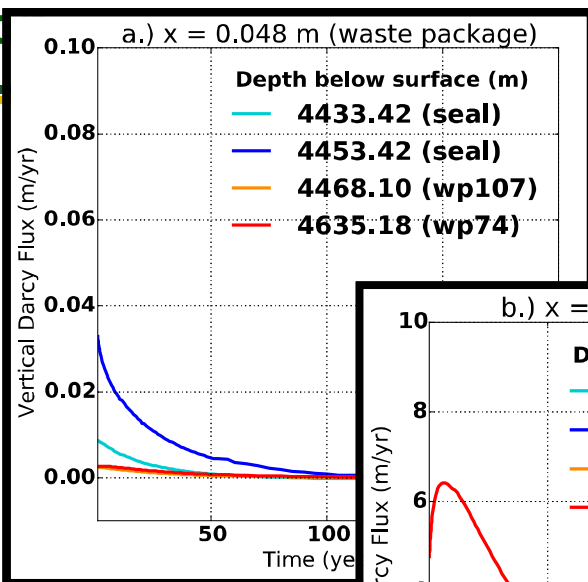
Used  
Fuel  
Disposition

# 2-D Radial Domain

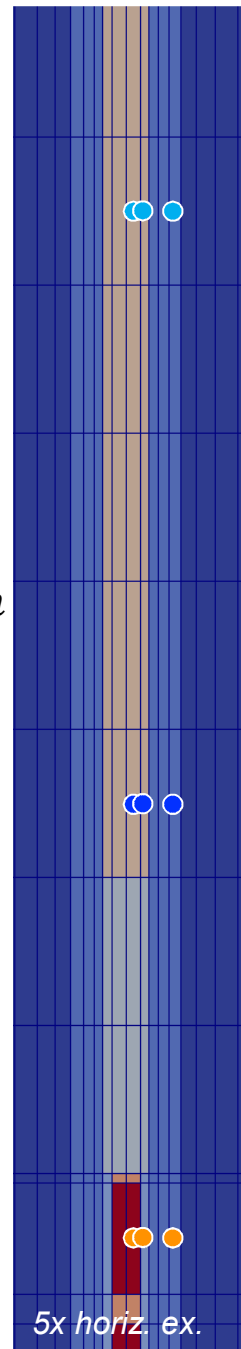
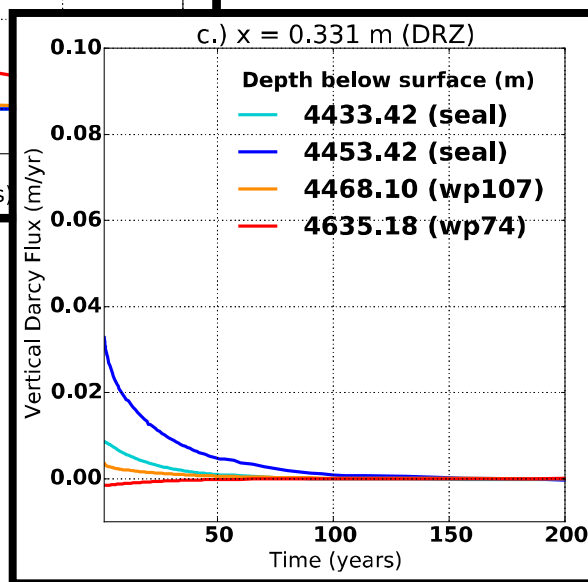
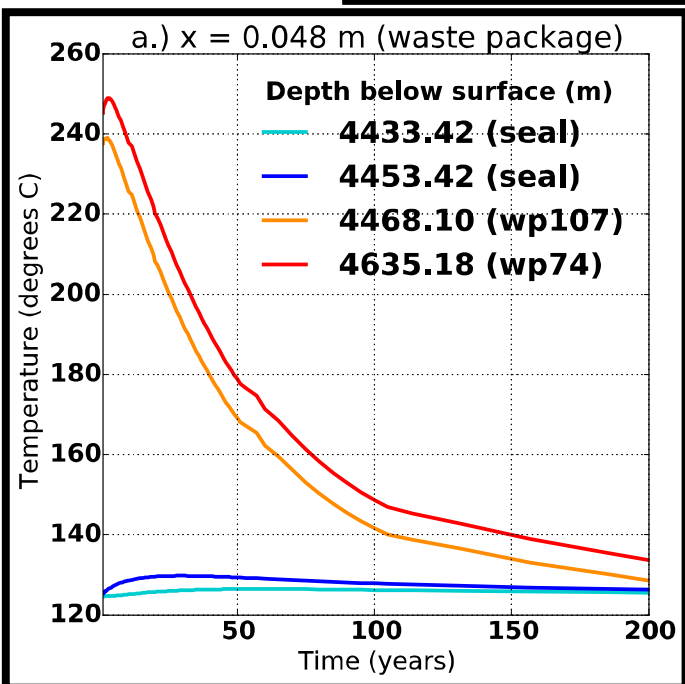


# Temperature and Darcy Flux

- T peaks ~5 yrs
- q peaks ~10 yrs
- H<sub>2</sub>O in DRZ moves <50 m



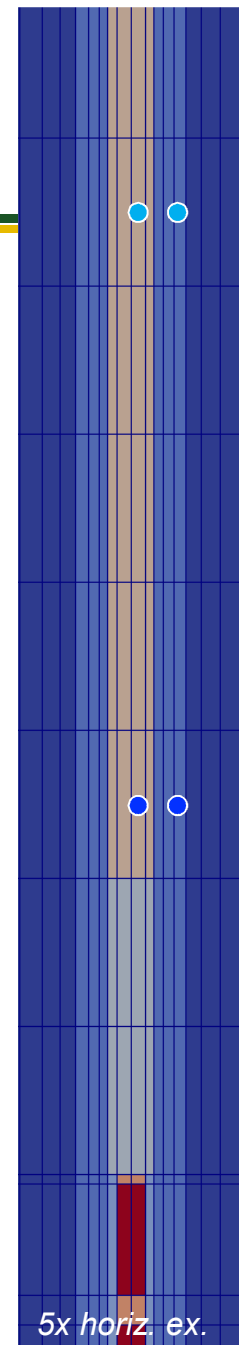
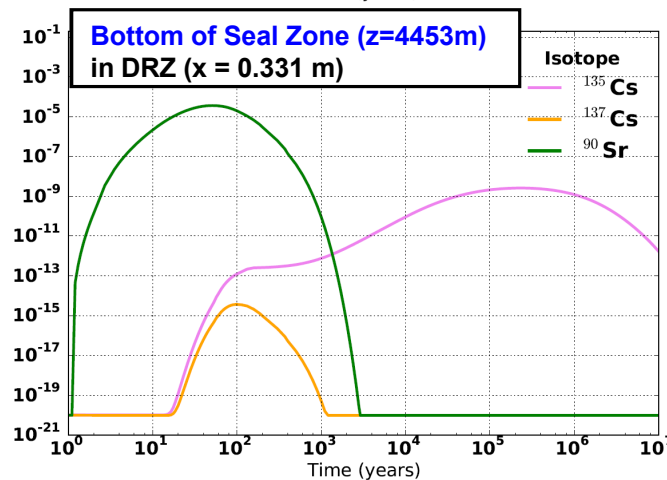
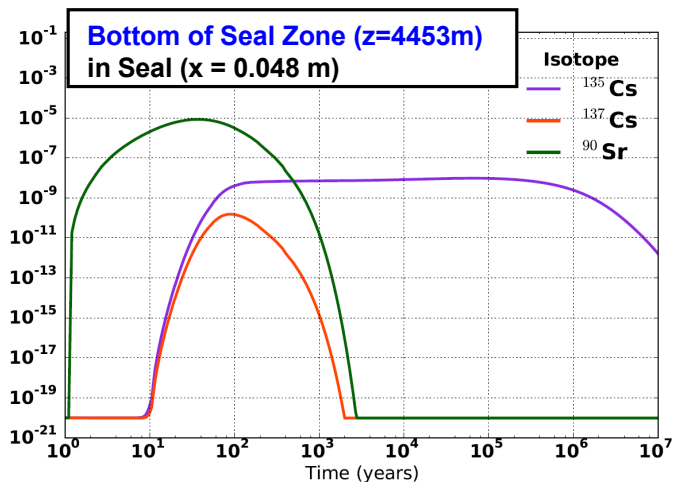
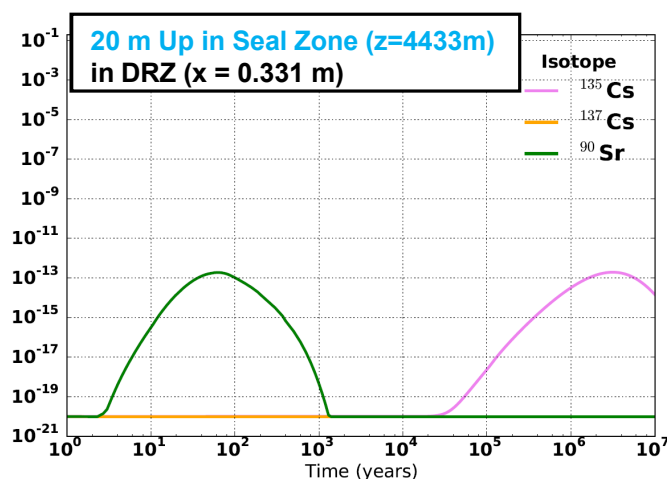
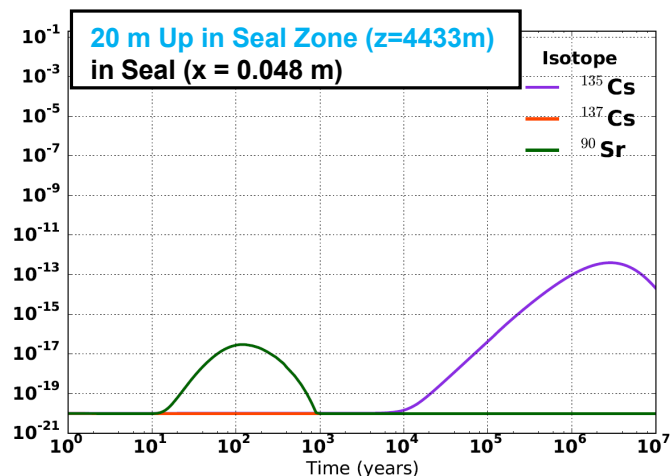
$$\frac{0.01 \frac{m}{y} * 50y}{0.01} = 50 m$$



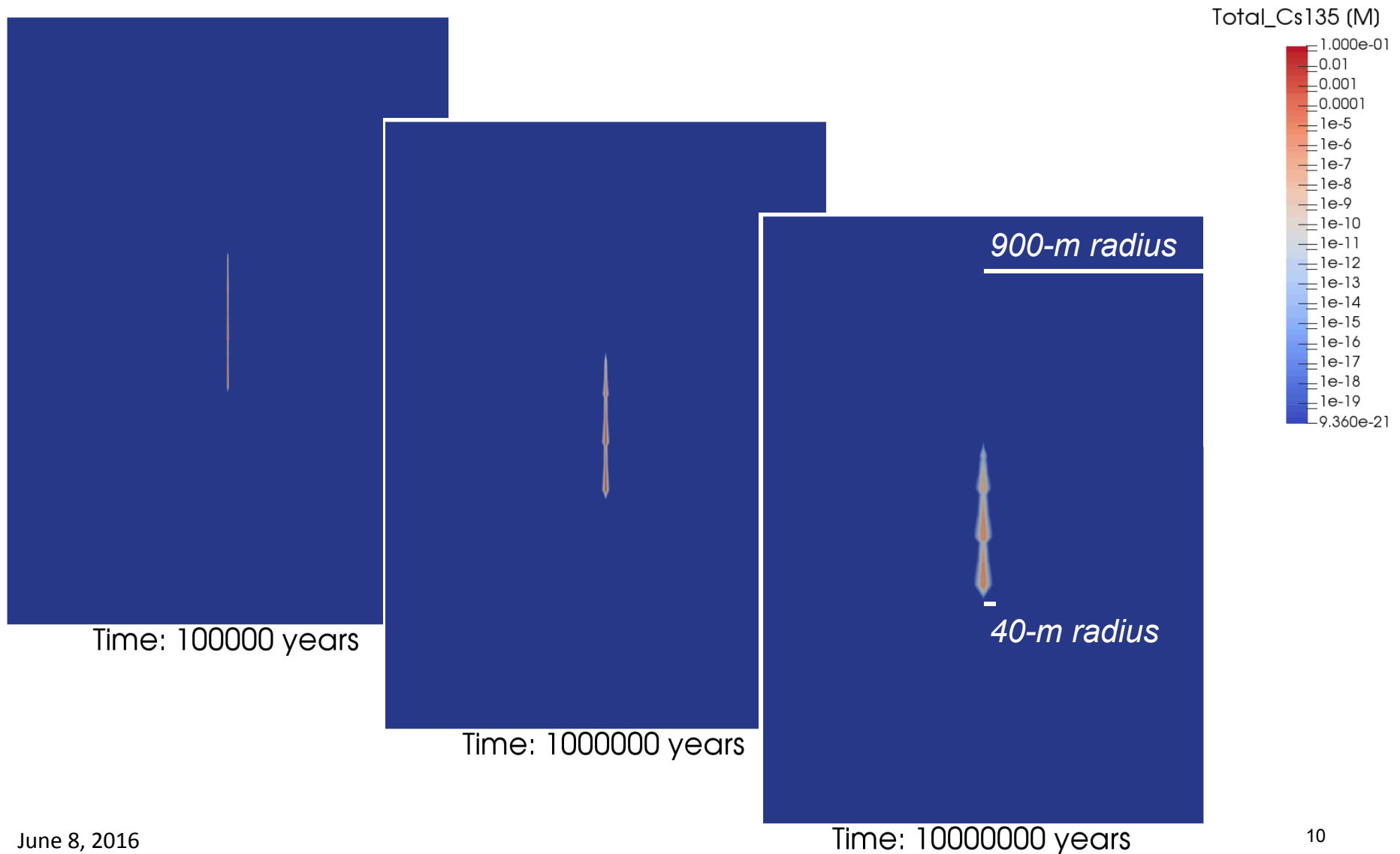


# Radionuclide Transport

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



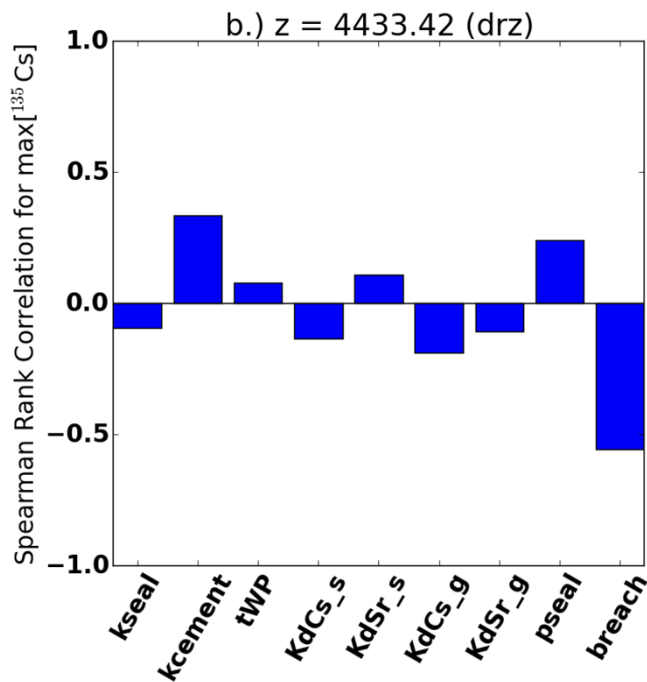
# Radionuclide Transport



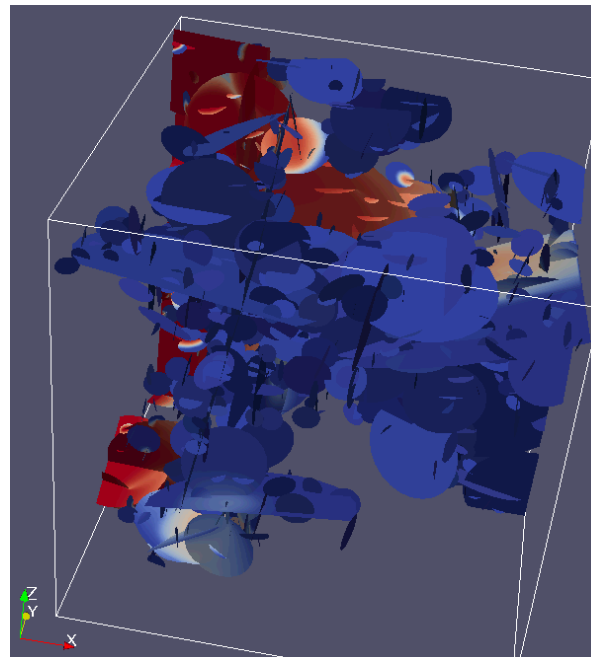
# Summary and Next Steps:

- 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

