SAND2017-5393C

DOE MANAGED HLW AND SNF DISPOSAL IN ARGILLITE HOST ROCK ANALYSIS OF THE EFFECT OF DECAY HEAT IN THE NEAR FIELD

Teklu Hadgu, Steven Gomez and Edward Matteo

SFWST Working Group Meeting

May 23-25, 2017

Sandia National Laboratories is a multi-mission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA-0003525. ***SAND2017-XXXX.***

Thermal Analysis of DOE Managed HLW and SNF

- Detailed thermal analysis for various disposal concepts
- Disposal in argillite host rock
- Single-pack and multi-pack packaging
- Thermal-only Semi-analytical methods and Thermal-Hydrology simulations
- Thermal decay data from Wilson (2016) and Emily Stein (2017)
- PFLOTRAN (Lichtner et al., 2015) used for Thermal-Hydrology simulations

Input for Thermal-Only Analysis Crystalline Host Rock

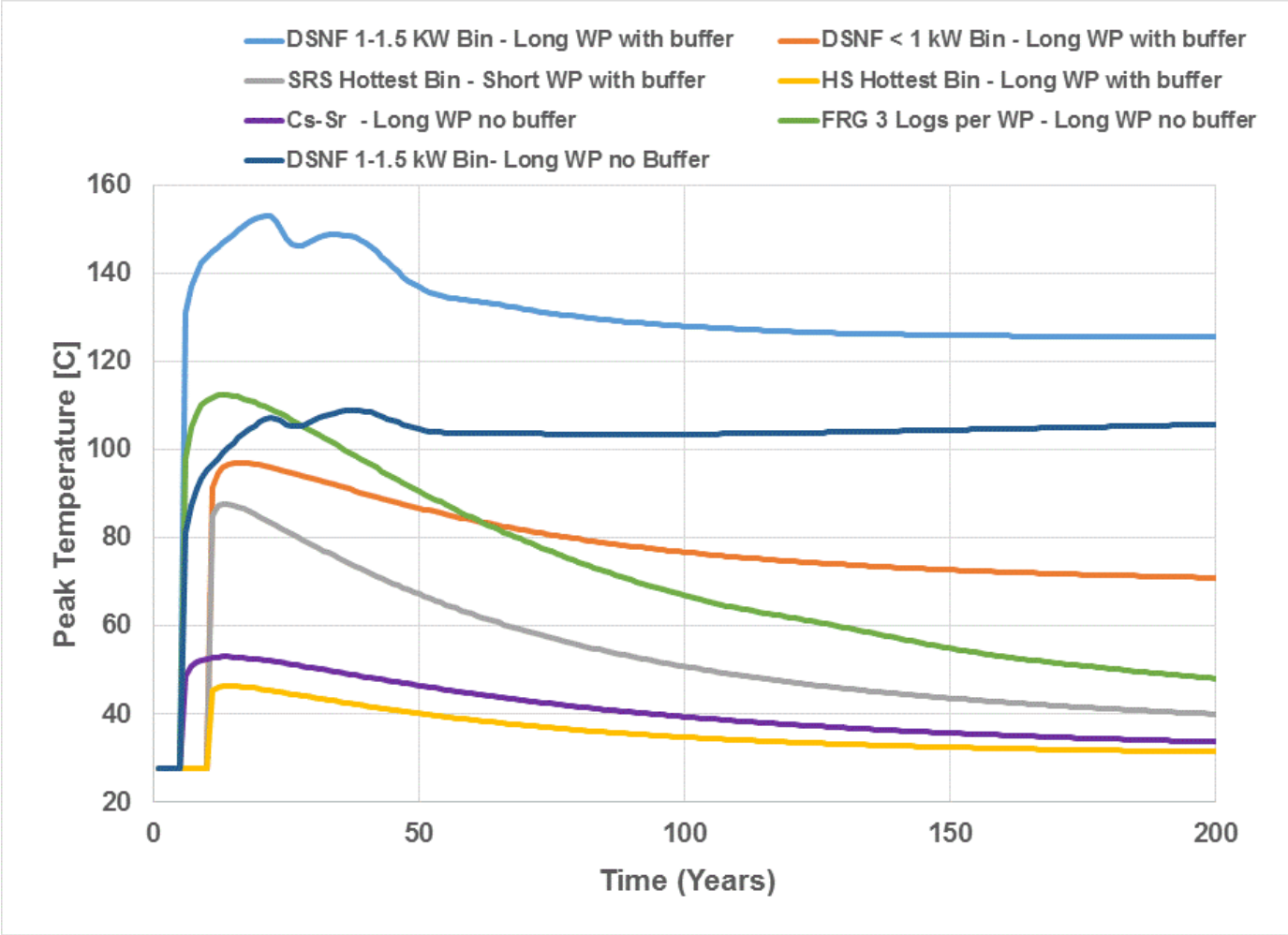
- Borehole Diameter – 2 m (with buffer), 0.78 m (without buffer)
- Drift Spacing – 30 m
- Waste package Spacing – 4.67 m (long WP) or 3.15 m (short WP)
- Rock and buffer thermal conductivity: 1.75/0.6 W/m K
- Storage time – 10, 50 ,100 years

Waste Package Sizes

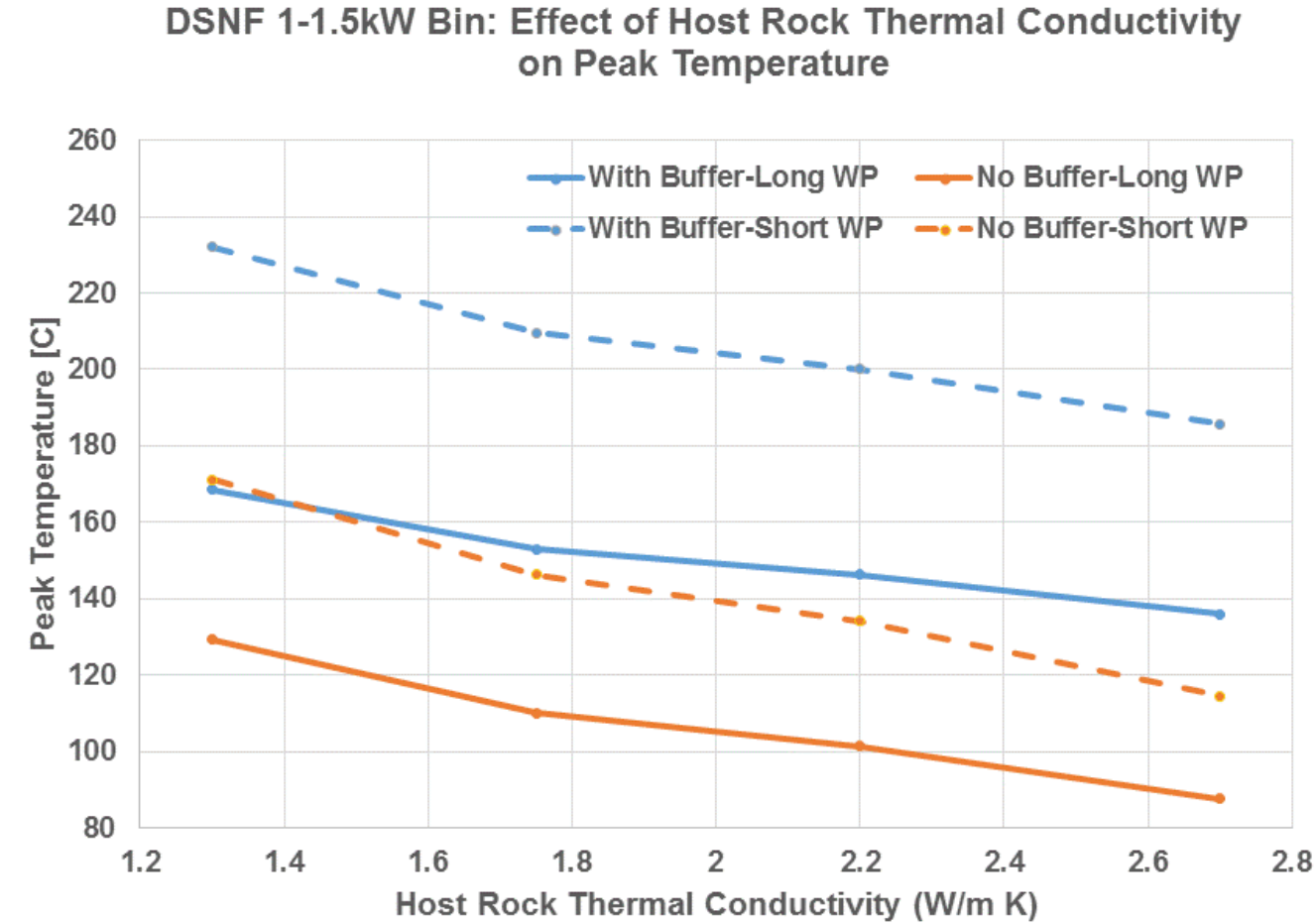
Waste Type	Diameter (in)	Length (in)
DSNF	24	180/120
SRS Glass	24	120
FRG	24	180
HS Glass	24	180
HS Cs/Sr Container	24	180

Sensitivity Analysis				
Drift Spacing m	10	15	20	
WP Spacing m	10	15	20	30
Rock Kth W/m K	1.3	2.2	2.7	
Buffer Kth W/m K	1.0	1.43		
Storage Time Yrs	20	30		

Temperature vs Time Plot Argillite Host Rock

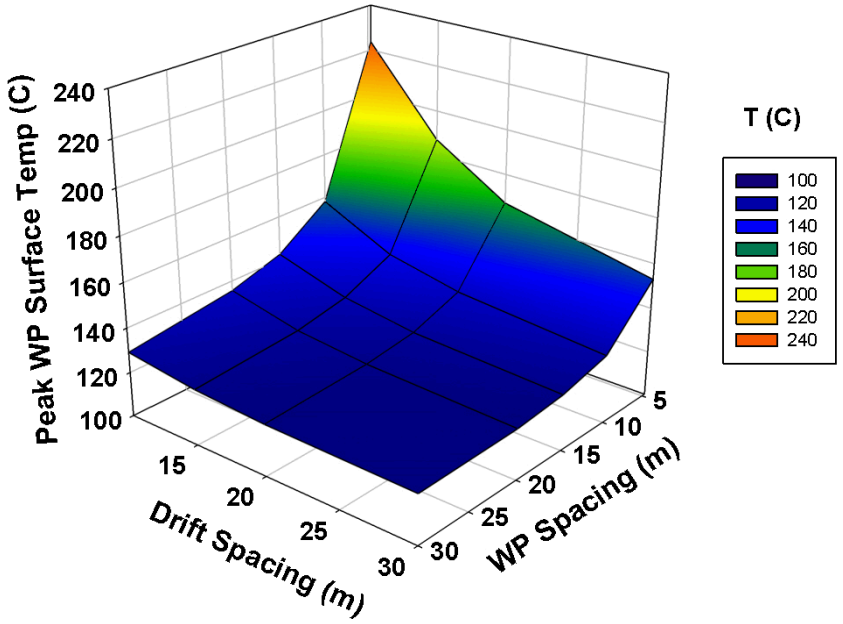


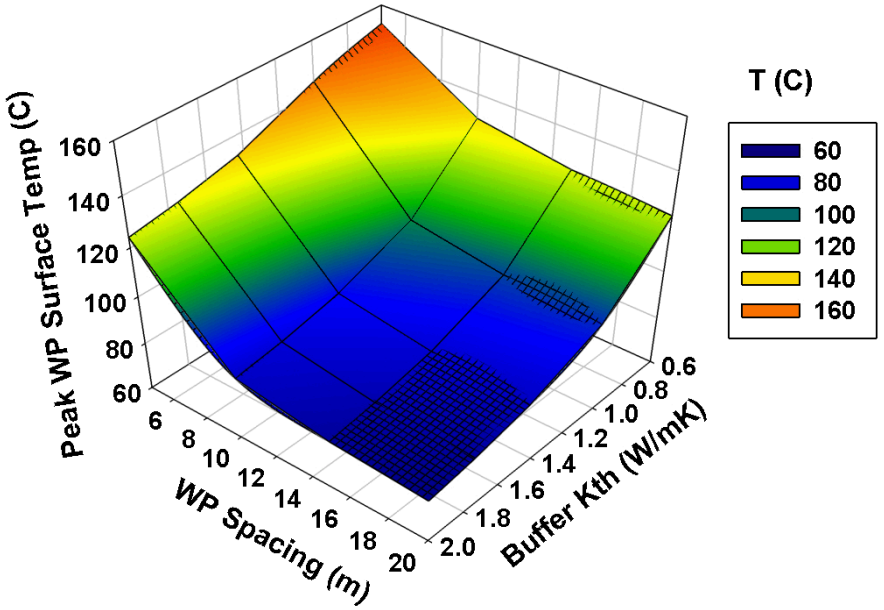
Effect of Rock Thermal Conductivity on Peak Temperature



Effect of Drift Spacing, Waste Package Spacing and Buffer Thermal Conductivity on Peak Temperature

DSNF 1.0-1.5 kW Bin decayed to 2038



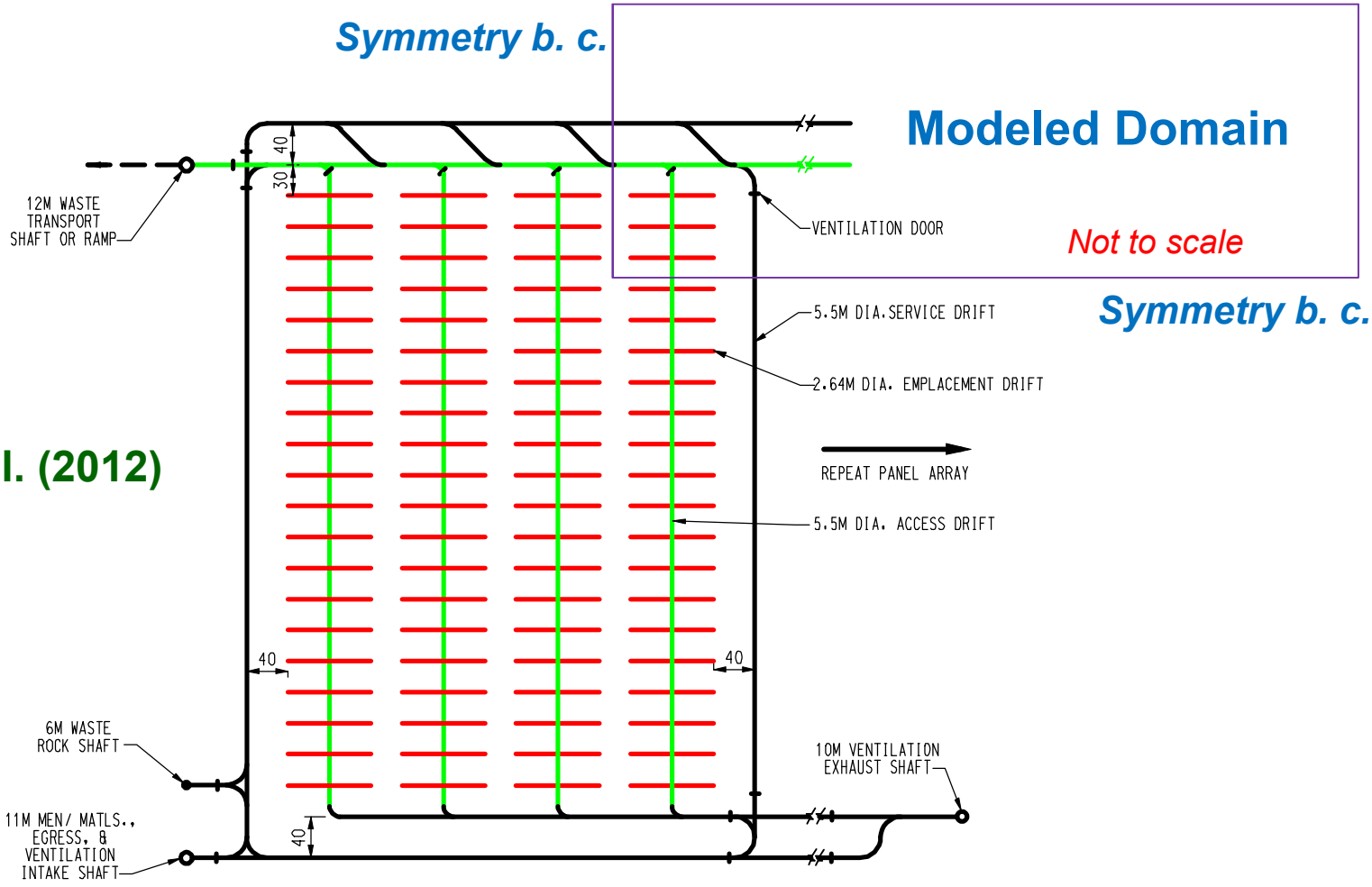


Thermal-Hydrologic Modeling Argillite Host Rock

- Domain represented by argillite rock with repository at 500 m depth
- Simulation domain: 1000 m x 1120 m by 1000 m depth
- Mesh size: 33,147,324
- Boundary Conditions:
  - Top: Constant Temperature (10 °C) and pressure (1 Atm.)
  - Bottom: Constant temperature of 35 °C and no fluid flux
  - No fluid or heat flux on sides
- Ambient temperature gradient corresponds to 25 °C /km

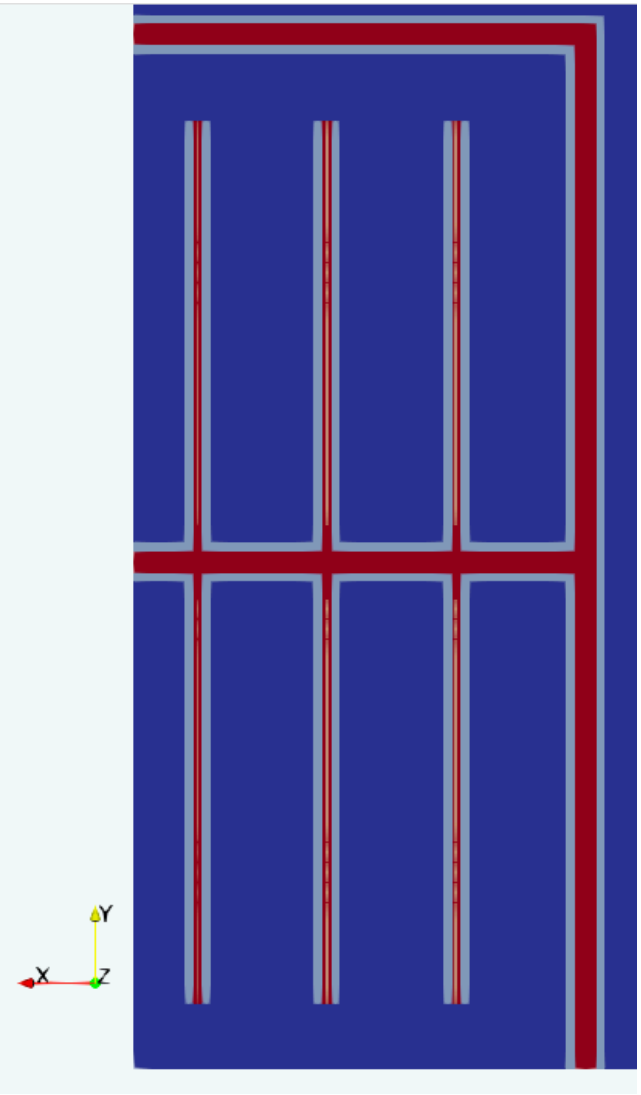
Material	Permeability (m^2)	Porosity (-)	Thermal K (W/m/K)	Heat Capacity (J/kg/K)
Argillite	1×10^{-19}	0.2	1.7	830.
DRZ	1×10^{-16}	0.2	1.7	830.
Buffer	1×10^{-19}	0.35	0.6/0.85	830.
Waste Package	1×10^{-20}	0.47	46.0	493.

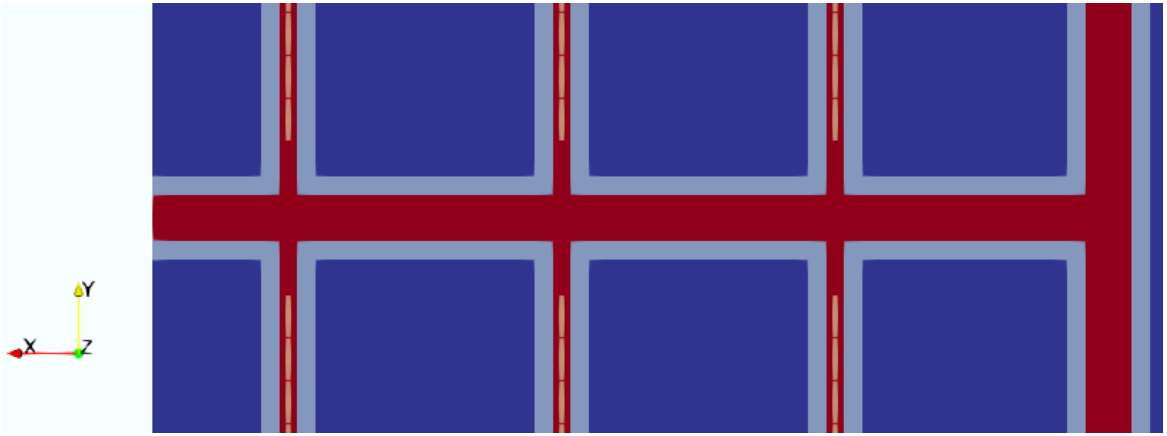
Clay/Shale Panel Concept Layout



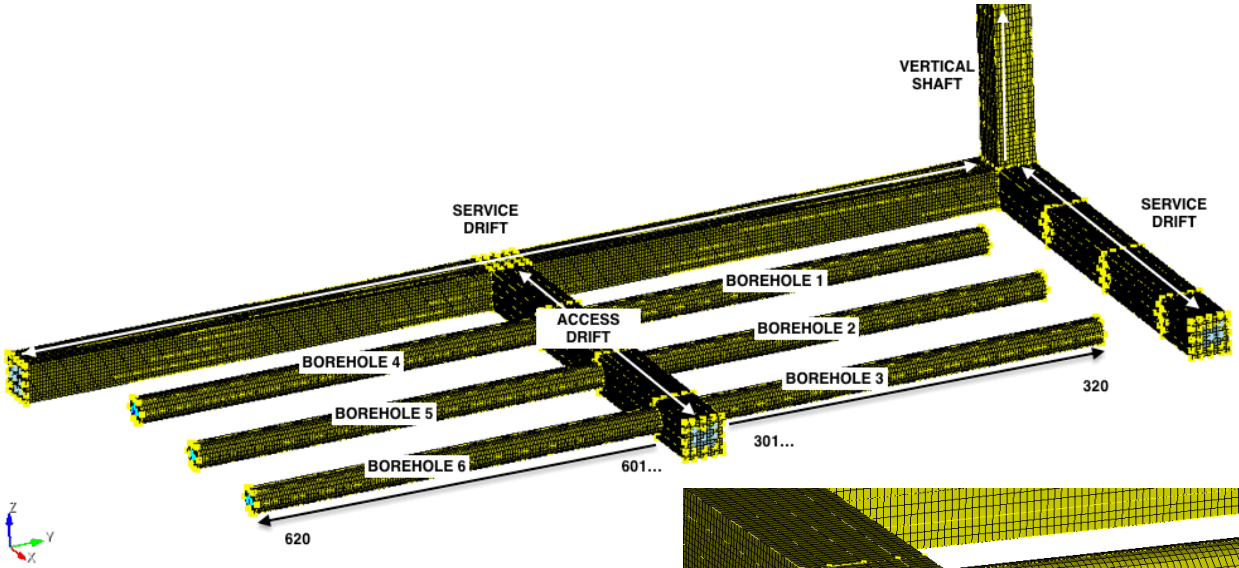
Hardin et al. (2012)

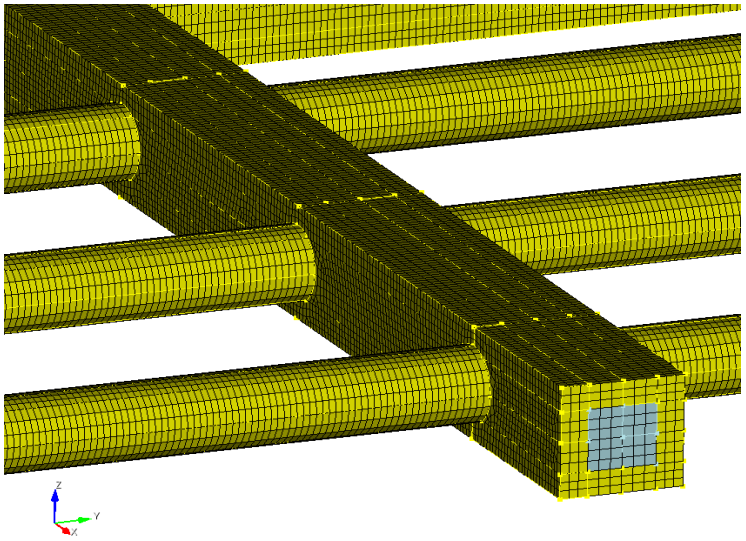
Modeled Domain Layout



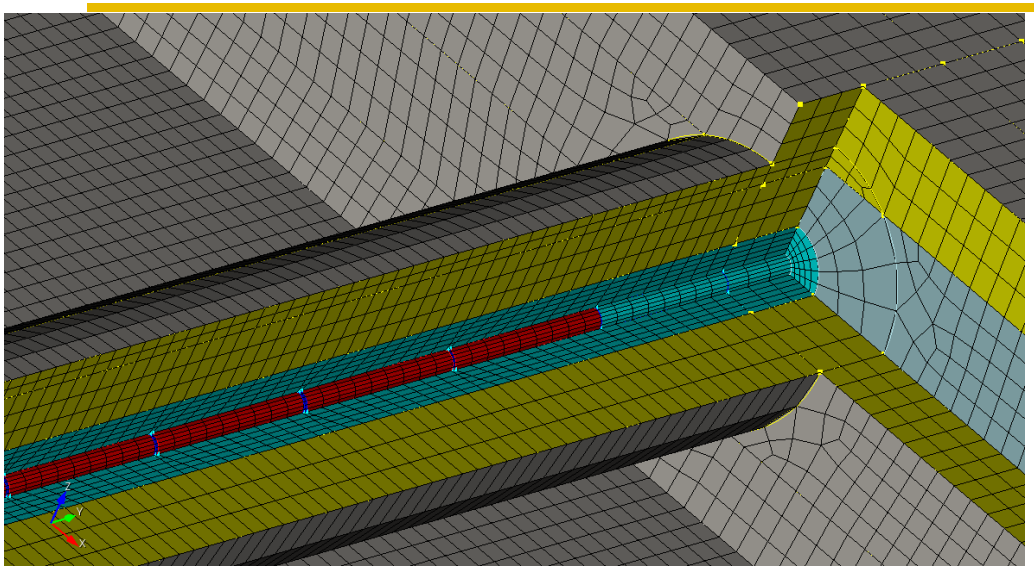


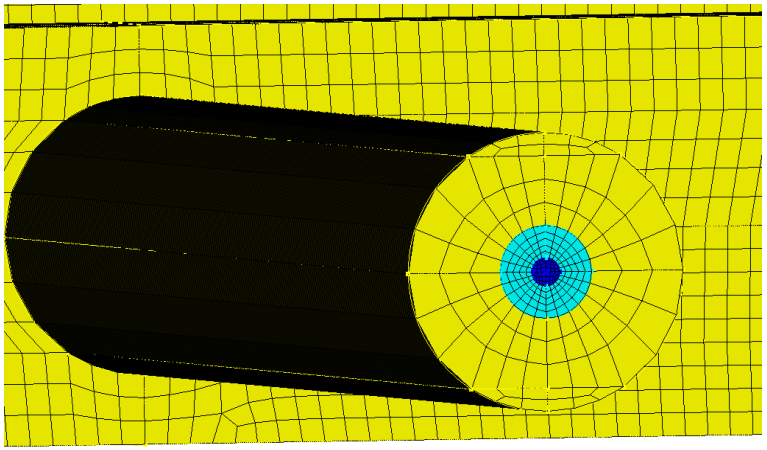
Details of Domain Layout

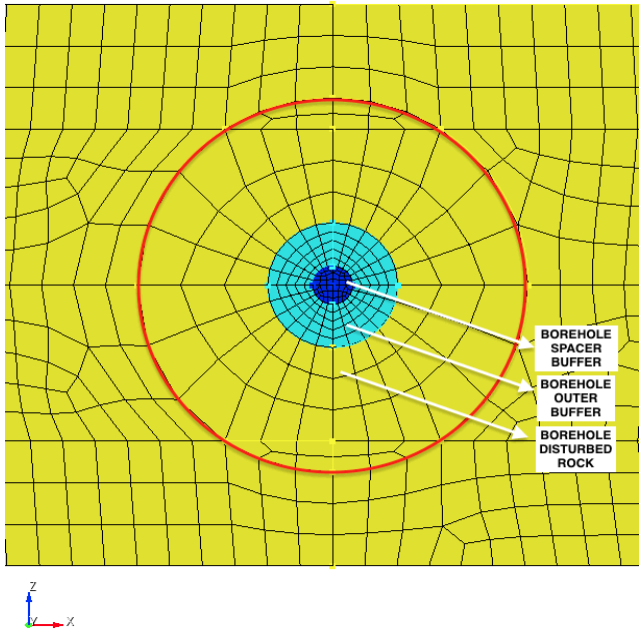




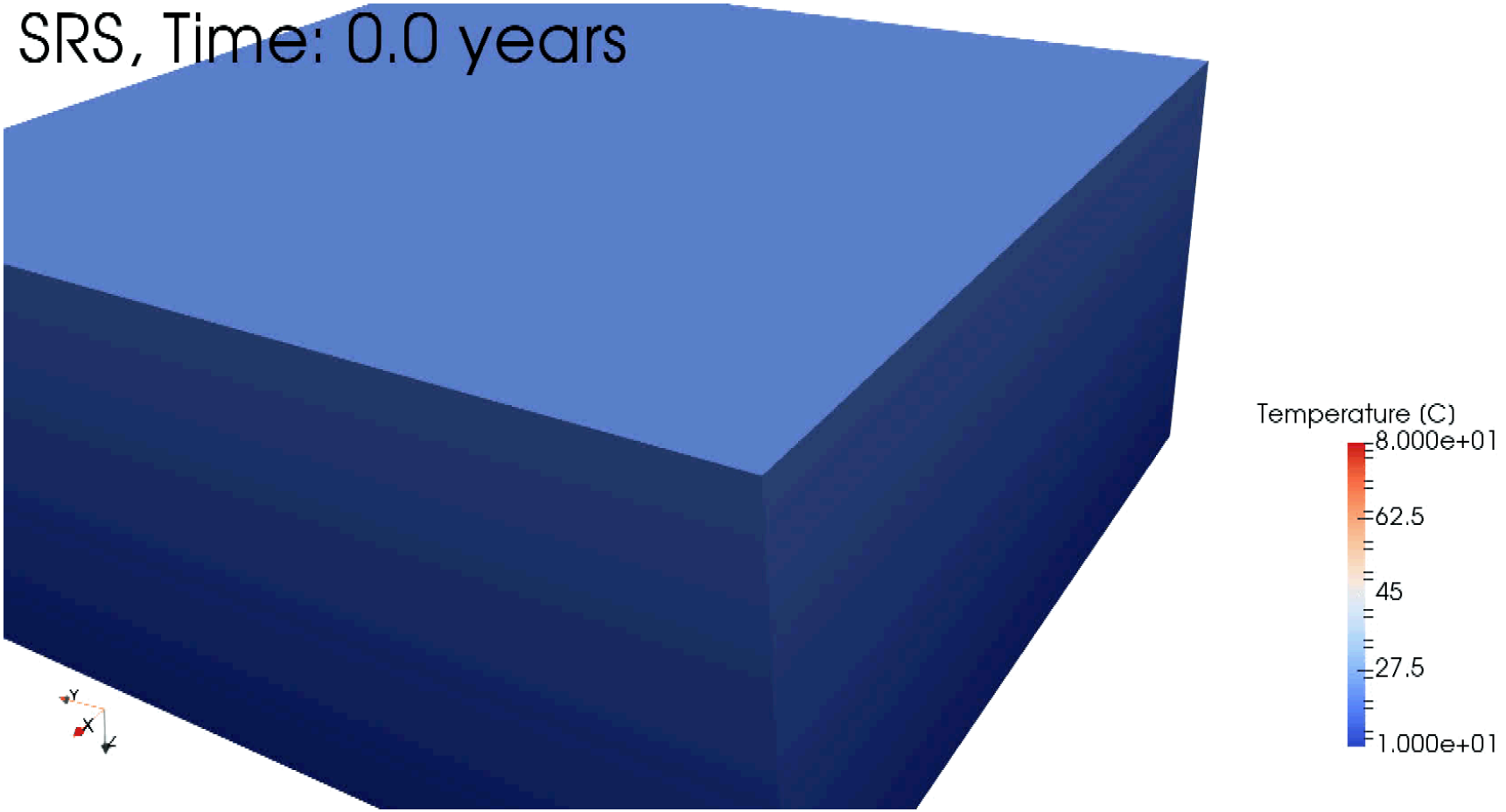
Meshing of Boreholes



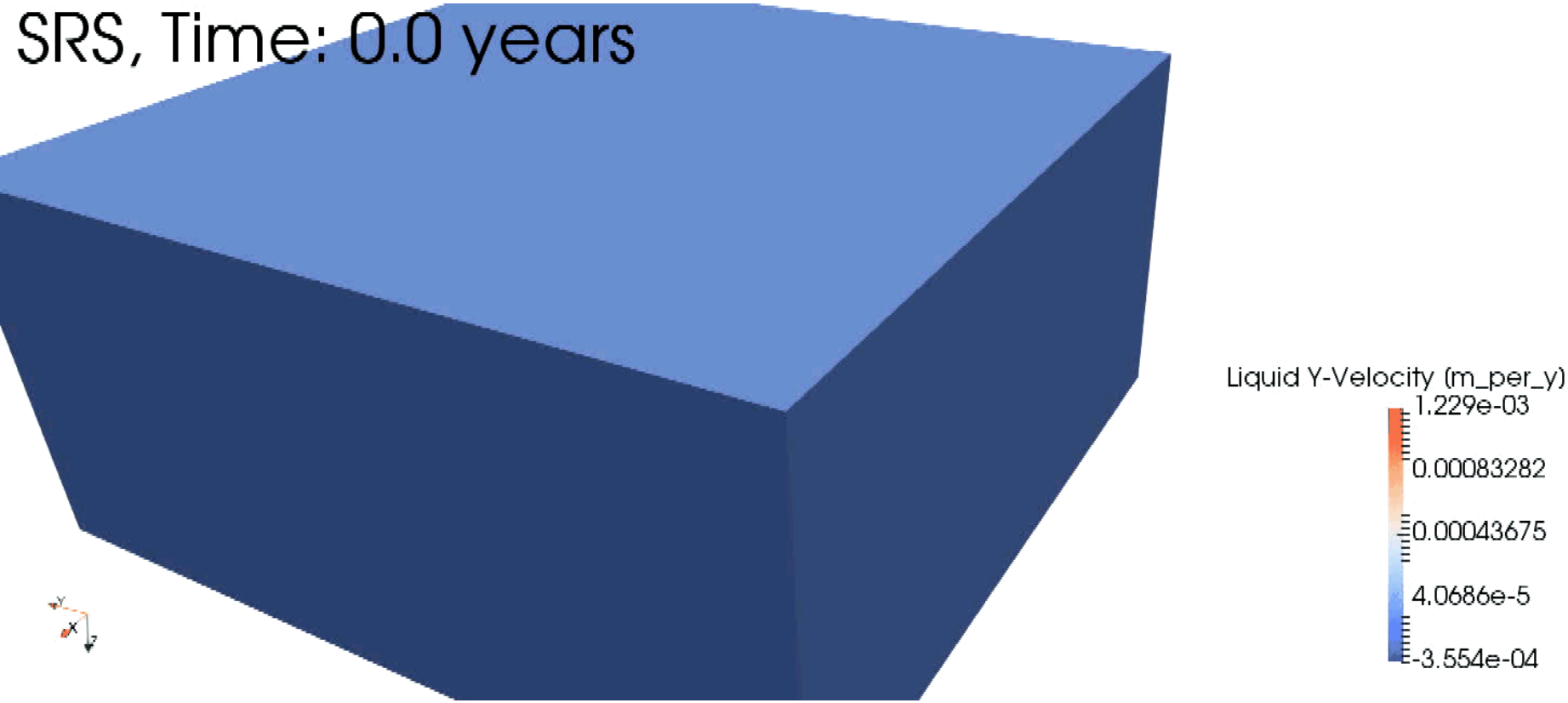




Thermal-Hydrologic Model: Preliminary Results – Temperature History for Disposal of SRS Waste



Thermal-Hydrologic Model: Preliminary Results – Fluid Velocity History for Disposal of SRS Waste



Future Work

- Complete thermal-only and thermal hydrology modeling
- Thermal hydrology modeling with two phase flow
- Sensitivity study on the role of DRZ
- Thermal hydrology modeling with buffer and without buffer
- Thermal hydrology modeling to study use of overpack
- Grid resolution

References

- E. HARDIN, T. HADGU, D. CLAYTON, H. GREENBURG, J. BLINK, M. SHARMA, M., SUTTON, J. CARTER, M. DUPONT, and P. RODWELL, *Disposal Concepts/Thermal Load Management (FY11/12 Summary Report).* FCRD-USED-2012-000219 Rev. 1. September, 2012. U.S. Department of Energy, Used Fuel Disposition R&D Campaign. (2012).
- Lichtner, P., Hammond, G., Lu, C., Karra, S., Bisht, S., Andre, B., Mills, R., and Kumar, J. (2015): PFLOTRAN user manual: A massively parallel reactive flow and transport model for describing surface and subsurface processes, Technical report LA-UR-15-20403, Los Alamos Natl. Lab., Los Alamos, N. M.
- Wilson, J. (2016) Decay Heat of Selected DOE Defense Waste Materials, FCRD-UFD-2016-000636, SRNL-RP-2016-00249.