U.S. Department of Energy
Office of Civilian Radioactive Waste Management

Performance Assessment: Engineered Barrier System Question 1

Presented to:
Nuclear Waste Technical Review Board

Presented by:
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YUCCA MOUNTAIN PROJECT

Summary of Supplemental Scientific Models and Analyses

Related to Performance Assessment EBS Question 1

KEY ATTRIBUTES OF SYSTEM	PROCESS MODEL FACTOR (Section of Science and Engineering Report)	TOPIC OF SUPPLEMENTAL SCIENTIFIC MODEL OR ANALYSIS	REASON FOR SUPPLEMENTAL SCIENTIFIC MODEL OR ANALYSIS			PERFORMANCE ASSESSMENT TREATMENT OF SUPPLEMENTAL SCIENTIFIC MODEL OR ANALYSIS	
			Unquantified Uncertainty Analysis	Update in Scientific Information	Cooler Thermal Operating Mode Analysis	TSPA Sensitivity Analysis	Included in Supplemental TSPA Model
Prolonging Waste Package Lifetime	Drip Shield Degradation and Performance (4.2.4)	Local chemical environment on surface of drip shields (including Mg, Pb) and potential for initiating localized corrosion	X				
	Waste Package Degradation and Performance (4.2.4)	Local chemical environment on surface of waste packages (including Mg, Pb) and potential for initiating localized corrosion	X				
		Aging and phase stability effects on A-22	X	X		X	
		Uncertainty in weld stress state following mitigation	X			X	X
		Geometry of defects	X			X	X
		Early failure due to improper heat treatment	X			X	X
		General corrosion rate of A-22: Temperature dependency	X		X	X	X
		General corrosion rate of A-22: uncertainty/variability partition	X			X	
		Long-term stability of passive films on A-22	X				
		Stress threshold for initiation of stress corrosion cracking	X	X		X	X
		Probability of non-detection of manufacturing defects		X		X	X
		Fraction of surface-breaking flaws		X		X	X
		Distribution of crack growth exponent (repassivation slope)	X	X		X	X

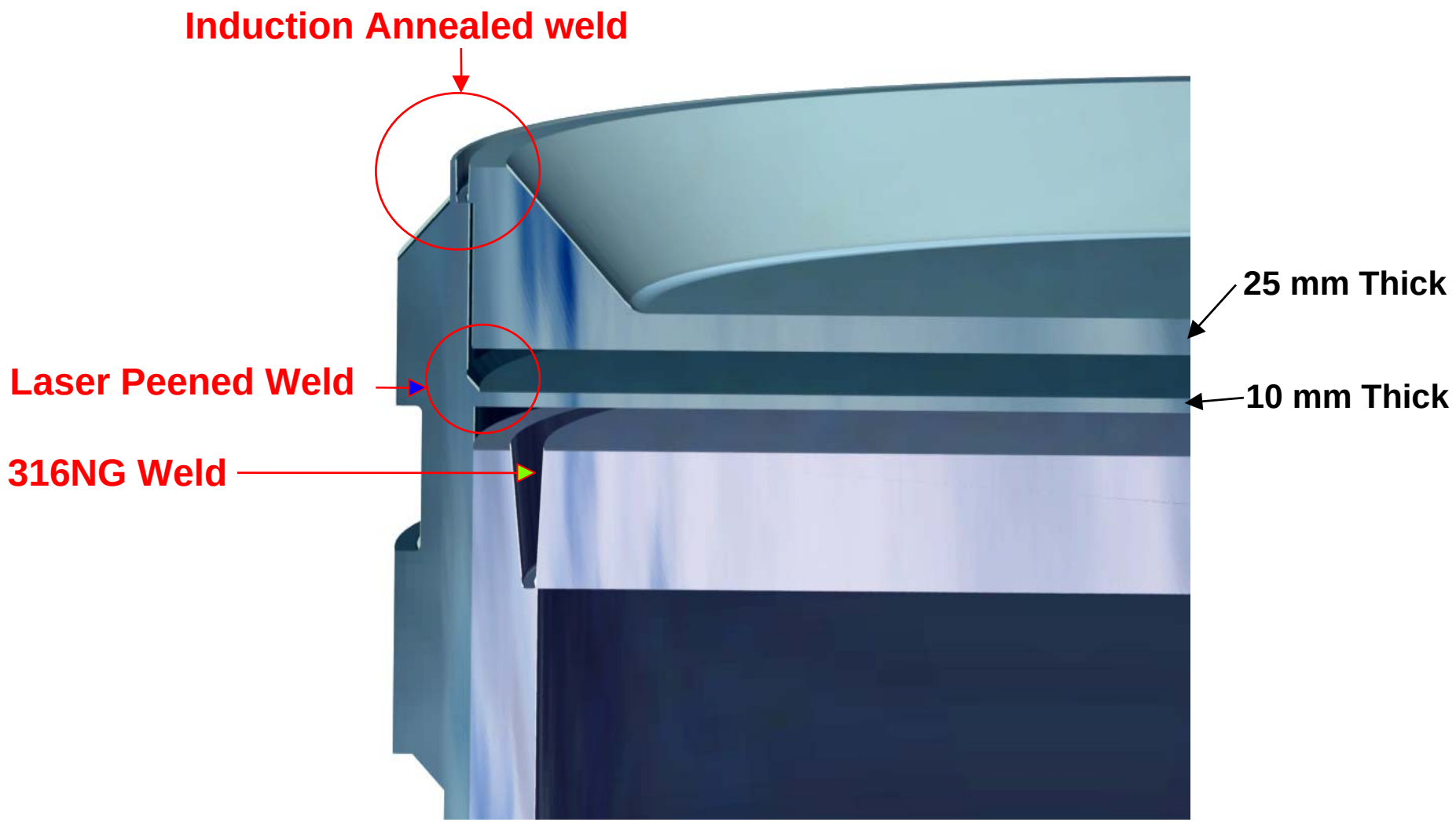
PA Consideration of Possible Differences Between EBS Components as Designed vs As Built

- **PA Assumes Repository will be Constructed, Operated and Closed as According to Design (nominal scenario)**
- **Requirements for Quality Assurance/Quality Controls Controls (Including Design Control and Inspections and Testing)**
- **Deviations from Design Subject to Regulatory Review and Re-Evaluation**
- **Performance Confirmation Program Required to Confirm Design Parameters**
- **Significant Deviations from Design will be Corrected**
- **System Level FEPS Analyses Describes Basis for Consideration**

Approach to Mitigate Stress Corrosion Cracking (SCC)

- **Sources of stress in waste package**
  - **Over yield residual stresses expected in as-welded condition - other applied stresses are minimal**
    - **If total stress exceeds initiation threshold, SCC can occur**
- **Current mitigation approach is to:**
  - **Solution anneal and quench as-fabricated waste package in shop prior to loading and final closure welding**
    - **Quenching demonstrated to put waste package surface in compression**
  - **Local induction annealing and laser peening will produce compressive stresses in final closure welds**

Final Closure Welds in Waste Package Lids



What if Induction Annealing or Laser Peening Cannot Be Demonstrated at the Commercial Scale?

- **Use a Single Closure Lid Design**
- **Use two lids with the same stress mitigation technique**
- **Develop another low residual stress welding process under evaluation**
  - **Ultra narrow groove welding**
  - **Application of last welding passes underwater or with spray cooling**
  - **Plasma arc welding**
  - **Hot wire automatic tungsten inert gas weld**
  - **Cold wire automatic tungsten inert gas weld**
  - **Electron beam welding**
  - **Laser welding**

PA Analysis of A One Lid Design: General Approach

- **Two Cases Analyzed:**
  - **Case 1: No Induction Annealed Lid (outer lid removed)**
  - **Case 2: No Laser Peened Lid (inner lid removed)**

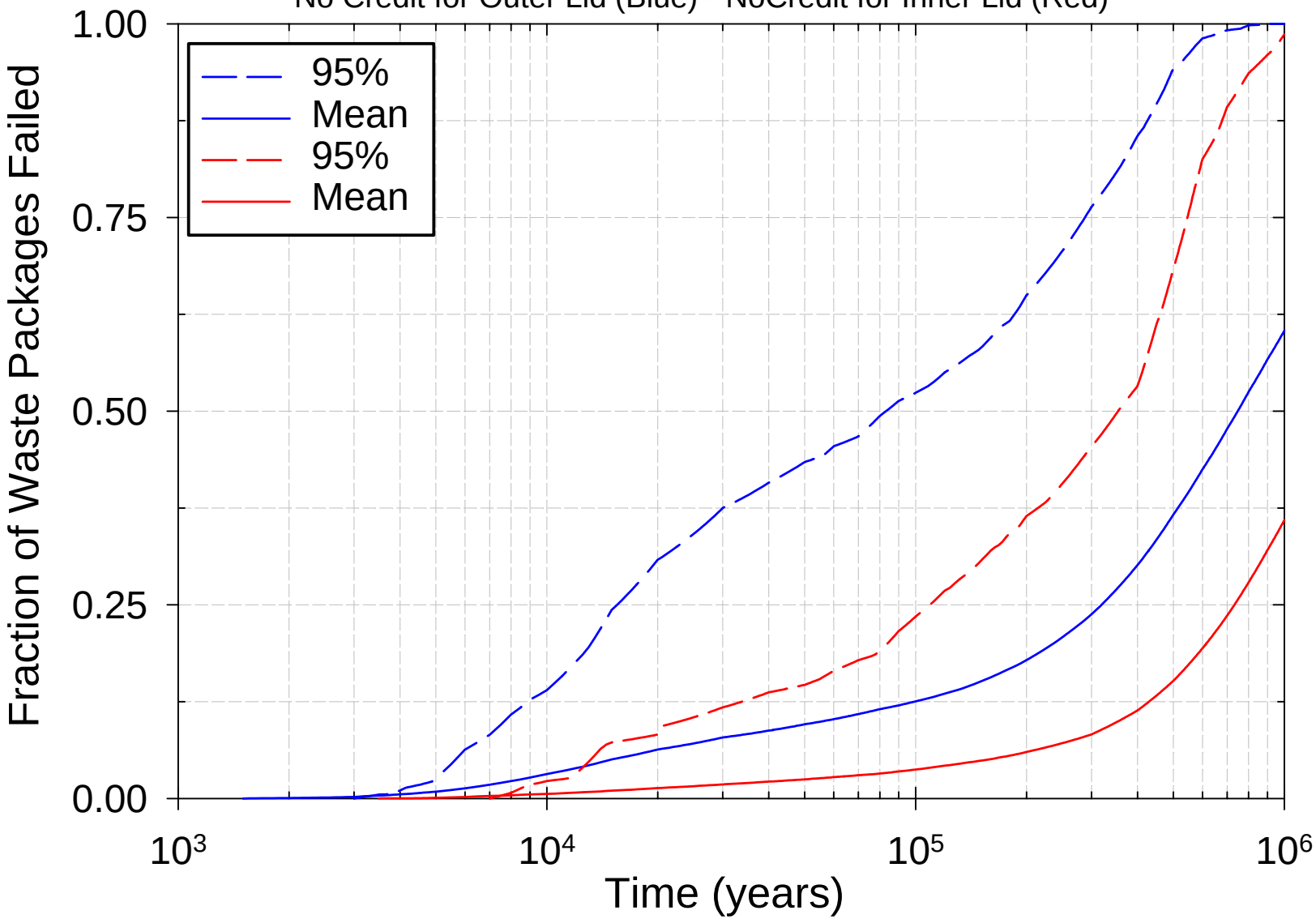
- **High End of Thermal Operating Mode Used in Both Cases for comparative purposes**
- **Uses Updated Temperature Dependent General Corrosion Model for Both Cases (Unquantified Uncertainty & Thermal Comparison)**
- **Treatment of weld flaws has been updated (Update in Scientific Information)**

PA Analysis of A One Lid Design General Approach
(Continued)

- **Threshold Stress Uncertainty for SCC crack initiation has been Updated (Newly Quantified Uncertainty)**
- **SCC Crack Growth exponent (repassivation slope) for the Slip Dissolution Model has been updated. (Update in Scientific Information)**
- **Updated Probability for Improper Heat Treatment Considered (early Waste Package Failure Mechanism) included in Scenario (Newly Quantified Uncertainty)**

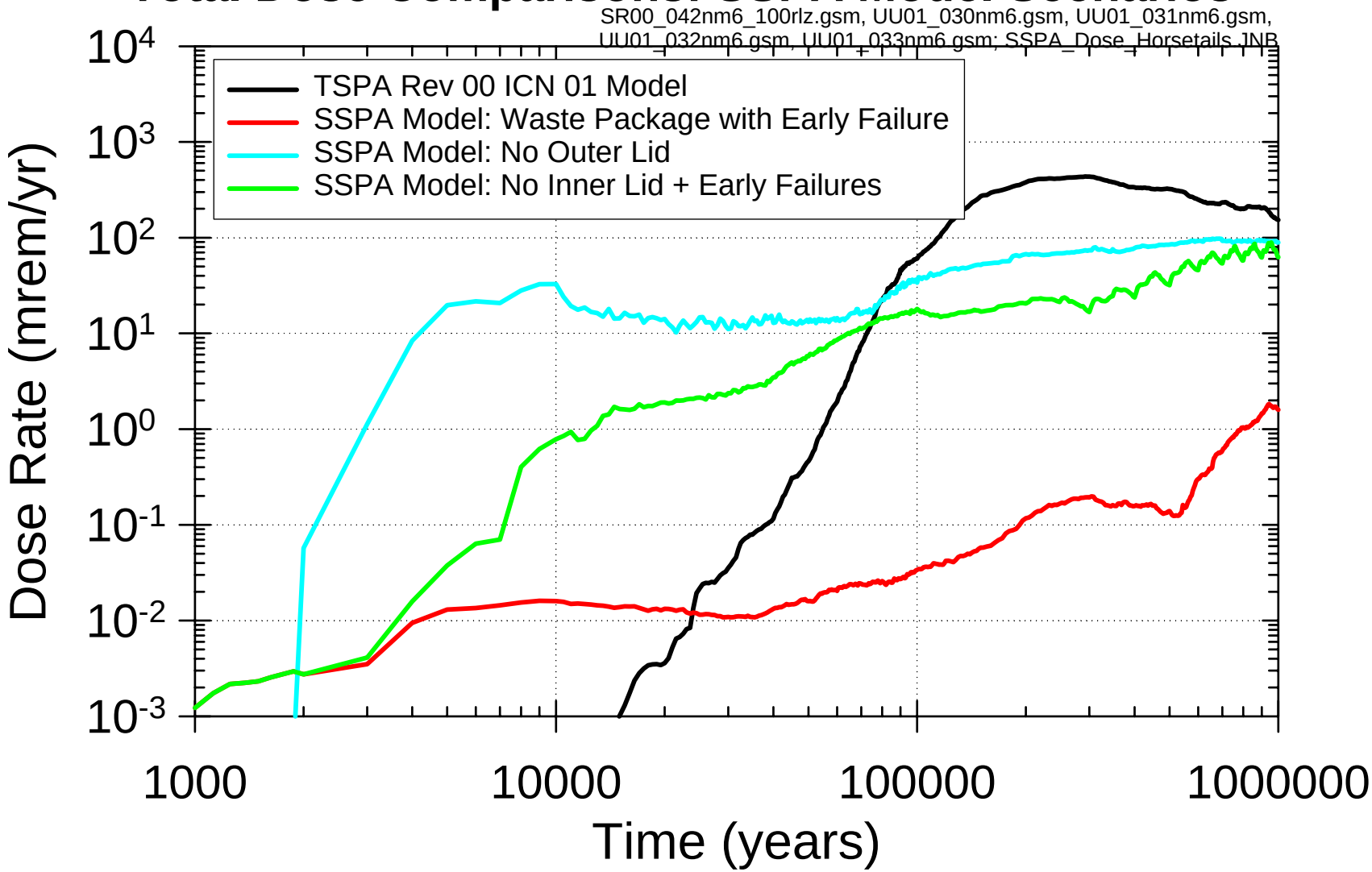
Waste Package 1st Failure

Temperature-Dependent General Corrosion
No Credit for Outer Lid (Blue) - NoCredit for Inner Lid (Red)

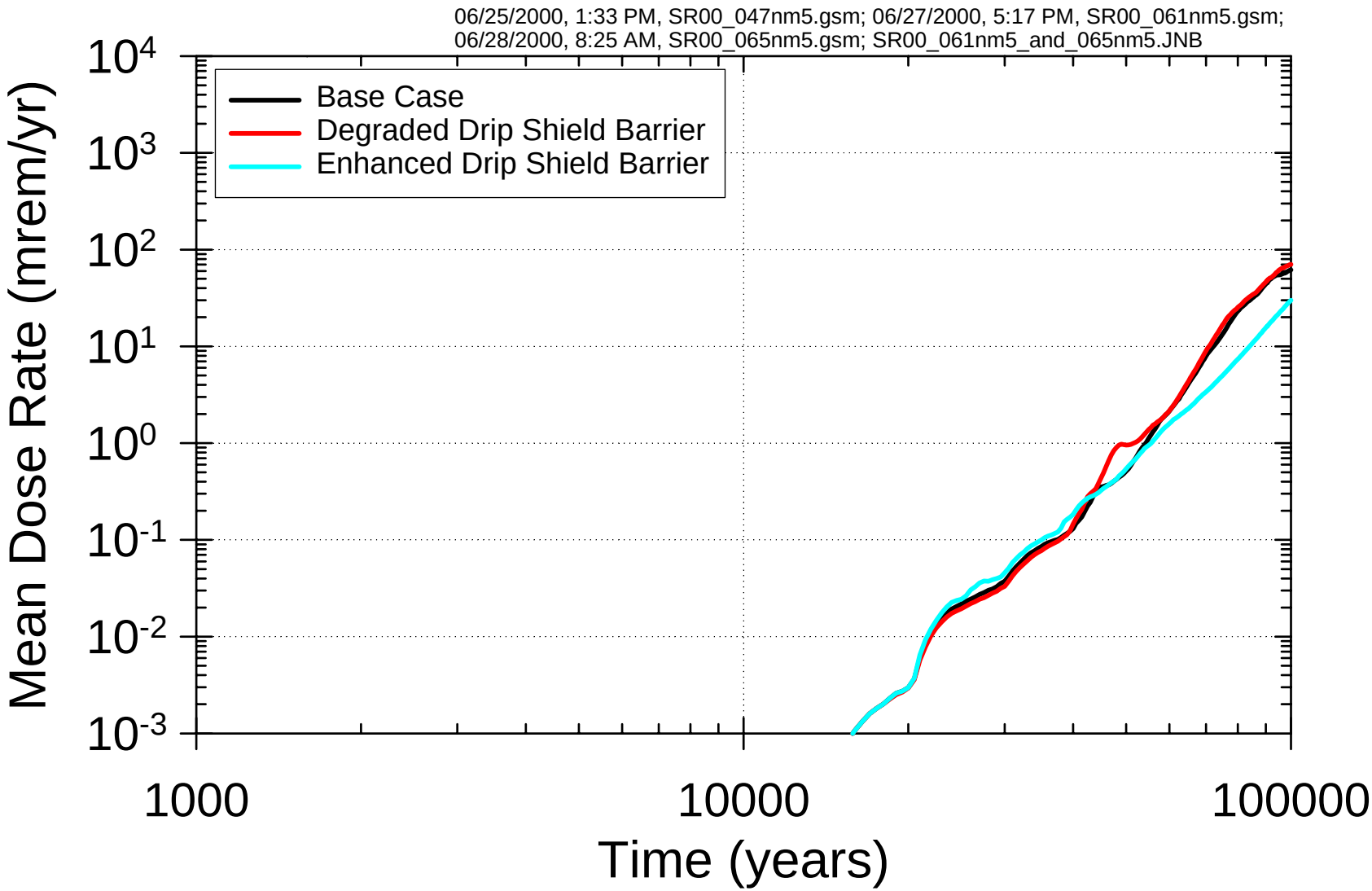


Preliminary

Total Dose Comparisons: SSPA Model Scenarios



Preliminary
Drip Shield Barrier Sensitivity

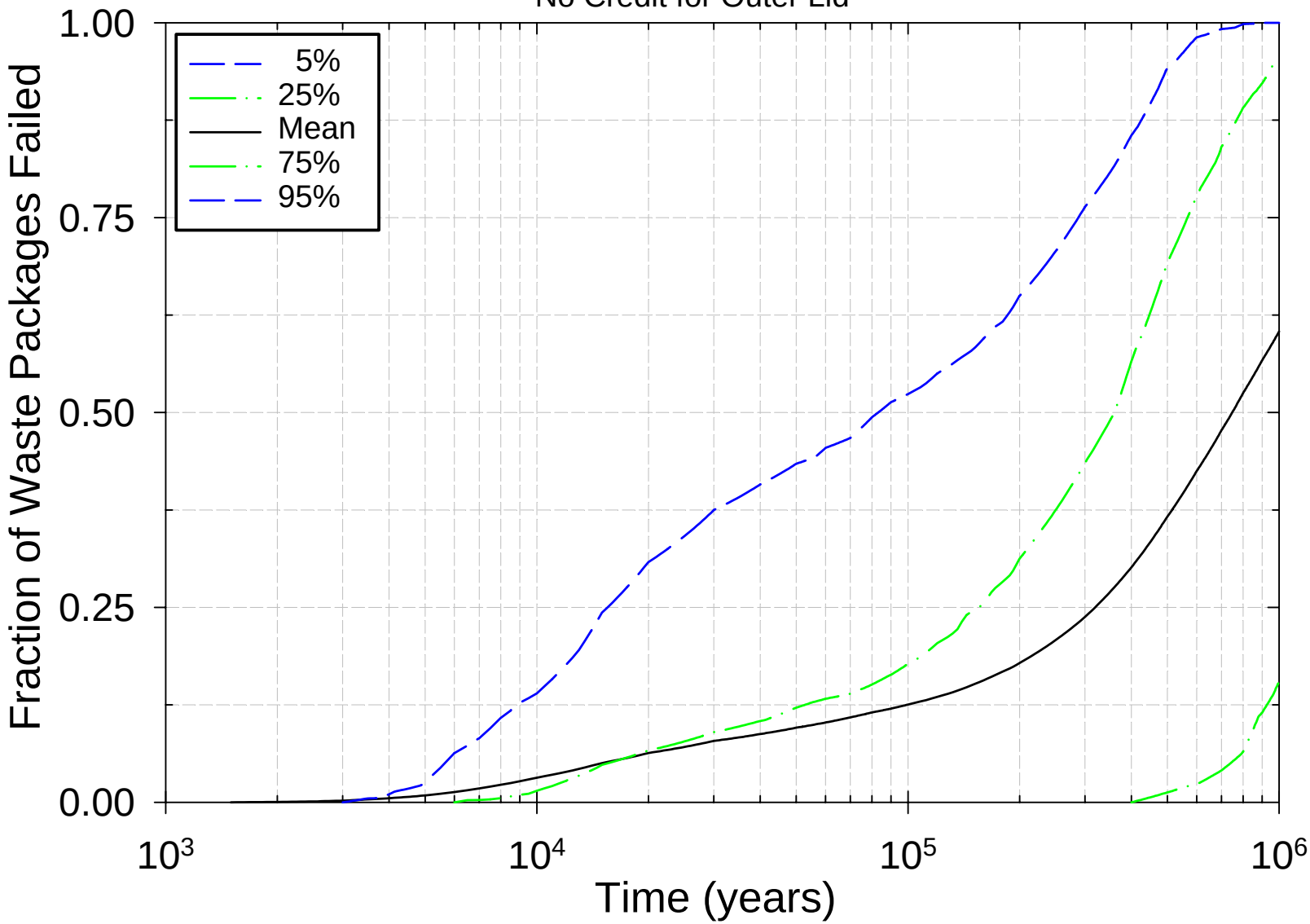


Engineered Barrier System: Question 1

Backup Slides

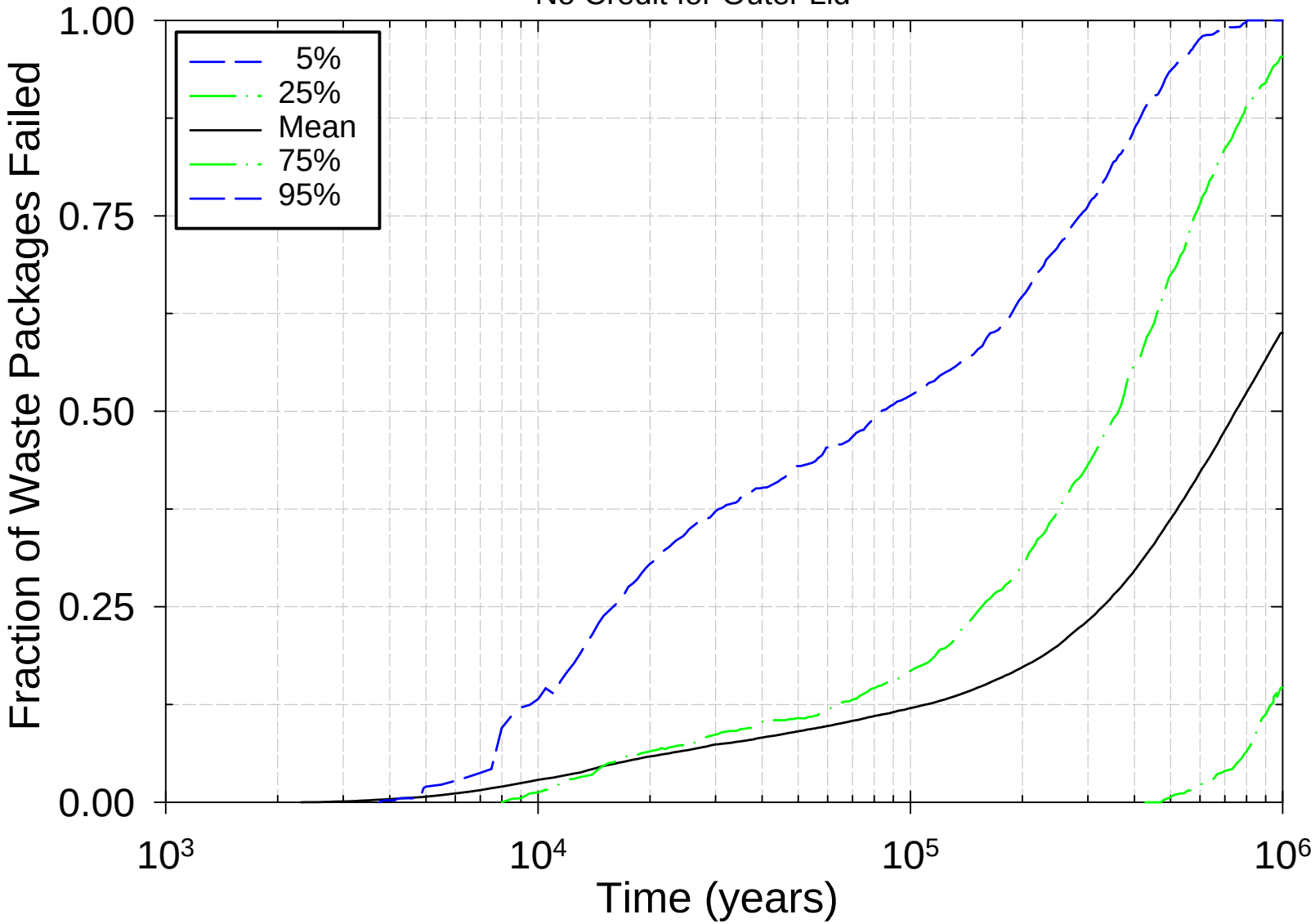
Waste Package 1st Failure

Temperature-Dependent General Corrosion
No Credit for Outer Lid



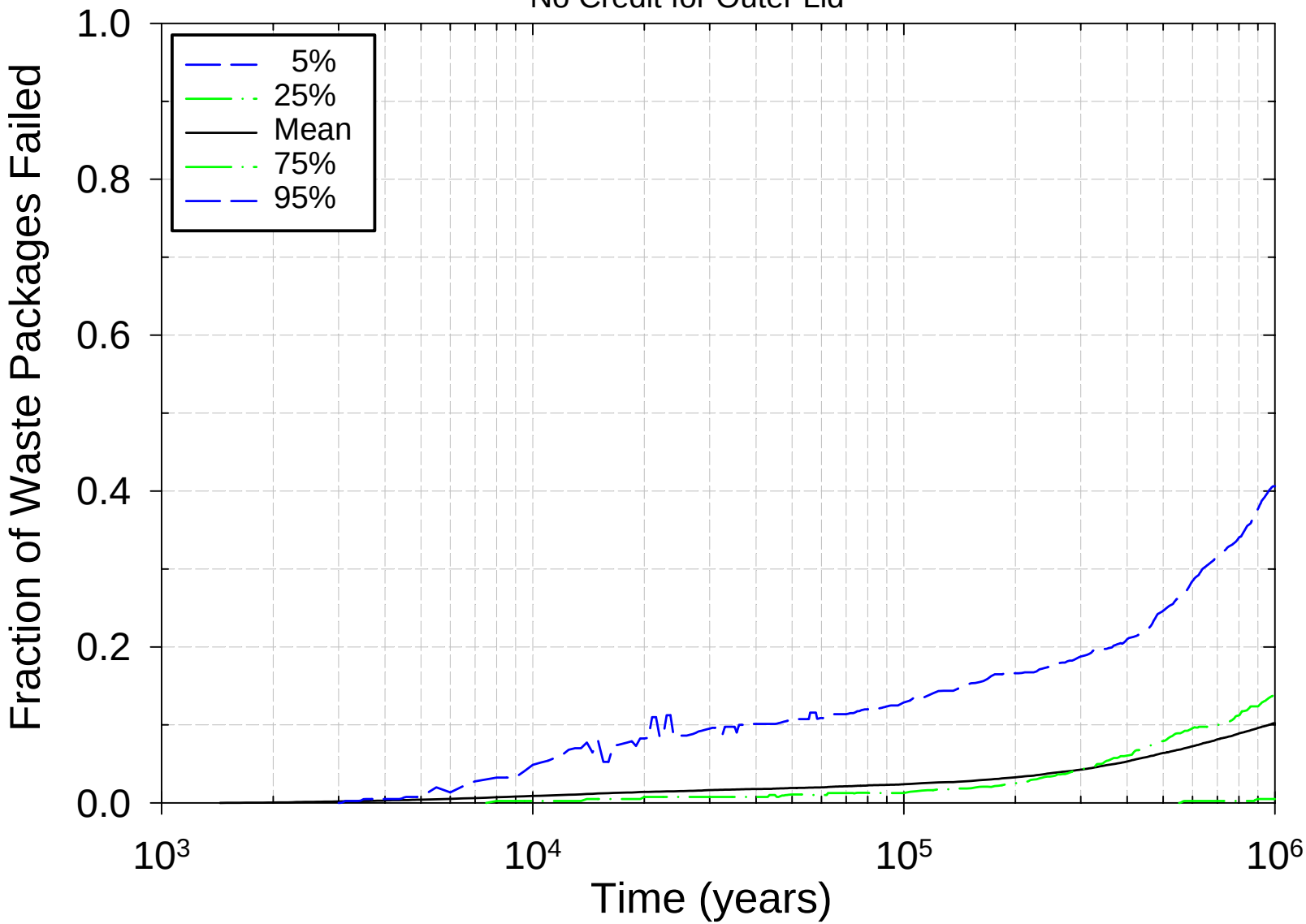
Waste Package 1st Patch Failure

Temperature-Dependent General Corrosion
No Credit for Outer Lid



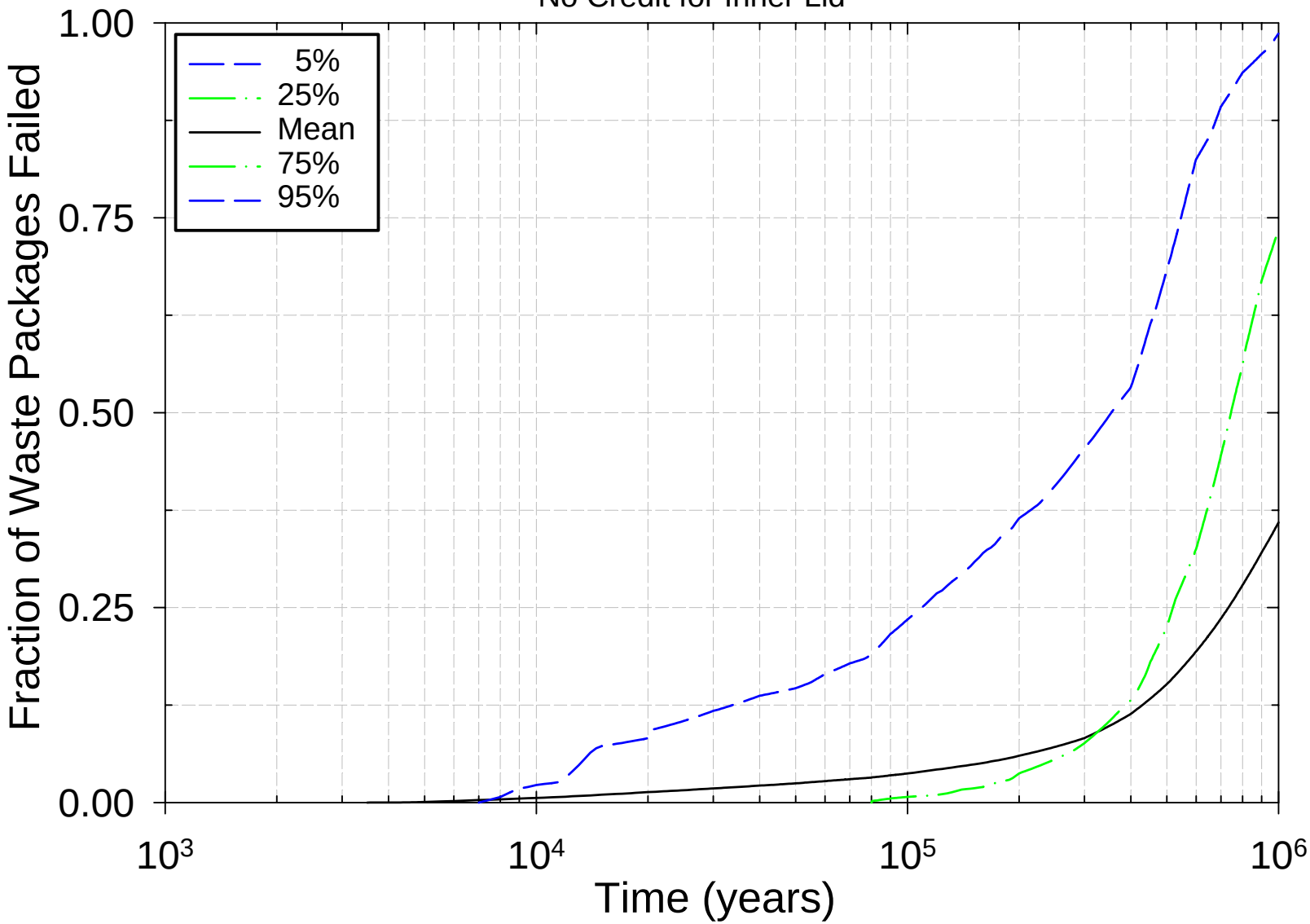
Waste Package 1st Crack Failure

Temperature-Dependent General Corrosion
No Credit for Outer Lid



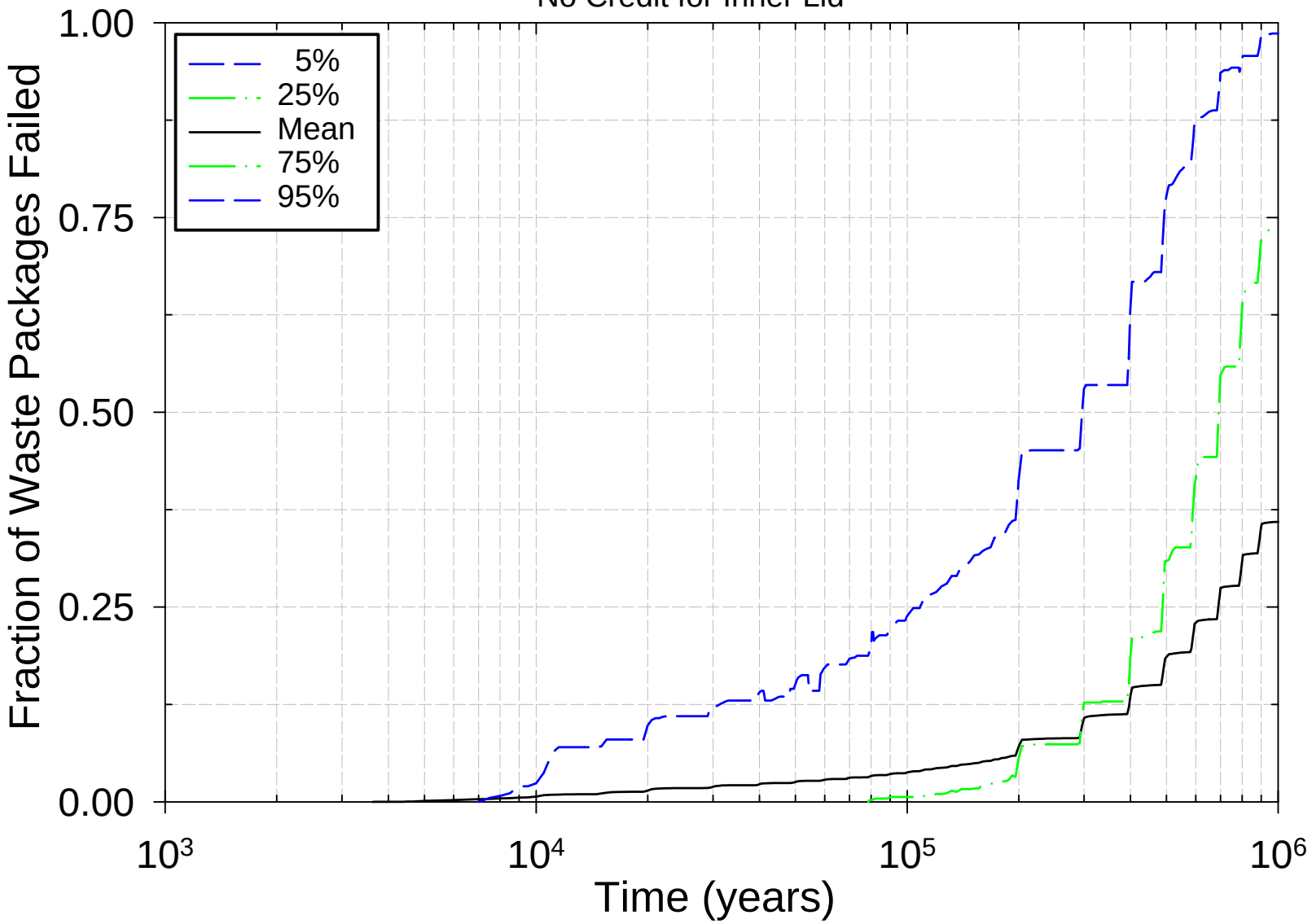
Waste Package 1st Failure

Temperature-Dependent General Corrosion
No Credit for Inner Lid



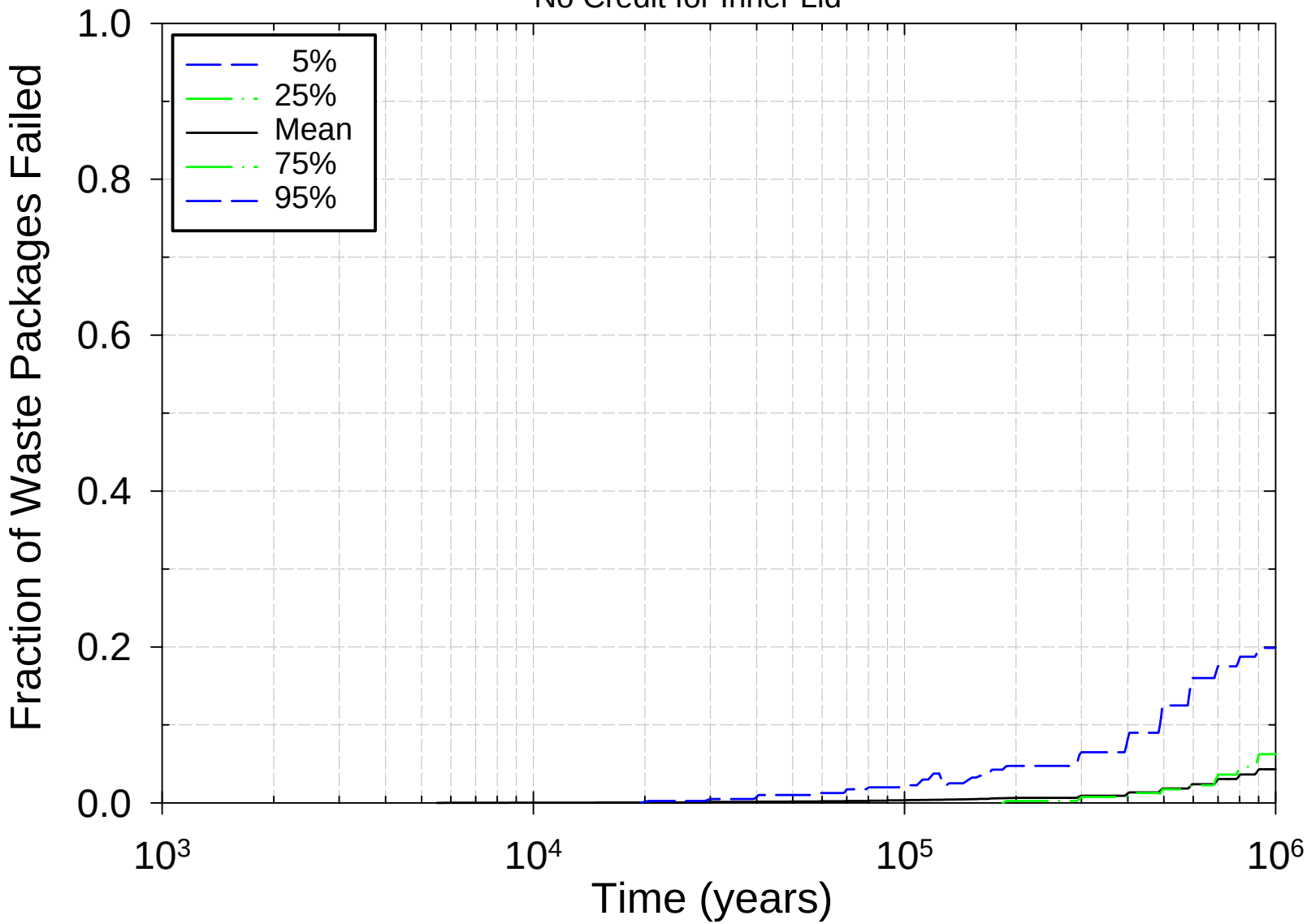
Waste Package 1st Patch Failure

Temperature-Dependent General Corrosion
No Credit for Inner Lid



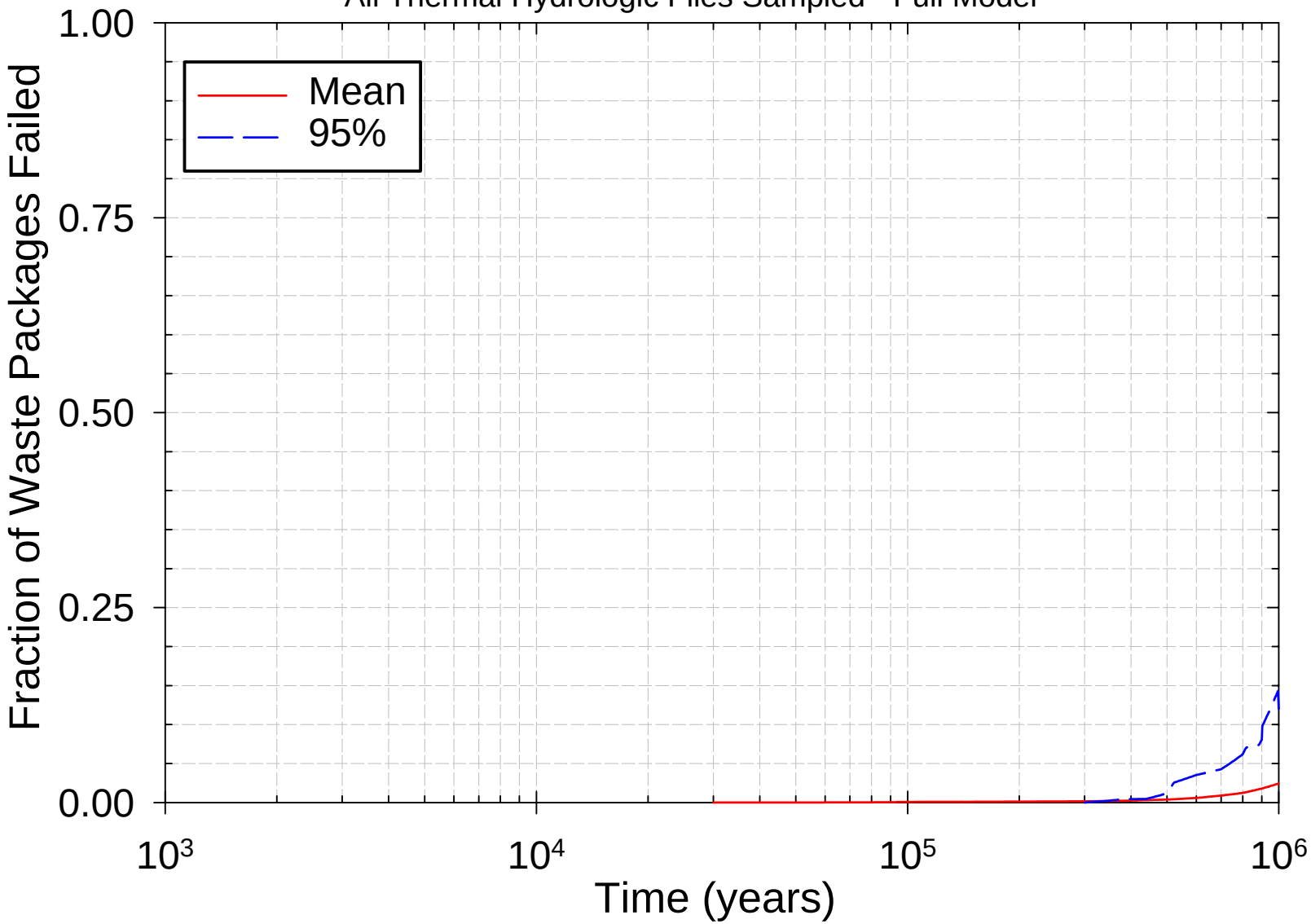
Waste Package 1st Crack Failure

Temperature-Dependent General Corrosion
No Credit for Inner Lid



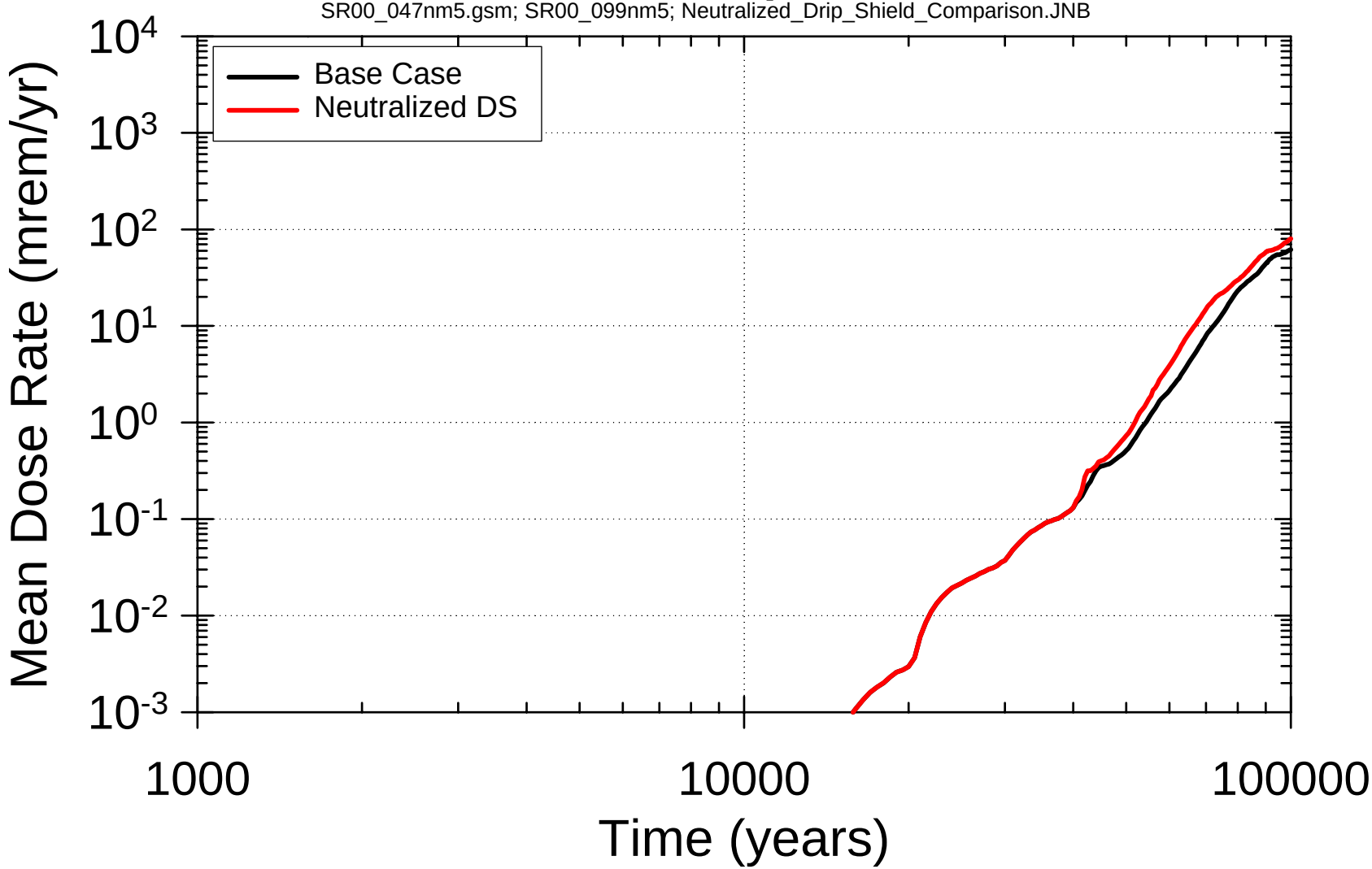
Waste Package 1st Failure

Temperature-Dependent General Corrosion
All Thermal Hydrologic Files Sampled - Full Model



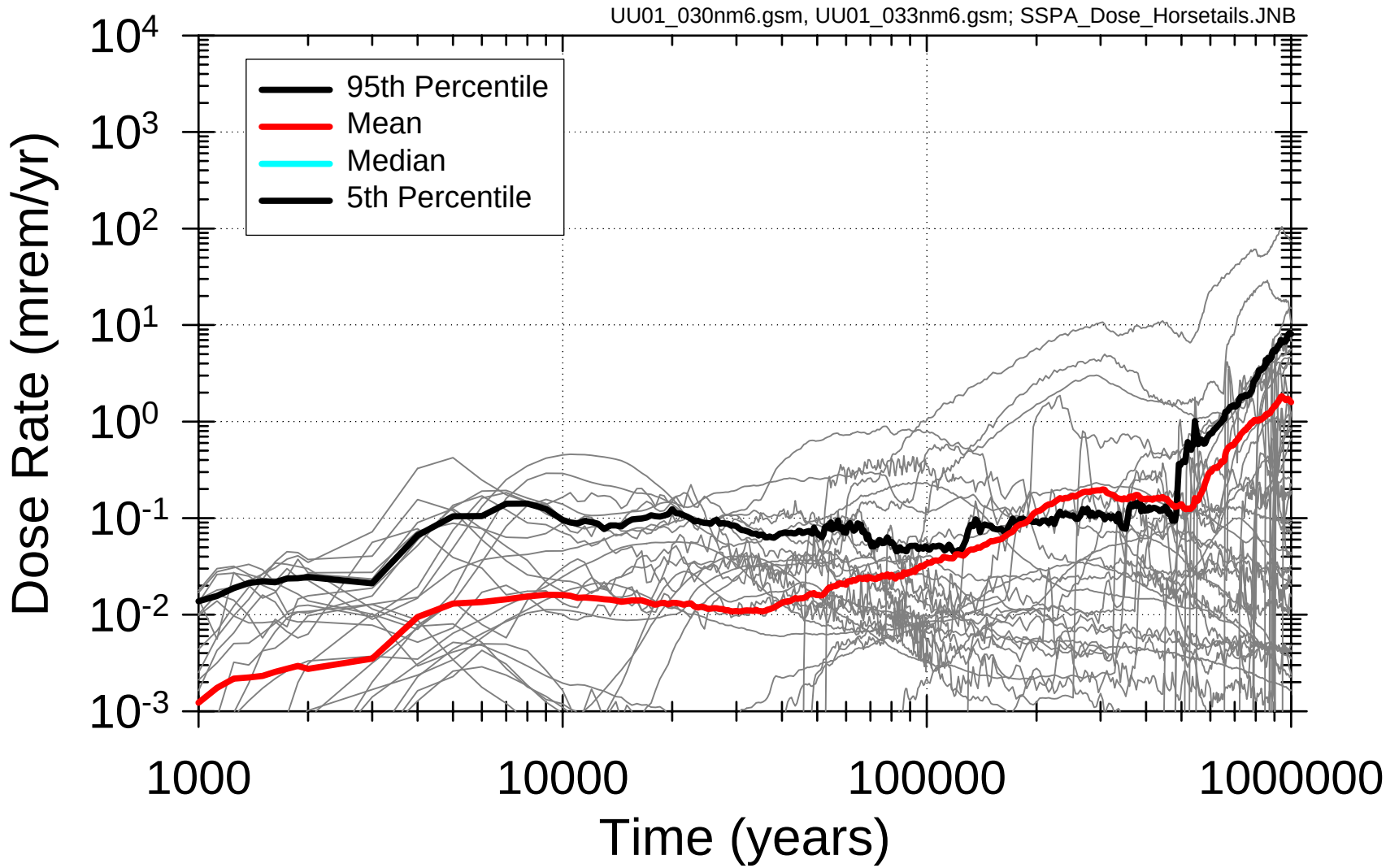
Preliminary
Neutralized Drip Shield

SR00_047nm5.gsm; SR00_099nm5; Neutralized_Drip_Shield_Comparison.JNB



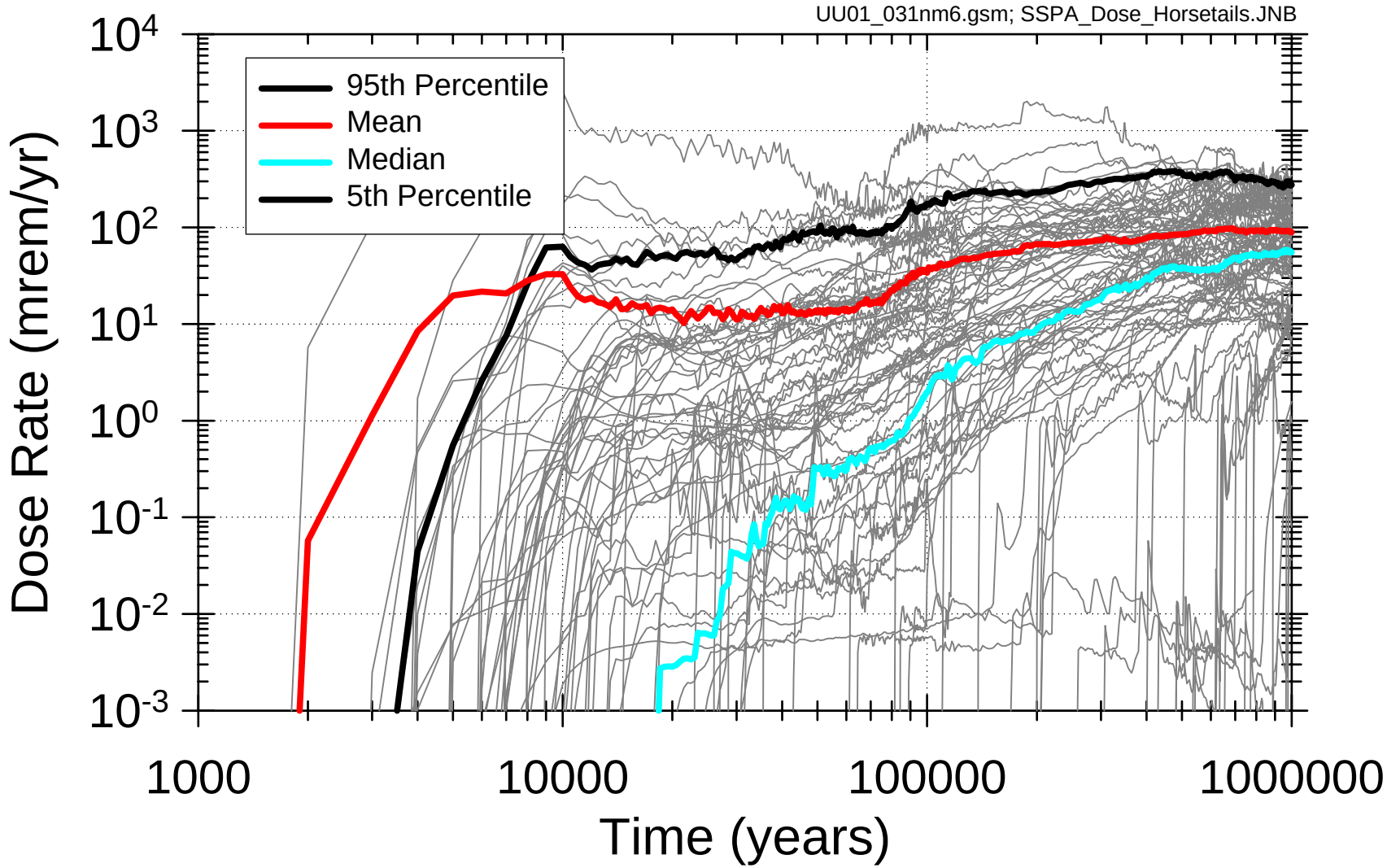
Preliminary

SSPA Model: WP Failure w/ Early Failures



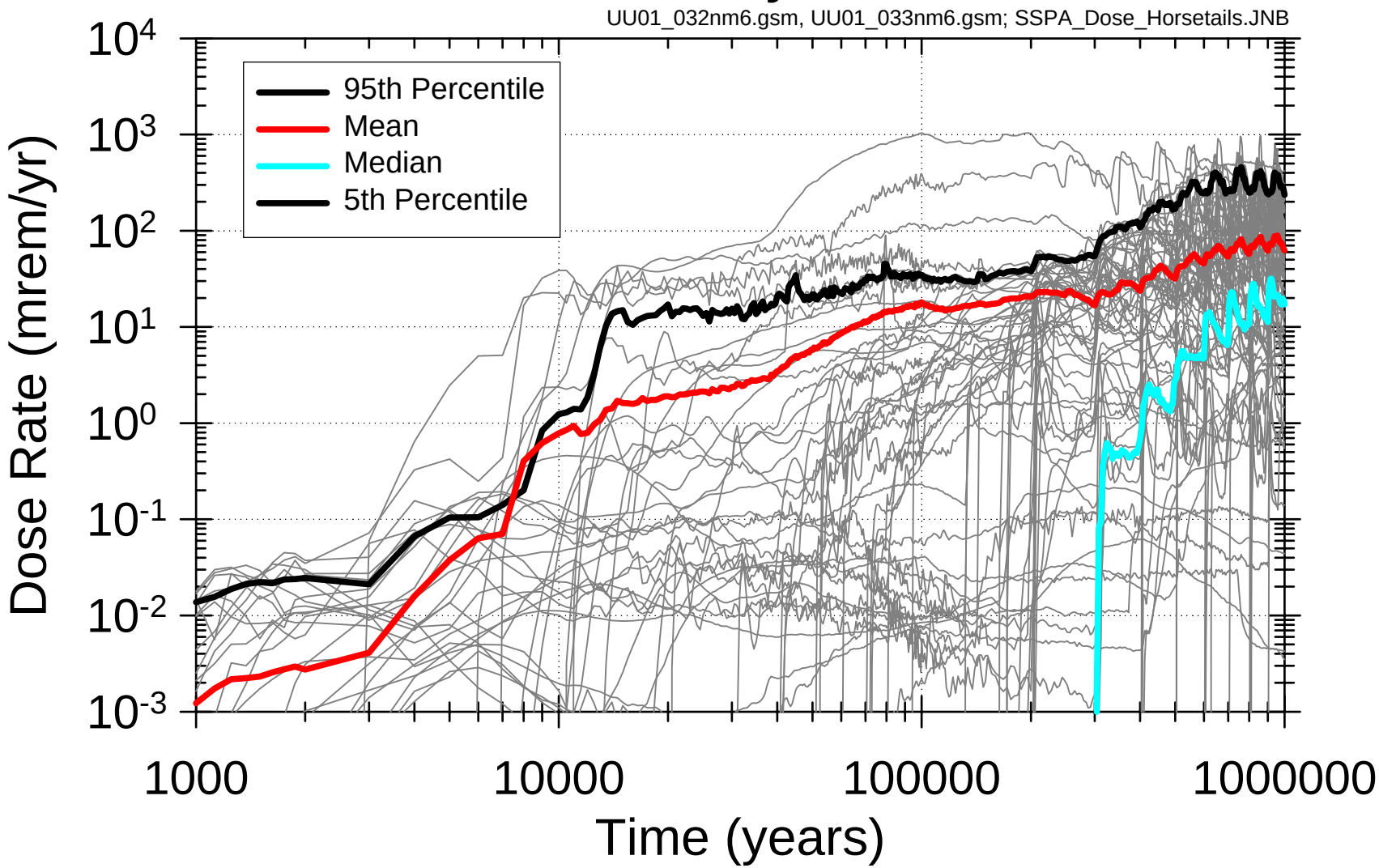
Preliminary

SSPA Model: WP Failures w/ No Outer Lid



Preliminary

SSPA Model: WP Failure w/ Early Failures & No Inner Lid



Poisson Probabilities for Improper Heat Treatment of Waste Packages

Number of Packages	Probability	Cumulative Probability
0	0.76896	0.76896
1	0.20202	0.97098
2	0.02654	0.99752
3	2.32392e-3	0.99984
4	1.52634e-4	0.99999
5	8.01996e-6	1.00000