Understanding the RPPCR PA:

Inherent Conservatisms

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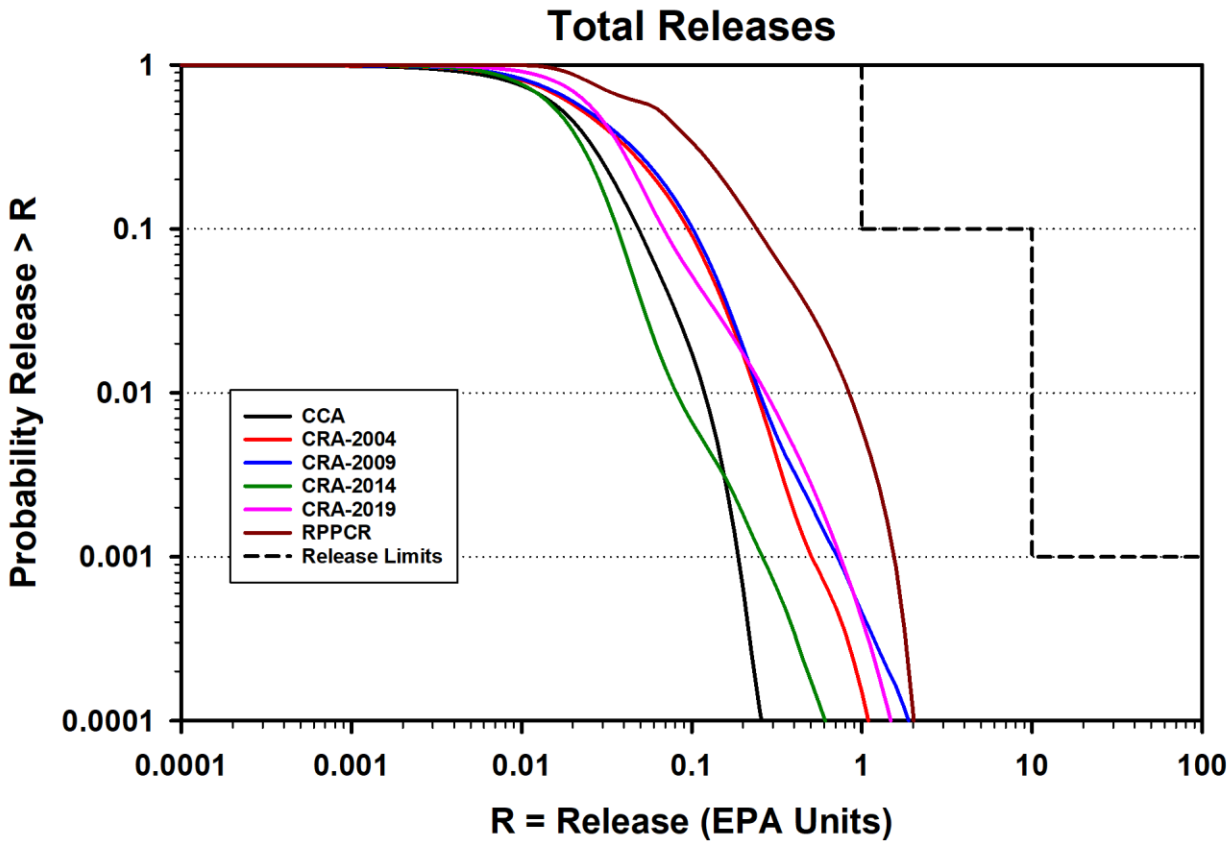
Understanding PA

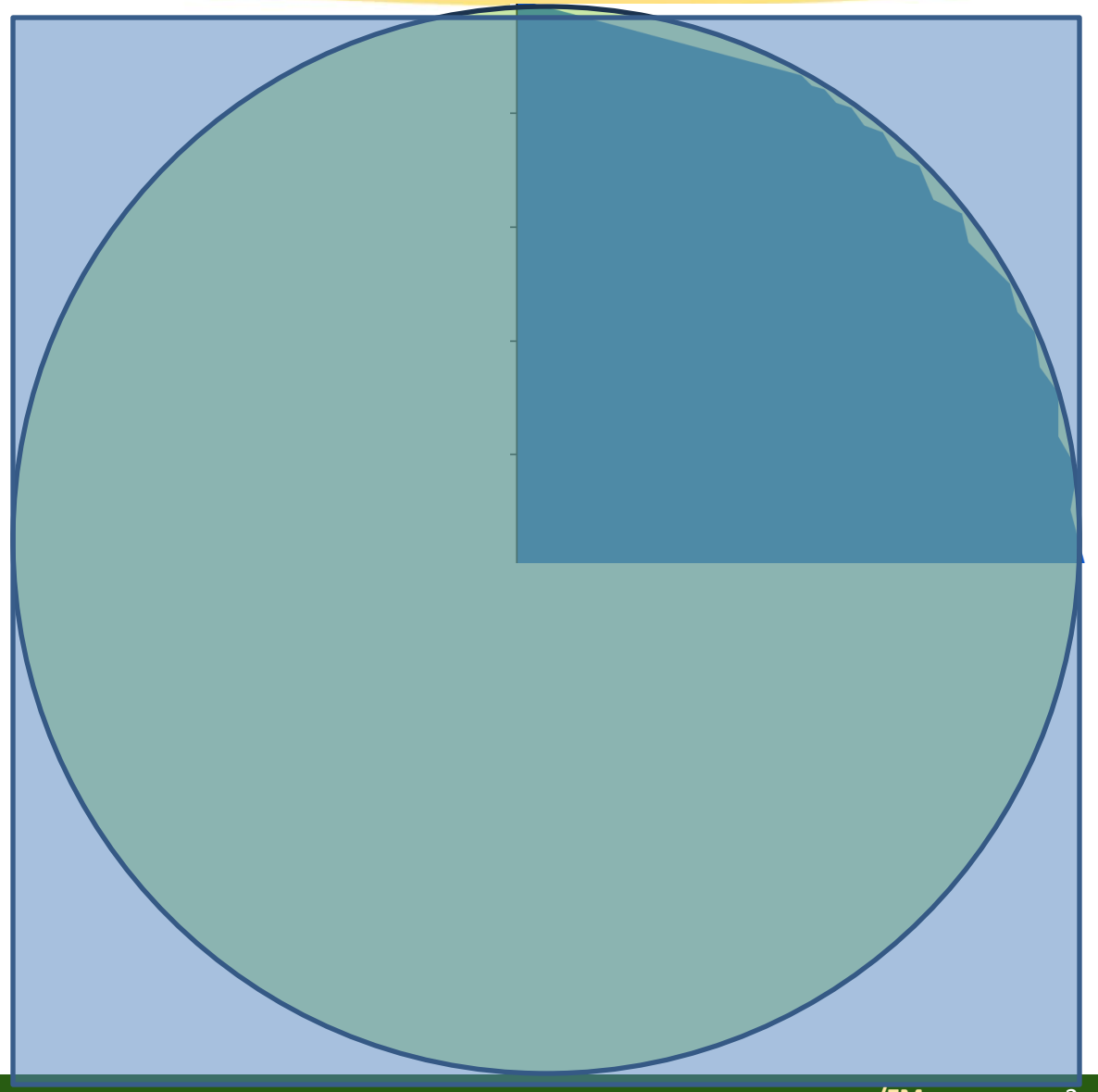
- Features, events, processes and the 10ka regulatory period causes substantial uncertainty in projecting disposal system performance
  - Proof of performance *is not to be had in the ordinary sense of the word*… *(40 CFR 191.13b*)
  - Systems designed *for reasonable expectation of undisturbed performance* over 10 ka (*40 CFR 191.24)*
  - PA is used to provide a *reasonable expectation for containment* over 10 ka (*40 CFR 191.24*)



Understanding PA

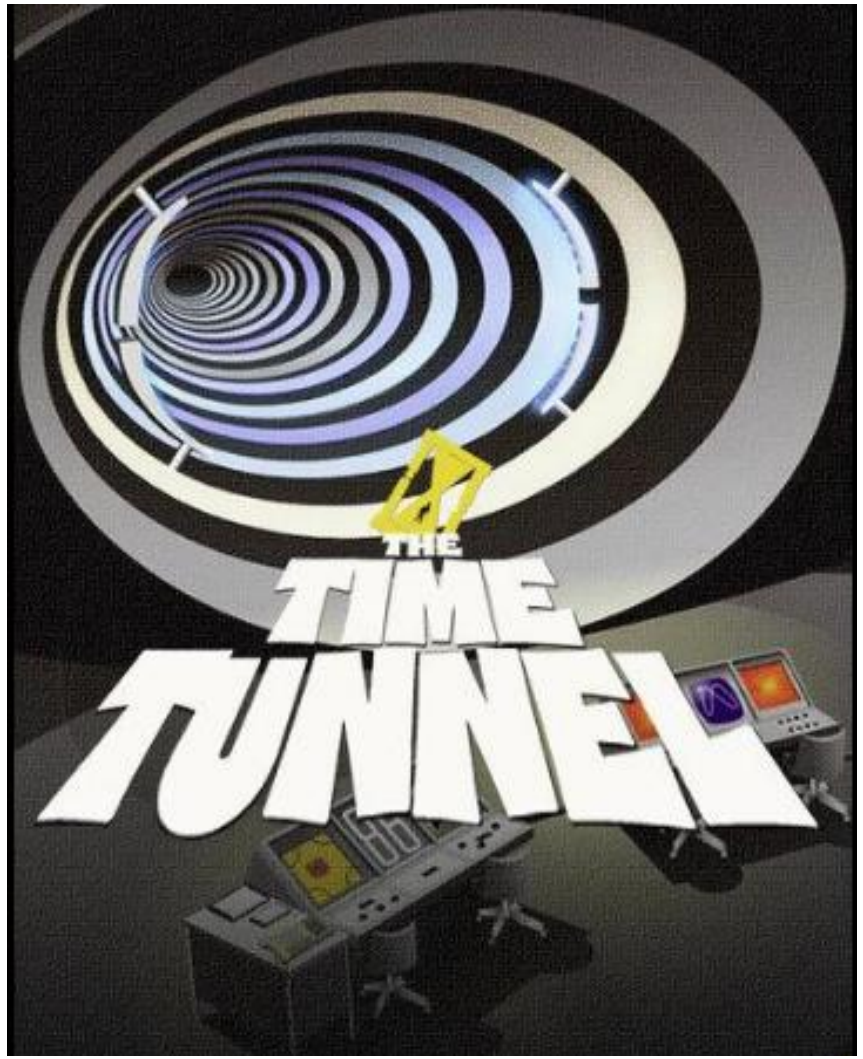
- Confidence in PA depends on level of knowledge of the site
  - *assumption-based* rely heavily on expert judgment and theoretical models
  - *evidence-supported* grounded in empirical data and rigorous scientific methods

- PA uses *conservatisms* to account for uncertainties in long-term performance
  - Simplified, scientifically-acceptable models
  - results err on the side of caution
  - potential risks are not underestimated



Evolution of PA

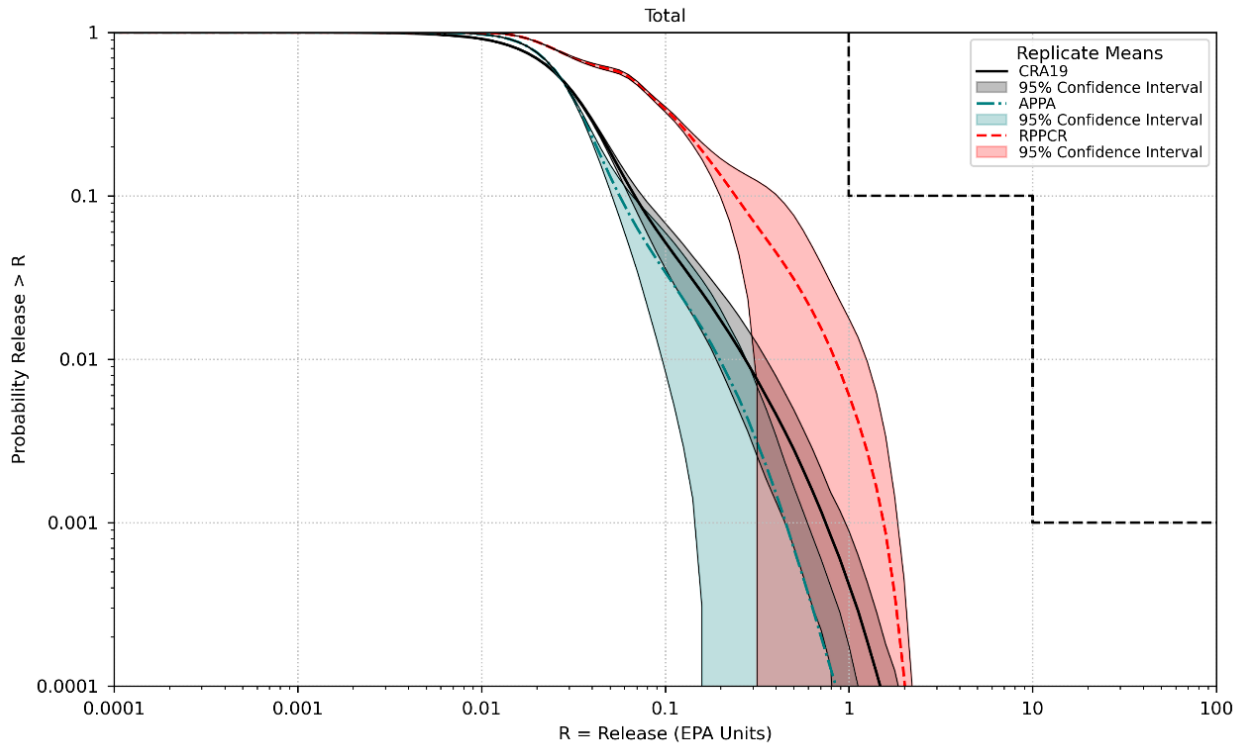
- The DOE requires PA to evolve
  - …shall be maintained to evaluate changes that affect performance, design, and operating basis
  - …be revised when changes in waste forms, containers, inventory, facility design, operations, closure concepts, or an improved understanding of the disposal system
  - Nothing about regulatory enhancements
- Stakeholders expect PA to evolve
- Regulators expect PA to evolve



https://www.imdb.com/title/tt0060036/

RPPCR PA

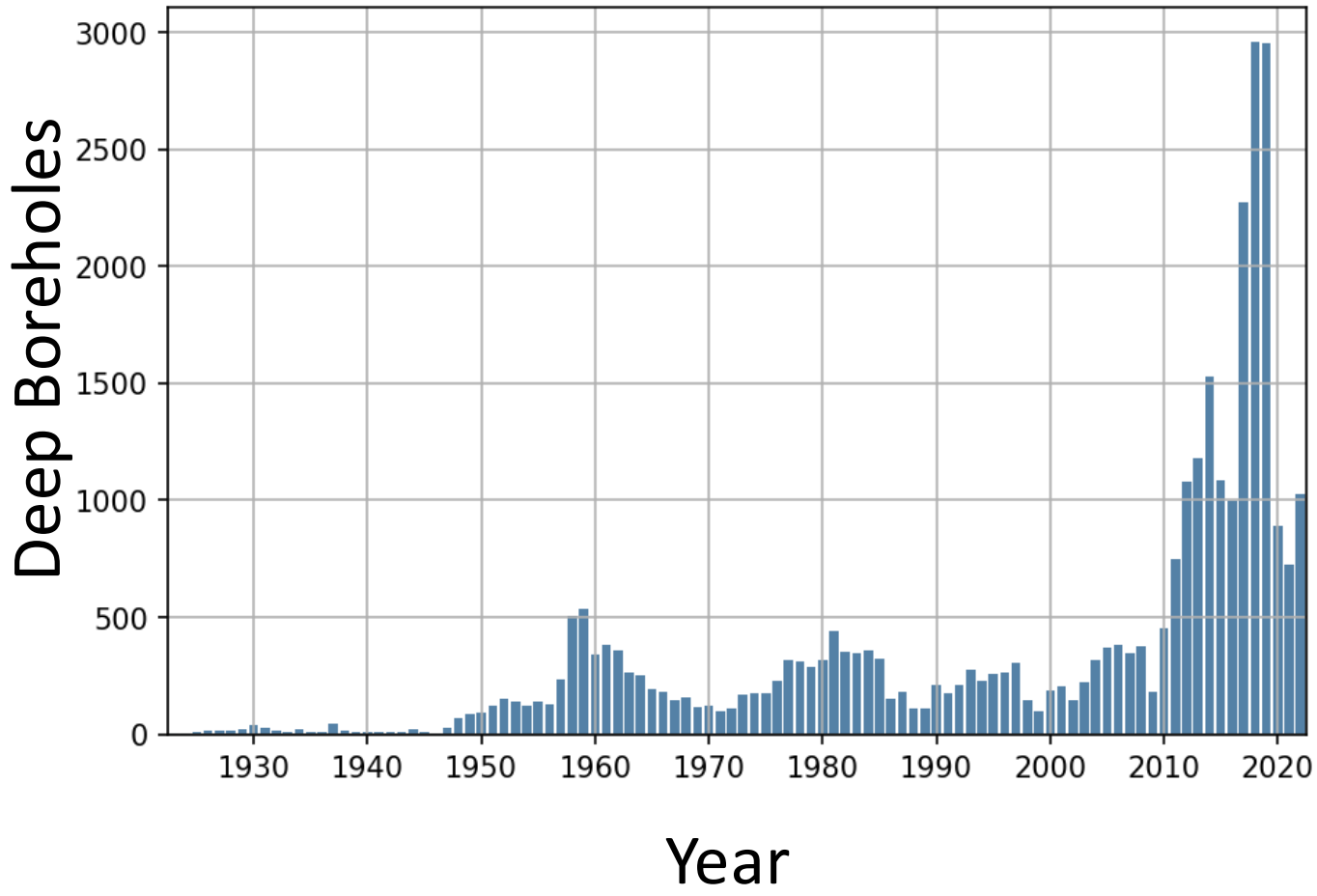
- Replacement panels do not significantly change long-term performance
- Some changes in the PA that affect long-term performance
- Most significant of these changes are:
  - Drilling rate
  - Inventory
  - Creep-closure model- porosity surface
  - Long-term borehole permeability distribution



Drilling Rate

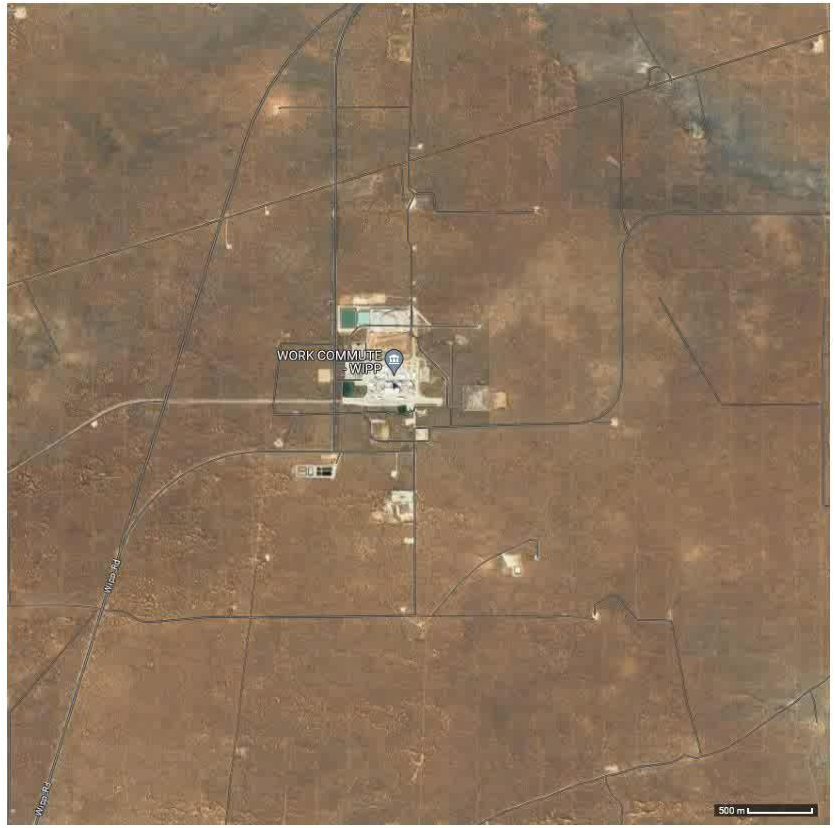
- 40 CFR § 194.33 defines a drilling *rate* as the average rate of deep drilling events (i.e., holes ≥ 660 m) over the 100 years before the PA calculation

Compliance Analysis	Drilling Rate (bh/km^2/yr)	Increase From CCA rate
CCA (1996)	4.68×10^{-3}	-
CRA-2014	6.73×10^{-3}	44%
CRA-2019	9.90×10^{-3}	112%
RPPCR (2024)	13.89×10^{-3}	197%



Visualization

WIPP 4 mi by 4 mi
Land Withdrawal Act Area



Post-Closure time:
100 years

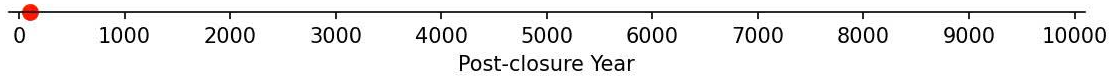
Representative Analysis:
RPPCR

Drilling Rate:
0.01389 / (km^2 yr)

Well Count:
0 wells

Well Density:
0.00 wells / (km^2)

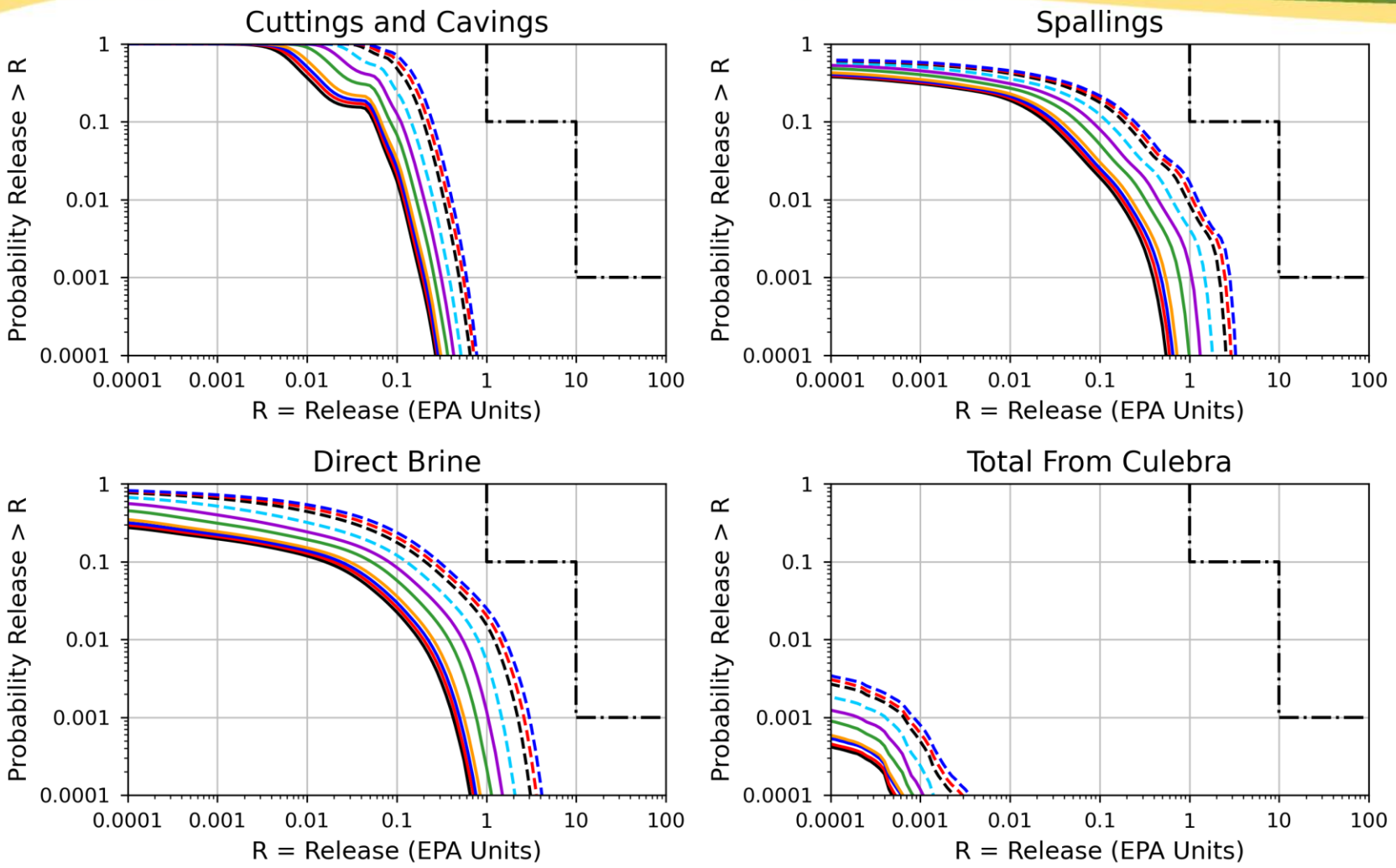
- Wells



Number of wells inside the Land Withdrawal Act Area at the current drilling rate

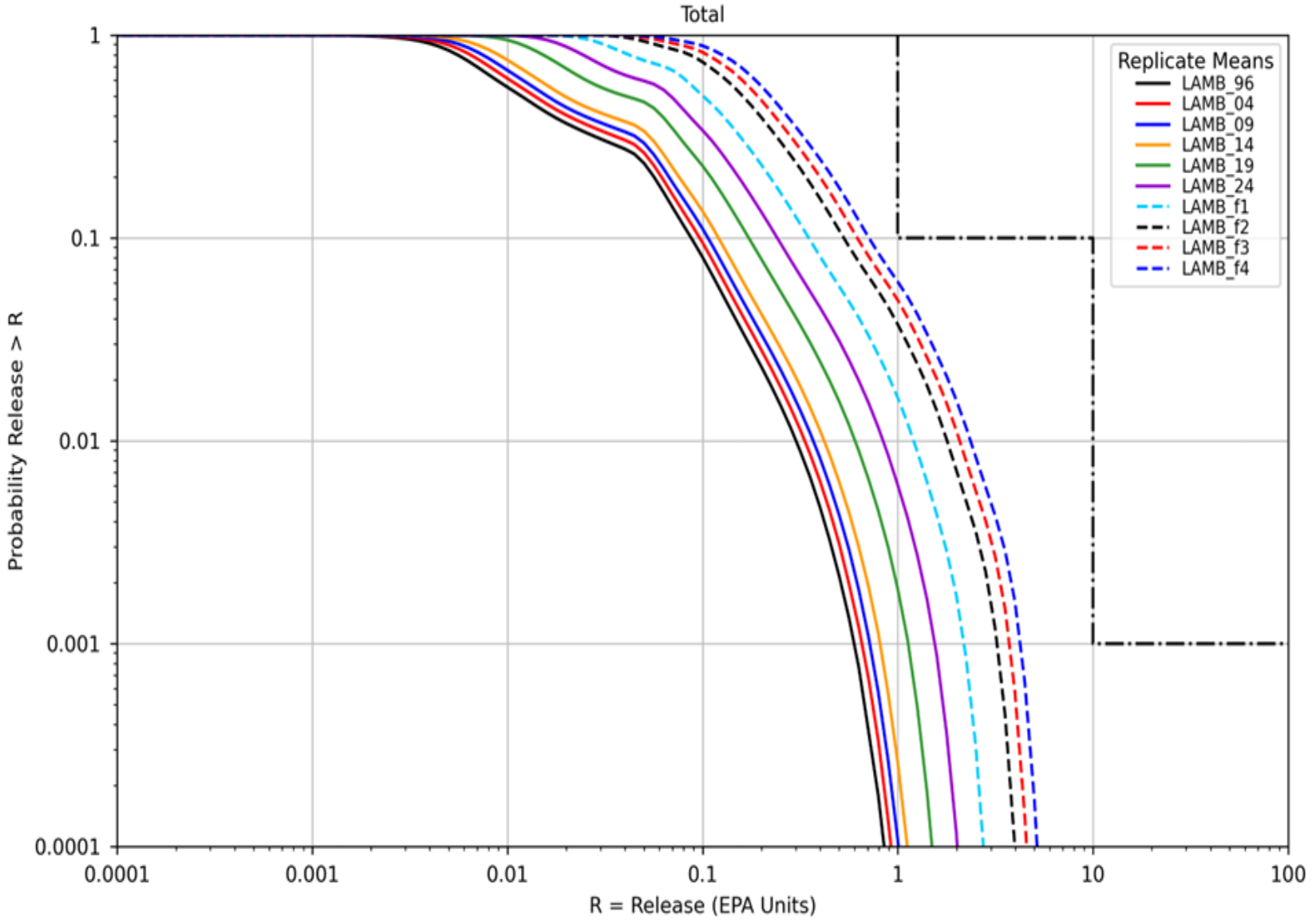
- Typical drill pad is 2 to 4 acres
- Well pads typically a caliche base, leaving a lasting marker of drilling
- At the projected rate, assuming a unform distribution, each 10 ft x by 10 ft section of the LWA boundary will be penetrated by a borehole

Mean Releases by Mechanism



- A drilling intrusion is the only significant pathway for releases from WIPP
- Increase in releases from all mechanisms

Total Releases



- Increased with drilling rate
- Mean curves do not cross the compliance limits
  - WIPP regulated on the mean
- 95% confidence interval is greater than 1 EPA Unit at a probability of 0.1 for drilling rates above 0.035 bh/km^2/yr

Inventory

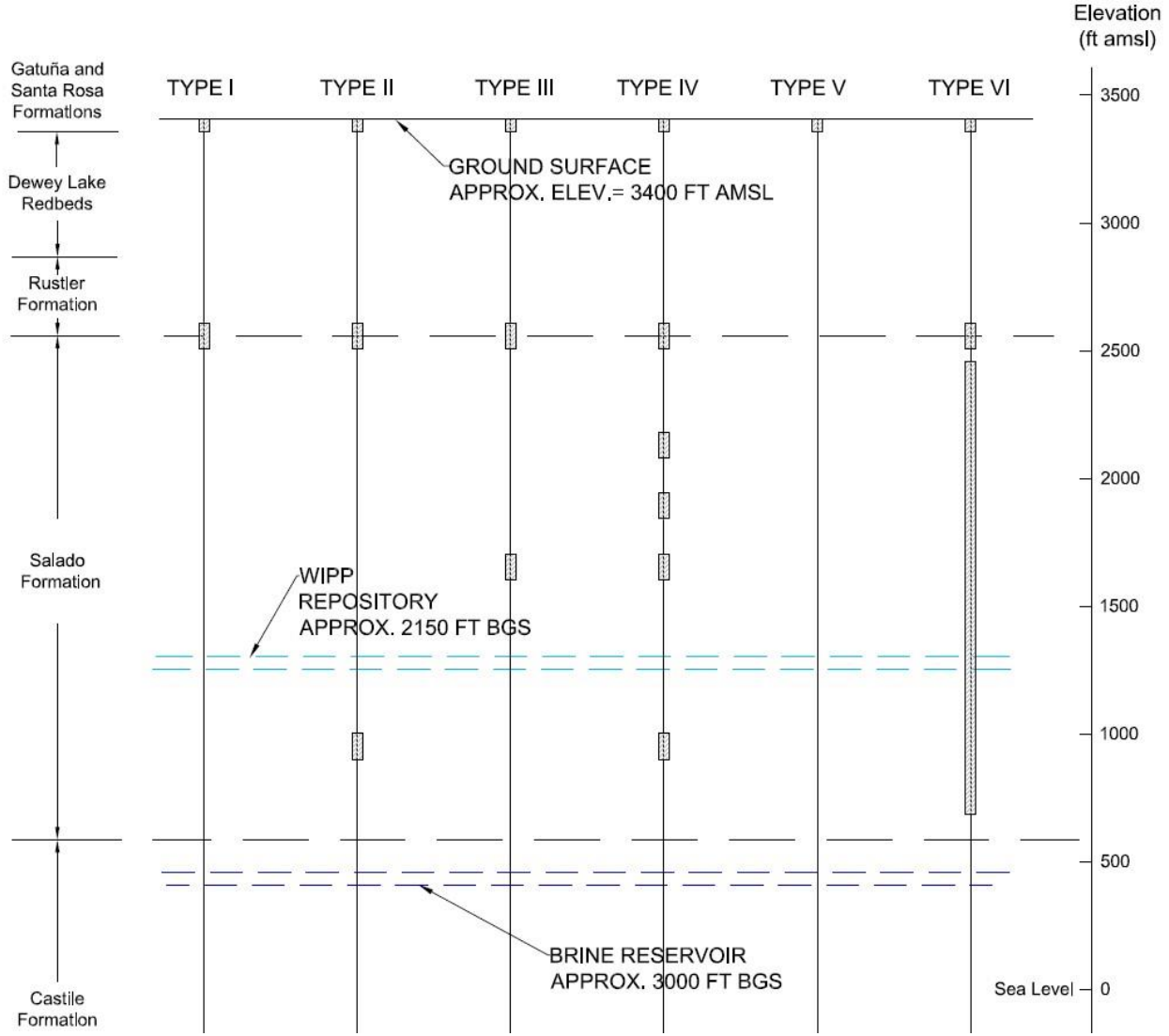
- At least 2 additional waste streams
  - *pit production waste*
  - *34 metric tons of surplus Pu*
- Current and projected waste streams are similar, ratios may be different
  - *Idaho waste will be declining (including compacted waste).*
  - *EM waste will be increasing but the general composition will be very similar*
  - *Oxide (i.e., surplus plutonium) waste will be increasing*
  - *Pit production waste will be increasing; composition similar to existing pit production waste*
- Surplus Pu waste very similar to waste accepted from Rocky Flats
- Surplus Pu waste has no new components that challenge the existing models

Adulterant effects on Chemical Conditions

- Adulterant does not significantly change pH and E_h of either brine
  - pH measurements, ±0.1 pH units
  - Oxidation-Reduction Potential (ORP) measurements, ±50 mV
- Results are consistent with thermodynamic model predictions
  - E_h and pH
  - Effects of high ionic strength
  - Redox-active components
- Data suggests that H_2 atmosphere in the glovebox controlled the E_h

Borehole Permeability

- Long-term releases may occur after plugging and abandonment
- Plugging and abandonment is assumed to be "*consistent with practices in the Delaware Basin at the time a compliance application is prepared*" (40 CFR § 194.33(c)(1)).
- Boreholes are plugged and abandoned using one of six plugging configurations
  - For each CRA, pattern probability reassessed
  - Continuous plug not expected to degrade during 10 ka period



Note: Plug thickness is exaggerated approx. 27 to 40 times

Upper Bound for Borehole Fill Materials

- Degraded cement grout and steel casing determines long-term permeability

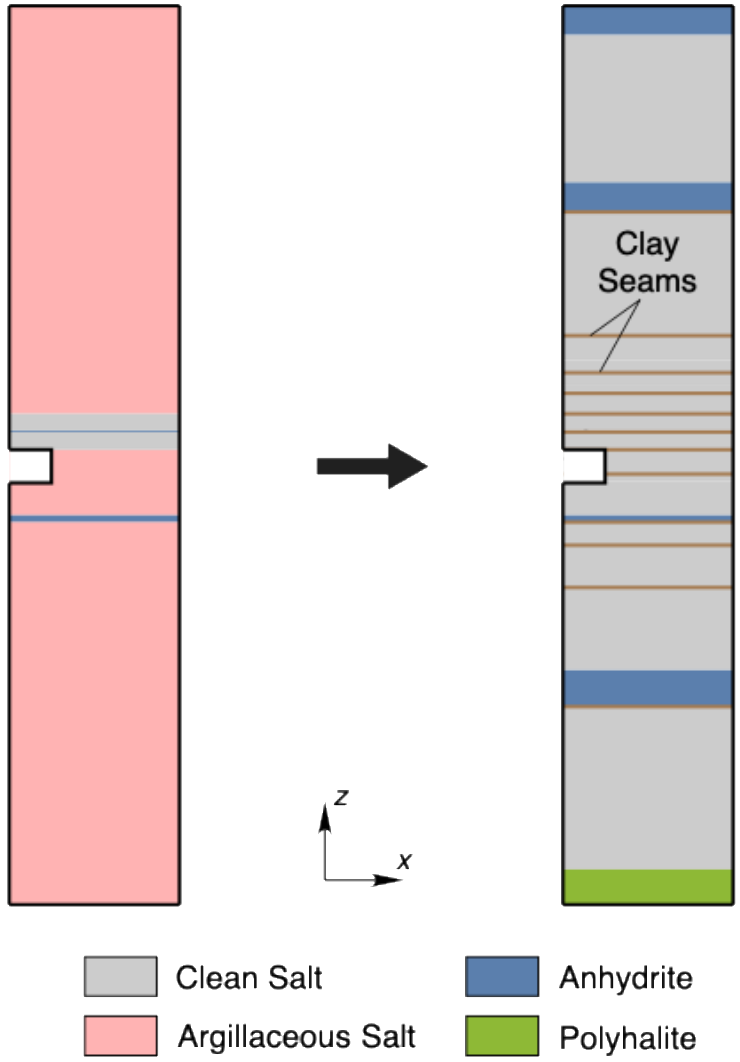
- Degraded cement-based grouts behave like silt
  - $k_0 = 10^{-15}$ m^2 and decreases with time
  - maximum $k_{field} = 6 \times 10^{-16}$ m^2
  - degraded grout, $k \leq 10^{-14}$ m^2

- Degraded steel behaves like granular iron
  - $k \leq 10^{-15}$ m^2
  - 1,000 - 10,000 < current PA values
  - maximum $k_{field} < 10^{-15}$ m^2 (confinement, non-uniform particle sizes, and mineral precipitation)

Location	k (m^2)	k (md)	K (cm/s)
Current upper value	1.0×10^{-11}	10,000	1.0×10^{-2}
Current lower value	1.0×10^{-12}	1,000	1.0×10^{-3}
Propose upper value	1.0×10^{-14}	10	1.0×10^{-5}
Proposed lower value	1.0×10^{-15}	1	1.0×10^{-6}

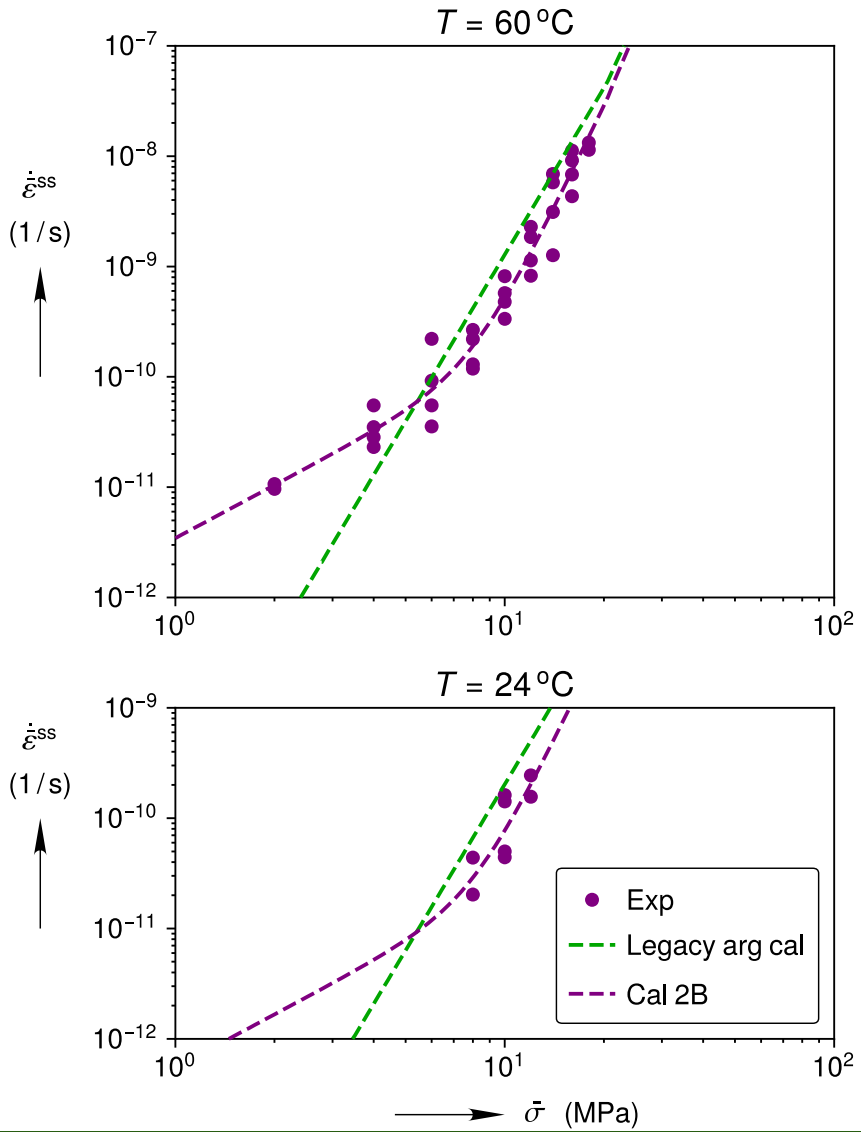
Creep Closure Model

- Modified creep law for the host rock
- New constitutive model for the waste compaction
  - Added a stress-strain relationship
- Revised stratigraphy
  - Clay seams were not previously represented
  - Additional anhydrite interbeds
- Improved scientific basis for the disposal room porosity
  - Consistent with Creep Closure Conceptual Model
  - Consistent Gas Generation Conceptual Model

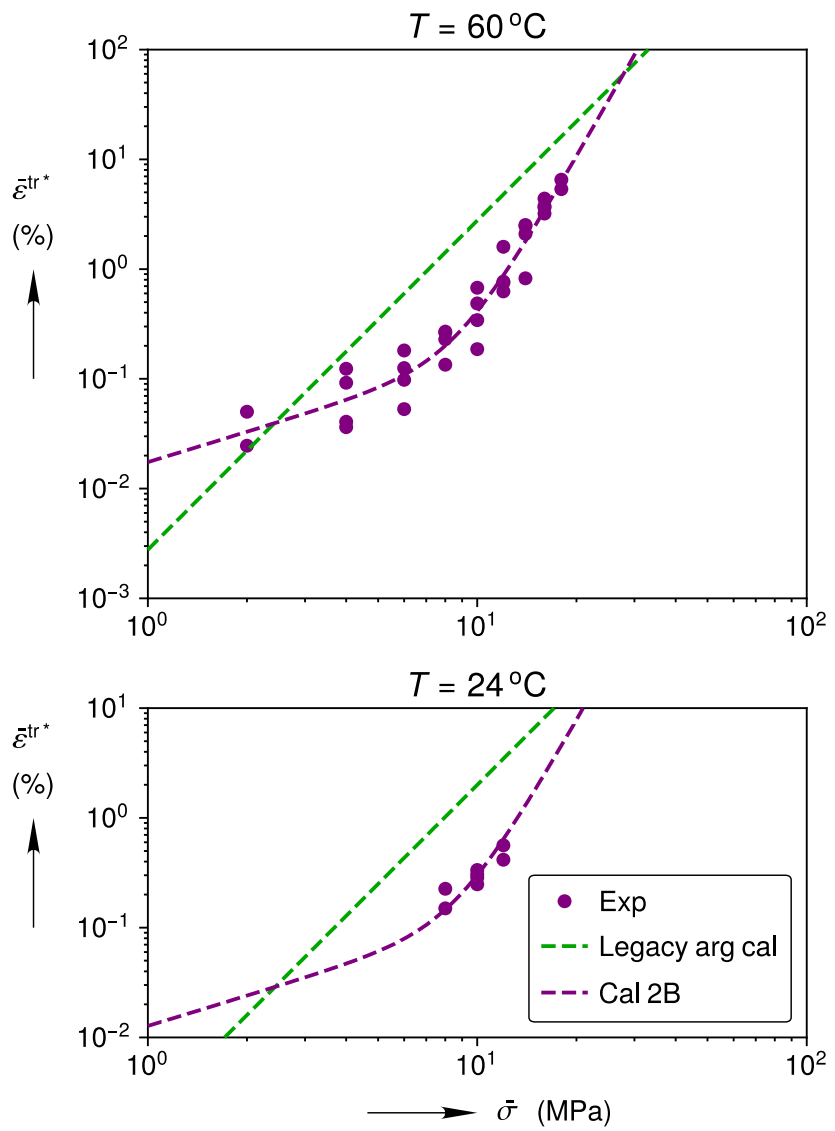


Improved Salt Constitutive Model

Steady-State Strain Rate

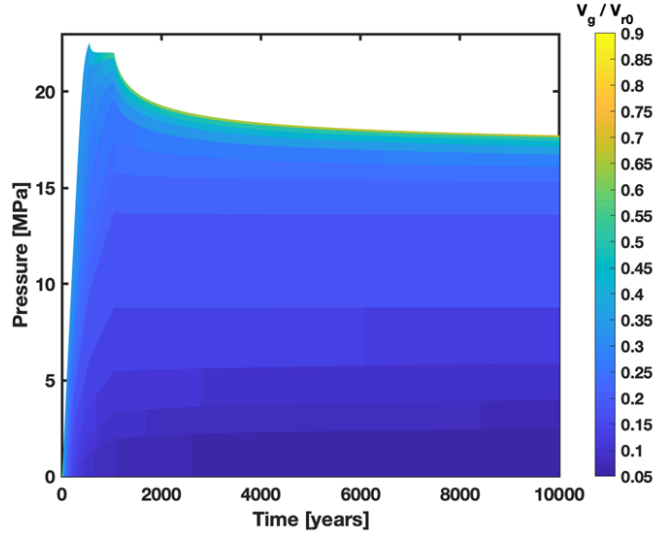


Transient Strain Limit

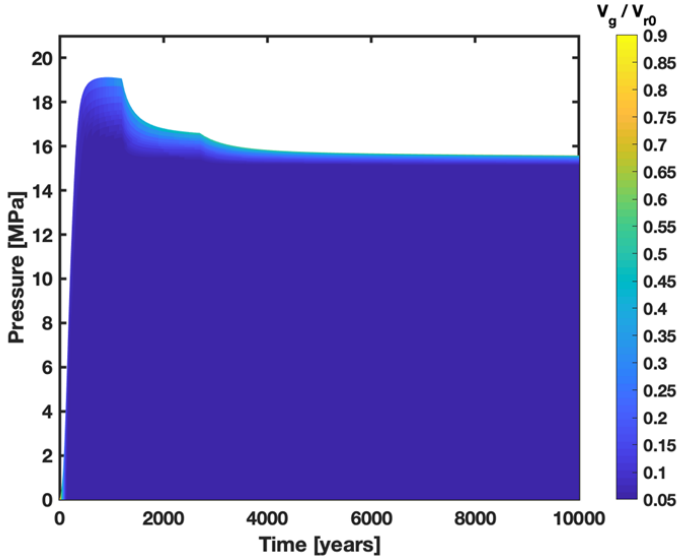


Creep Closure Model

- The new disposal room porosity model has a stronger scientific basis
  - accounting for salt creep at low stresses is the most significant change
  - eliminated the non-physical, out-of-plane stresses in the waste compaction model
  - updated the gas generation model
- Legacy vs. new porosity response surface
  - new porosity surface is less sensitive to fluid pressures



Legacy Porosity Surface



Updated Porosity Surface

Conclusions

- PA continues to use *conservatisms* to account for uncertainties in long-term performance
- The WIPP PA is evolving from *assumption-based* to *evidence-supported*
- The DOE does not believe that changes in the RPPCR cause a significant departure from CRA-2019

Questions