



Performance Assessment Updates for Waste Isolation Pilot Plant Recertification

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Outline

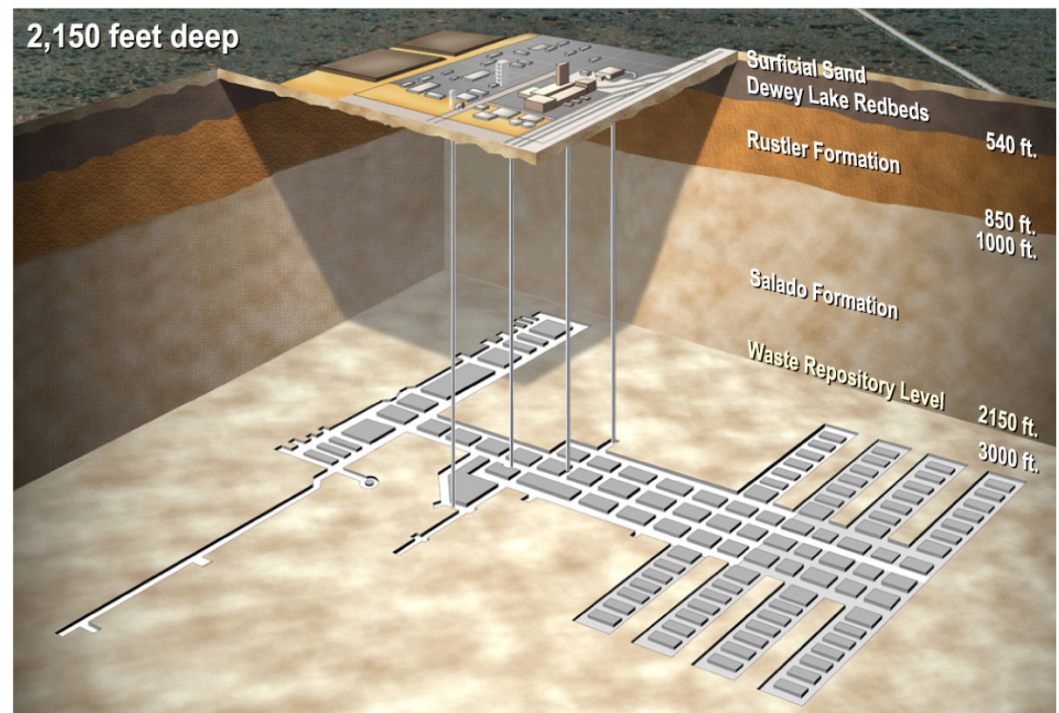
- WIPP Regulatory Requirements and PA
 - Release Mechanisms and Compliance Metric
- 2014 WIPP Compliance Recertification Application
 - Repository Planned Changes
 - “Standard” Updates
 - Parameter and Implementation Refinements
- Approach and Results
- Summary



The Waste Isolation Pilot Plant (WIPP)

WIPP is a permanent disposal facility for transuranic waste

- Located in southeast New Mexico
- Operated by U.S. Department of Energy (DOE)
- Long-term performance regulated by U.S. Environmental Protection Agency (EPA)
- Waste is emplaced in a salt formation deep underground
- Long-term regulatory compliance is demonstrated via Performance Assessment (PA) undertaken by SNL Carlsbad





WIPP Long-Term Regulatory Requirements

- Regulatory requirements guide the WIPP PA framework.
 - The WIPP must be designed to provide *reasonable expectation* that *cumulative releases* of radionuclides to the accessible environment for *10,000 years* after disposal from all *significant processes and events* shall be less than specified *release limits*

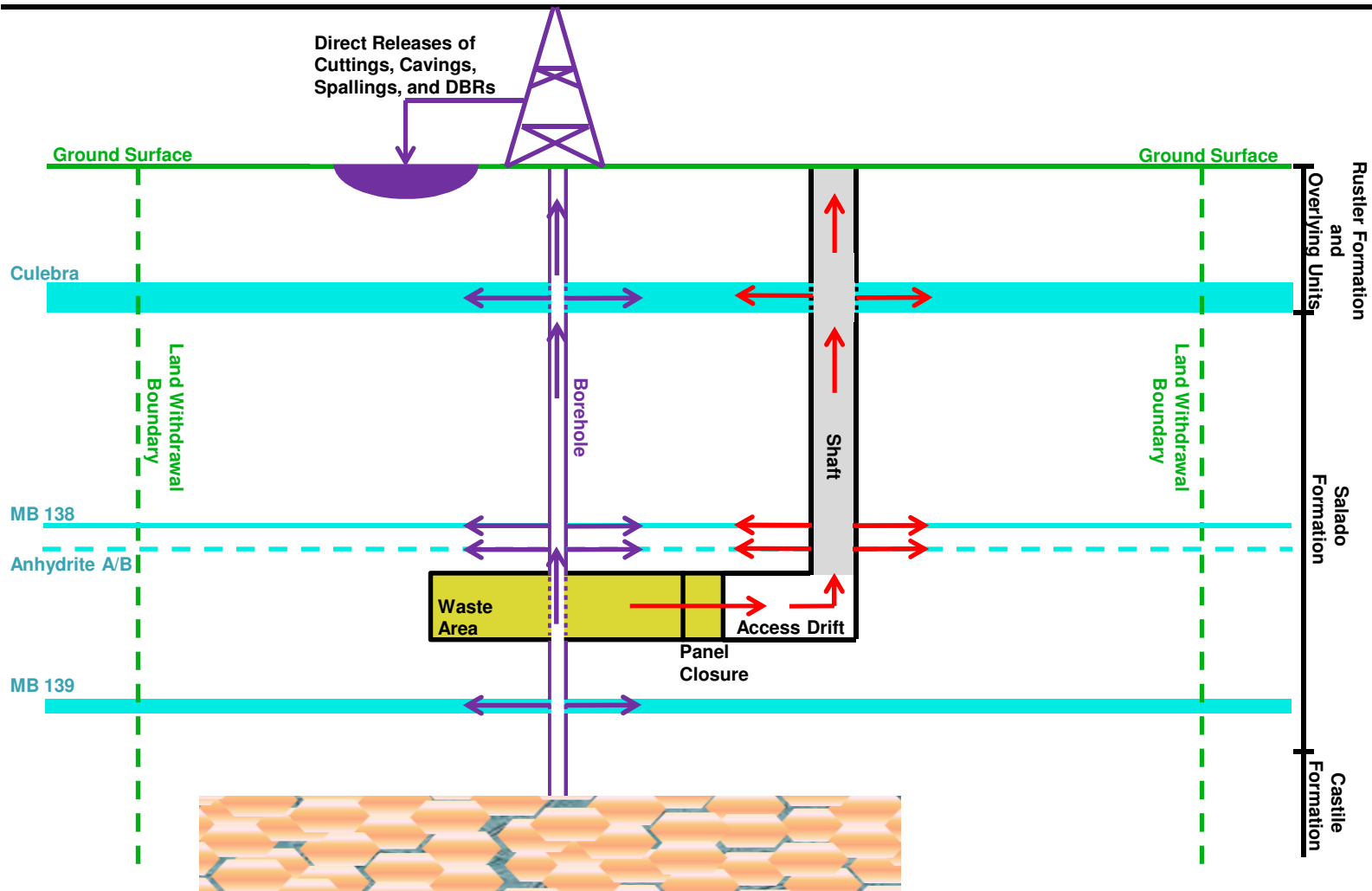


WIPP Regulatory Requirements

- Reasonable expectation: regulations acknowledge substantial uncertainties
- 10,000 years: PA must predict behavior for entire regulatory time period
- Significant processes and events: PA must include all of these, including the possibility of human intrusion



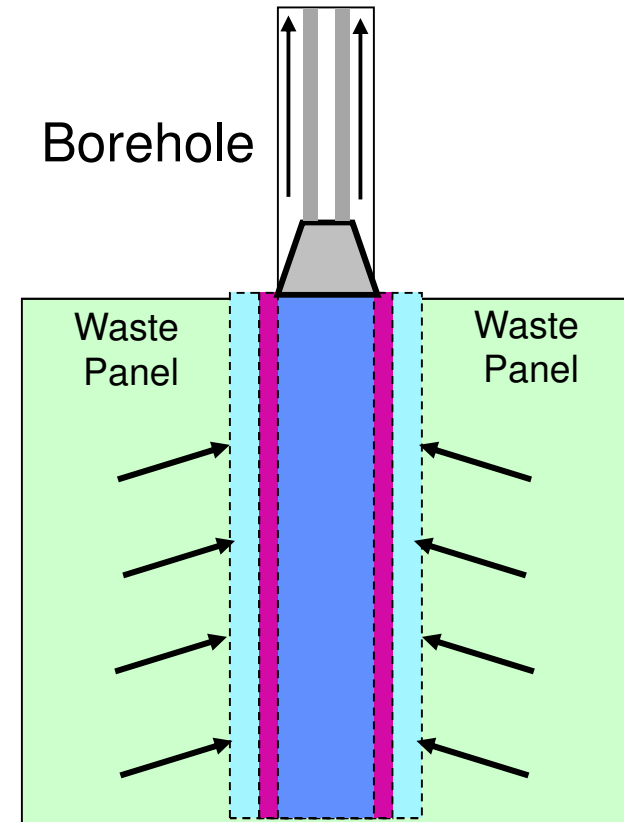
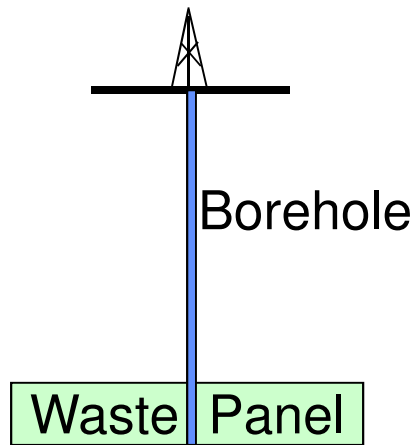
Release Pathways



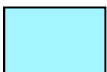
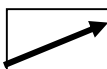




Direct Release Mechanisms Considered in WIPP PA

Direct Releases Dominate Total Releases

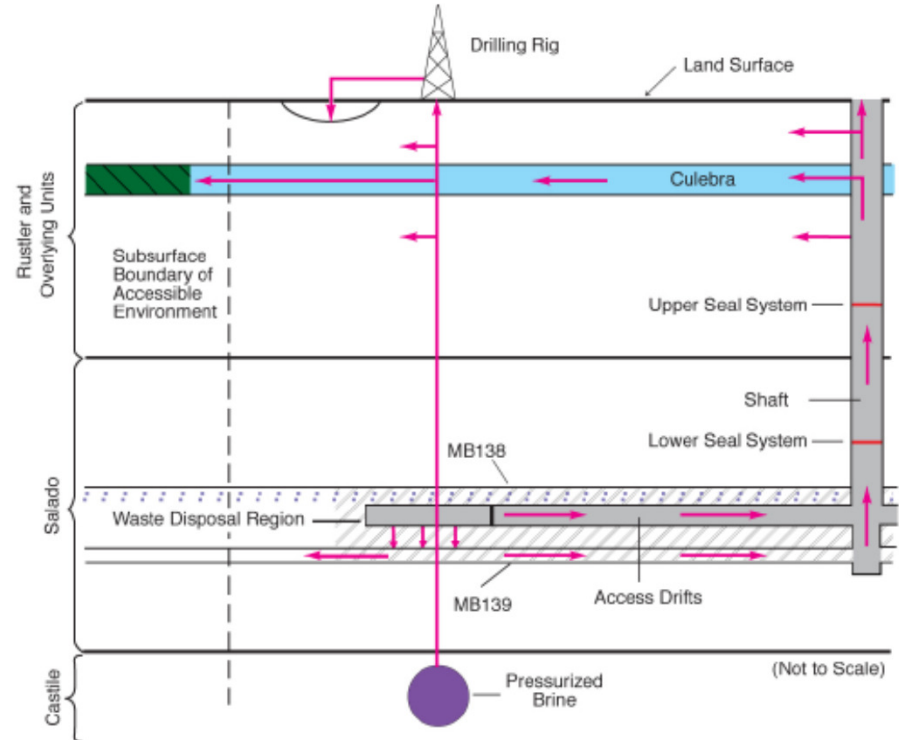
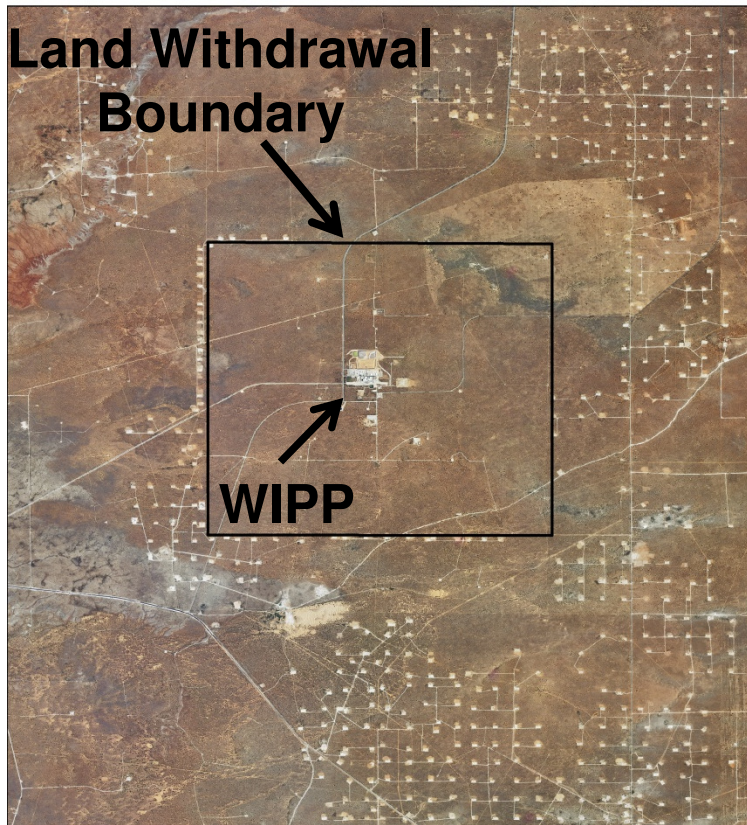


-  Cuttings (Solids from Drilling)
-  Cavings (Solids from Drilling)
-  Spallings (Solids from Pressure Release)
-  Direct Brine Release (DBR) (Brine from Pressure Release)



Long-Term Release Mechanisms Considered in WIPP PA

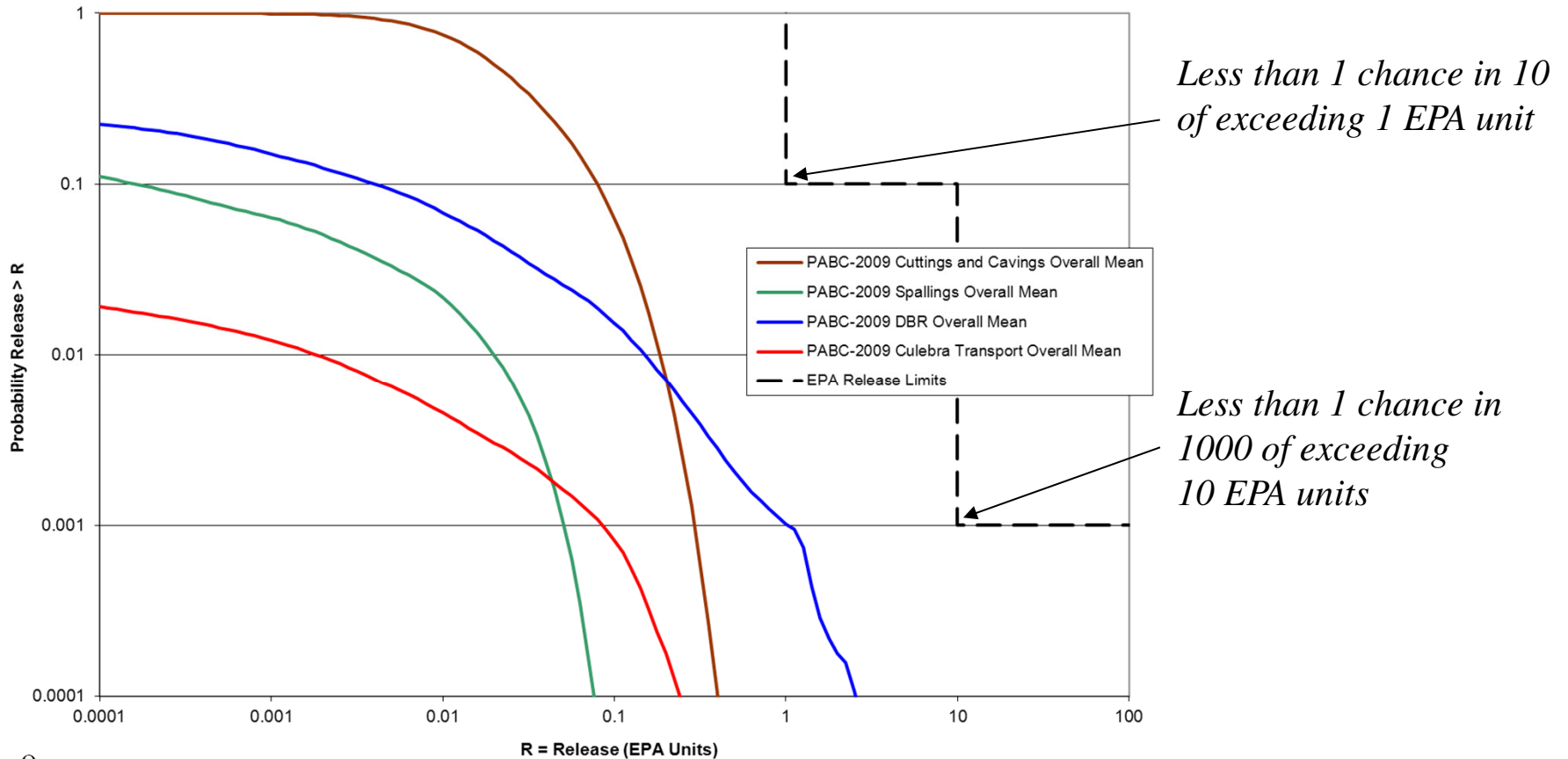
Radionuclide Transport through Groundwater Comprise Long-Term Releases





The CCDF is the Measure of Compliance

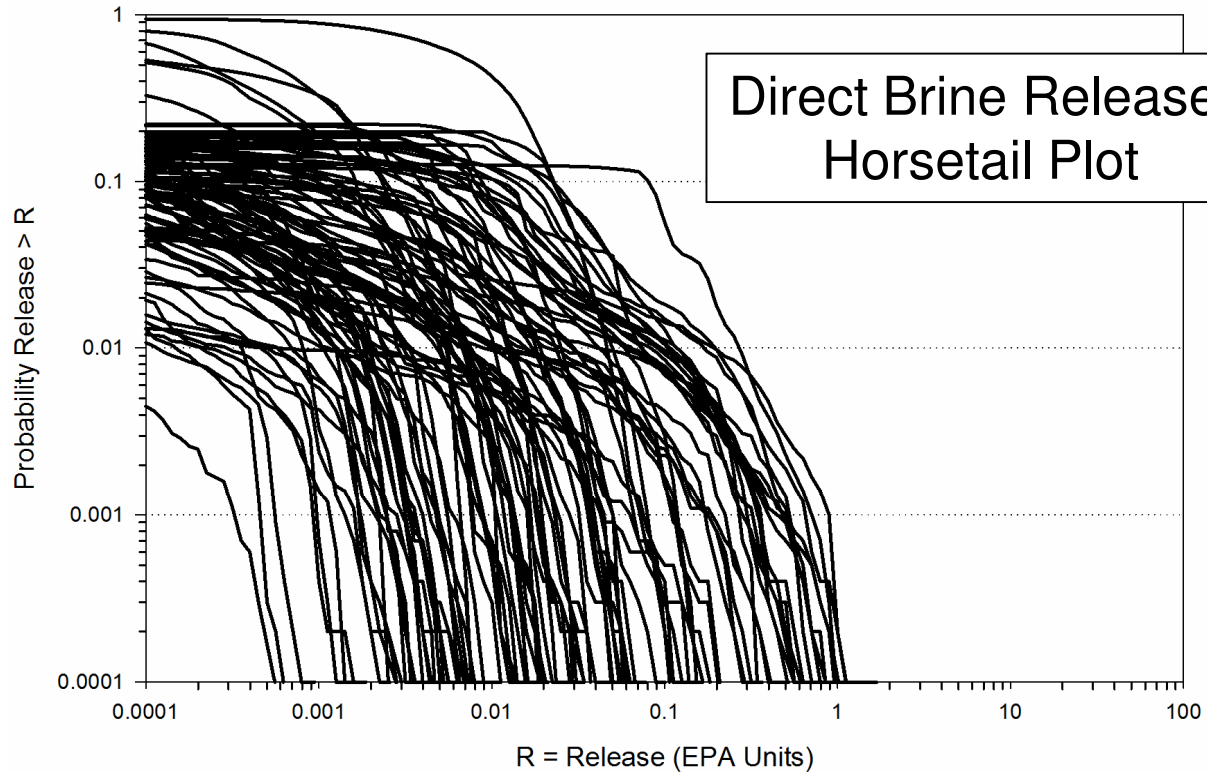
Each Release Component is Quantified by a Complementary Cumulative Distribution Function (CCDF)





CCDF Mean Assembly

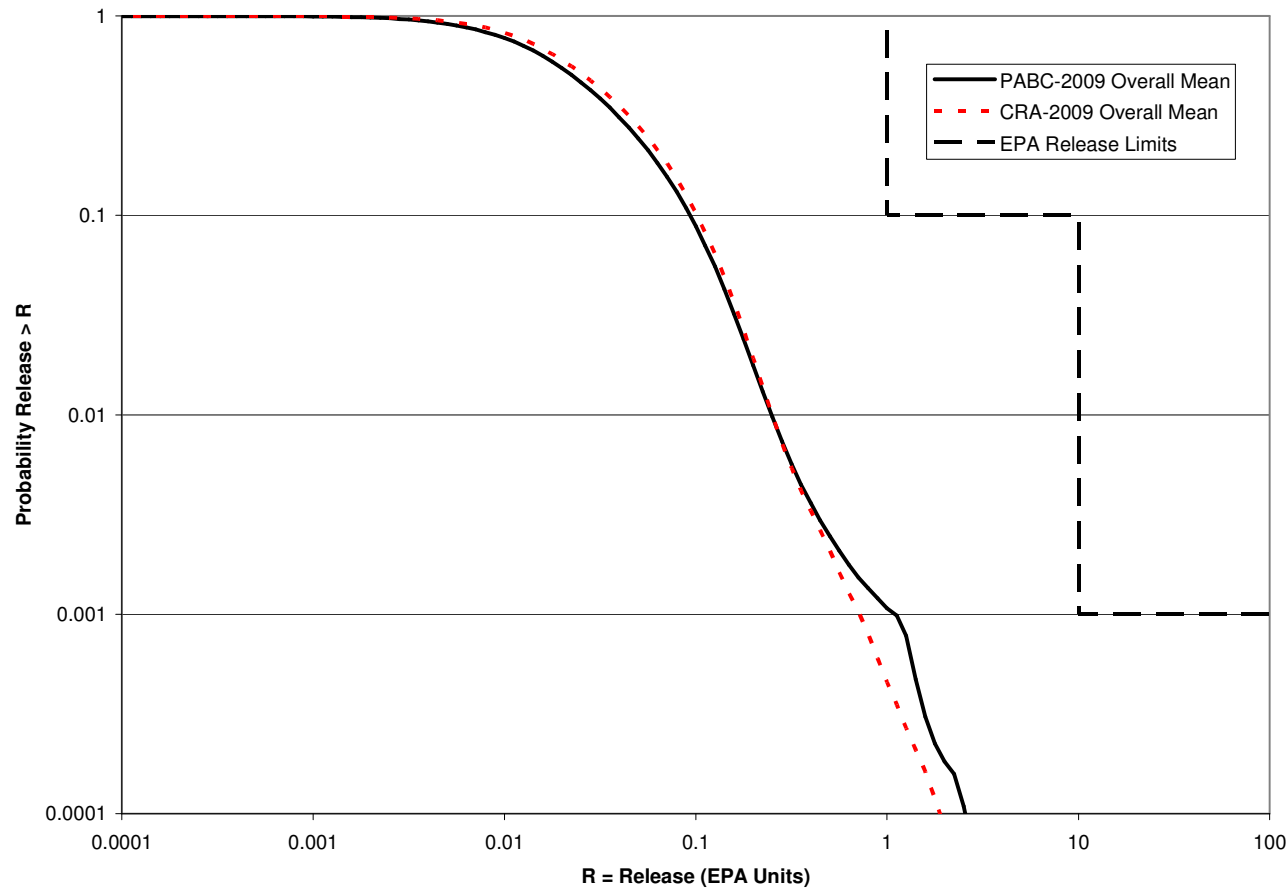
Each mean CCDF is the average of 300 individual CCDFs obtained for each release component.





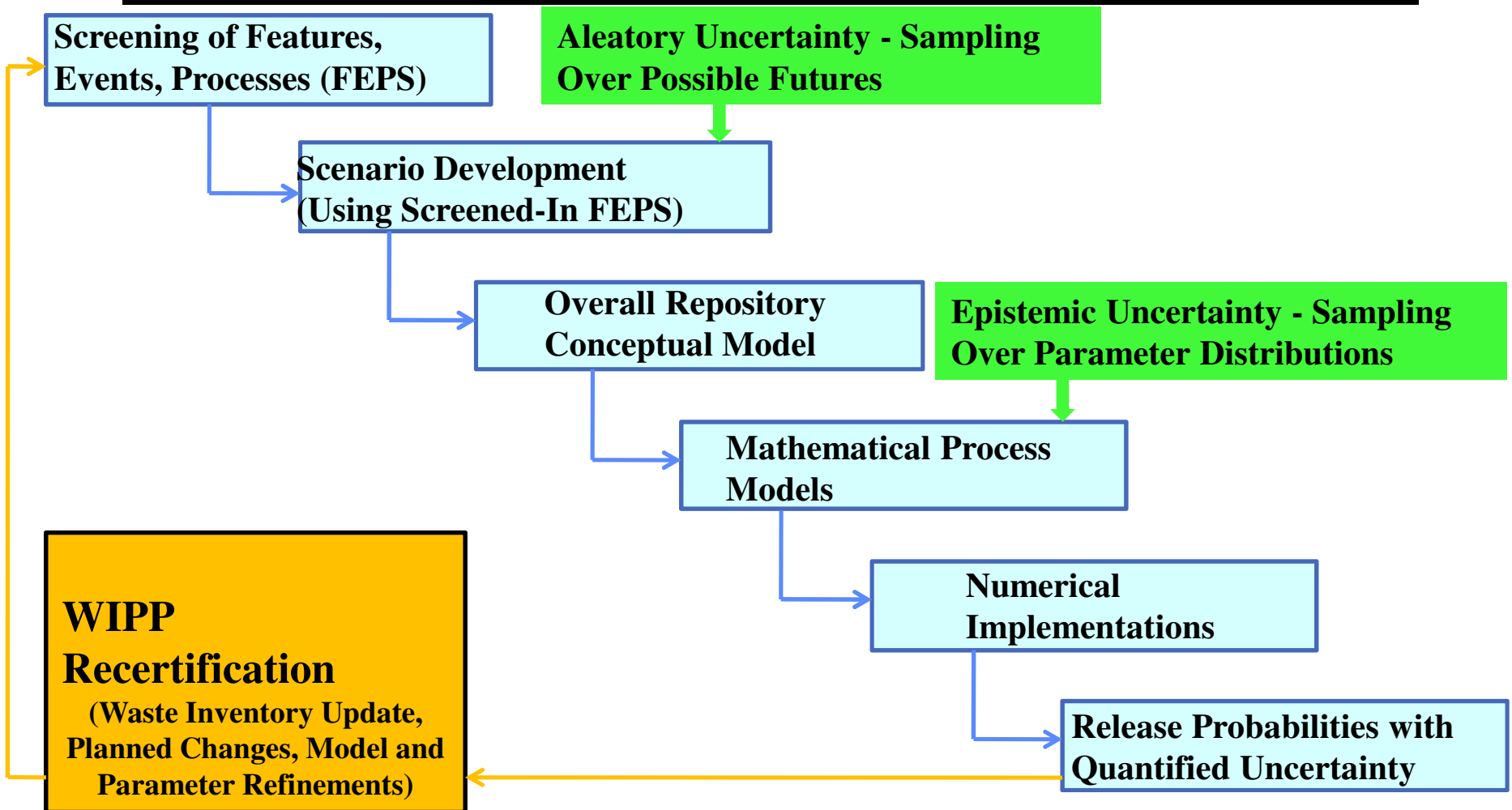
Total Release CCDF

Total releases from the repository are compared to regulatory release limits to determine compliance.





WIPP PA Flow





WIPP Recertification

Federal regulations require that the WIPP be recertified every five years following the first waste shipment of 1999.

- The current regulatory baseline is that established by the 2009 Performance Assessment Baseline Calculation (PABC-2009).
- The 2014 Compliance Recertification Performance Assessment (CRA-2014 PA) demonstrates continued compliance of the WIPP with federal containment requirements.
- A number of changes/refinements are included in the CRA-2014 PA (e.g. incorporate new data and experimental results).



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Repository Planned Changes Included in the CRA-2014 PA

Revised Panel Closure Design

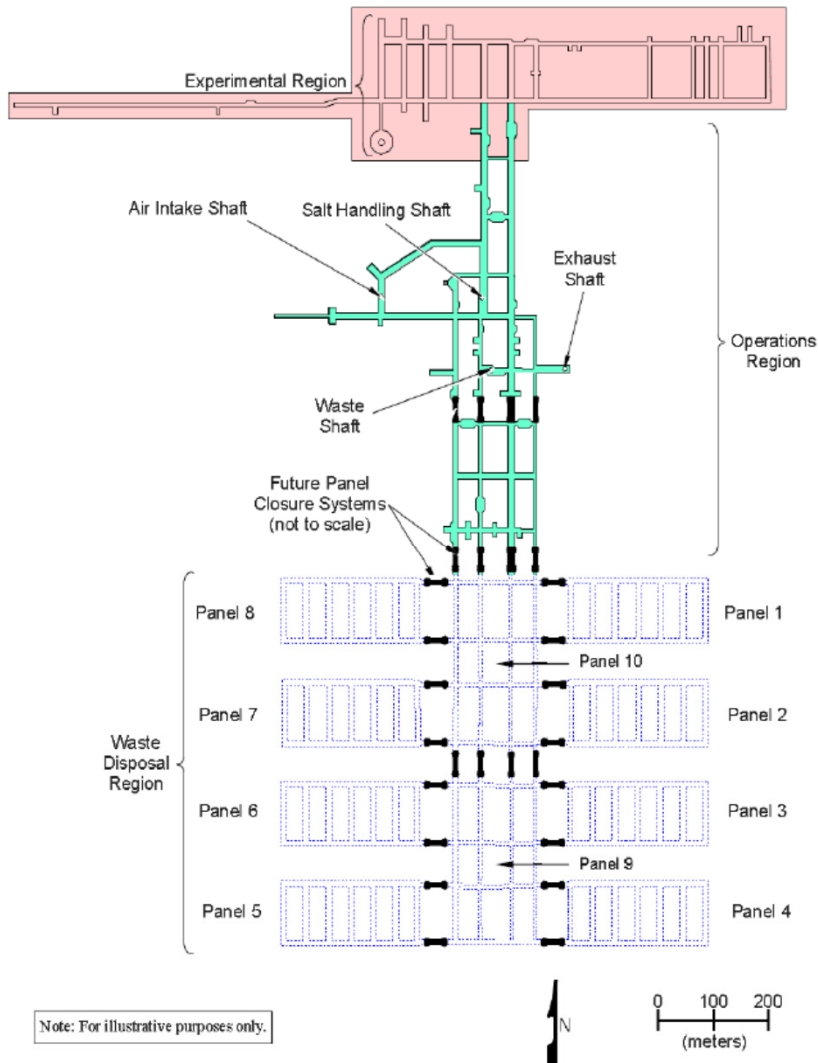
- A revised panel closure design is included in the CRA-2014 PA.

Additional Excavated Volume

- Additional excavated volume is included in the WIPP experimental region for proposed salt disposal experiments.



WIPP Panel Closures



- WIPP panel closures have been represented in PA since the original 1996 Compliance Certification Application.
- The function of panel closures is to protect workers during the operational period of the repository.
- Panel closures are included in PA because they are part of the disposal system, not because they inhibit releases. *The panel closure system was not designed or intended to support long-term repository performance.*



Panel Closure Redesign

- The DOE submitted a Planned Change Request to the EPA to formally request a change to the approved design.
- The panel closure design was changed to a Run-of-Mine Panel Closure System (ROMPCS), with approval via a federal rulemaking process.



ROMPCS Parameters

ROMPCS parameters and timings were developed over a period of 1 ½ years.

- ROMPCS represented as 100 feet of run-of-mine salt.
- Calculations and data analyses were performed to determine ROMPCS parameters and their temporal extent.
- Numerous technical exchanges were held with the EPA to discuss and refine the ROMPCS representation in PA.



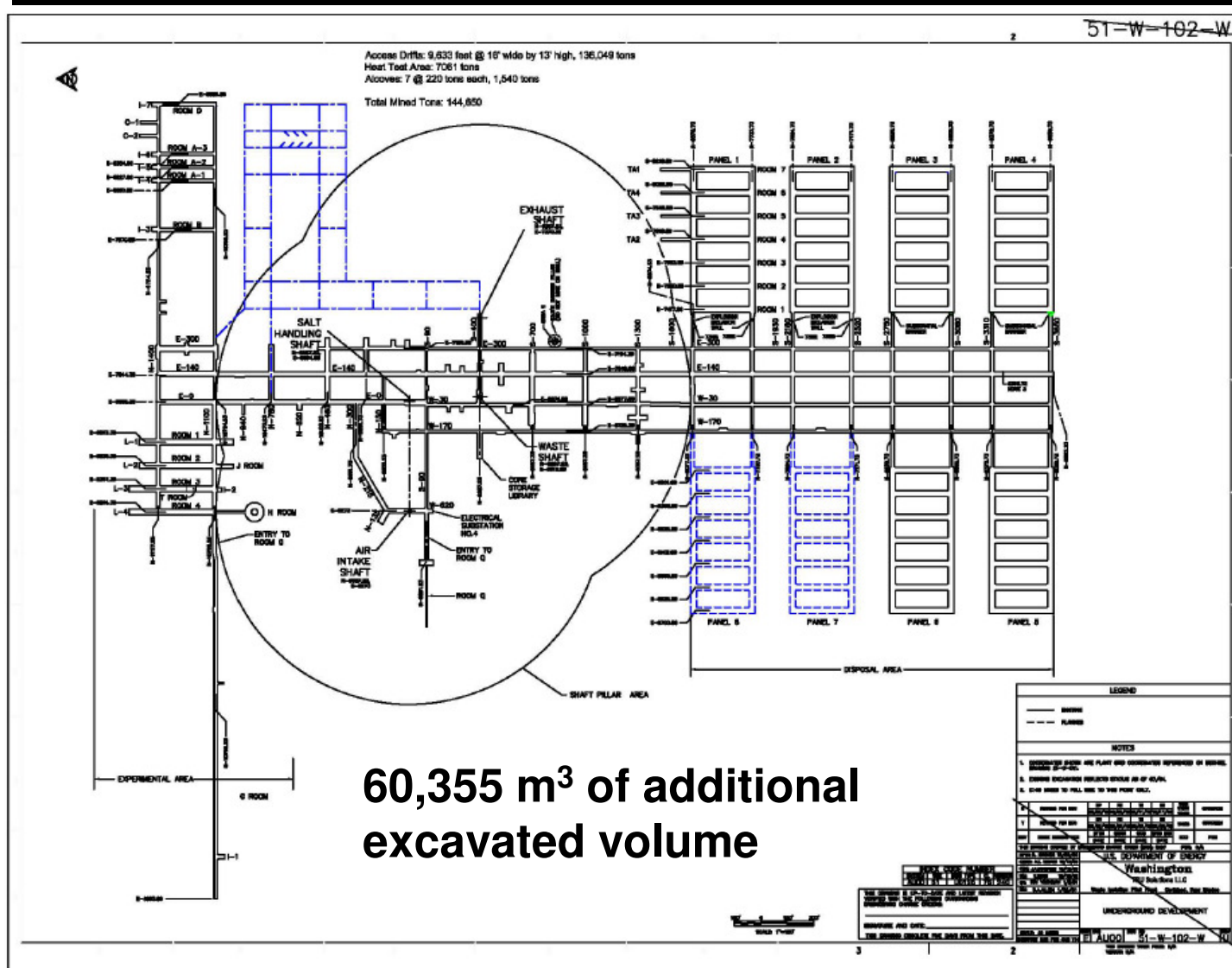
ROMPCS Evolution

The ROMPCS is modeled as having short-term and long-term characteristics, with properties based on three time periods

- 0 to 100 years: Emplaced ROM salt undergoes some re-consolidation with no impact on surrounding salt rock.
- 100 to 200 years: ROMPCS continues to re-consolidate with no impact on surrounding salt rock.
- 200 to 10000 years: ROMPCS is re-consolidated and the surrounding salt rock is healed.



Additional Excavation for Salt Disposal Investigation Experiments





Potential Impacts

Increased experimental volume potentially reduces pressure in experimental region.

- Over time, pressure reduction may also be seen in waste area.
- Waste area pressure reduction may increase cumulative brine inflow, and consequently brine saturation, in waste-containing regions.

Release mechanisms dependent on brine saturation and/or pressure.

- Spallings
- Direct Brine Releases

An impact assessment was undertaken to quantify excavation impacts on spallings and DBRs.



Spallings and DBR Necessary Conditions

Spallings release volumes are dependent on pressure.

- Pressure ≥ 10 MPa is a necessary condition (lowest pressure yielding tensile failure of repository material).

DBR volumes are dependent on pressure and waste brine saturation.

- Pressure ≥ 8 MPa is a necessary condition (hydrostatic pressure of drilling fluid).
- Waste brine saturation must not be less than the waste residual brine saturation (sampled from uniform distribution developed during CCA).



Excavation Impact Assessment Summary

The proposed additional excavation for salt disposal investigations results in

- Lower average pressure in repository waste regions
- Slightly higher brine saturation in waste regions
- An overall reduction in spillings releases
- Effectively no change to DBRs
- No noticeable change to Total Normalized Releases

The additional excavation was shown to have negligible impact to regulatory compliance, and so was included in the CRA-2014 PA.



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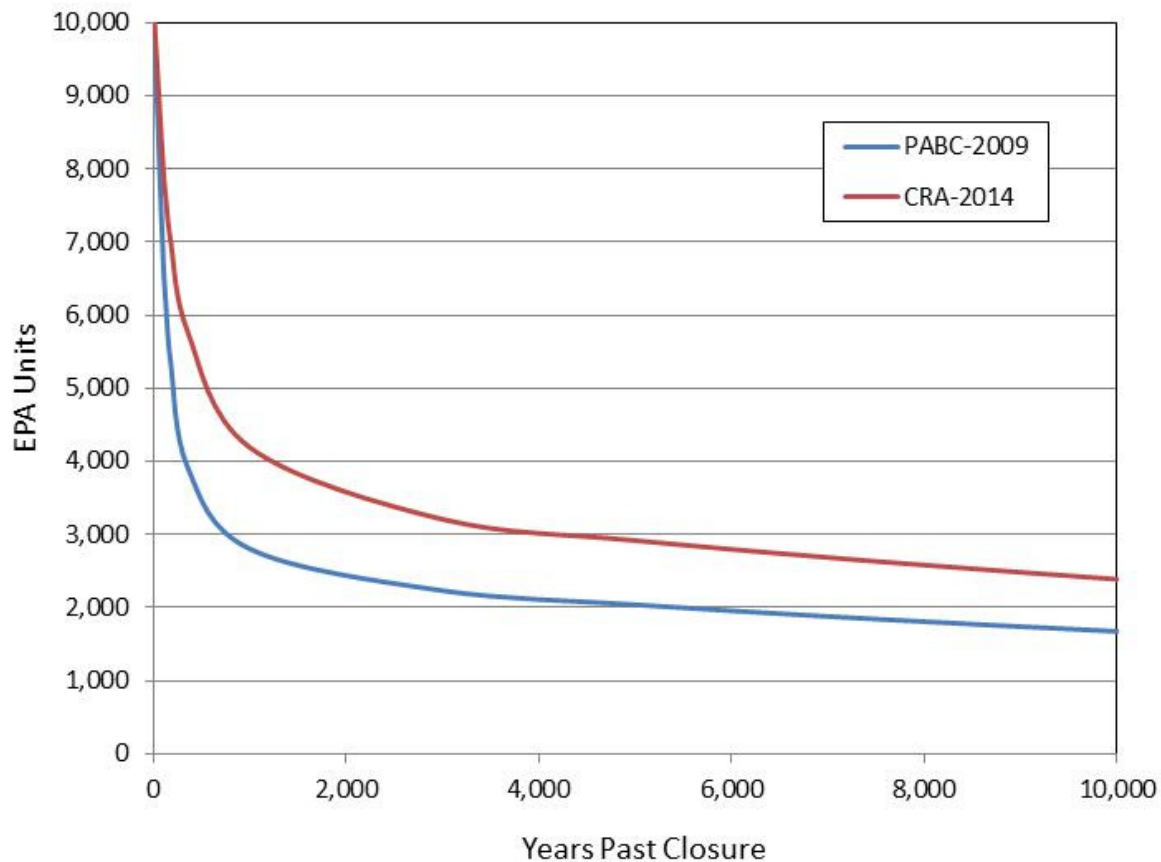
“Standard” Updates Included in the CRA-2014 PA

- Drilling Rate
- Plugging Pattern Probabilities
- Inventory
 - Radionuclides
 - Waste Materials
 - Organics
- Radionuclide Solubilities and their Uncertainty



Waste Inventory

Inventory parameters in the CRA-2014 PA are updated to reflect information collected through December 31, 2011.



Difference primarily due to increased ^{239}Pu in the CRA-2014 PA waste inventory



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Parameter and Implementation Refinements Included in the CRA-2014 PA

- Waste Shear Strength
- Steel Corrosion Rate
- Probability of Brine Pocket Encounter during Hypothetical Drilling Intrusion
- Radionuclide Concentration/Brine Volume Dependence
- Expanded Water Balance
- Colloid Enhancement Parameters



Waste Shear Strength

The waste shear strength is the ability of waste to resist erosion, and is one of the most important parameters in WIPP PA.



Cuttings and cavings are the dominant release mechanism. Cavings volumes are a function of waste shear strength.

SNL vertical flume experimental facility and the data obtained therein enabled a refinement to the waste shear strength parameter.

Surrogate degraded waste samples were used to determine lower value of shear strength uncertainty range



Iron Corrosion

Corrosion of iron generates gas, increasing repository pressures.



Repository pressure directly impacts spallings and direct brine releases. Higher repository pressures typically translate to higher releases.

Steel coupon samples were used at SNL Carlsbad to experimentally determine iron corrosion rates

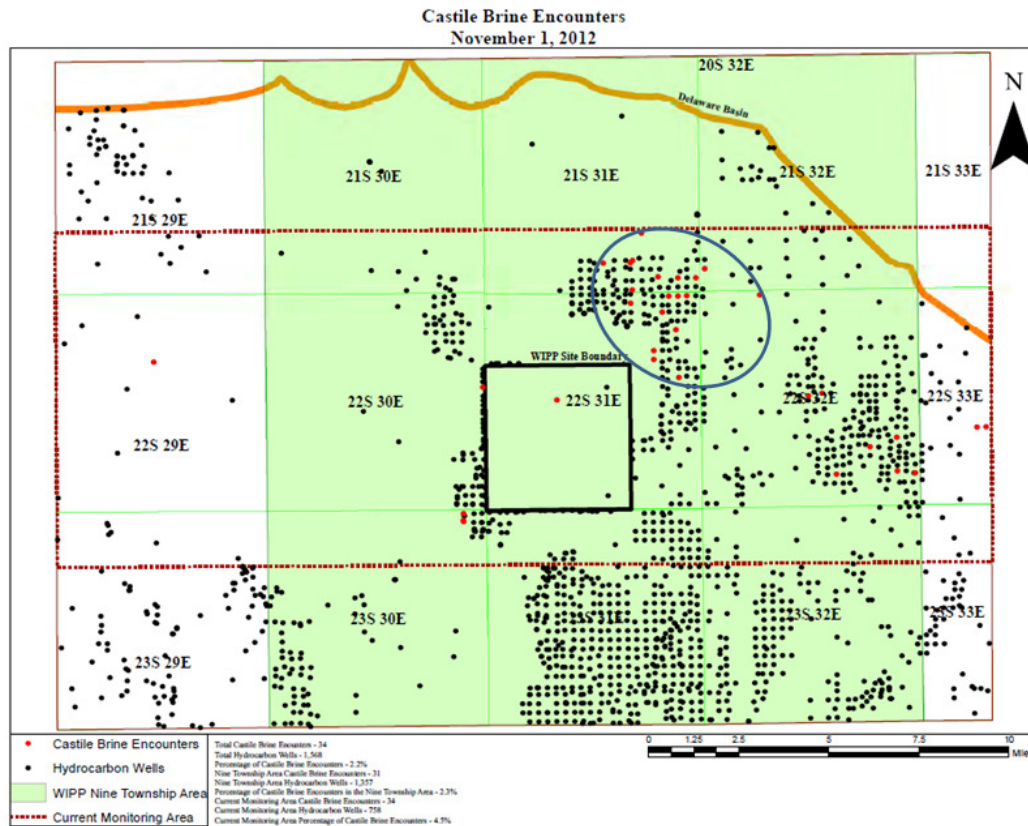
Iron corrosion experiments were performed over a number of years

Experimental results enabled a refinement to the gas generation rate used in WIPP PA, resulting in lower repository pressures on average



Pressurized Brine Encounters

WIPP PA includes intrusion scenarios that model borehole drilling through the repository and into underlying pressurized brine.



Underground regions of pressurized brine have been encountered at the WIPP site. Brine inflow to the repository can increase direct brine releases.

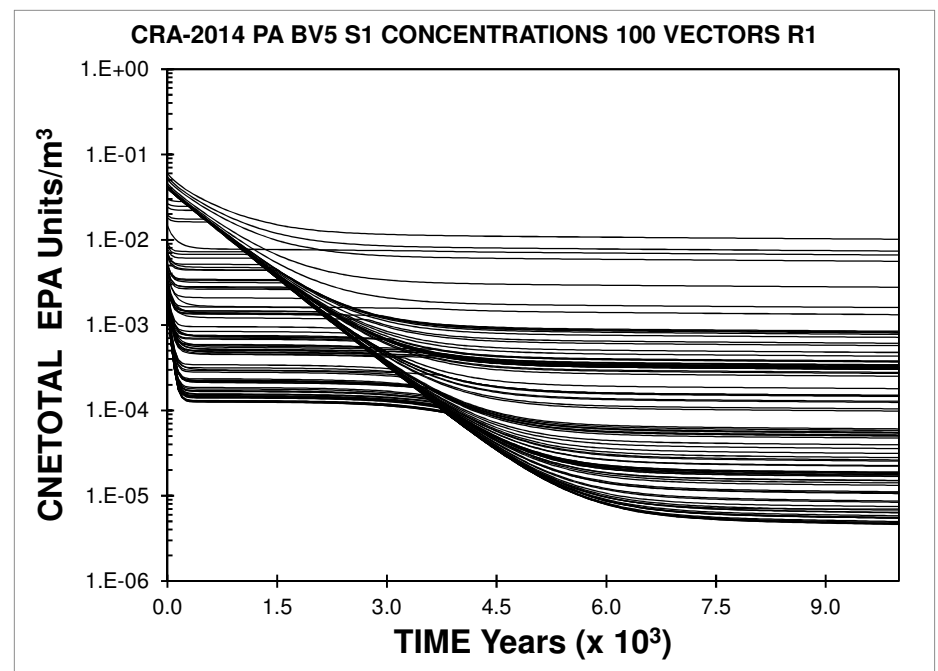
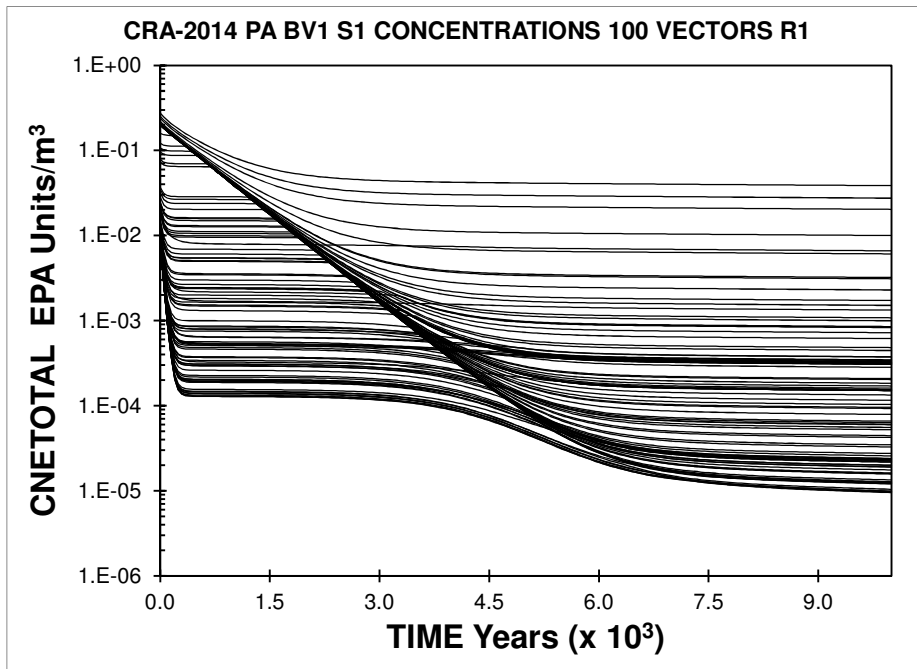
New data and analyses enabled a refinement to the probability of encountering pressurized brine in the CRA-2014 PA.

Direct brine releases were reduced as a result.



Radionuclide Concentration Dependence on Repository Brine Volume

Radionuclide concentrations in brine are dependent on the repository brine volume.



Total mobilized radionuclide concentrations (CNETOTAL) decrease as brine volumes increase.



Water Budget Refinement

Repository water balance is refined to include a more complete set of gas and brine producing and consuming reactions for the existing conceptual model.

- MgO hydration consumes water and produces brucite.
- The carbonation of brucite forms hydromagnesite.
- Hydromagnesite dehydrates to form magnesite.
- Iron hydroxide sulfidation produces water.



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CRA-2014 PA Approach

CRA-2014 PA changes are included sequentially so that compliance impacts can be reasonably isolated.

The CRA-2014 PA is comprised of 4 cases:

Case CRA14-BL

Includes:

- New Panel Closure
- Additional Excavation
- Updated Inventory
- Updated Solubilities (Single Brine Volume)
- Updated Drilling Parameters
- Revised Colloid Factors

Case CRA14-TP

Includes CRA14-BL changes plus:

- Waste shear strength update
- Update to the probability of encountering pressurized brine during a hypothetical drilling intrusion

Case CRA14-BV

Includes CRA14-TP changes plus:

- Variable Brine Volume

Case CRA14-0

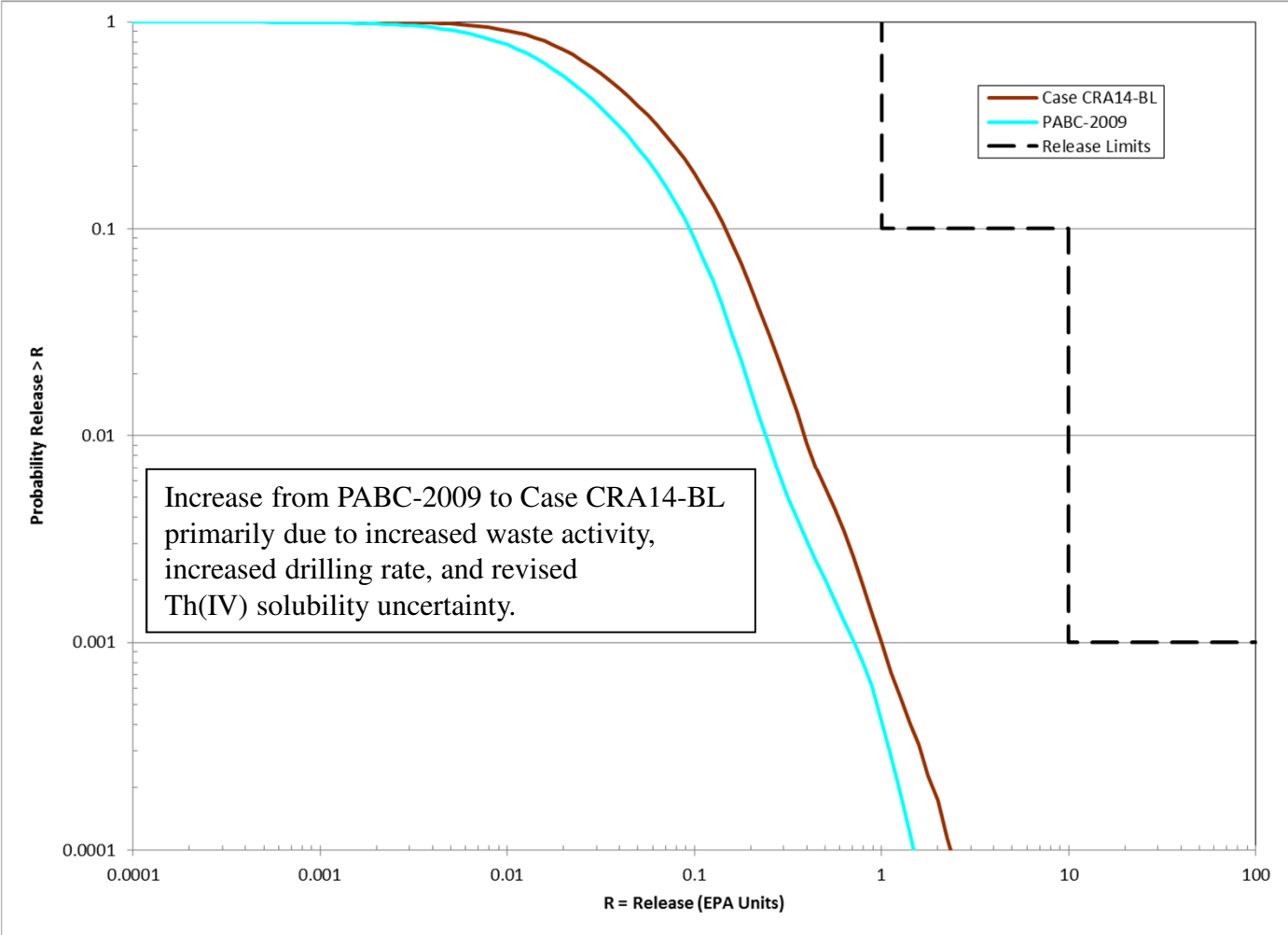
Includes CRA14-BV changes plus:

- Steel Corrosion Update
- Water Budget Refinement

Case CRA14-0 includes all changes in the CRA-2014 PA, and is the “formal” compliance calculation.

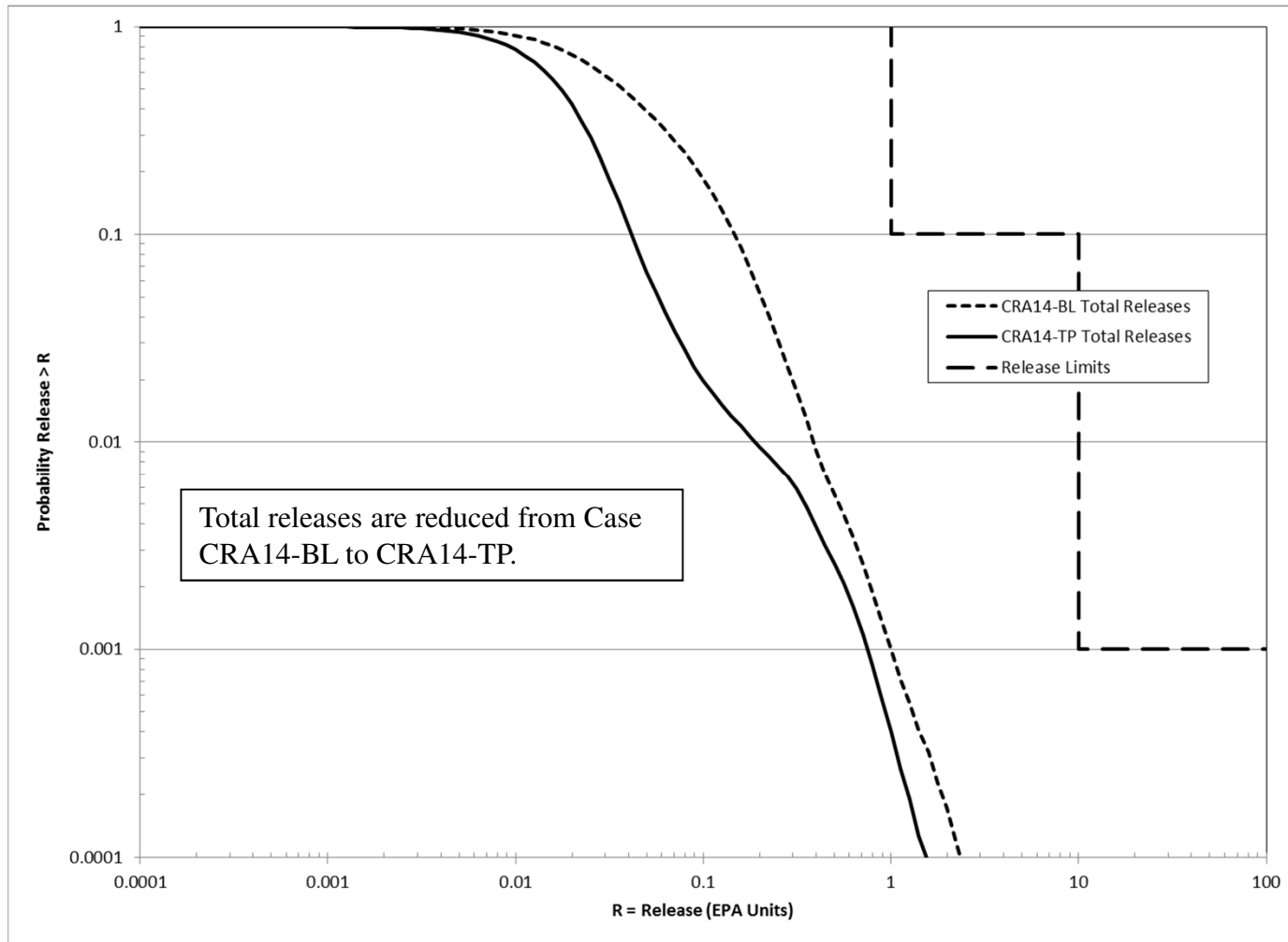


Case CRA14-BL Results



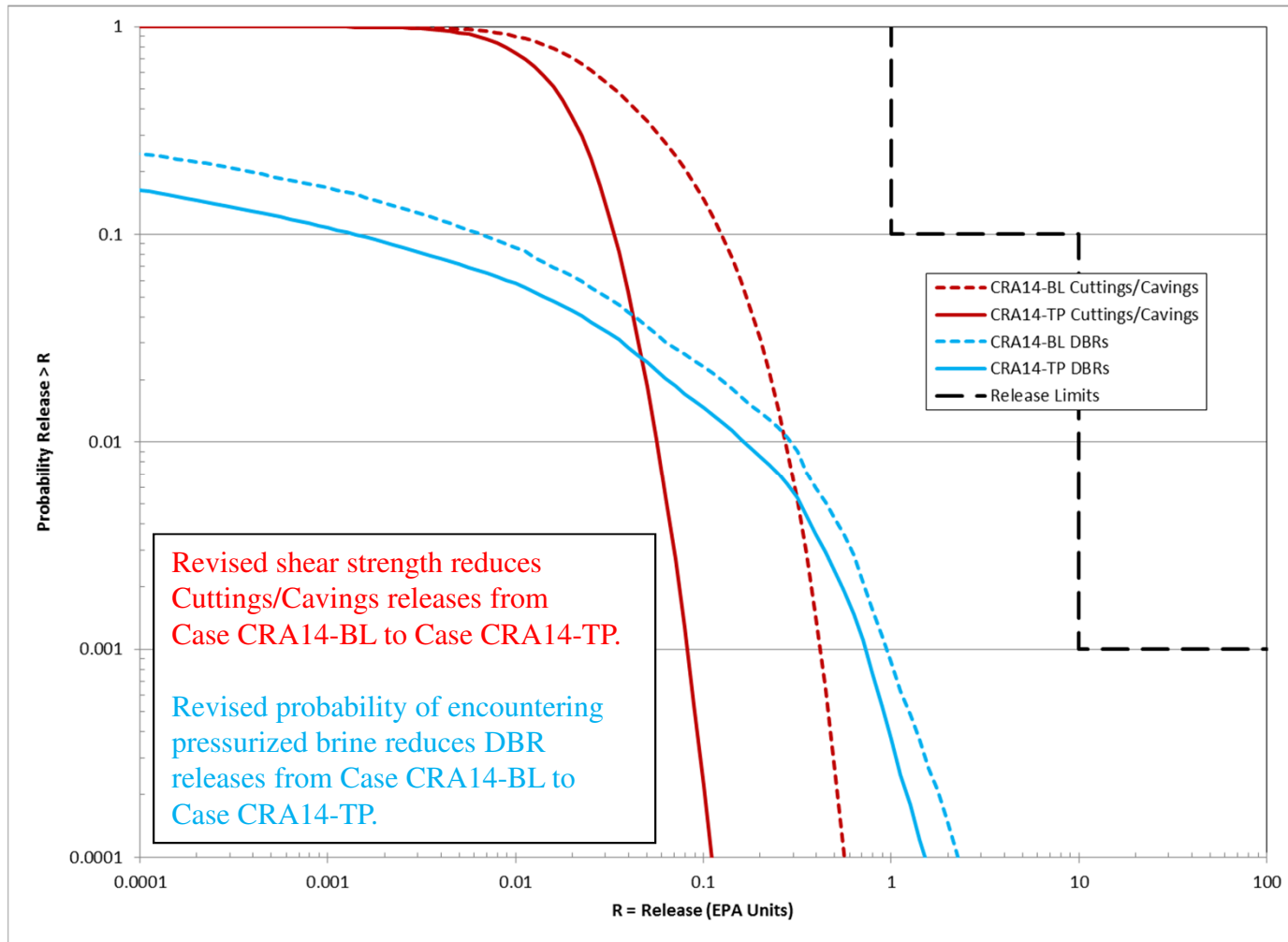


Case CRA14-TP Results



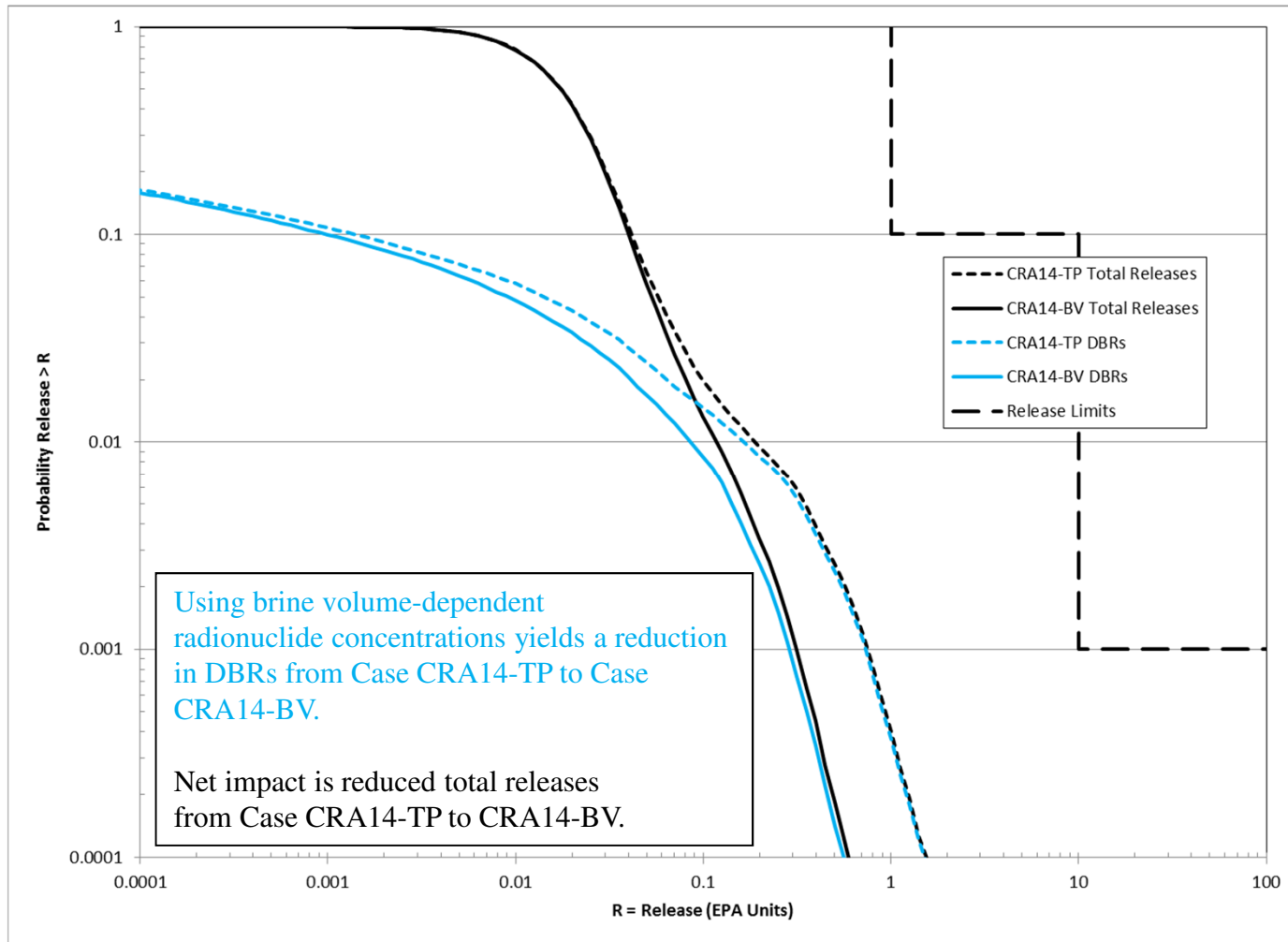


Case CRA14-TP Results



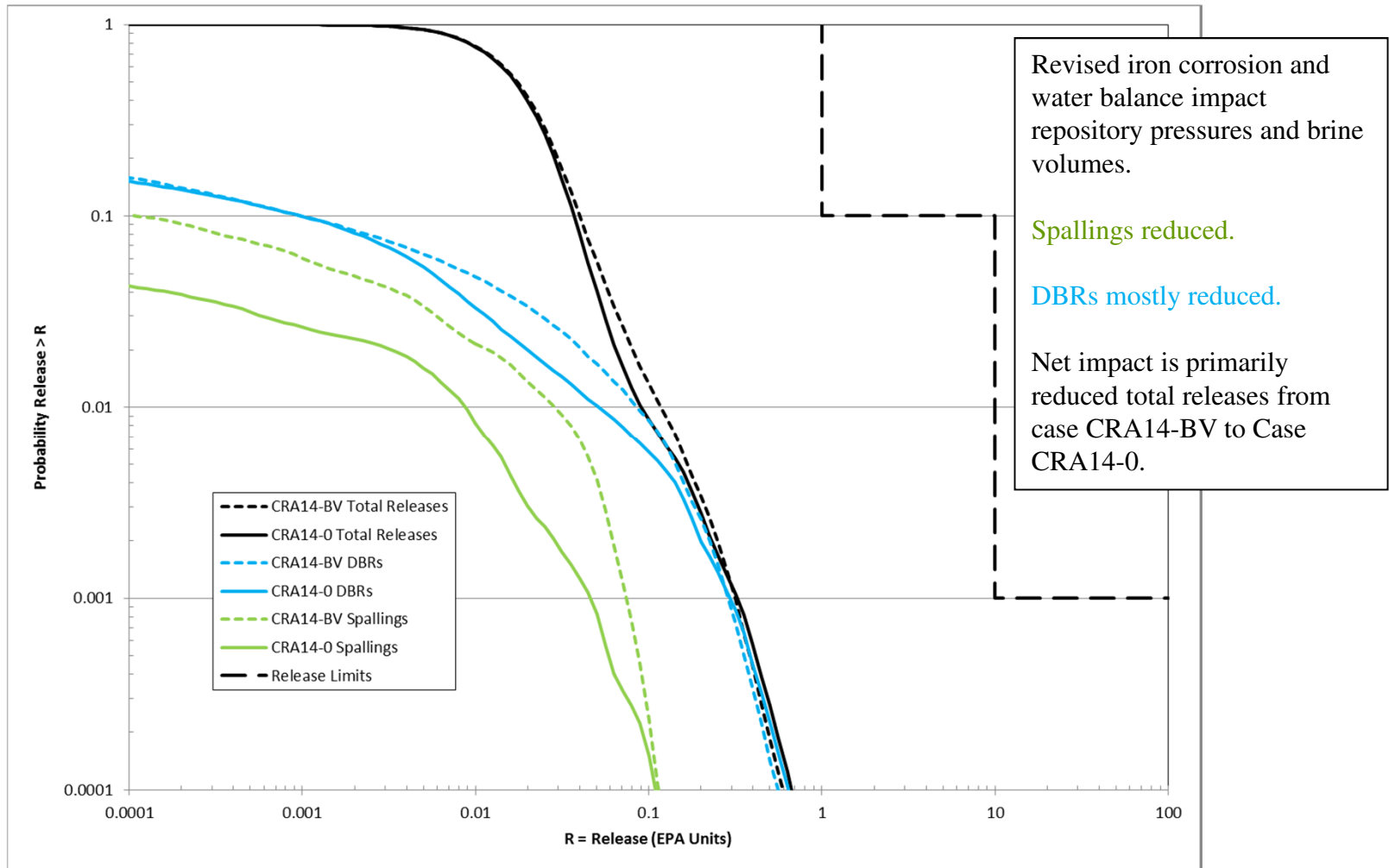


Case CRA14-BV Results



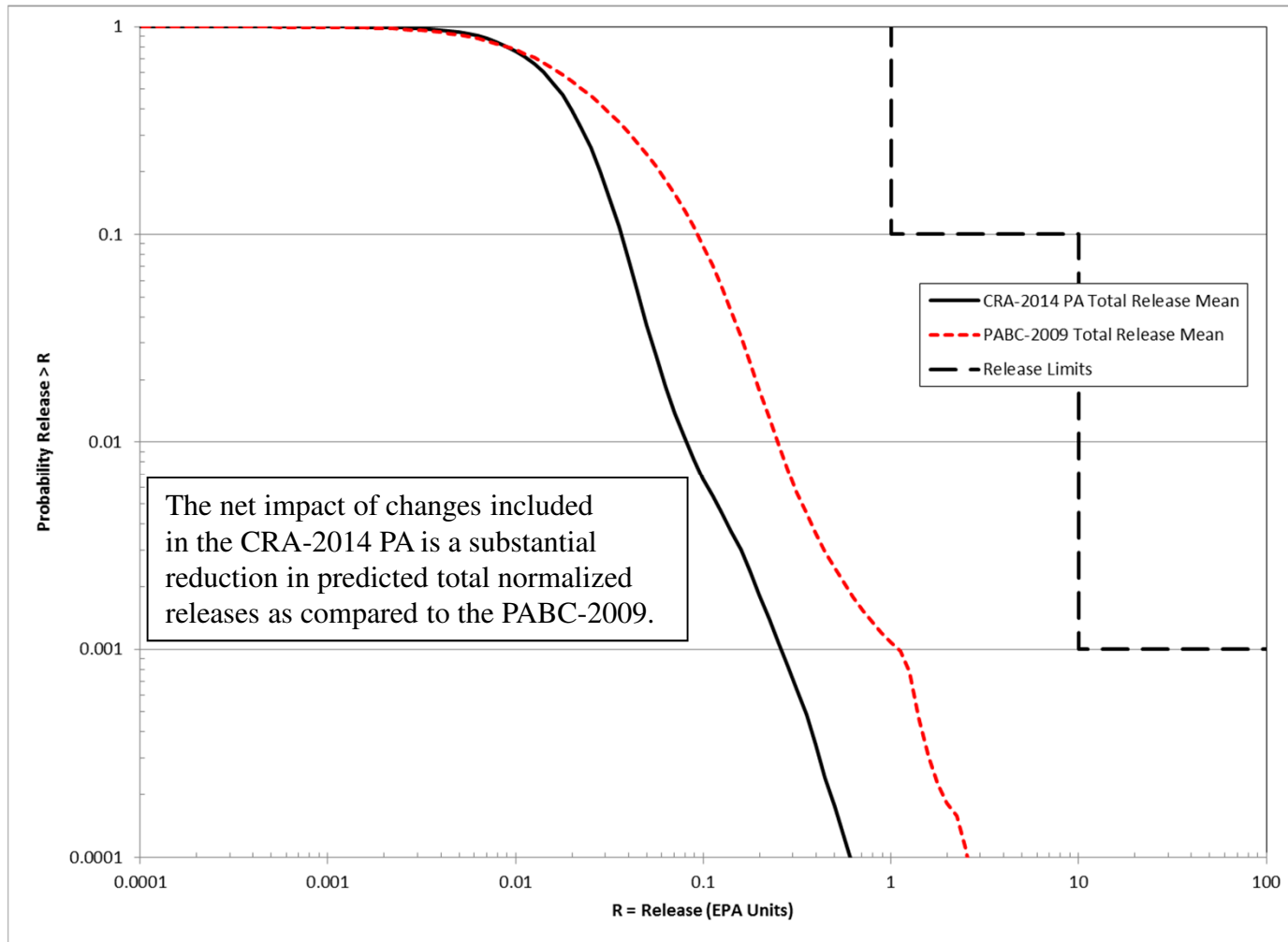


CRA14-0 Results





CRA-2014 PA Main Result





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Summary

- The CRA-2014 PA includes planned repository changes and numerous refinements/updates.
- Changes are included sequentially so that compliance impacts can be reasonably isolated.
- Predicted total normalized releases obtained in the CRA-2014 PA are less than those found in the PABC-2009. The WIPP remains in compliance with long-term federal containment requirements.