Beta Dose Calculations

- External beta dose rate not in contact with skin
  - Point Source, 10 mCi, distance of 0.1 m

$$\dot{D} = \left(27 \frac{rad - m^2}{Ci - hr}\right) \frac{A}{d^2}$$

$$\dot{D} = \left(27 \frac{rad - m^2}{Ci - hr}\right) \frac{10\ mCi}{(0.1\ m)^2} \left(\frac{Ci}{1000\ mCi}\right) = 27 \frac{rad}{hr}$$

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Beta Dose Calculations

- External β dose rate in contact with skin
  - 50 cm^2 area, 10 mCi Source, E_{max} = 1 MeV
  - What is the skin dose rate with no glove?
  - With one glove?
  - With two gloves?

$$\dot{D} = C_f \frac{A}{a}$$

$$\dot{D} = C_f \frac{10\ mCi}{50\ cm^2} = 0.2 \frac{mCi}{cm^2} C_f$$

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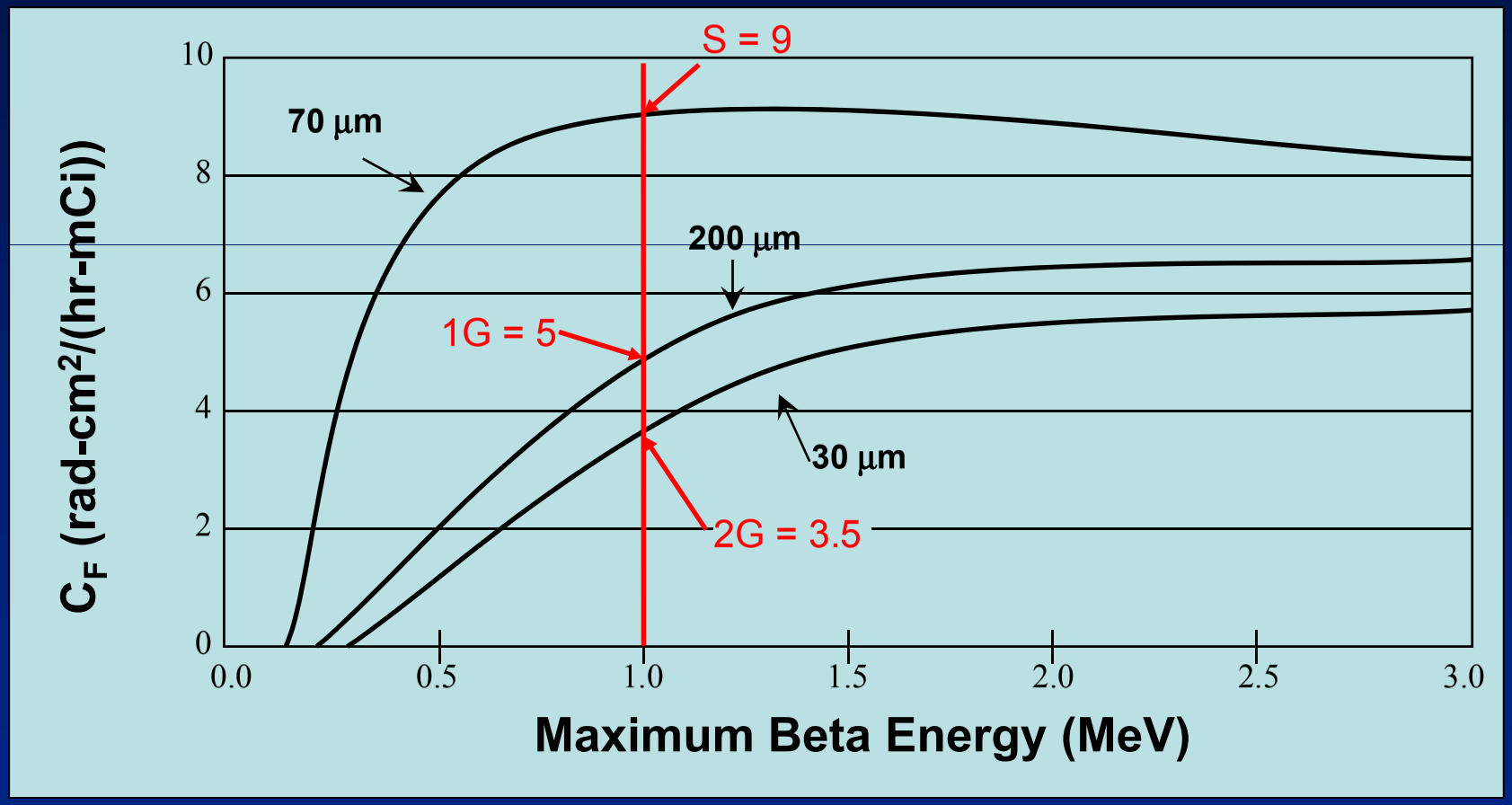
Healy Curves



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Beta Dose Calculations

- Skin dose rate with no glove?

$$\dot{D} = 0.2\frac{mCi}{cm^2} \cdot 9\frac{rad - cm^2}{hr - mCi} = 1.8 \ \ rad/hr$$

- Skin dose rate with one glove?

$$\dot{D} = 0.2\frac{mCi}{cm^2} \cdot 5\frac{rad - cm^2}{hr - mCi} = 1.0 \ \ rad/hr$$

- Skin dose rate with two gloves?

$$\dot{D} = 0.2\frac{mCi}{cm^2} \cdot 3.5\frac{rad - cm^2}{hr - mCi} = 0.7 \ \ rad/hr$$

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Gamma Dose Calculations

- External gamma dose rate
  - Cs-137, A = 10 mCi, d = 0.1 m
  - What are the deep, eye, and shallow dose equivalent rates?
  - First calculate exposure rate

$$\dot{X} = \Gamma \frac{A}{d^2}$$

$$\dot{X} = \Gamma \frac{10\ \text{mCi}}{(0.1\,\text{m})^2} \cdot \frac{\text{Ci}}{1000\ \text{mCi}} = 1 \frac{\text{Ci}}{\text{m}^2} \Gamma$$

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Gamma Dose Calculations

- Gamma Ray Energy and Specific Gamma Ray Constant

Nuclide	Γ (R-m^2)/(hr-Ci)	Energy (keV)
^{137}Cs	0.33	662

Gamma Dose Calculations

- Now Convert to Dose Equivalent Rate
  - rem/R conversion factor

Photon Energy (keV)	Conversion Factors at Depth		
	1 cm ("Deep")	0.3 cm (Lens of Eye)	0.007 cm ("Shallow")
662	0.28	0.67	0.9

  - Note: The conversion factors for Cs-137 have been changed in this example for demonstration purposes

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Gamma Dose Calculations

- Deep dose equivalent rate?

$$\dot{D} = 1\frac{Ci}{m^2} \cdot 0.33\frac{R - m^2}{hr - Ci} \cdot 0.28\frac{rem}{R} = 0.09\ rem/hr$$

- Eye dose equivalent rate?

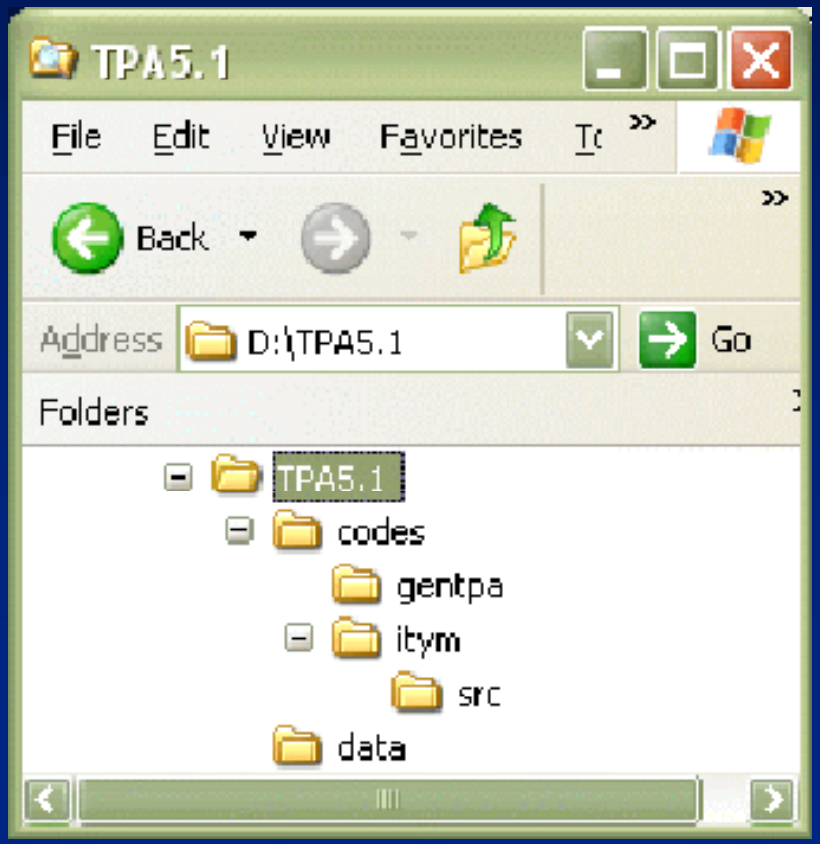
$$\dot{D} = 1\frac{Ci}{m^2} \cdot 0.67\frac{R - m^2}{hr - Ci} \cdot 0.28\frac{rem}{R} = 0.19\ rem/hr$$

- Skin dose equivalent rate?

$$\dot{D} = 1\frac{Ci}{m^2} \cdot 0.33\frac{R - m^2}{hr - Ci} \cdot 0.9\frac{rem}{R} = 0.3\ rem/hr$$

Running the TPA Code

- TPA Code Folder Structure



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Running the TPA Code

- Make working directory

```
d:\tpa5.1>mkdir tparun
```

- Set environment variables

```
SET TPA_TEST=d:\tpa5.1
SET TPA_DATA=d:\tpa5.1
```

- Copy input file (*tpa.inp*) to working directory

```
copy ..\tpa5.1\tpa.inp
```

- Redirect output from screen to file *tpa.out*

```
d:\tpa5.1\tparun>..\tpa.exe >tpa.out
```

Running the TPA Code

- Sample Output – Repository Information

```
================================================================
         exec: Welcome to TPA Version 5.1
       Job started: Mon Jul 02 16:00:19 2007
================================================================
REPOSITORY DESIGN INFORMATION
Subarea   Area       Waste    Number of WP
   #      [m^2]      [MTU]
   1     224091.0     3025.5         526
   2     448476.0     6108.4        1062
   3    1241313.5    16703.3        2904
   4     775953.1    10313.0        1793
   5     605892.0     8351.7        1452
   6     152357.0     1972.9         343
   7     318122.0     4003.3         696
   8     439350.0     5355.0         931
   9     305880.0     4158.6         723
  10     747165.5    10048.4        1747

Total Area [acre]          =  1299.382289078371
Total Buried Waste [MTU]   =  70040.00000000000
Repository AML [MTU/acre] =  53.90253552684494
Watts per MTU [W/MTU]      =  1327.684245650000
Watts per linear meter of drift [W/m] =  1450.448314791551
```

Running the TPA Code

- Sample Output – Global Parameters

```
Specified Global Parameters:

                Compliance Period =  10000.0 (yr)
          Maximum Simulation Time =  10000.0 (yr)
           Number Of Realizations =    500
               Number Of Subareas =     10
               Volcanism scenario =      0 (yes=1, no=0)
                Faulting scenario =      0 (yes=1, no=0)
     Mechanical failure scenarios:
                      Seismicity =      0 (yes=1, no=0)
              Drift Degradation =      1 (yes=1, no=0)
       Distance to Receptor Group =     18.0 (km)

**>>> CAUTION: CHECKING OF NUCLIDES AND CHAINS IS DISABLED <<<**
**>>> You may not be using the standard chains specified   <<<**
**>>> in the invent module.                                <<<**
**>>> (see "CheckNuclidesAndChains(yes=1,no=0)" in tpa.inp)<<<**

The specified path for data  = d:\ronj-\tpa51\
The specified path for codes = d:\ronj-\tpa51\
```

Running the TPA Code

- Sample Output – Subarea 1 Results

```
------------------------------------------------------------------
    subarea   1 of  10          realization    1 of  500
------------------------------------------------------------------
exec: calling uzflow
UZFLOW: Uncertainty parameter:    0.0000E+00
        Mean Annual Infiltration at Start(AAI0):    1.1469E+01
exec: calling driftdriver
exec: calling nfenvFl
exec: calling dsfail
dataFile= dsfailt.dat
exec: calling mechdriver (drip shield)
exec: calling  nfenv
exec: calling ebsfail
     ebsfail: No Weld Failure
     *** No WP Failure By Localized Corrosion ***
     *** No WP Failure By General Corrosion Only ***
exec: calling mechdriver (waste package)
exec: calling volcano
exec: failed WPs from INITIAL   event =      1 at time =      0.0 yr
exec: failed WPs from VOLCANIC  event =    525 at time =    487.6 yr
 *** failed WPs: all WPs failed ( 526 ) ***
     *** drift degradation fraction is 1.000  ***
exec: calling ebsrel
      ebsrel: running spent fuel waste form
      ebsrel: running glass waste form
```

Running the TPA Code

- Sample Output – Subarea 1 Results

```
                Highest release rates from Sub Area 1
            Tc99    2.2025E+00 [Ci/yr/SA] at  1.103E+03 yr
            Ja241   6.7460E-01 [Ci/yr/SA] at  1.524E+03 yr
            Am241   6.2201E-01 [Ci/yr/SA] at  1.562E+03 yr
            Ja243   3.9391E-01 [Ci/yr/SA] at  8.691E+03 yr
            Am243   1.6704E-01 [Ci/yr/SA] at  8.691E+03 yr
            Ni59    1.0217E-01 [Ci/yr/SA] at  3.076E+03 yr
exec: calling uzft
                Highest release rates from UZ
            Tc99    1.8862E+00 [Ci/yr/SA] at  1.562E+03 yr
            Cs135   2.9505E-02 [Ci/yr/SA] at  5.308E+03 yr
            Se79    1.2585E-02 [Ci/yr/SA] at  1.854E+03 yr
            I129    7.5069E-03 [Ci/yr/SA] at  1.562E+03 yr
            Cl36    4.3575E-03 [Ci/yr/SA] at  1.562E+03 yr
            I129    4.5698E-03 [Ci/yr/SA] at  3.151E+03 yr
            Cl36    2.6083E-03 [Ci/yr/SA] at  3.151E+03 yr
    The remaining  28  nuclide(s) have zero release
```

Running the TPA Code

- Sample Output – Results at End of Simulation

```
                    Highest annual dose from GS
              Am241  1.4537E+02 [mrem/yr] at  4.876E+02 yr
              Am243  1.6351E+01 [mrem/yr] at  4.876E+02 yr
               Nb94  5.3678E+00 [mrem/yr] at  4.876E+02 yr
              Pu240  5.2035E+00 [mrem/yr] at  4.876E+02 yr
              Sn126  3.6009E+00 [mrem/yr] at  4.876E+02 yr
              Pu239  2.7093E+00 [mrem/yr] at  4.876E+02 yr
exec: end realizations

exec: Peak Mean Dose is 5.62483E-01 rem/yr at     487.6 yr, based on
10 realizations.

exec:  Run Successfully Completed
```

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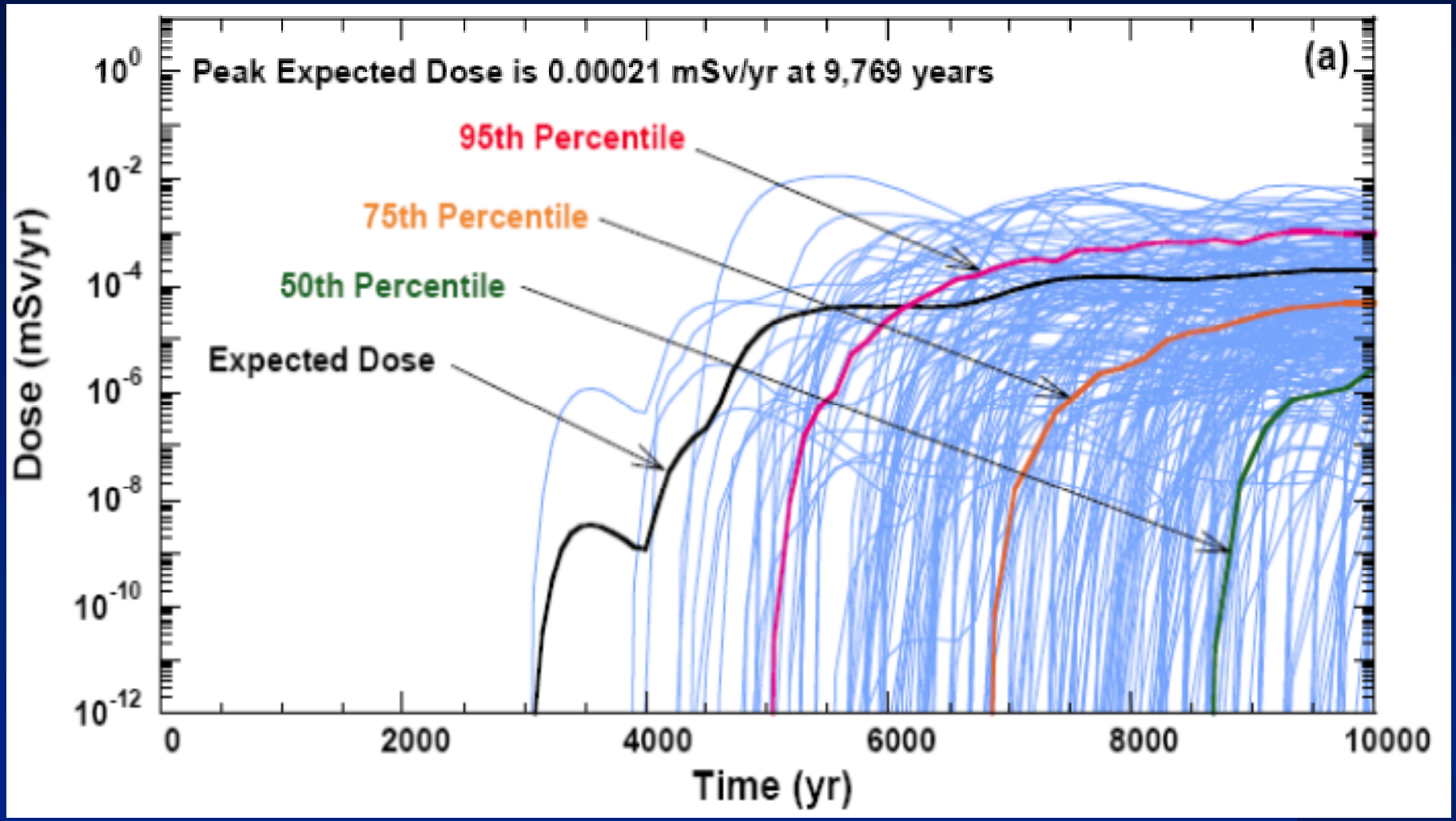
Groundwater Dose 350 realizations



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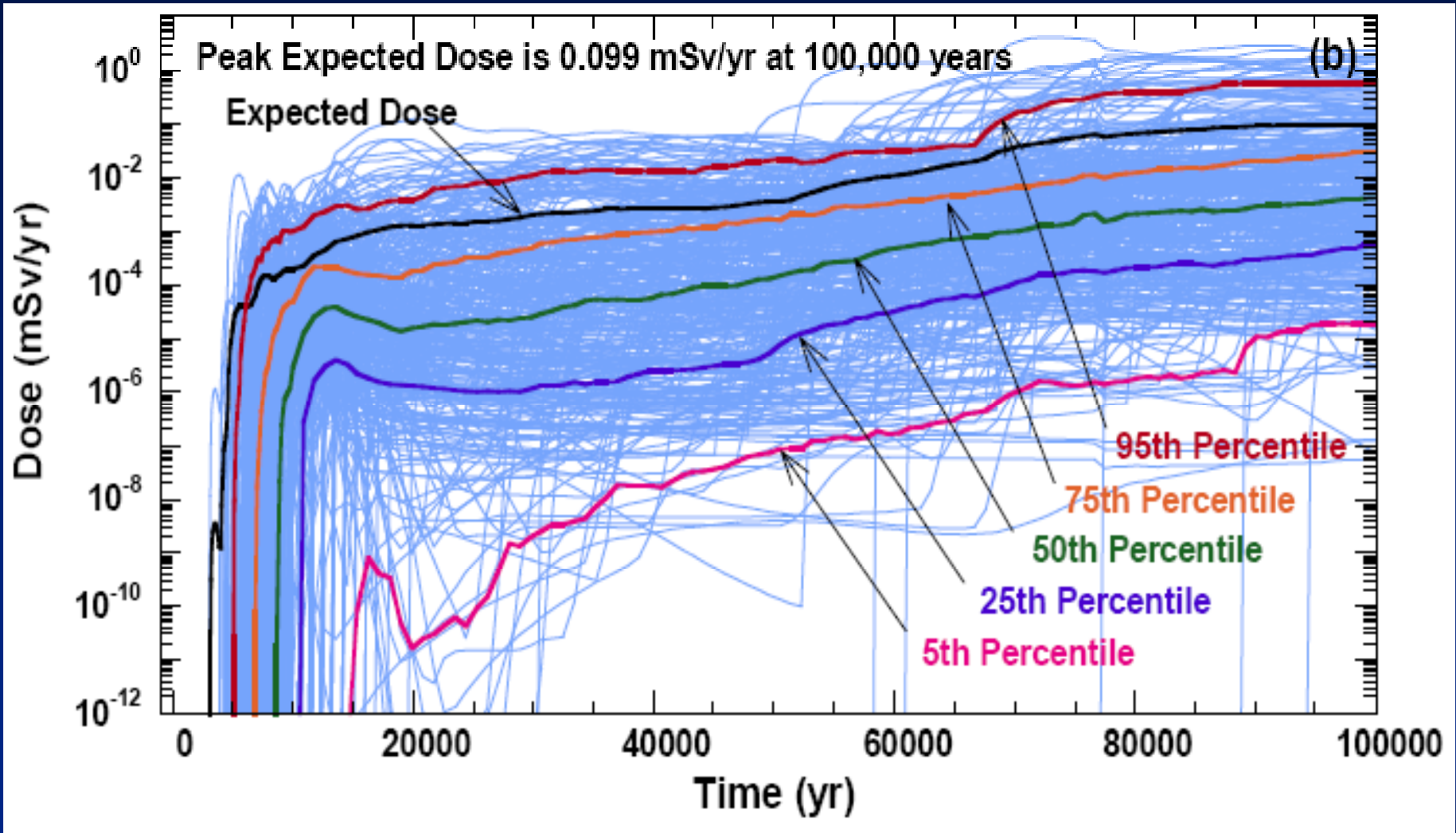
Groundwater Dose 350 realizations



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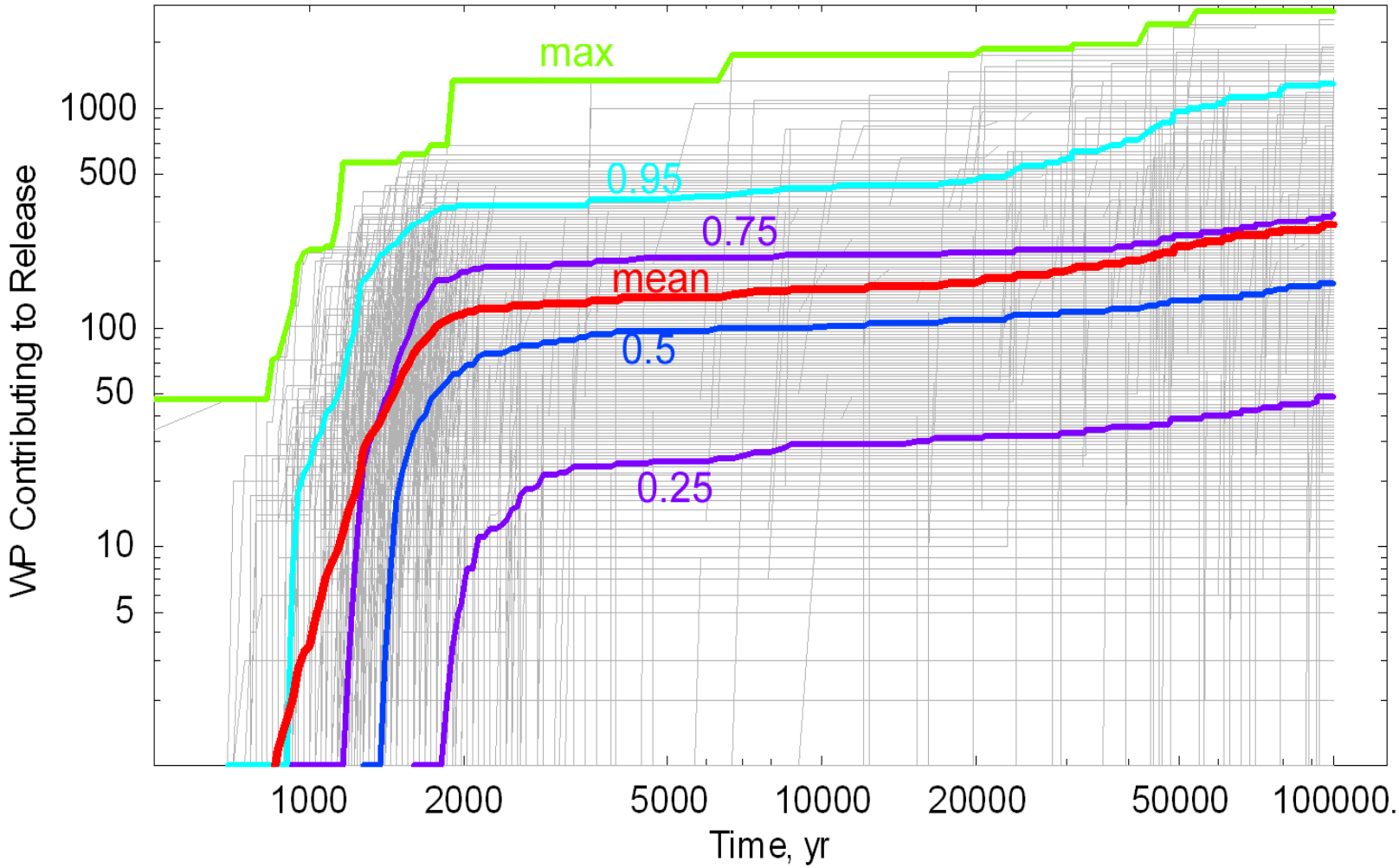
Waste Packages Failing



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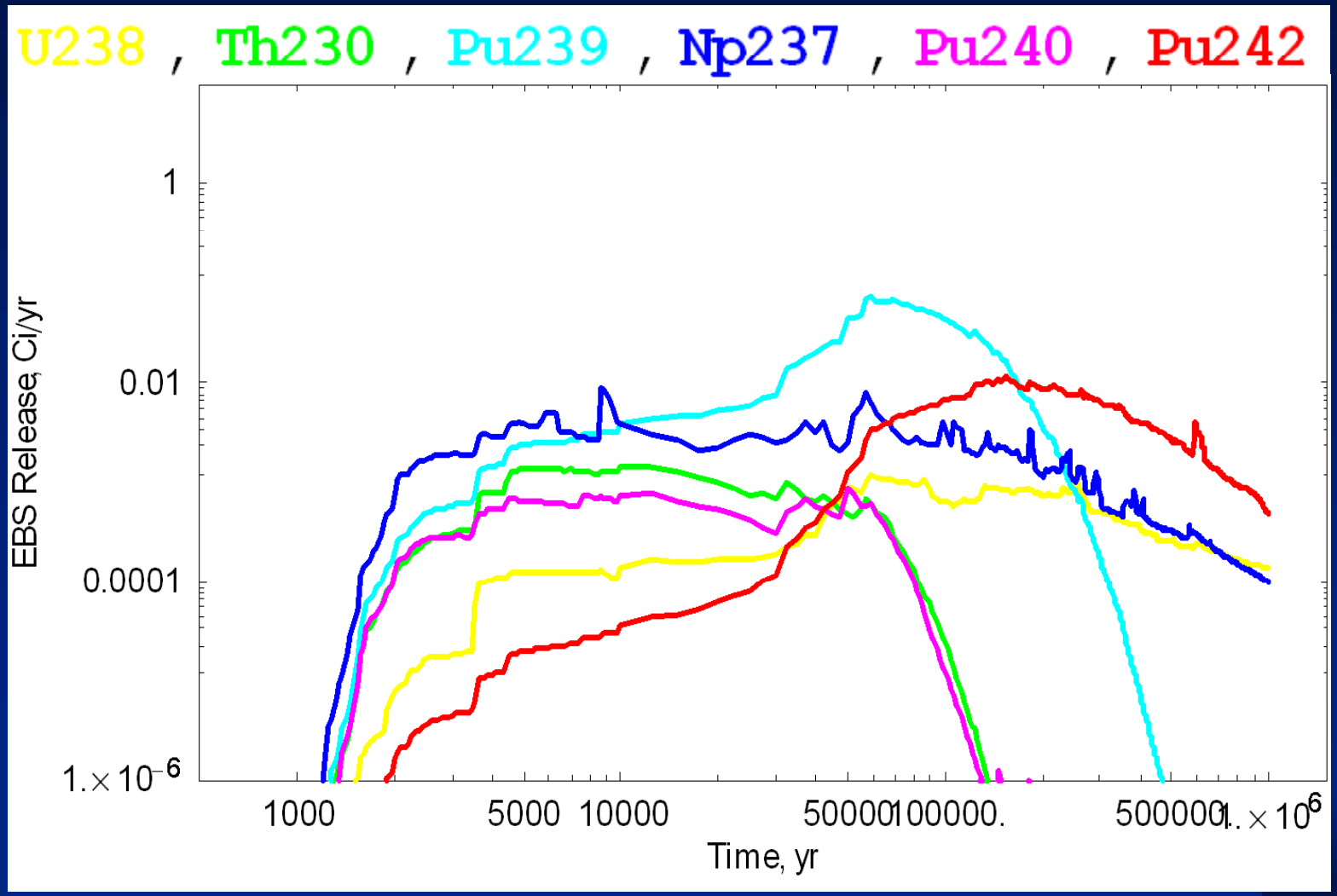
1,000,000 year run 500 realizations



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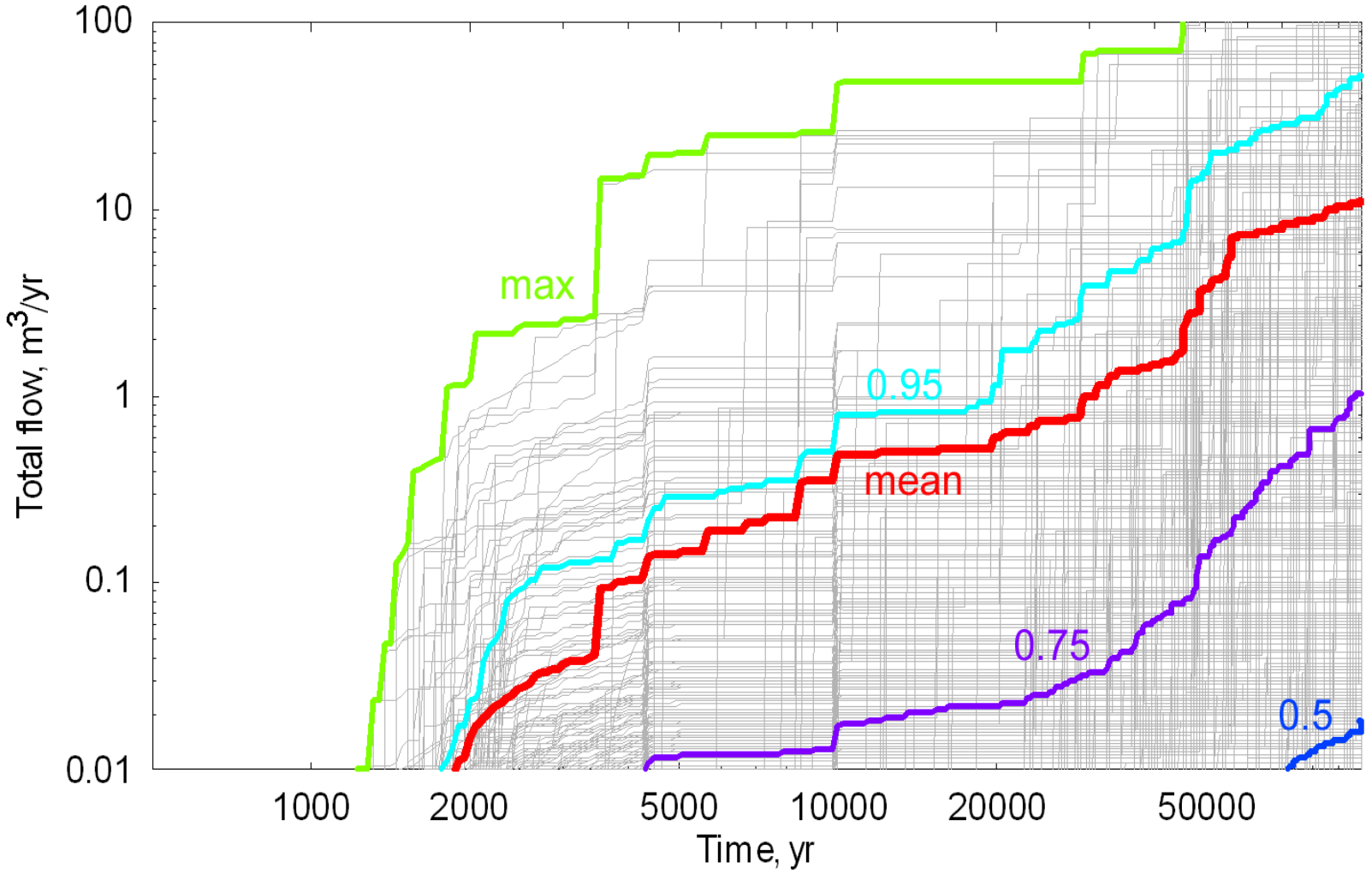
Average Flow per Breached WP



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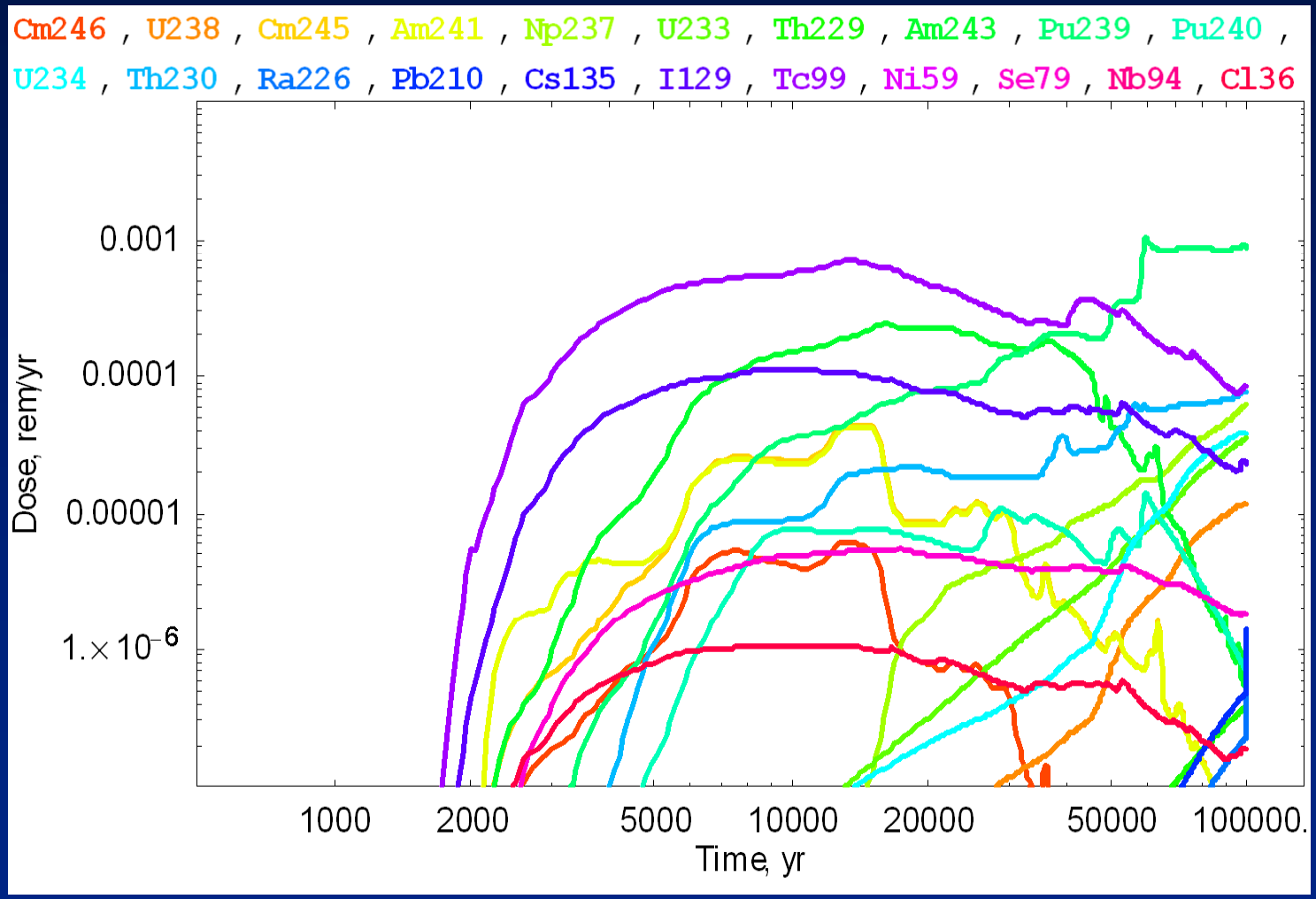
Dose by Radionuclide



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WP Temperature by Subarea