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Moving from 2D to 3D Flow Modeling for the Waste Isolation Pilot Plant Performance Assessment

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Disposal IV

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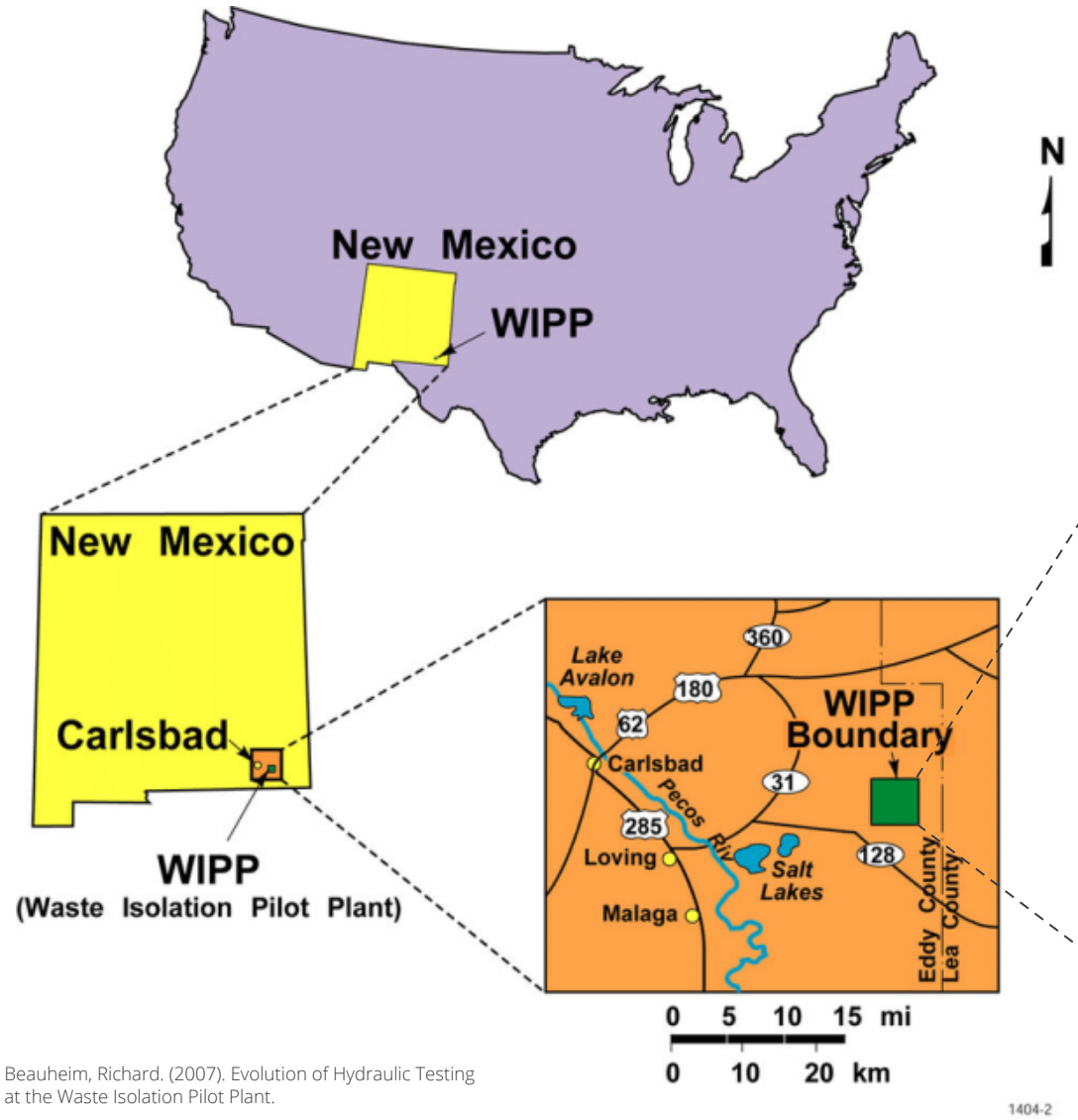
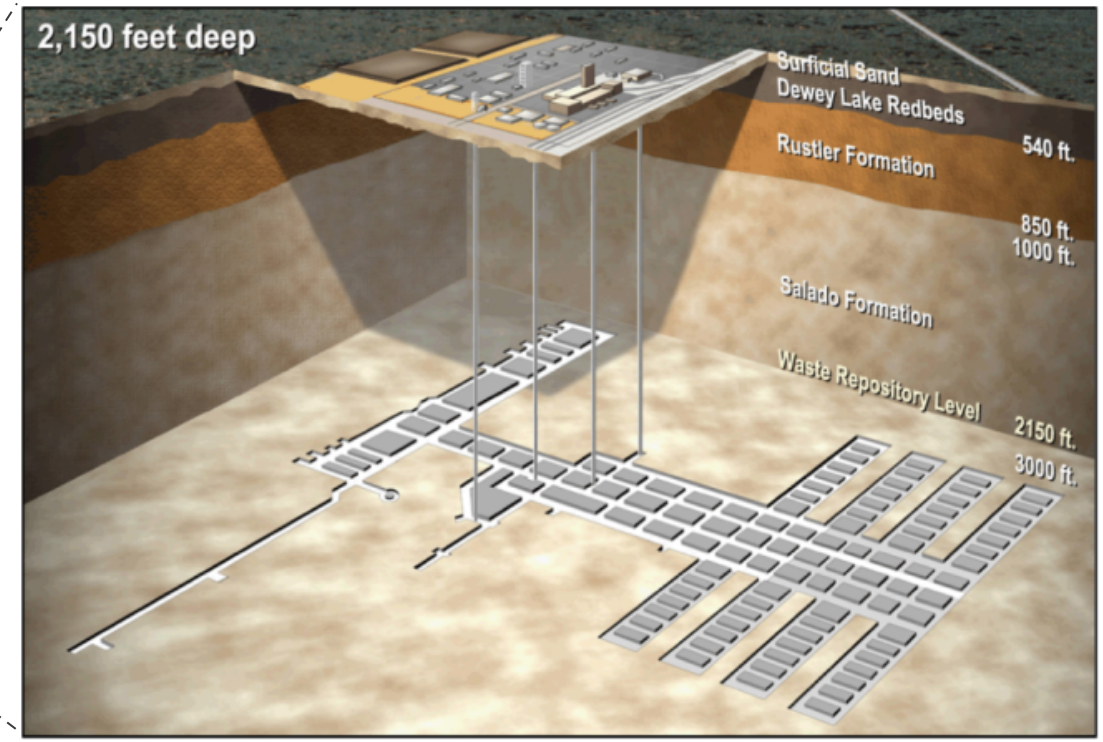
Waste Isolation Pilot Plant (WIPP)

- The WIPP is the nation's only licensed deep geologic repository for defense-related transuranic waste
- Operated by U.S. Department of Energy (DOE)
- Long-term performance regulated by U.S. Environmental Protection Agency (EPA)





Beauheim, Richard. (2007). Evolution of Hydraulic Testing at the Waste Isolation Pilot Plant.

Outline

Need for 3D modelling capability

Description of 2D and 3D models

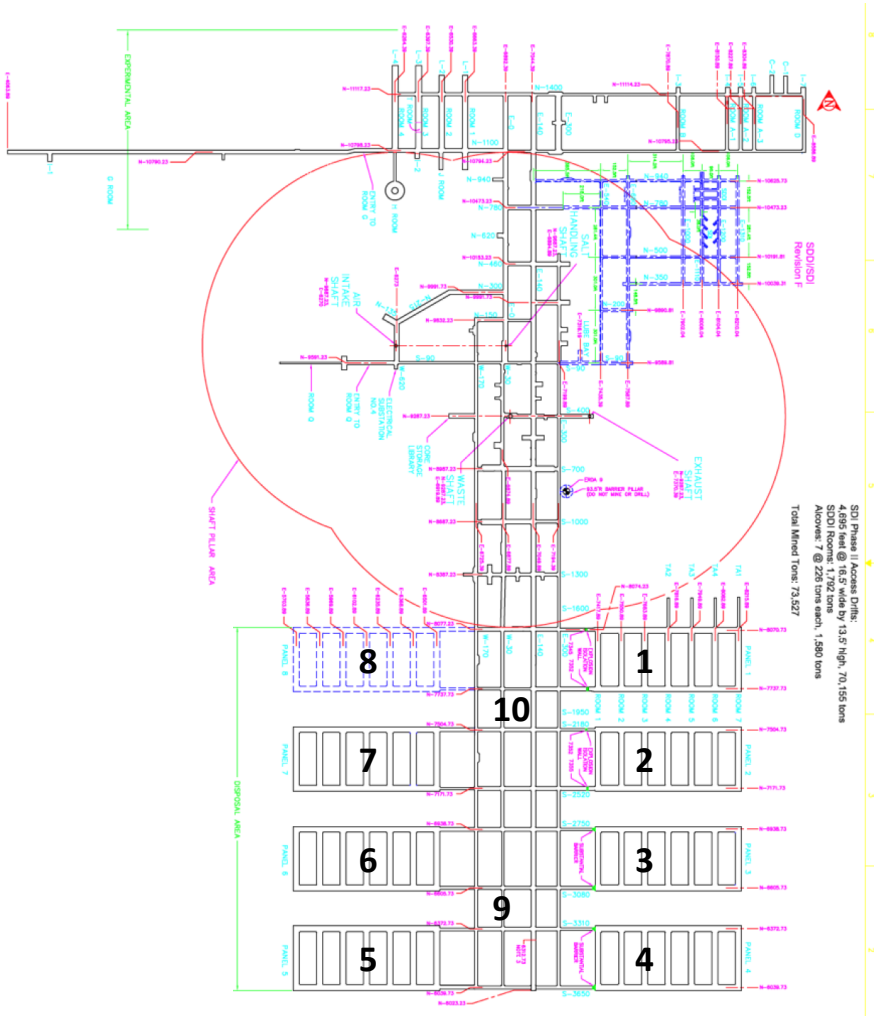
Simulation scenarios

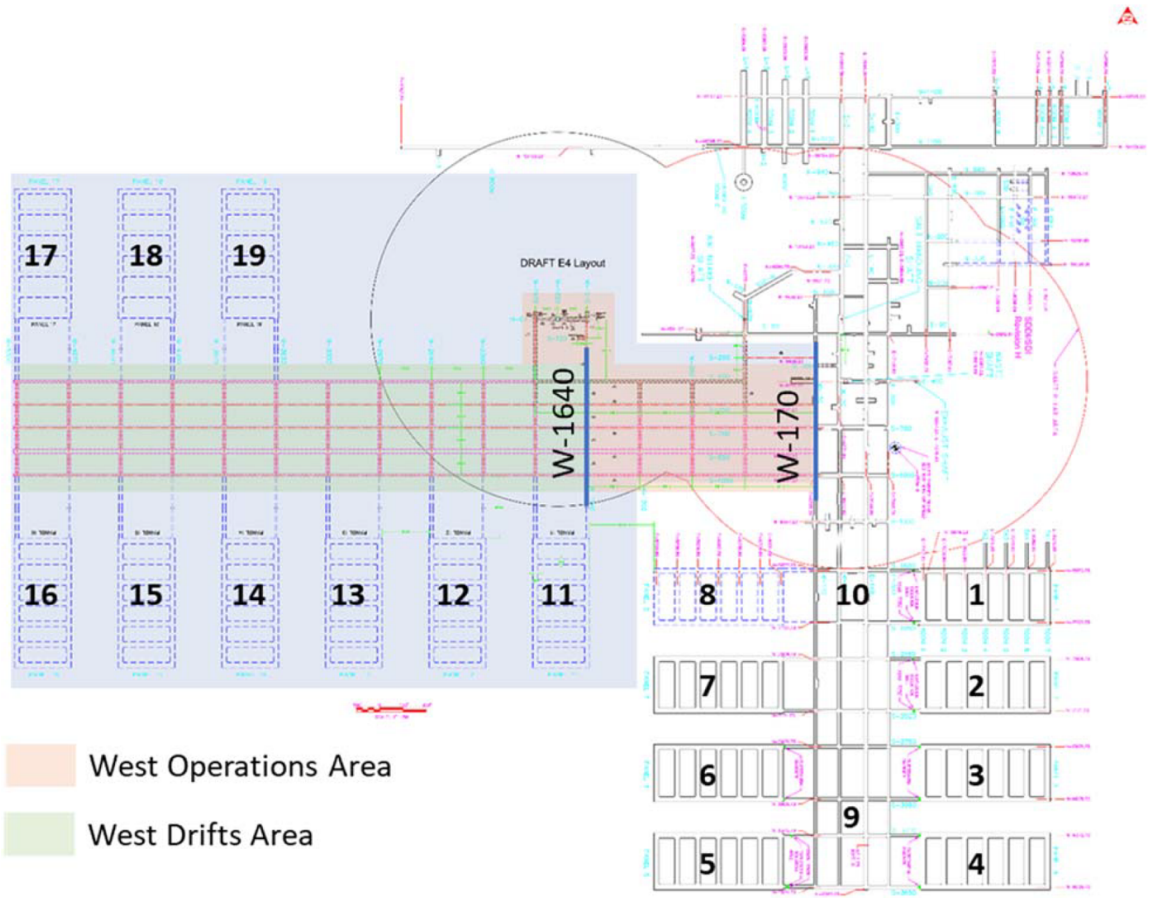
Comparison quantities

Results

Need for 3D modelling capability: Layout of the repository

Replacement panels impact the symmetry of the repository





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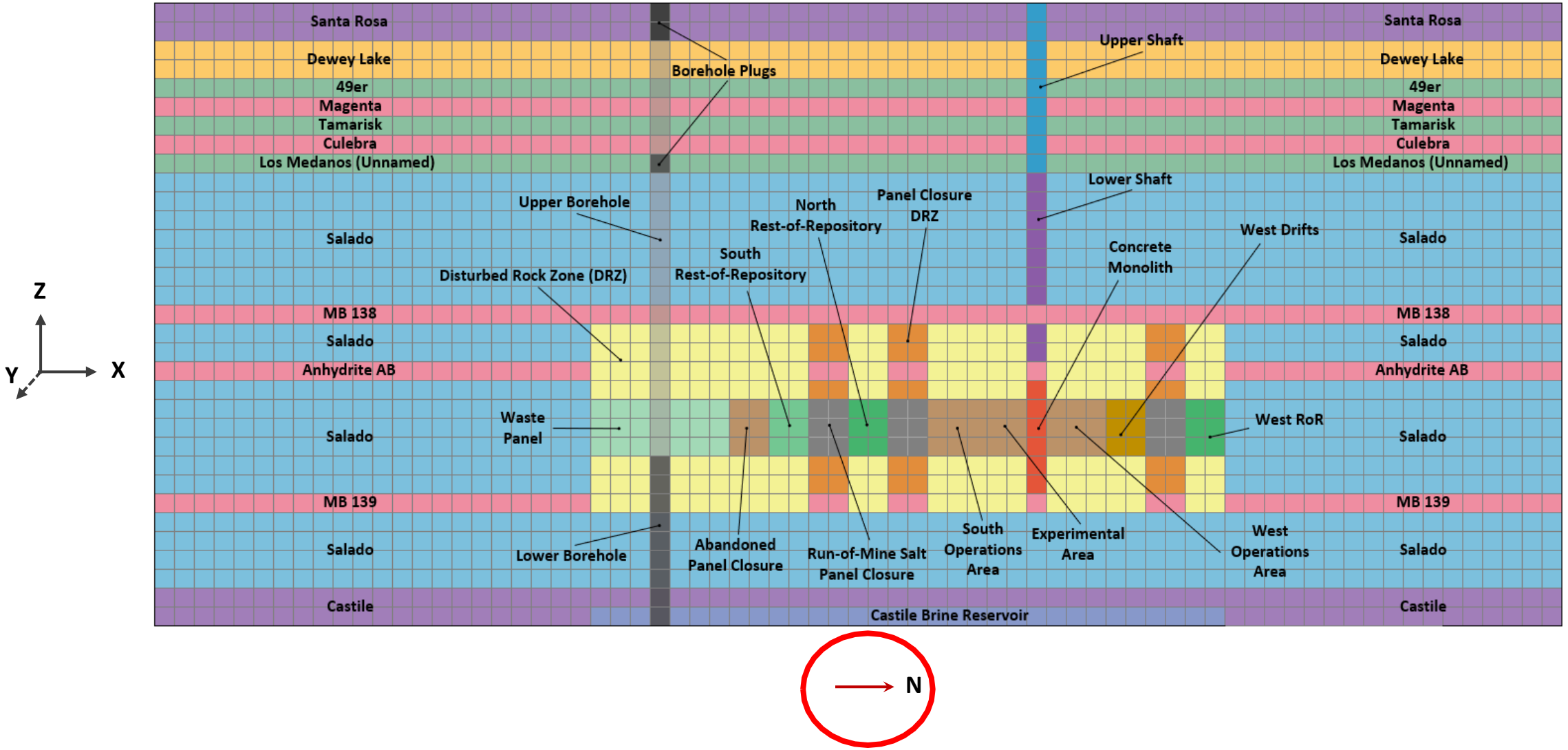
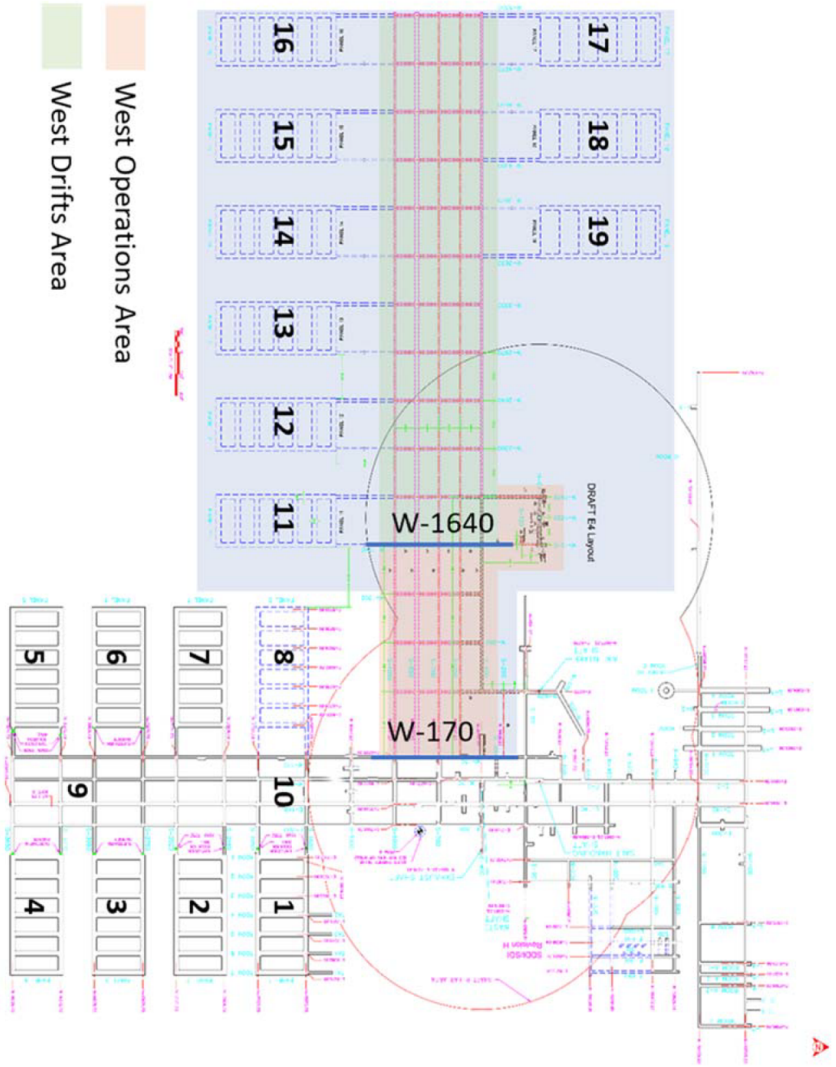
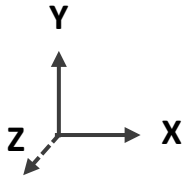
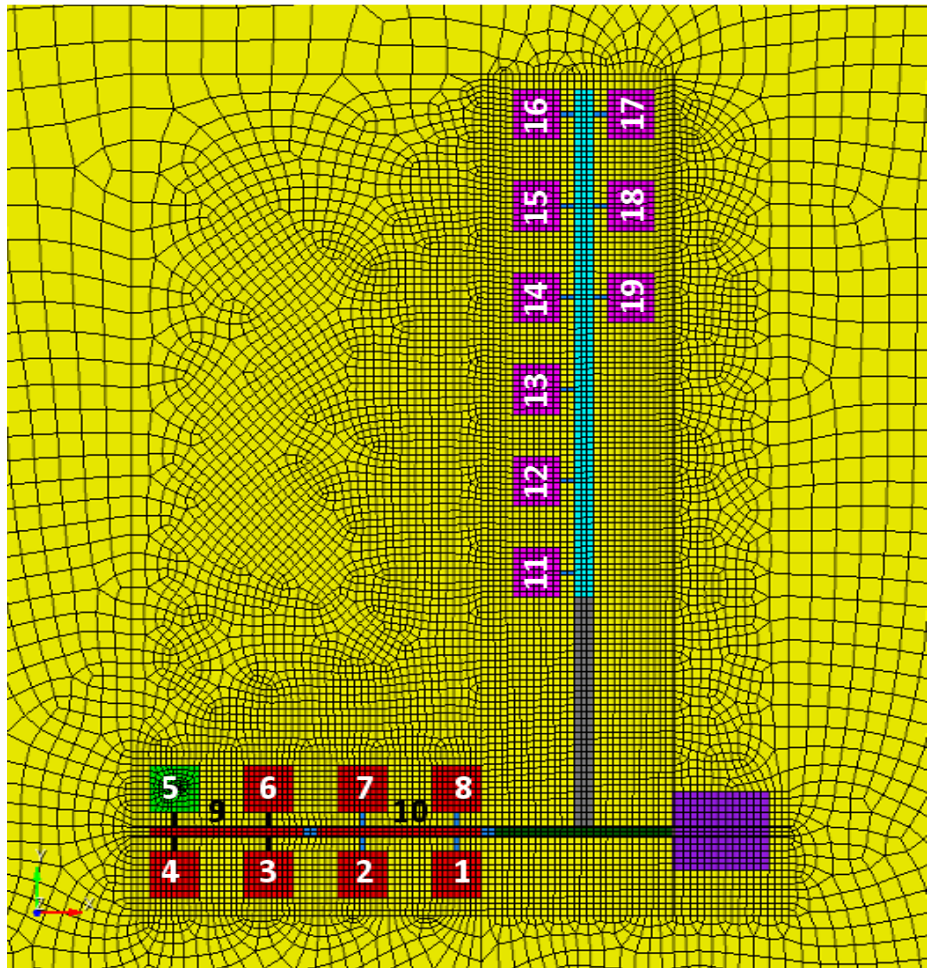
2D model with additional panels



3D model for simulation







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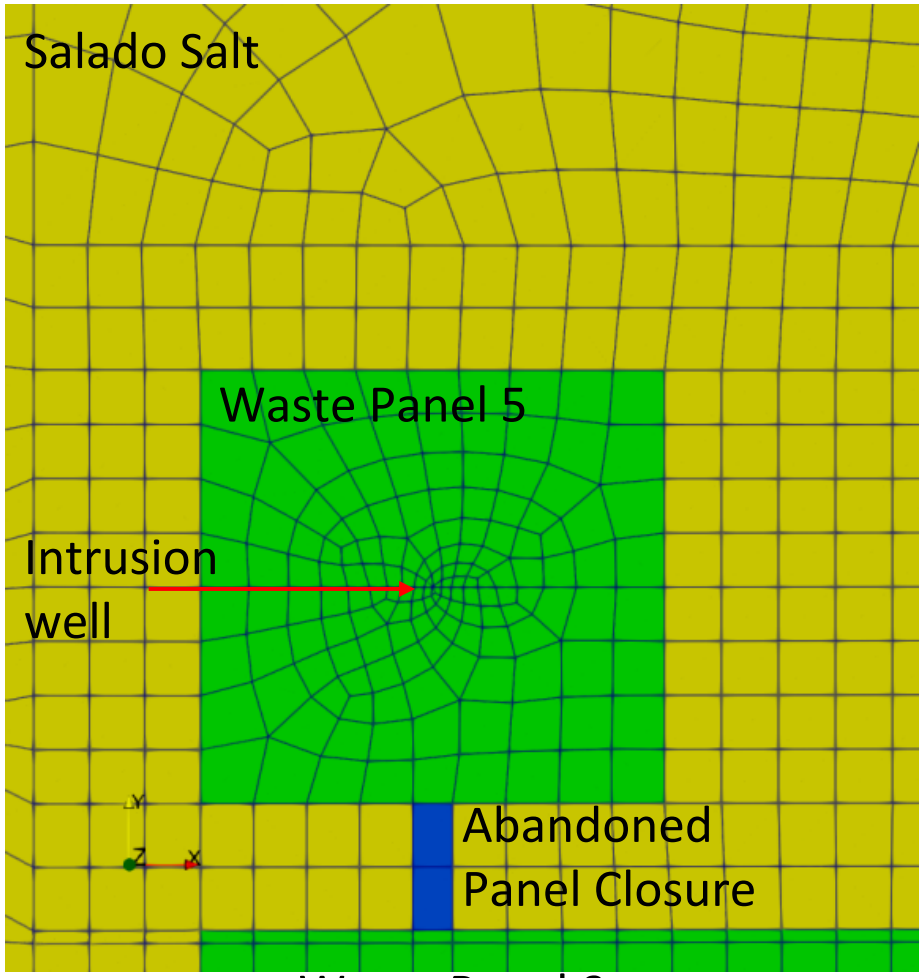
3D model details

- Rectangular volumes:
  - Each individual waste panel
  - Waste panel closures
  - Operations area
  - Experimental area
  - Shaft
- Rectangular explicitly gridded borehole
- Vertical grid resolution identical to 2D mesh
- Disturbed rock zoned (DRZ) above and below the repository
- XY extent of the model is 30.7x28.3 km, identical to Culebra modelling studies (Kuhlman, 2010)
- 531,894 grid cells



Simulation scenarios

Two types of wellbore intrusion into waste panel 5

- E1: intrusion through the repository and into a brine pocket in the Castile Reservoir below
- E2: intrusion into the repository

Latin Hypercube sampling of size 100 to create a replicate

Replicate 1 of 3 has been analyzed

600 simulations in the analysis

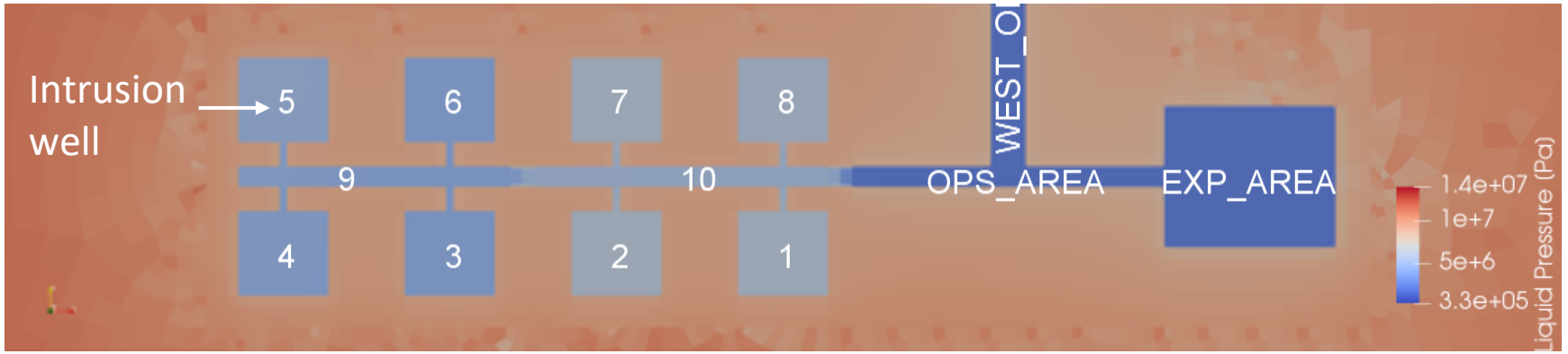
Not all simulations finish in 3D

Flow simulations are run in PFLOTRAN

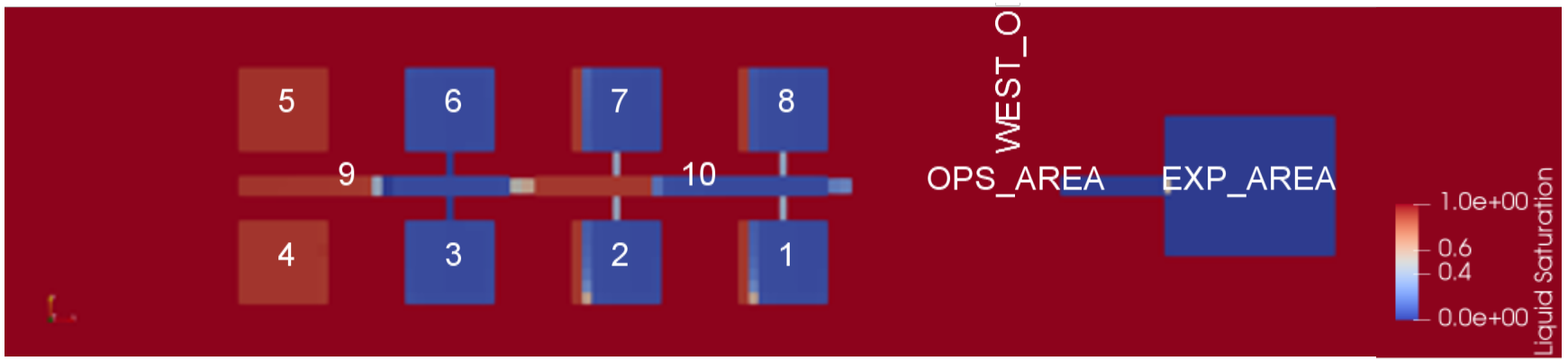
Scenario	Description	Percent of 3D Simulations completed
S1-BF	Undisturbed	99%
S2-BF	E1 at 350 years	96%
S3-BF	E1 at 1,000 years	98%
S4-BF	E2 at 350 years	97%
S5-BF	E2 at 1,000 years	99%
S6-BF	E2 at 1,000 years; E1 at 2,000 years.	99%

Example 3D Simulation Result

Brine Pressure



Brine Saturation



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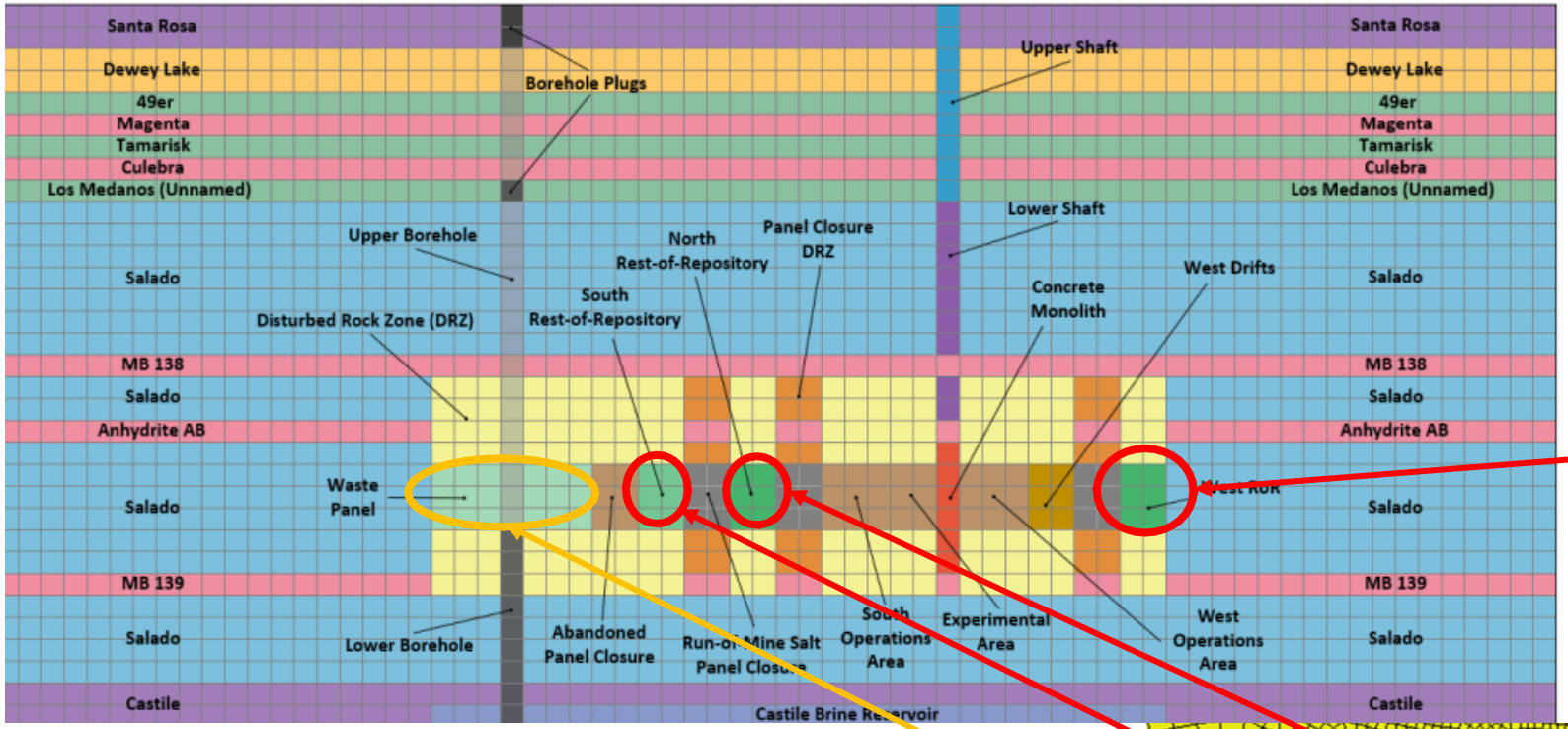
Simulation results for scenario s6, v002 at elevation z=382.5m at 2001 years, one year after second borehole intrusion through waste panel 5 into the Castile brine reservoir.

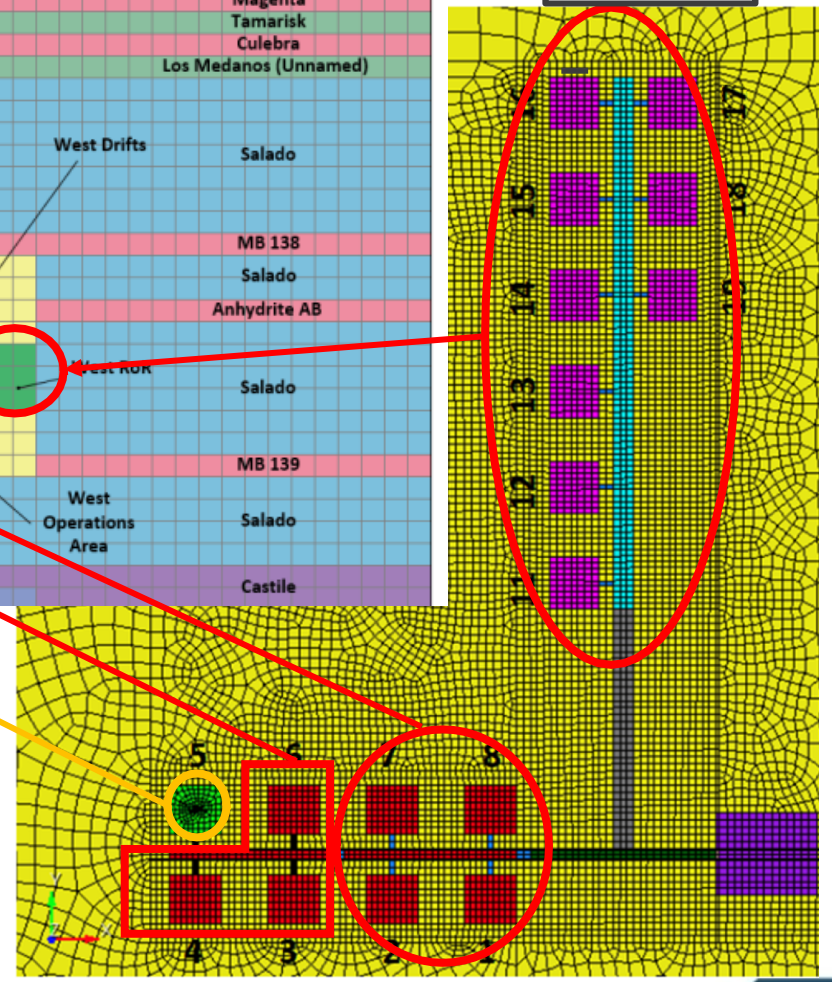
BRAGFLO and PFLOTRAN Results Mapping for Comparison

The comparison focuses on values that impact WIPP releases

- Brine flows up/down the borehole
- Volume averaged brine pressures and saturations in waste areas



Panels only (purple) does not include the West Operations (light blue).



Model mapping

PFLOTRAN → BRAFGLO:

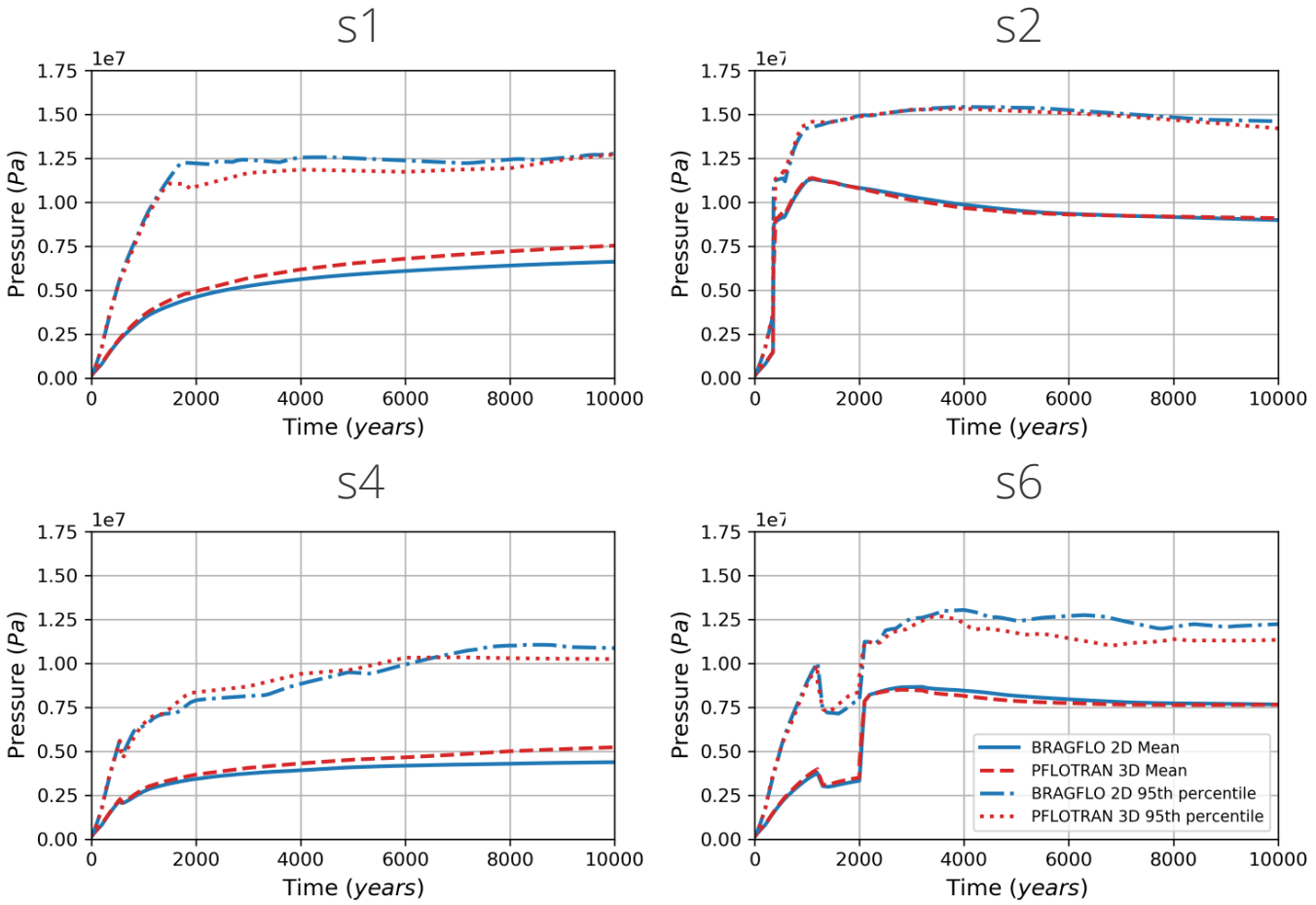
- Panels 3, 4, 6, and 9 → South Rest-of-Repository
- Panels 1, 2, 7, 8, and 10 → North Rest-of-Repository
- Panels 11 through 19 → West Rest-of-Repository
- Panel 5 → Waste Panel

Results: Waste Panel Brine Pressures

In all waste areas and all scenarios, the brine pressure results follow the same trends

In some scenarios and areas, BRAGFLO shows a slightly lower mean brine pressure than PFLOTRAN

s1: no wellbore intrusion
s2: intrusion into Castile at 350 y
s4: intrusion into repository at 350 y
s6: intrusion into repository at 1000 y and intrusion into Castile at 2000 y

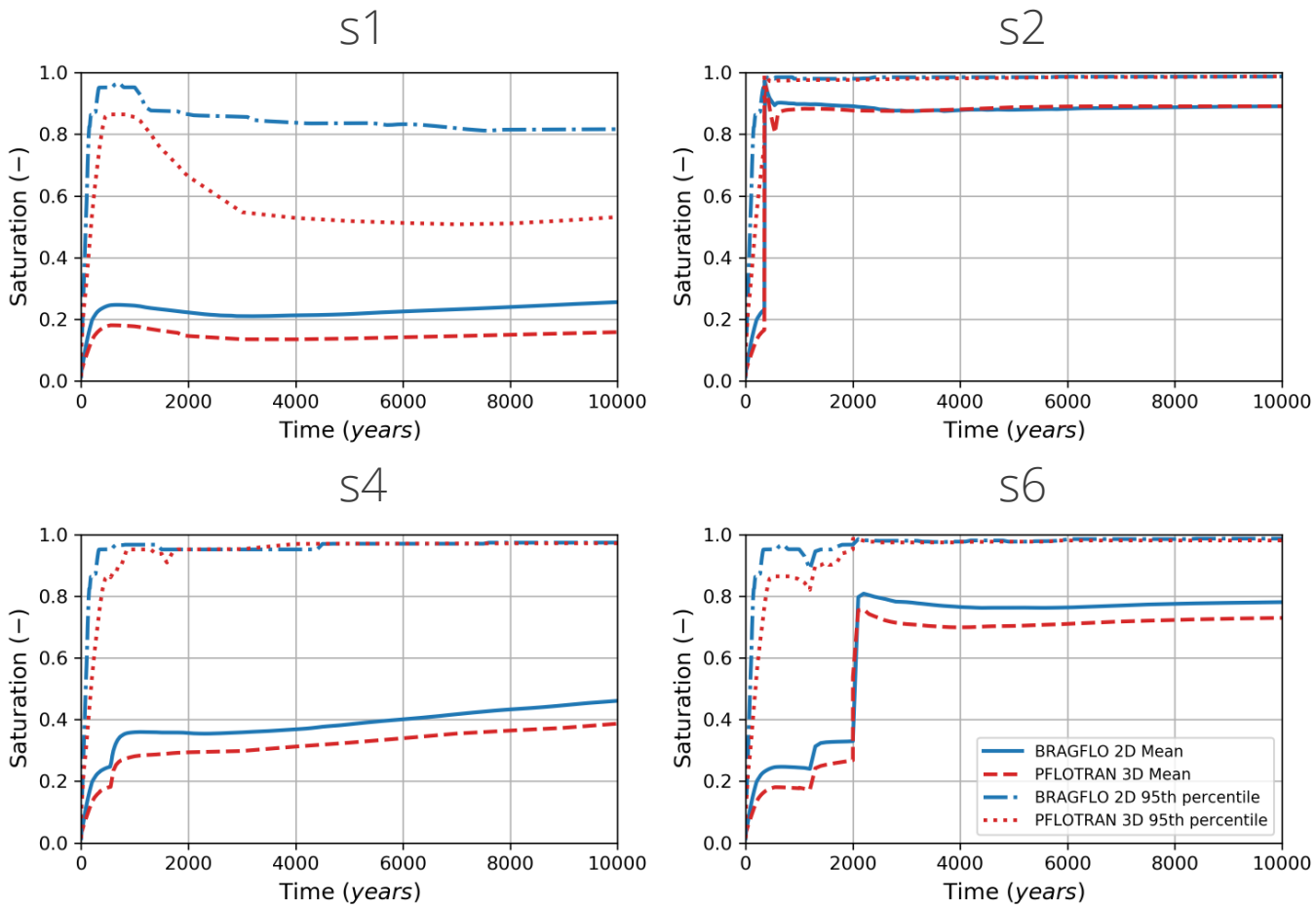


Results: Waste Panel Brine Saturations

In all waste areas and all scenarios, the brine saturation results follow the same trends

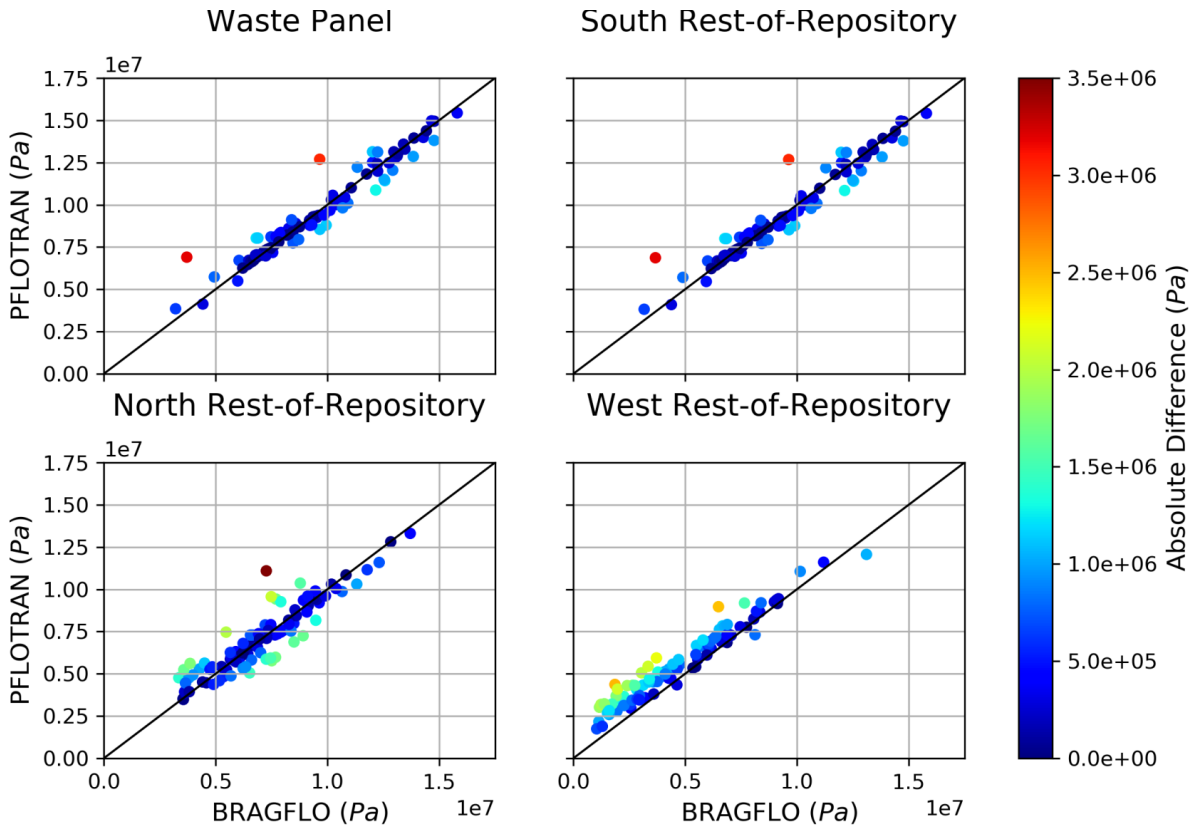
In some scenarios and areas, BRAGFLO shows a slightly higher mean brine saturation than PFLOTRAN

s1: no wellbore intrusion
s2: intrusion into Castile at 350 y
s4: intrusion into repository at 350 y
s6: intrusion into repository at 1000 y
and intrusion into Castile at 2000 y

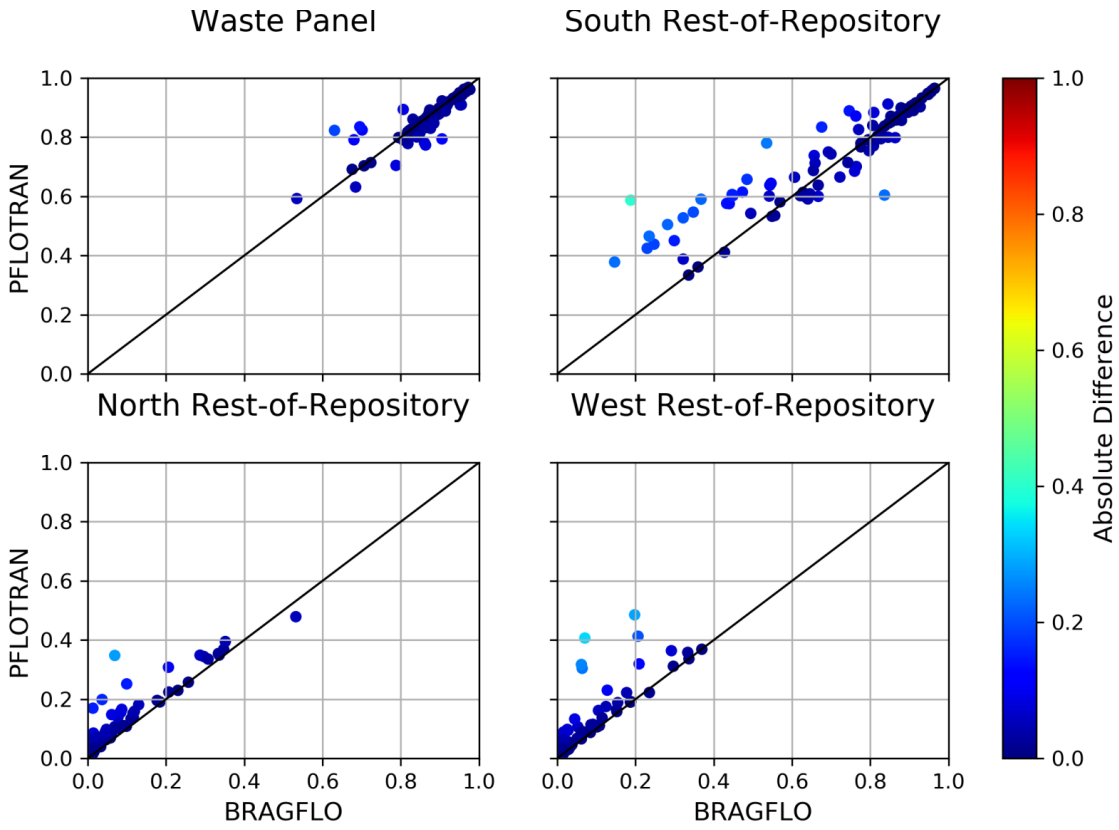


Scenario s2: Other Waste Brine Pressures and Saturations

Pressure



Saturation



Conclusions

- A comparison was done between 2D BRAGFLO and 3D PFLOTRAN Salado flow models
- Despite the difference in dimensionality, the models show similar trends in the quantities that drive WIPP PA releases (brine pressure, brine saturation, and brine flow up the borehole).
  - Results are similar in magnitude and range of uncertainty
  - Results for lumped waste regions are similar in 2D and 3D
- The agreement between the two models demonstrates that the 2D representation of the repository is
  - An appropriate simplification of the 3D geometry
  - Adequate for estimating releases from the disposal system
- 3D PFLOTRAN model
  - Natural progression of increased fidelity and realism
  - Provides opportunity to explore scenarios and situations such as heterogeneous waste loading
  - Will allow use of a single software for flow and transport

References

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Acknowledgements:

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