SRR-CWDA-2021-00098
Revision 0

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TO: Kent Rosenberger, 705-1C
Larry Romanowski, 705-1C

FROM: Steven P. Hommel, 705-1C Steven Hommel Digitally signed by Steven Hommel Date: 2021.11.17 14:02:21 -05'00'

REVIEWED BY: Greg Flach, 705-1C GREGORY FLACH (Affiliate) Digitally signed by GREGORY FLACH (Affiliate) Date: 2021.11.17 14:04:30 -05'00'

SUBJECT: Supplemental Analysis of Screened RSI-1 Model Results

On November 9, 2021 U.S. Nuclear Regulatory Commission (NRC) technical staff sent email requesting a supplemental analysis of earlier modeling results. Specifically, they requested an additional analysis of modeling results described in *Evaluation of the Combined Uncertainties Associated with the Long-Term Performance of Saltstone Disposal Facility Flow Barriers* (SRR-CWDA-2021-00066). This report is related to the Saltstone Disposal Facility (SDF) Performance Assessment (PA) (SRR-CWDA-2019-00001).

The text of this emailed request is as follows:

The NRC staff requests additional data from the model runs that the DOE[a] already ran to respond to the NRC Request for Supplemental Information Comment-1 (RSI-1) for the NRC review of the DOE Saltstone Disposal Facility Performance Assessment.

The information is needed to support the review of near-field flow and transport.

This request does not need the DOE to perform any additional model runs or the DOE to perform any additional modeling.

In response to RSI-1, the DOE provided a revised probabilistic analysis with 1,000 realizations (SRR-CWDA-2021-00066). Additional information from that analysis is needed to understand the risk-significance of the barriers in the vadose zone transport model. Please provide the dose results and input sampled parameter values from a subset of those realizations with the following parameter value/ranges:

1. HFC[b]=2
2. Infiltration rate >1 in/yr
3. P-averaging term > 0

For the dose results, please provide statistics and color coding of the peak doses by key parameter (e.g., infiltration rate, roof composite barrier Ksat[c], p-Averaging term, Tc solubility, saltstone Ksat initial, effective diffusion coefficient).

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In addition, please provide the flow data (i.e., Excel files similar to what was provided with Section 4.4.2 of SRR-CWDA-2021-00066) from the above subset of realizations that also meet the following criteria:

1. One realization with relatively high infiltration (i.e., greater than 10 in/yr) and relatively high flow through saltstone grout
2. One realization with relatively high infiltration and relatively low flow through saltstone grout
3. One realization with relatively moderate infiltration (i.e., 5-10 in/yr) and relatively high flow through saltstone grout
4. One realization with relatively moderate infiltration and relatively low flow through saltstone grout
5. One realization with relatively low infiltration (i.e., 1-5 in/yr) and relatively high flow through saltstone grout
6. One realization with relatively low infiltration and relatively low flow through saltstone grout

Notes: (a) DOE = U.S. Department of Energy
(b) HFC = High Density Polyethylene (HDPE) Failure Condition
(c) Ksat = Saturated Hydraulic Conductivity

This memorandum has been prepared to present the requested supplemental analyses. As a prerequisite to understanding this memorandum, readers should be familiar with the SDF PA (SRR-CWDA-2019-00001) and should read related reports: SRR-CWDA-2021-00040, SRR-CWDA-2021-00056, and SRR-CWDA-2021-00066.

Requested Subset of Realizations

The requested supplemental analyses are limited to RSI-1 Model realizations that meet three criteria: (1) the High Density Polyethylene (HDPE) failure condition (HFC) sampled in the RSI-1 Model should the "partial failure" condition (HFC=2), (2) the peak infiltration rate should be greater than 1 in/yr, and (3) the p-averaging term (used to mathematically blend the material properties and intact and degraded materials) should be greater than zero. Of the 1,000 realizations from the RSI-1 Model, only 33 realizations meet all three conditions. Table 1 identifies this subset of realizations.

Note that limiting this analysis to only use realizations with the peak infiltration rates that are greater than 1 in/yr (with no technical basis for such screening) is going to give a sample set with preferentially high doses because it excludes any barriers or conditions that limit higher infiltration rates from occurring.

Table 1. RSI-1 Model Realizations that Meet the NRC Screening Criteria

Realization	Maximum Infiltration Rate (in/yr)	HDPE Failure Condition	p-Averaging Term
R#25	12.048	2	0.6488
R#30	5.3006	2	0.3870
R#33	6.5643	2	0.1373
R#74	12.945	2	0.7080
R#105	3.3895	2	0.1093
R#106	3.3276	2	0.3208
R#153	2.9773	2	0.6044
R#236	1.0202	2	0.5669
R#246	17.477	2	0.5030
R#325	8.539	2	0.2901
R#337	12.029	2	0.5997
R#351	3.0577	2	0.7333
R#356	3.2902	2	0.7695
R#410	1.2842	2	0.2133
R#425	17.14	2	0.2749
R#443	5.7809	2	0.1881
R#448	15.073	2	0.7974
R#466	3.1011	2	0.1193
R#520	2.5276	2	0.3955
R#546	1.1176	2	0.4574
R#548	2.363	2	0.9248
R#573	3.3135	2	0.0286
R#578	2.8373	2	0.3992
R#601	3.1079	2	0.0664
R#649	1.3491	2	0.5836
R#710	8.6397	2	0.6136
R#757	7.3438	2	0.4666
R#820	2.9616	2	0.0377
R#833	2.1293	2	0.3882
R#873	1.2221	2	0.5800
R#925	1.369	2	0.1652
R#930	1.6384	2	0.5636
R#977	2.0623	2	0.2201

Figure 1 shows peak doses to the MOP at the 100-meter boundary from these 33 realizations. As expected, this screening criteria yields dose results are generally considered higher than expected. As points of reference, the SDF PA showed the median of the peak doses was 3.1 mrem/yr within 10,000 years (SRR-CWDA-2019-00001) and the complete RSI-1 dataset (using all 1,000 realizations) showed the median of the peak doses was 11 mrem/yr within 10,000 years (SRR-CWDA-2021-00066).

Key Parameters

The email from the NRC technical staff requested "For the dose results, please provide statistics and color coding of the peak doses by key parameter (e.g., infiltration rate, roof composite barrier Ksat, p-Averaging term, Tc solubility, saltstone Ksat initial, effective diffusion coefficient)."

Figure 1 shows the peak doses from each of the 33 realizations. Figure 2 shows these same peak doses, but the values have been "color coded" based on the respective peak infiltration rates. Note that Appendix A shows the evolution of the infiltration rates over time. In Figure 2, the orange and red data points represent realizations with higher peak infiltration rates, yellow for intermediate peak infiltration rates, and blue and green for lower peak infiltration rates. As expected, most of the realizations with the highest peak infiltration rates had higher doses.

Figure 1. Peak Doses from RSI-1 Model Realizations that Meet the NRC Screening Criteria

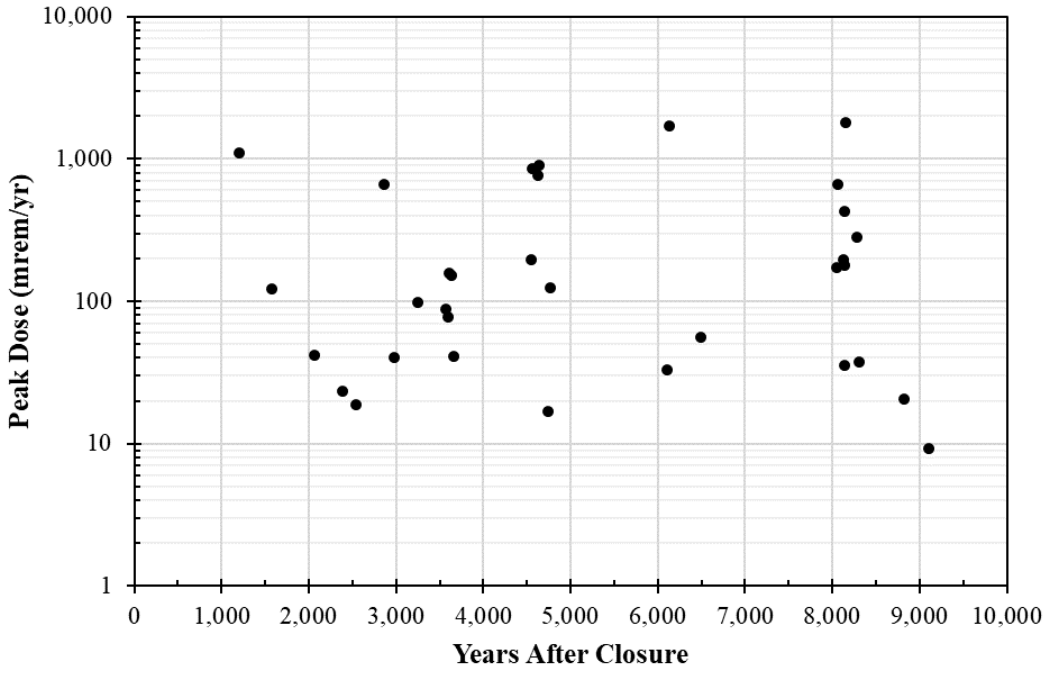
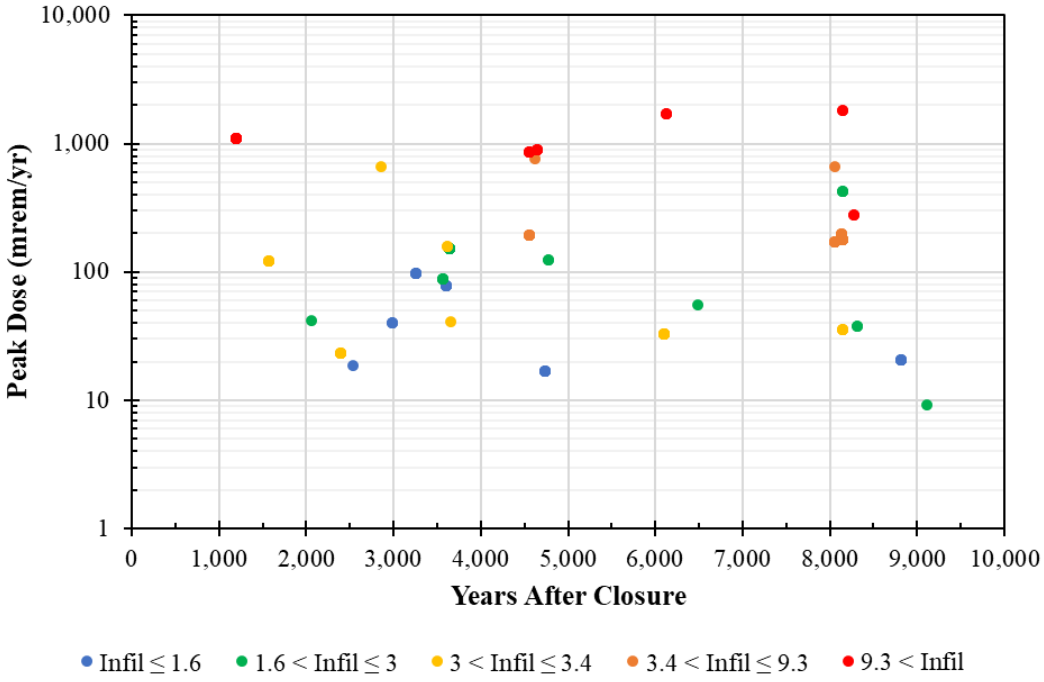


Figure 2. Peak Doses from RSI-1 Model Realizations that Meet the NRC Screening Criteria, Colored by Peak Infiltration Rates



Note: Values used for color-coding are units of in/yr.

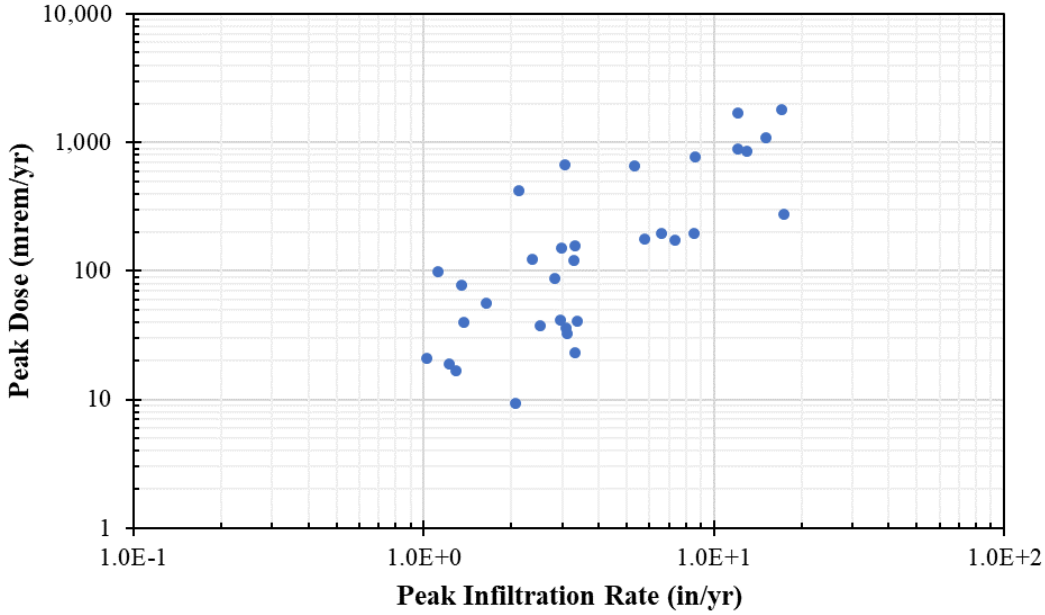
These values are quantified in Table 2. Statistics are also included at the bottom of the table.

Table 2. Peak Infiltration Rates and Peak Doses from RSI-1 Model Realizations that Meet the NRC Screening Criteria

Realization	Peak Infiltration Rate in 10,000 years (in/yr)	Year of Peak Dose	Peak Dose (mrem/yr)
25	12.0	6,130	1,712
30	5.3	8,060	663.1
33	6.6	4,550	194.5
74	12.9	4,560	852.9
105	3.4	3,660	40.9
106	3.3	2,390	23.3
153	3.0	3,640	150.8
236	1.0	8,820	20.7
246	17.5	8,280	279.5
325	8.5	8,130	196.8
337	12.0	4,640	898.5
351	3.1	2,860	668.3
356	3.3	1,570	121.4
410	1.3	4,740	16.8
425	17.1	8,150	1,801
443	5.8	8,140	178.7
448	15.1	1,200	1,098
466	3.1	8,140	35.8
520	2.5	8,310	37.5
546	1.1	3,250	98.0
548	2.4	4,770	124.0
573	3.3	3,610	157.6
578	2.8	3,570	88.3
601	3.1	6,100	32.8
649	1.3	3,600	78.2
710	8.6	4,620	769.6
757	7.3	8,050	173.2
820	3.0	2,060	41.9
833	2.1	8,140	425.5
873	1.2	2,540	18.8
925	1.4	2,980	40.3
930	1.6	6,490	56.0
977	2.1	9,110	9.3
Statistics			
Maximum	17.5	9110	1801
95th	17.2	8907	1738
75th	7.94	8135	544
Median	**3.11**	**4640**	**124**
25th	2.10	3410	38.9
5th	1.09	1459	14.5
Minimum	1.02	1200	9.29
Mean	**5.40**	**5299**	**336**

Figure 3 provides an alternative depiction of the relationship between the peak infiltration rates and the peak doses. Based on the distribution of data points in this figure, it appears that if infiltration rates through the SDF closure cap can be limited to less than 1 in/yr, the resulting peak doses would be unlikely to exceed 25 mrem/yr.

Figure 3. Peak Doses Versus Peak Infiltration Rates for Selected Realizations

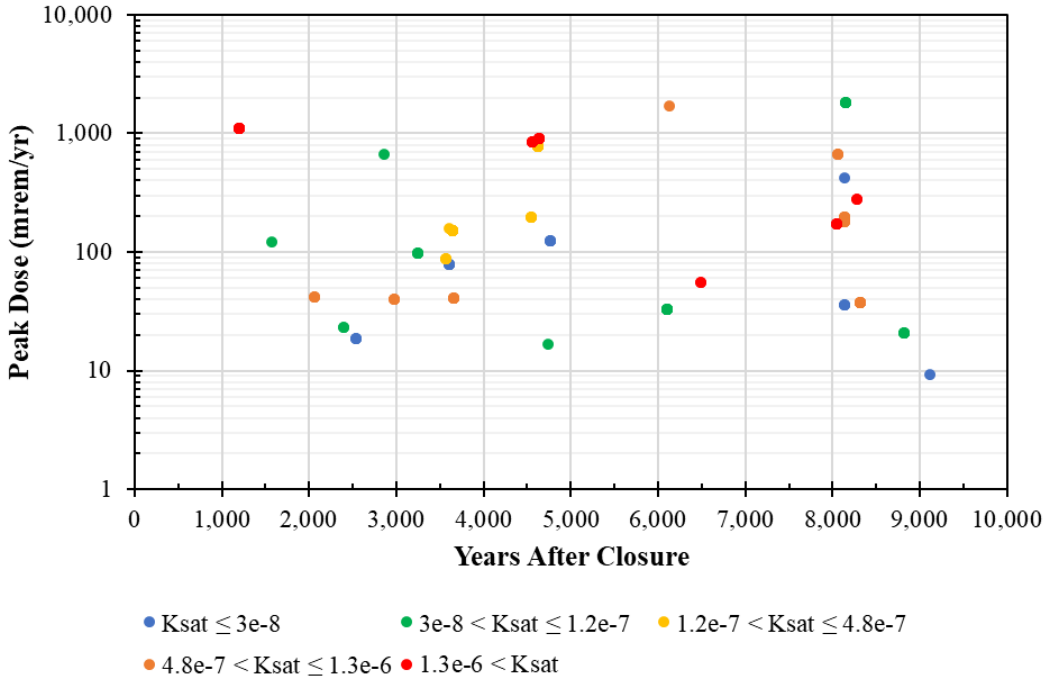


The composite barrier at the roofs of the Saltstone Disposal Units (SDUs) are made up of HDPE and a geosynthetic clay liner. As the HDPE within this composite barrier becomes partially failed, the applied HDPE-GCL Ksat value increases over time. Appendix B shows the evolution of the HDPE-GCL Ksat values for the selected realizations.

Figure 4 shows the same peak doses from Figure 1, but this time the values have been "color coded" based on the final HDPE-GCL Ksat values at 10,000 years. For Figure 4, the orange and red data points represent realizations with higher peak HDPE-GCL Ksat values, yellow for intermediate peak HDPE-GCL Ksat values, and blue and green for lower peak HDPE-GCL Ksat values.

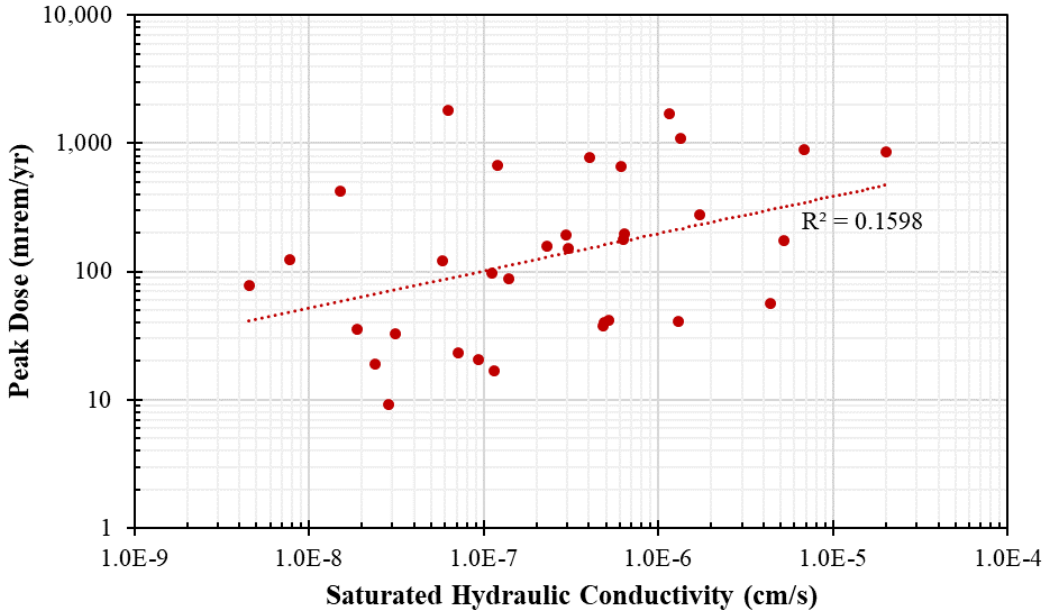
Figure 5 provides an alternative depiction of the relationship between the peak HDPE-GCL Ksat values and the peak doses. Although this relationship is not as strong as the infiltration-to-dose relationship (from Figure 3), there is still an observable positive correlation suggesting that higher Ksat values will result in higher doses.

Figure 4. Peak Doses from RSI-1 Model Realizations that Meet the NRC Screening Criteria, Colored by Peak HDPE-GCL Ksat Values



Note: Values used for color-coding are units of cm/s.

Figure 5. Peak Doses Versus Peak HDPE-GCL Ksat Values for Selected Realizations



Note: The correlation (R^2) value in this figure is based on a Power Law trendline.

Table 3 provides the initial and final (10,000-year) HDPE-GCL Ksat values for each realization and includes a statistical summary of the values.

Table 3. HDPE-GCL Ksat Values from RSI-1 Model Realizations that Meet the NRC Screening Criteria

Realization	Initial HDPE-GCL Ksat (cm/s)	Final HDPE-GCL Ksat (cm/s)	Ratio: Final/ Initial
25	7.92E-08	1.16E-06	14.6
30	1.57E-08	6.14E-07	39.1
33	1.49E-08	2.94E-07	19.7
74	1.50E-07	2.01E-05	134.3
105	2.30E-08	1.29E-06	56.1
106	6.08E-09	7.15E-08	11.8
153	8.47E-09	3.06E-07	36.2
236	5.35E-10	9.38E-08	175.3
246	7.15E-09	1.71E-06	239.2
325	9.79E-08	6.36E-07	6.5
337	4.27E-08	6.77E-06	158.8
351	1.75E-08	1.20E-07	6.8
356	9.57E-10	5.79E-08	60.5
410	1.21E-09	1.14E-07	94.4
425	2.57E-09	6.27E-08	24.4
443	1.82E-08	6.26E-07	34.4
448	6.29E-09	1.34E-06	213.7
466	8.80E-10	1.89E-08	21.5
520	4.97E-08	4.81E-07	9.7
546	3.81E-09	1.12E-07	29.4
548	4.77E-09	7.77E-09	1.6
573	8.63E-09	2.29E-07	26.6
578	2.53E-09	1.38E-07	54.7
601	5.30E-09	3.10E-08	5.8
649	3.04E-10	4.51E-09	14.8
710	5.49E-09	4.01E-07	73.0
757	9.46E-08	5.25E-06	55.5
820	1.60E-08	5.17E-07	32.4
833	1.86E-09	1.52E-08	8.2
873	3.17E-10	2.38E-08	75.2
925	6.57E-08	4.86E-07	7.4
930	3.77E-08	4.39E-06	116.6
977	4.50E-10	2.86E-08	63.5
Statistics			
Maximum	1.50E-07	2.01E-05	239.2
95th	1.13E-07	1.08E-05	221.3
75th	3.03E-08	8.96E-07	74.1
Median	**7.15E-09**	**2.94E-07**	**34.4**
25th	2.19E-09	6.03E-08	13.2
5th	3.13E-10	6.79E-09	4.6
Minimum	3.04E-10	4.51E-09	1.6
Mean	**2.39E-08**	**1.44E-06**	**58.2**

Next, the p-averaging term and the associated saltstone Ksat will be studied. Note that Appendix C shows the evolution of the saltstone Ksat values for the selected realizations.

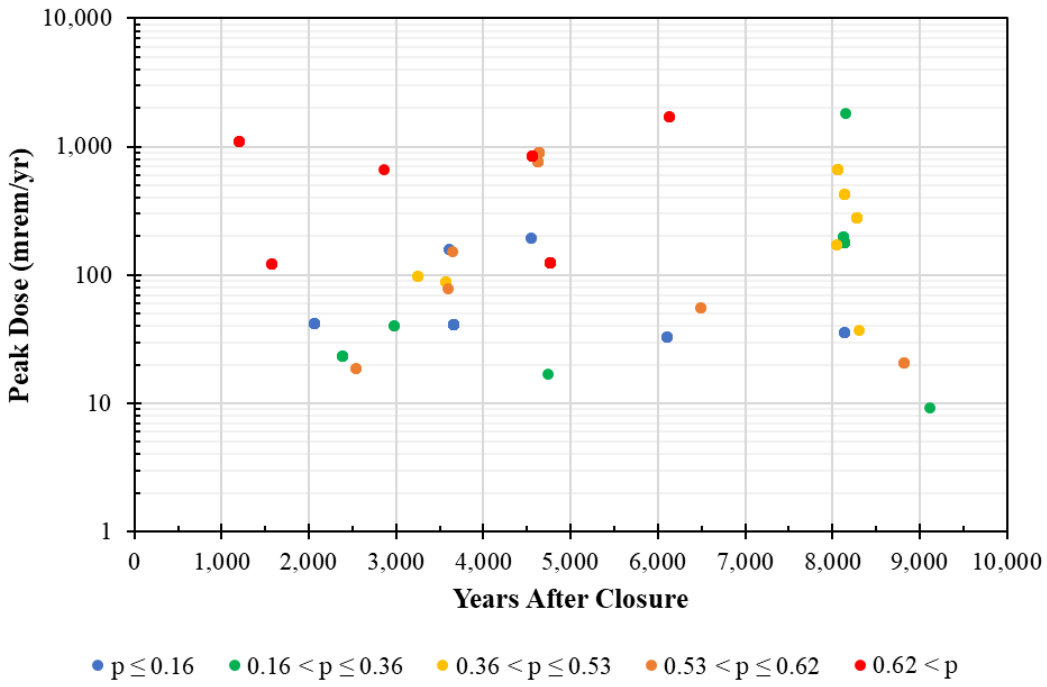
Figures 6 and 7 show the same peak doses from Figure 1, but this time the values have been "color coded" based on the p-averaging term (Figure 6) and the final saltstone Ksat values at 10,000 years

(Figure 7). For Figure 6, the orange and red data points represent realizations with higher p-averaging terms, yellow for intermediate p-averaging terms, and blue and green for lower p-averaging terms. For Figure 7, the orange and red data points represent realizations with higher peak saltstone Ksat values, yellow for intermediate peak saltstone Ksat values, and blue and green for lower peak HDPE-GCL Ksat values. Figure 6 shows that the p-averaging term appears to be somewhat more significant when peak doses occur early; this may be related to the influence that the p-averaging term has on the saltstone Ksat when accounting for the assumed initial cracking of saltstone.

Next, Figures 8 and 9 provide alternative depictions of the relationship between the p-averaging term and the peak doses (for Figure 8) and the between the final saltstone Ksat values and the peak doses (for Figure 8). Although these relationships are not as strong as the infiltration-to-dose relationship (from Figure 3), there is still an observable positive correlation suggesting that higher p-averaging terms and higher Ksat values will result in higher doses.

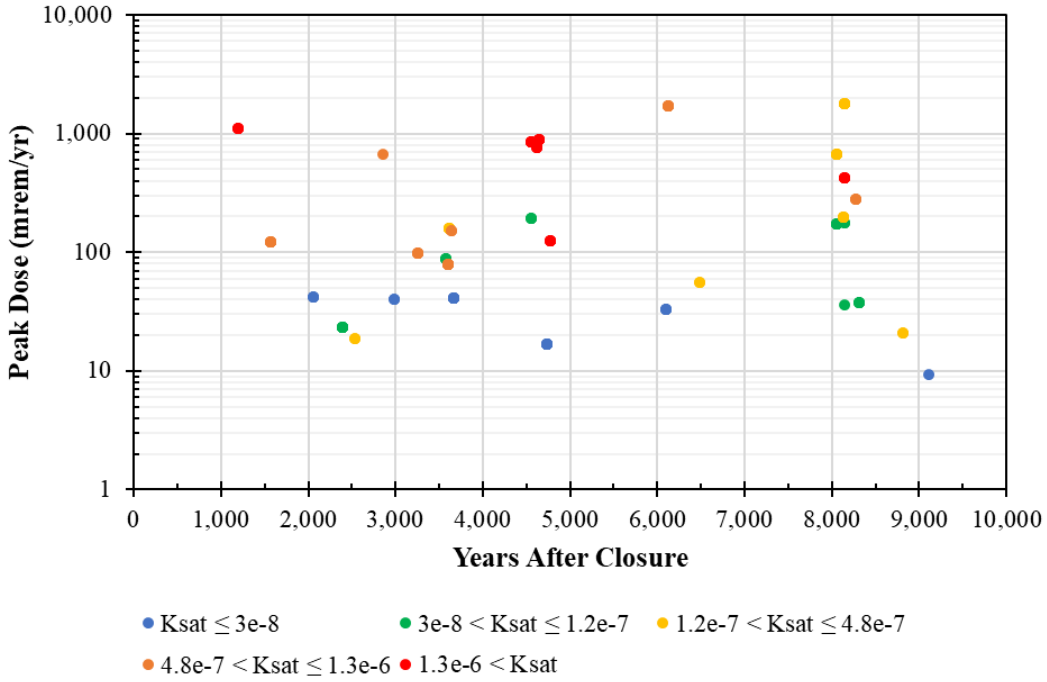
The relationship between the p-averaging term and the peak doses (Figure 8) appears to be less significant than the previous parameters discussed. However, Figure 10 has been included to show that while the p-averaging term may not be strongly related to dose, it is strongly related to the final saltstone Ksat, which does have a stronger influence on dose as depicted in Figure 9.

Figure 6. Peak Doses from RSI-1 Model Realizations that Meet the NRC Screening Criteria, Colored by p-Averaging Term



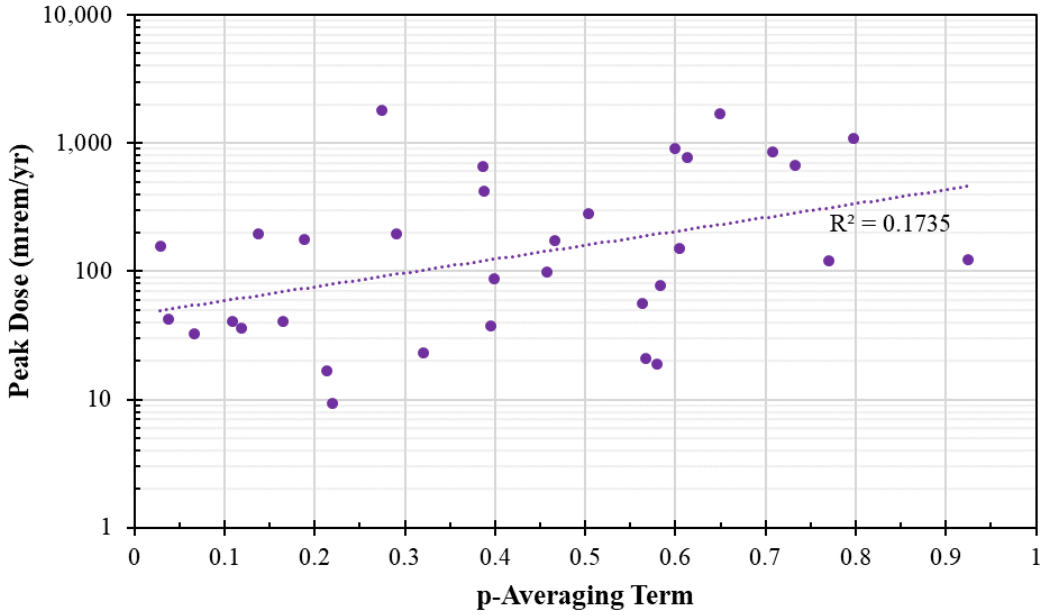
Note: Values used for color-coding are unitless.

Figure 7. Peak Doses from RSI-1 Model Realizations that Meet the NRC Screening Criteria, Colored by Peak Saltstone Ksat Values



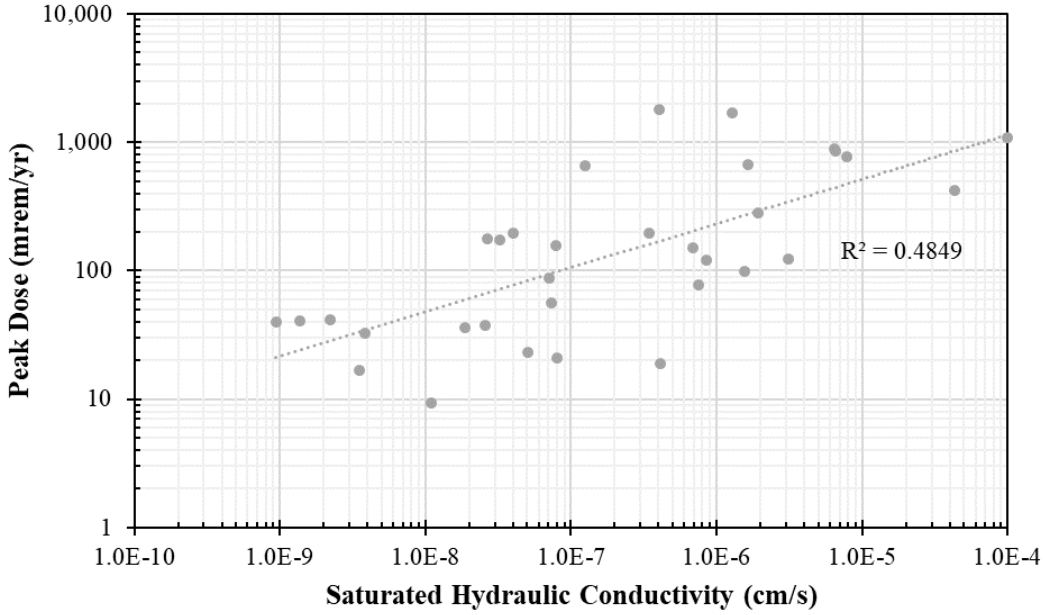
Note: Values used for color-coding are units of cm/s.

Figure 8. Peak Doses Versus p-Averaging Terms for Selected Realizations



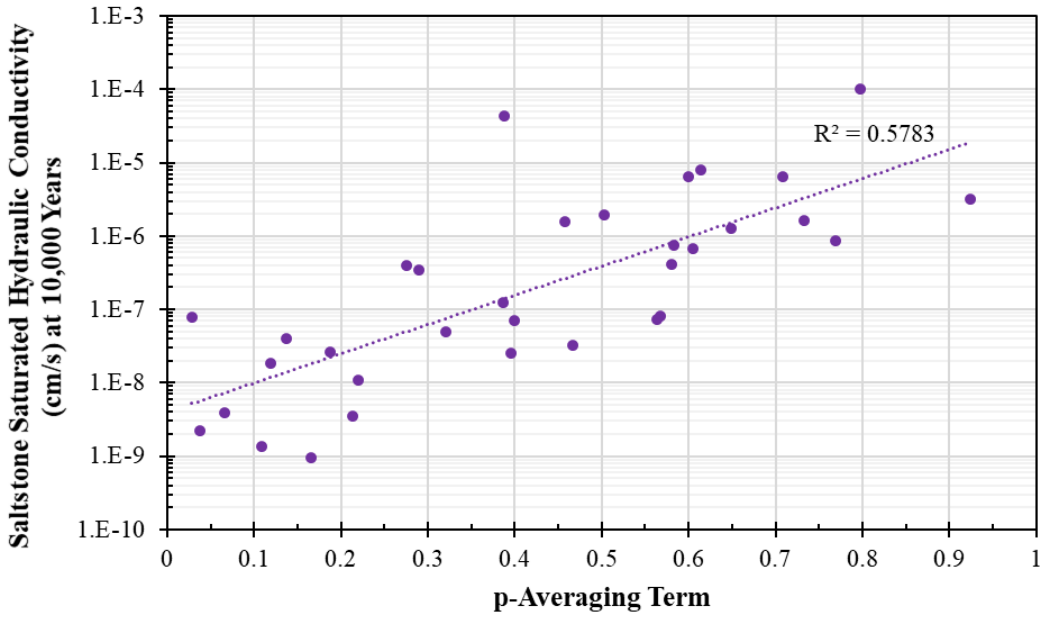
Note: The correlation (R^2) value in this figure is based on an Exponential trendline.

Figure 9. Peak Doses Versus Peak Saltstone Ksat Values for Selected Realizations



Note: The correlation (R^2) value in this figure is based on a Power Law trendline.

Figure 10. Peak Saltstone Ksat Values Versus p-Averaging Terms for Selected Realizations



Note: The correlation (R^2) value in this figure is based on an Exponential trendline.

Table 4 provides the initial and final (10,000-year) saltstone Ksat values for each realization and includes a statistical summary of the values.

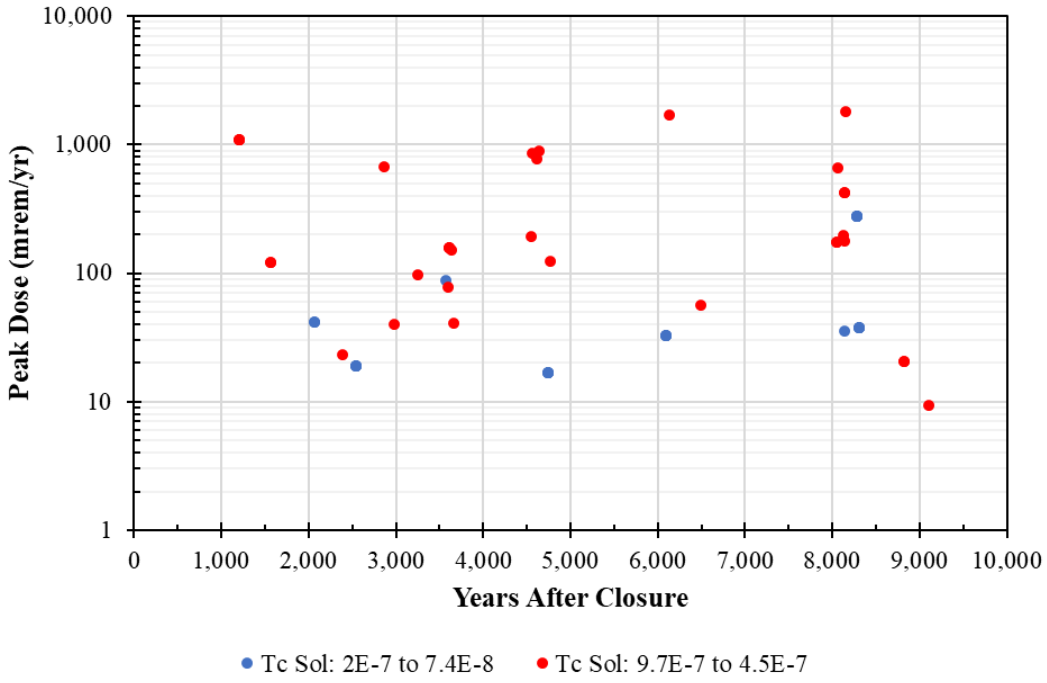
Table 4. Saltstone Ksat Values from RSI-1 Model Realizations that Meet the NRC Screening Criteria

Realization	Initial Saltstone Ksat (cm/s) (no initial cracks)	Initial Saltstone Ksat (cm/s) (with initial cracks)	Final Saltstone Ksat (cm/s)	Ratio: Final/ Initial (no cracks)	p-Averaging Term
25	1.5E-10	2.1E-09	1.3E-06	8,811	0.649
30	3.9E-10	4.2E-09	1.2E-07	319	0.387
33	1.1E-08	1.5E-08	4.0E-08	3.53	0.137
74	2.7E-10	1.5E-07	6.5E-06	24,053	0.708
105	7.6E-11	8.3E-11	1.4E-09	18.0	0.109
106	7.2E-11	2.6E-10	5.0E-08	698	0.321
153	3.3E-10	7.8E-09	6.8E-07	2,052	0.604
236	1.4E-10	1.5E-08	8.0E-08	563	0.567
246	4.9E-10	3.9E-09	1.9E-06	3,942	0.503
325	4.6E-11	1.6E-10	3.4E-07	7,493	0.290
337	1.8E-09	1.2E-08	6.5E-06	3,616	0.600
351	7.4E-11	8.3E-08	1.7E-06	22,274	0.733
356	9.5E-11	2.5E-07	8.5E-07	8,974	0.770
410	9.4E-10	1.5E-09	3.5E-09	3.77	0.213
425	1.6E-11	3.8E-11	4.0E-07	25,693	0.275
443	6.2E-10	7.9E-10	2.7E-08	42.8	0.188
448	1.1E-09	4.0E-07	1.0E-04	92,212	0.797
466	8.8E-10	1.2E-09	1.9E-08	21.2	0.119
520	3.2E-10	6.0E-10	2.6E-08	80.9	0.395
546	4.3E-10	3.5E-09	1.6E-06	3,611	0.457
548	6.9E-10	4.5E-07	3.1E-06	4,578	0.925
573	2.1E-08	2.4E-08	7.9E-08	3.72	0.029
578	1.6E-09	8.4E-09	7.1E-08	43.1	0.399
601	1.9E-09	2.3E-09	3.9E-09	2.01	0.066
649	2.7E-10	2.7E-09	7.6E-07	2,780	0.584
710	5.8E-10	1.8E-08	7.9E-06	13,510	0.614
757	1.6E-10	8.4E-09	3.3E-08	210	0.467
820	4.3E-10	4.6E-10	2.2E-09	5.12	0.038
833	2.9E-09	7.2E-09	4.3E-05	15,187	0.388
873	1.3E-08	3.2E-08	4.1E-07	31.7	0.580
925	2.6E-10	3.4E-10	9.4E-10	3.58	0.165
930	1.8E-10	3.4E-09	7.3E-08	416	0.564
977	3.8E-11	7.5E-11	1.1E-08	285	0.220
Statistics					
Maximum	2.13E-08	4.47E-07	9.96E-05	92,212	0.925
95th	1.55E-08	4.17E-07	6.03E-05	45,649	0.836
75th	1.01E-09	1.62E-08	1.60E-06	8,152	0.602
Median	**3.89E-10**	**3.92E-09**	**1.24E-07**	**563**	**0.399**
25th	1.44E-10	6.94E-10	2.61E-08	26.4	0.201
5th	3.15E-11	6.43E-11	1.23E-09	3.07	0.035
Minimum	1.56E-11	3.83E-11	9.37E-10	2.01	0.029
Mean	**1.90E-09**	**4.56E-08**	**5.38E-06**	**7,319**	**0.420**

Figure 11 shows the same peak doses from Figure 1, but this time the values have been "color coded" based on the sampled technetium (Tc) solubility. In the SDF PA, Tc solubility was sampled

between two conditions: either using 2.0E-07 mol/L that transitions to 7.4E-08 mol/L or 9.7E-07 mol/L that transitions to 4.5E-07 mol/L. For Figure 11, the first condition is shown with blue data points and the second condition is shown with red data points. As would be expected, higher solubility limits generally lead to higher doses.

Figure 11. Peak Doses from RSI-1 Model Realizations that Meet the NRC Screening Criteria, Colored by Tc Solubility Condition



Note: Values used for color-coding are units of mol/L.

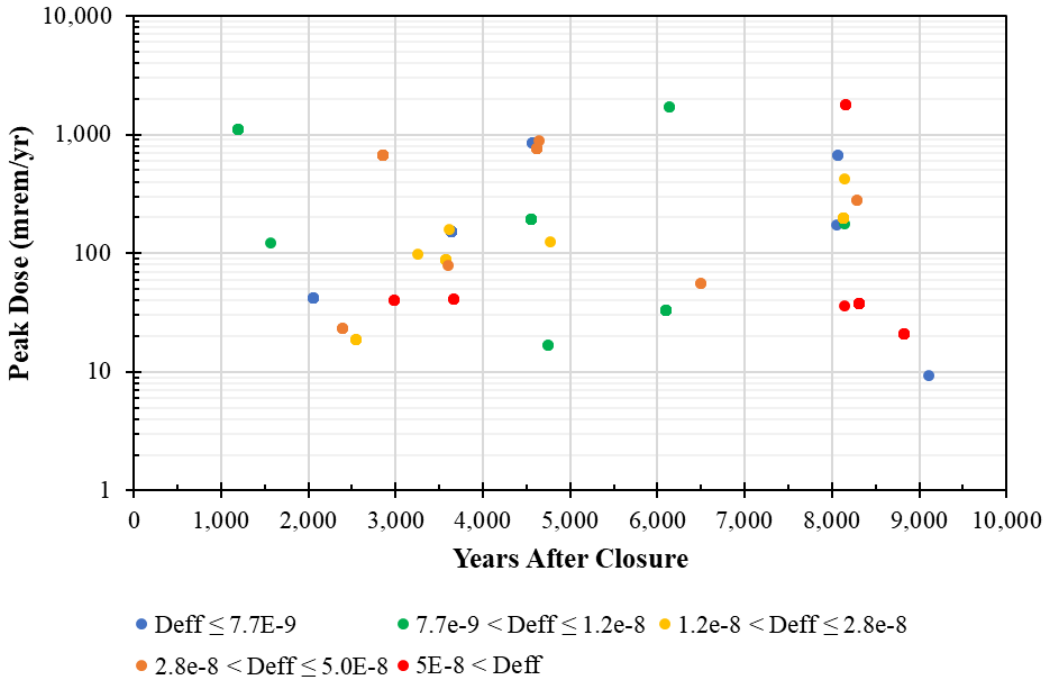
Next, the NRC requested that the effective diffusion coefficient (Deff) be included as one of the parameters of interest. Figure 12 shows the color-coded Deff versus dose comparison, but there is no observable relationship. For Figure 12, the orange and red data points represent realizations with higher Deff values, yellow for intermediate Deff values, and blue and green for lower Deff values. It is postulated that there is no relationship because under these higher infiltration rates, advective decalcification drove saltstone degradation much more than the diffusive decalcification (see figures in Appendix C).

Finally, while not explicitly requested in the email from the NRC technical staff, Figure 13 shows the same peak doses from Figure 1, but this time the values have been "color coded" based on the sampled sand degradation durations (i.e., the amount of time it takes for the silting in process to occur). For Figure 13, the orange and red data points represent realizations with longer sand degradation durations, yellow for intermediate durations, and blue and green for shorter sand degradation durations. In this figure, the magnitude of the peak doses does not appear to have a significant relationship with the sand degradation durations, but the timing of the peak doses does.

Figure 14 provides an alternative depiction of the relationship between the sand degradation durations and the timing of the peak doses. Based on the distribution of data points in this figure,

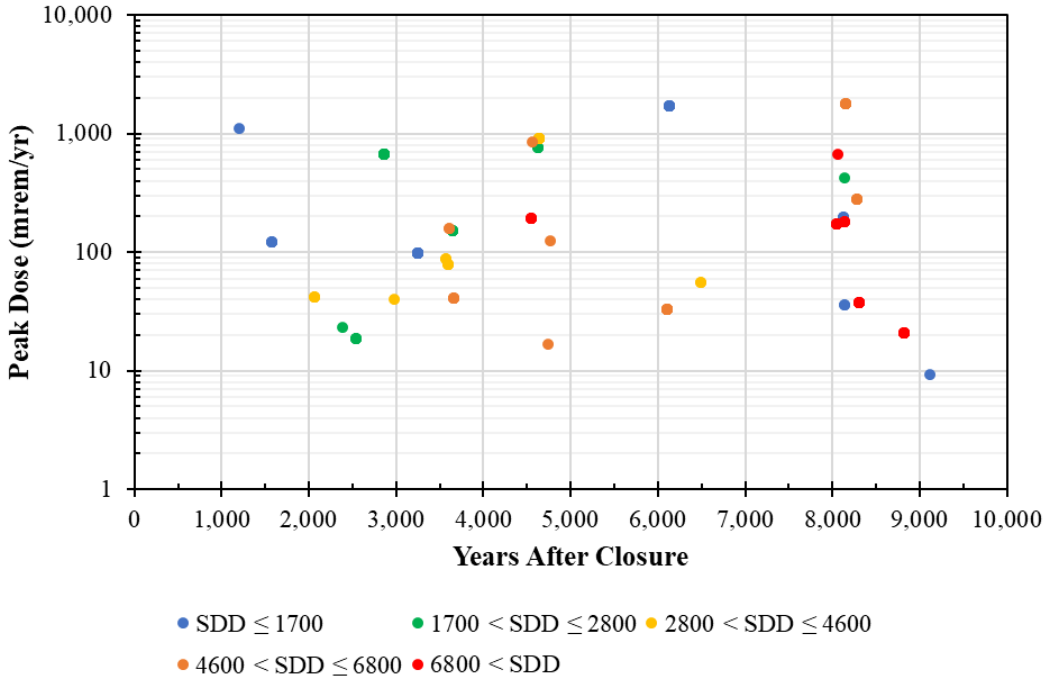
it appears that the timing of the peak doses is closely related to the timing of the sand degradation duration. This suggest that if the silting-in process can be prevented or mitigated, it may delay the timing of the peak doses.

Figure 12. Peak Doses from RSI-1 Model Realizations that Meet the NRC Screening Criteria, Colored by Effective Diffusion Coefficient



Note: Values used for color-coding are units of cm^2/s.

Figure 13. Peak Doses from RSI-1 Model Realizations that Meet the NRC Screening Criteria, Colored by Sand Degradation Duration



Note: SDD = Sand Degradation Duration. Values used for color-coding are units of years.

Figure 14. Peak Doses Versus Peak Saltstone Ksat Values for Selected Realizations

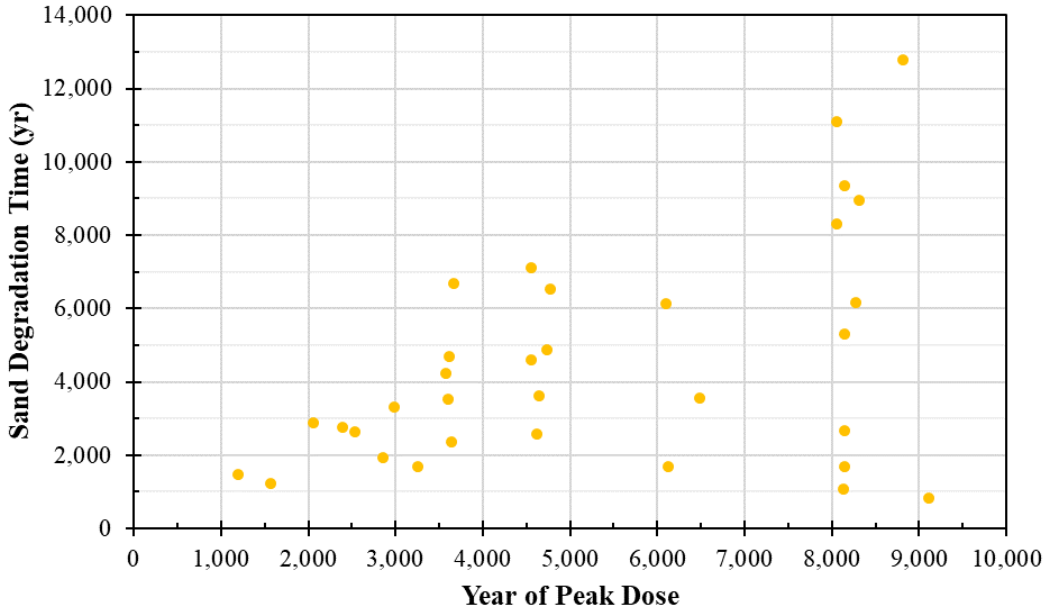


Table 5 provides additional values for selected parameters from each realization and includes a statistical summary of the values.

Table 5. Other Selected Parameter Values from RSI-1 Model Realizations that Meet the NRC Screening Criteria

Realization	Tc Solubility [a]	Effective Diffusion Coefficient (cm^2/s)	Sand Degradation Duration (Years)
25	High	7.8E-09	1,684
30	High	5.4E-09	8,312
33	High	9.9E-09	7,099
74	High	5.9E-09	4,606
105	High	1.3E-07	6,675
106	High	3.5E-08	2,755
153	High	7.1E-09	2,362
236	High	6.8E-08	12,800
246	Low	3.4E-08	6,164
325	High	1.9E-08	1,077
337	High	3.6E-08	3,634
351	High	4.9E-08	1,949
356	High	8.0E-09	1,237
410	Low	8.4E-09	4,868
425	High	7.5E-08	5,317
443	High	7.9E-09	9,353
448	High	1.1E-08	1,467
466	Low	5.3E-08	1,699
520	Low	5.5E-08	8,942
546	High	1.3E-08	1,680
548	High	2.1E-08	6,519
573	High	2.0E-08	4,700
578	Low	1.8E-08	4,218
601	Low	9.0E-09	6,132
649	High	3.4E-08	3,523
710	High	4.4E-08	2,592
757	High	5.3E-09	11,100
820	Low	3.4E-09	2,870
833	High	2.4E-08	2,664
873	Low	1.3E-08	2,634
925	High	1.4E-07	3,318
930	High	3.4E-08	3,568
977	High	3.0E-09	833
Statistics			
Maximum	Not Applicable	1.4E-07	12,800
95th	Not Applicable	1.3E-07	11,610
75th	Not Applicable	4.0E-08	6,341
Median	Not Applicable	**1.9E-08**	**3,568**
25th	Not Applicable	7.9E-09	2,155
5th	Not Applicable	3.3E-09	1,004
Minimum	Not Applicable	3.0E-09	833
Mean	Not Applicable	**3.0E-08**	**4,496**

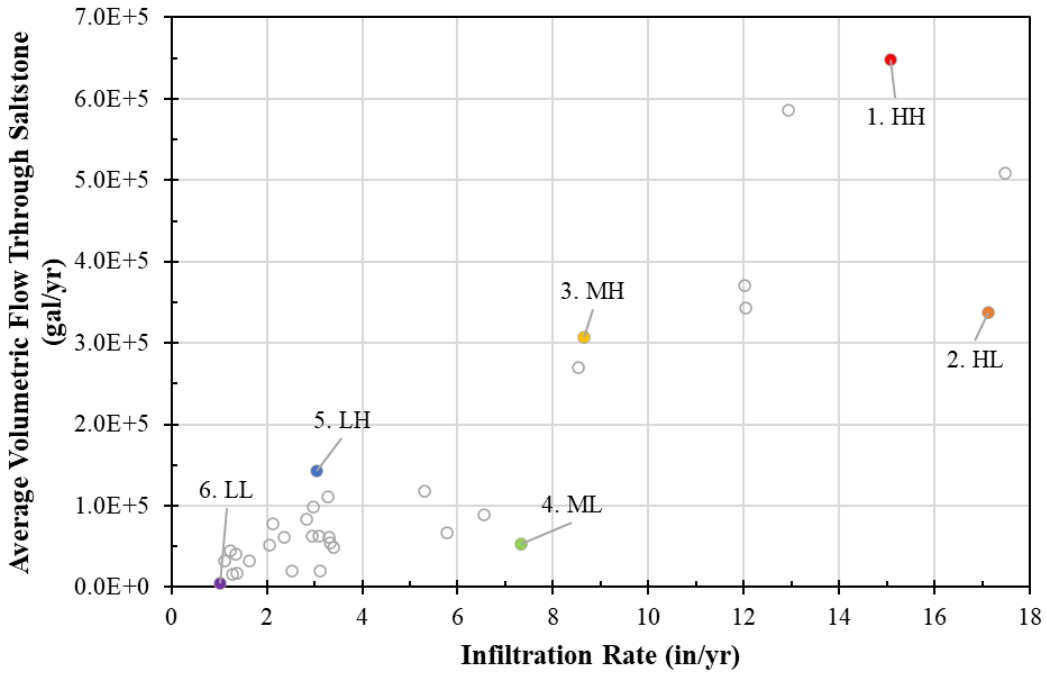
Notes: (a) For Tc solubility: Low = 2.0E-07 mol/L → 7.4E-08 mol/L; High = 9.7E-07 mol/L → 4.5E-07 mol/L.

Selection of Flow Data Files

The email from the NRC technical staff requested "please provide the flow data (i.e., Excel files similar to what was provided with Section 4.4.2 of SRR-CWDA-2021-00066) from the above subset of realizations" that meet additional criteria. The flow data files will be transmitted as requested along with this memorandum.

Because all of the realizations from the subset (Table 1) had infiltration rates of 1 in/yr or greater, and because the infiltration rates affect saltstone degradation (via advective decalcification) as well as saltstone flow, there was a very strong correlation between the infiltration rate and the saltstone flow rate, as shown in Figure 15. The NRC email specified the criteria for the infiltration rates, where an infiltration rate of 1 in/yr to 5 in/yr was "Low", 5 in/yr to 10 in/yr was "Moderate", and greater than 10 in/yr was high. After organizing the realizations by this infiltration criteria, the realizations with the highest and lowest saltstone flows within each of these subsets was then selected to fulfill the desired criteria.

Figure 15. Peak Doses Versus Peak Saltstone Ksat Values for Selected Realizations



1. HH = High Infiltration, High Saltstone Flow (Realization 448)
2. HL = High Infiltration, Low Flow (Realization 425)
3. MH = Moderate Infiltration, High Flow (Realization 710)
4. ML = Moderate Infiltration, Low Flow (Realization 757)
5. LH = Low Infiltration, High Flow (Realization 351)
6. LL = Low Infiltration, Low Flow (Realization 236)

The realizations that were selected for the development of these flow field files are as follows:

1. **Realization 448** = One realization with relatively high infiltration (i.e., greater than 10 in/yr) and relatively high flow through saltstone grout

- Peak infiltration rate = 15.1 in/yr
- Average volumetric flow rate through saltstone grout = 6.5E+05 gal/yr
- Peak dose to the MOP = 1,098 mrem/yr

2. **Realization 425** = One realization with relatively high infiltration and relatively low flow through saltstone grout

   - Peak infiltration rate = 17.1 in/yr
   - Average volumetric flow rate through saltstone grout = 3.4E+05 gal/yr
   - Peak dose to the MOP = 1,801 mrem/yr

3. **Realization 710** = One realization with relatively moderate infiltration (i.e., 5-10 in/yr) and relatively high flow through saltstone grout

   - Peak infiltration rate = 8.6 in/yr
   - Average volumetric flow rate through saltstone grout = 3.1E+05 gal/yr
   - Peak dose to the MOP = 770 mrem/yr

4. **Realization 757** = One realization with relatively moderate infiltration and relatively low flow through saltstone grout

   - Peak infiltration rate = 7.3 in/yr
   - Average volumetric flow rate through saltstone grout = 5.3E+04 gal/yr
   - Peak dose to the MOP = 173 mrem/yr

5. **Realization 351** = One realization with relatively low infiltration (i.e., 1-5 in/yr) and relatively high flow through saltstone grout

   - Peak infiltration rate = 3.1 in/yr
   - Average volumetric flow rate through saltstone grout = 1.4E+05 gal/yr
   - Peak dose to the MOP = 668 mrem/yr

6. **Realization 236** = One realization with relatively low infiltration and relatively low flow through saltstone grout

   - Peak infiltration rate = 1.0 in/yr
   - Average volumetric flow rate through saltstone grout = 4.7E+03 gal/yr
   - Peak dose to the MOP = 21 mrem/yr

For each of these six realizations, 4 files were generated for transmittal to the NRC:

- *FlowDetail_SDU9_CaseP0XXX.tab*
  - Tab-delimited file generated from PORFLOW output providing flow data for modeled zones
- *FlowDetail_SDU9_CaseP0XXX.xlsx*

  - Excel file created from *FlowDetail_SDU9_CaseP0XXX.tab* to organize the flow data and to present it at 100 years, 1,000 years, and 10,000 years along with infiltration modeling results

- *GoldSim_SDU9_CaseP0XXX.tab*
  - Tab-delimited file generated from PORFLOW output that was used as the flow field input for RSI-1 GoldSim modeling

- *Excel_SDU9_CaseP0XXX.xlsx*
  - Excel file created from *GoldSim_SDU9_CaseP0XXX.tab* to present Darcy velocity, flow rate, and saturation data for modeled materials

where *XXX* is used to identify the six selected realizations: *236*, *351*, *425*, *448*, *710*, and *757*.

Per Appendix D, the SRS Classification Office has previously reviewed modeling files supporting tank closure Performance Assessments and determined that

> "Updates to the GoldSim and PORFLOW modeling files and programs, used for the calculations described above, do not require further review by the Classification Office. This also applies to modeling data for other waste tanks as we move through the decommissioning and closure process."

and advised the SRR Waste Disposal Authority to

> "generate a Request for Information Review and Release and attach this email when updates or new tanks are modeled and require submission to the regulators."

This memorandum serves as a unique identifier for the associated electronic files assembled for transmission to the NRC for a Request for Information Review & Release (ROI).

References

SRR-CWDA-2019-00001, *Performance Assessment for the Saltstone Disposal Facility at the Savannah River Site*, Savannah River Remediation, Aiken, SC, Rev. 0, March 2020.

SRR-CWDA-2021-00040, Hommel, S.P., *Evaluation of the Uncertainties Associated with the SDF Closure Cap and Long-Term Infiltration Rates, Savannah River Site*, Aiken, SC, Rev. 0, June 2021.

SRR-CWDA-2021-00056, Hommel, S.P., *Evaluation of the Uncertainties Associated with Long-Term SDF Saltstone Degradation*, Savannah River Site, Aiken, SC, Rev. 0, July 2021.

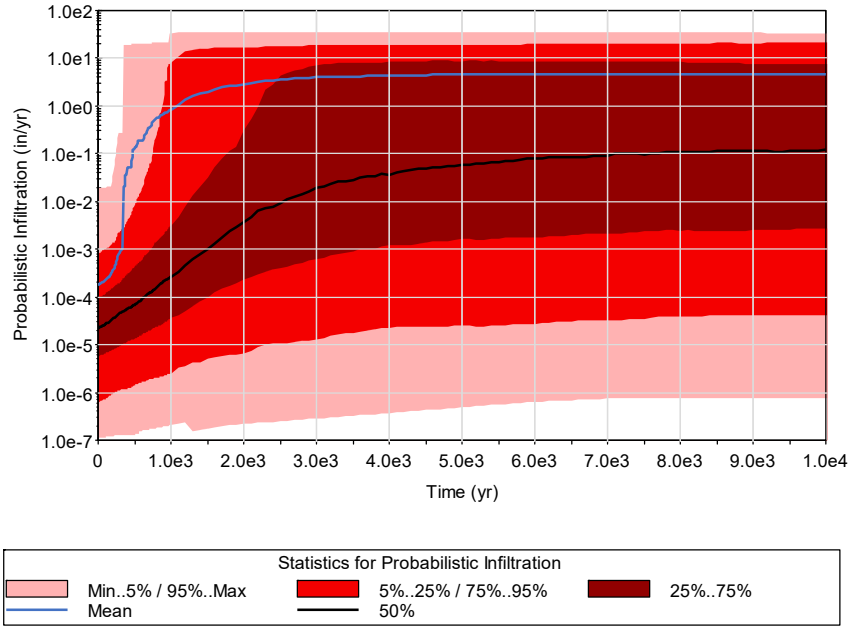
SRR-CWDA-2021-00066, Hommel, S.P., *Evaluation of the Combined Uncertainties Associated with the Long-Term Performance of Saltstone Disposal Facility Flow Barriers*, Savannah River Site, Aiken, SC, Rev. 0, August 2021.

Appendix A. Infiltration Curves

The following figures show the infiltration rates that correspond to each of the RSI-1 model realizations. These curves come from the probabilistic saltstone degradation model: *Probabilistic_SaltstoneDeg_Model_v1.001.gsm*, which was described in *Evaluation of the Uncertainties Associated with Long-Term Saltstone Degradation* (SRR-CWDA-2021-00056). These infiltration curves were used to develop the RSI-1 model realizations. The selected model results correspond to the realizations from Table 1.

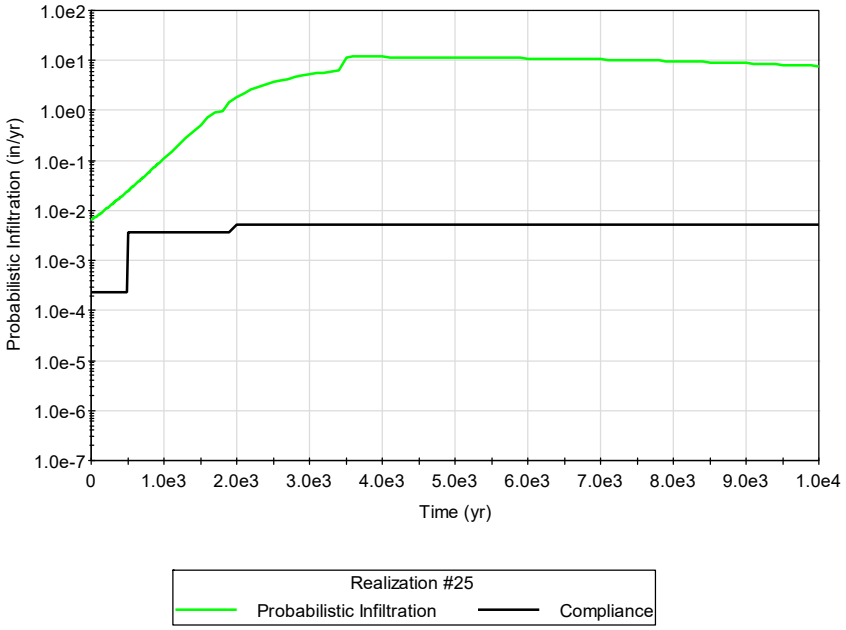
For context, the first figure shows the probabilities from using all 1,000 RSI-1 model realizations (i.e., the realizations depicted in this figure have not been screened). This figure shows that the median infiltration rate starts at approximately 2.4E-05 in/yr, then increases by nearly four orders of magnitude to approximately 0.12 in/yr over a 10,000-year period. The relatively large difference between the mean curve (blue) and the median curve (black) indicates that the mean curve is not representative of the central tendency of the infiltration rates. This is because a relatively small number of realizations had extremely high infiltration rates that drove up the mean.

Infiltration Rate Probabilities:

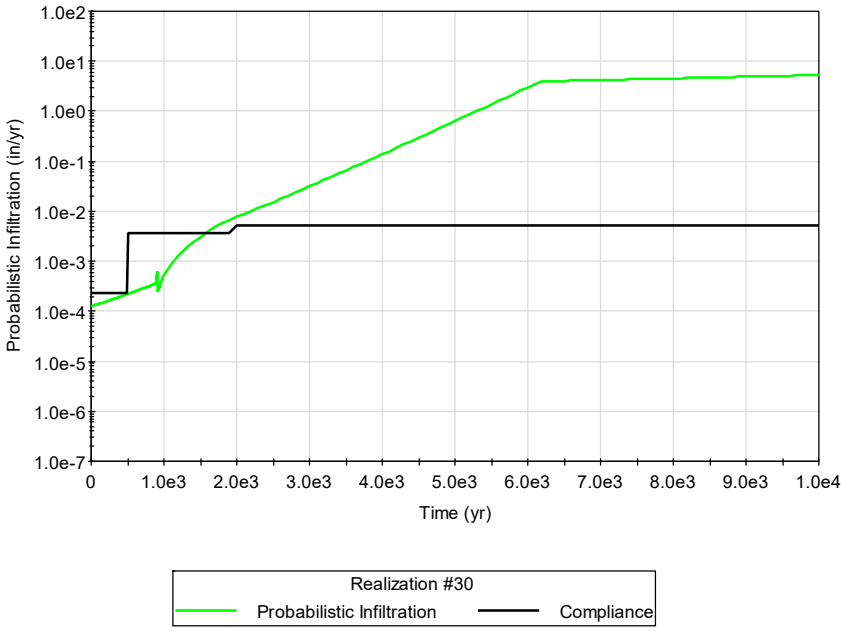


Each of the following infiltration rate figures shows two curves: the green curve represents the model result based on sampled infiltration rate parameters while the black curve is included for context, showing the infiltration rate used in the SDF PA Compliance Case (SRR-CWDA-2019-00001). Each of these realizations were selected because they had peak infiltration rates that were greater than 1 in/yr.

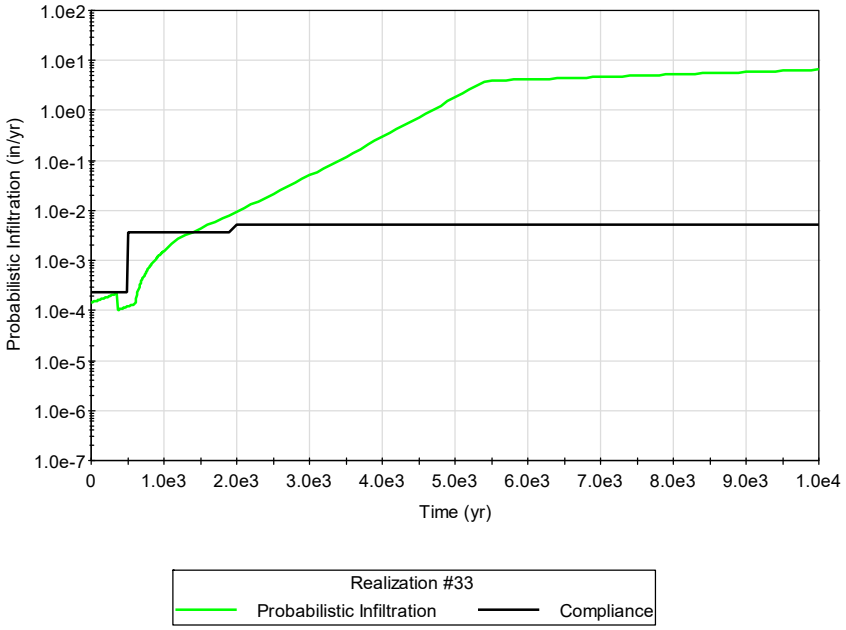
Realization 25 Infiltration Rate:



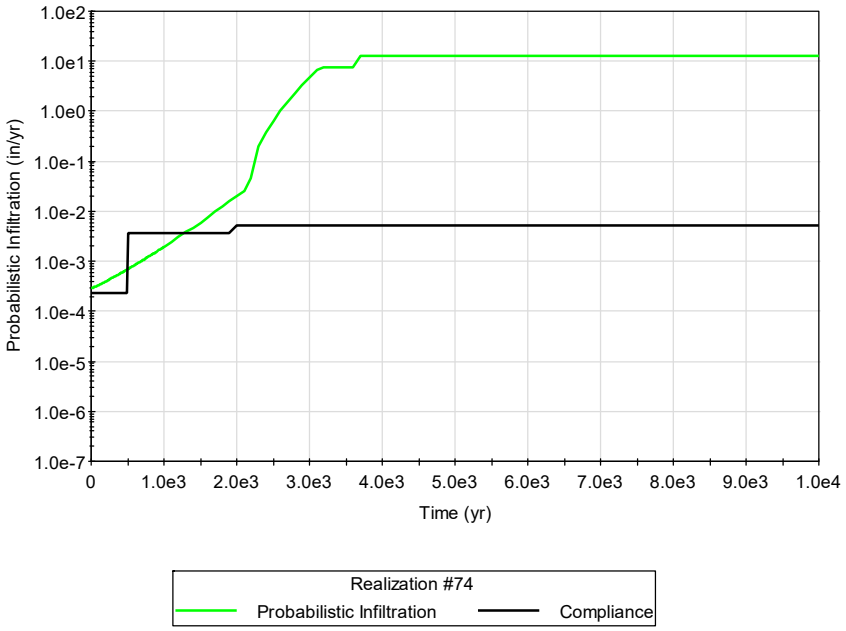
Realization 30 Infiltration Rate:



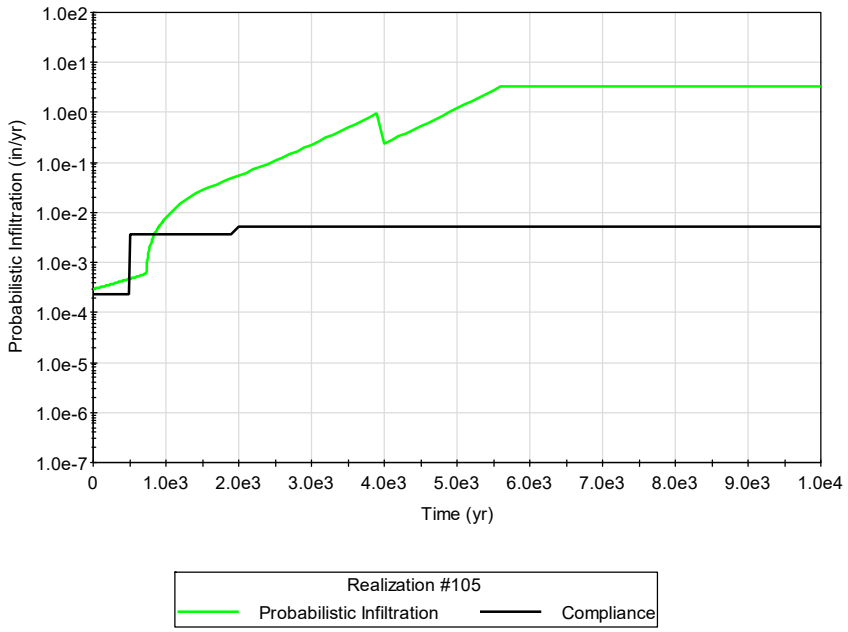
Realization 33 Infiltration Rate:



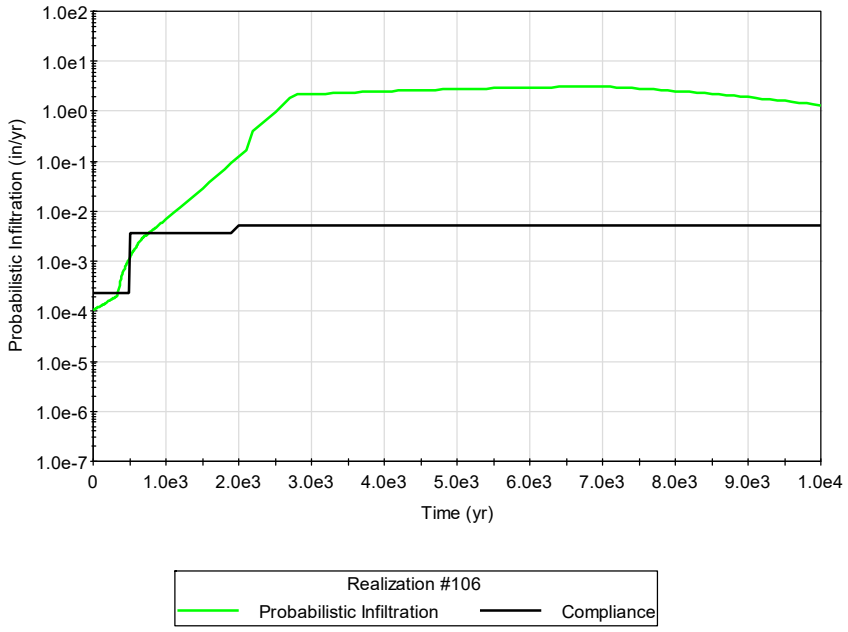
Realization 74 Infiltration Rate:



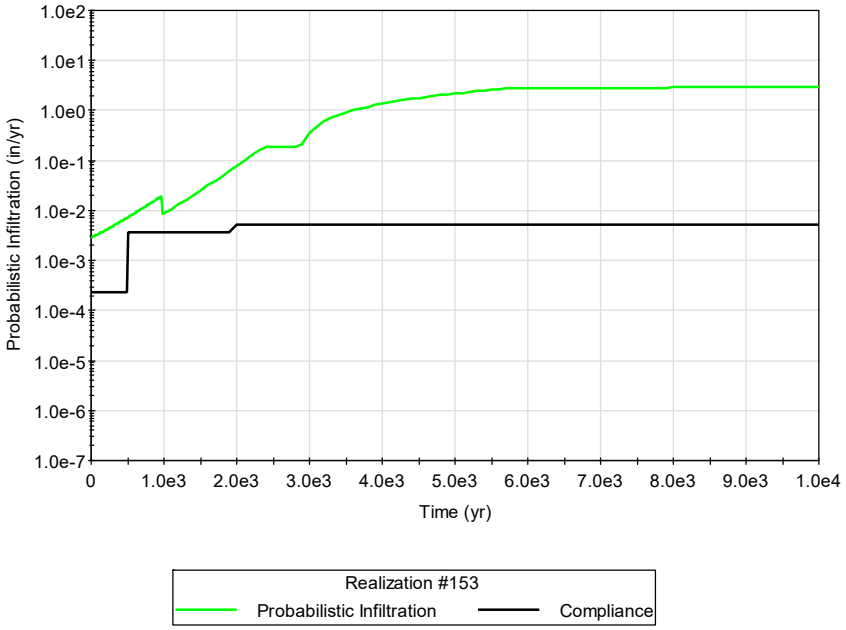
Realization 105 Infiltration Rate:



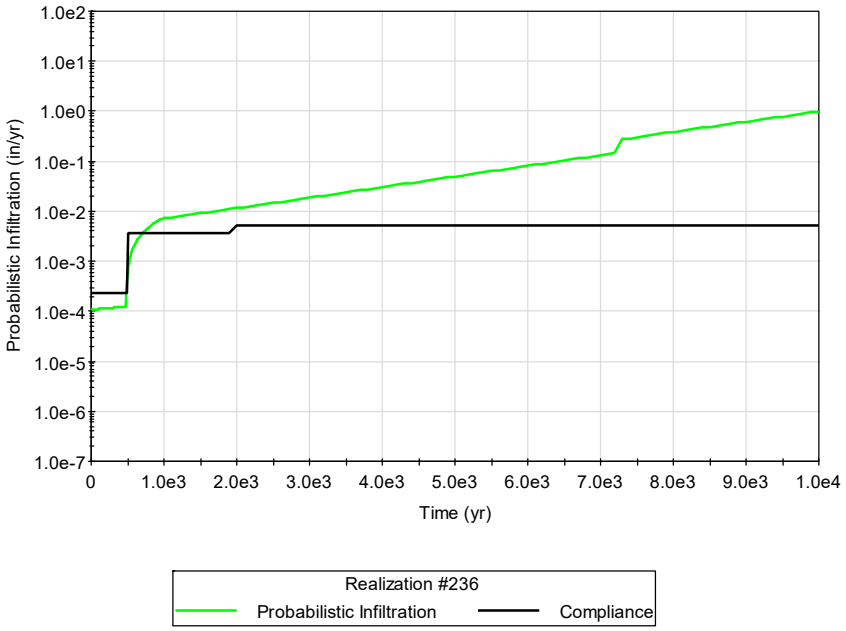
Realization 106 Infiltration Rate:



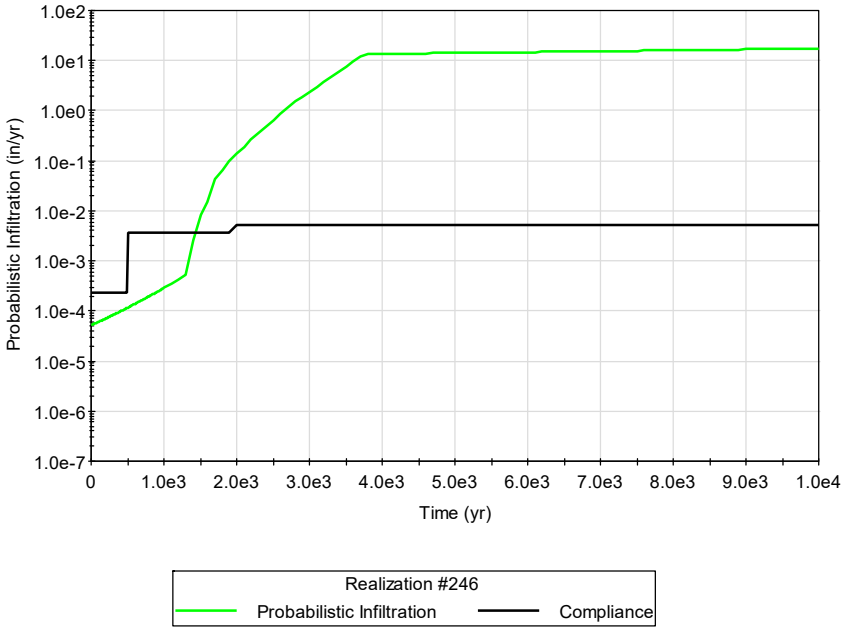
Realization 153 Infiltration Rate:



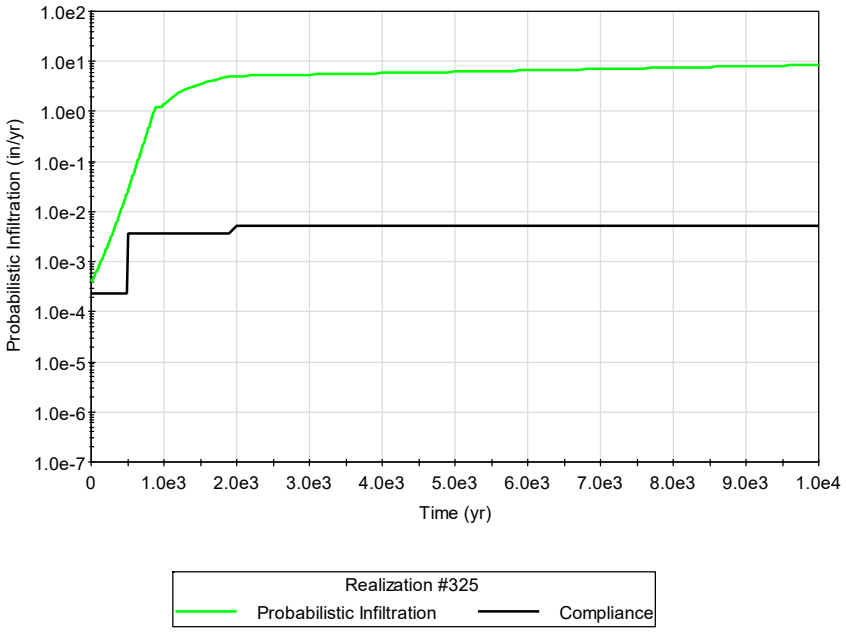
Realization 236 Infiltration Rate:



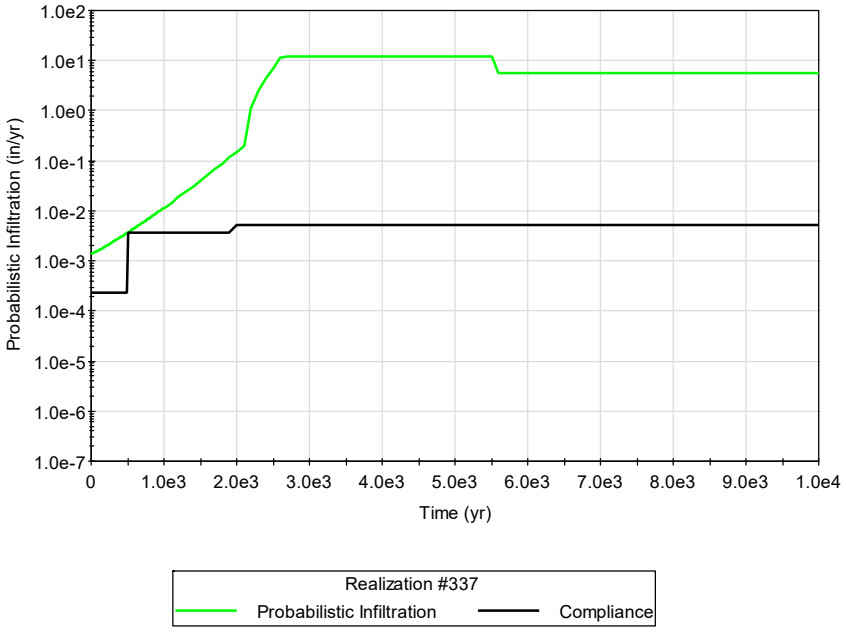
Realization 246 Infiltration Rate:



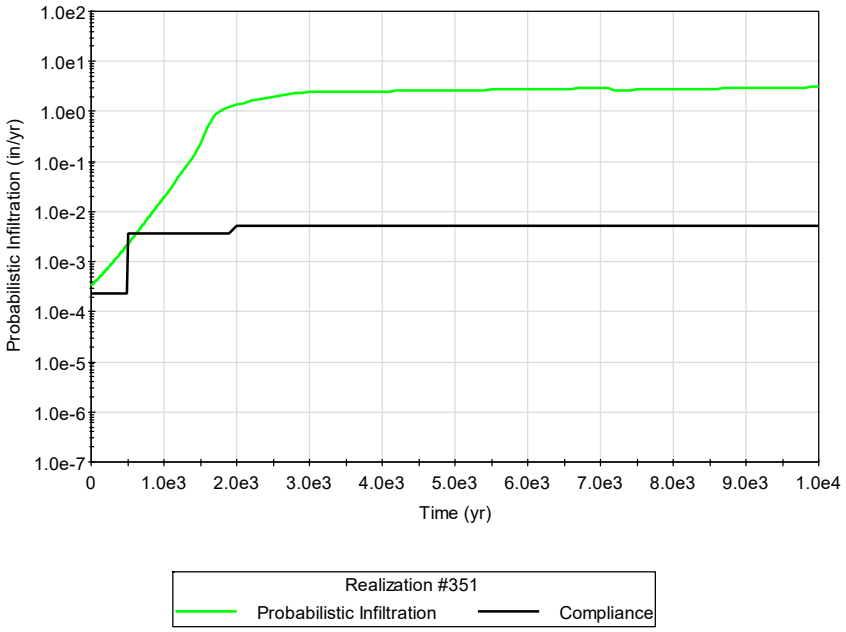
Realization 325 Infiltration Rate:



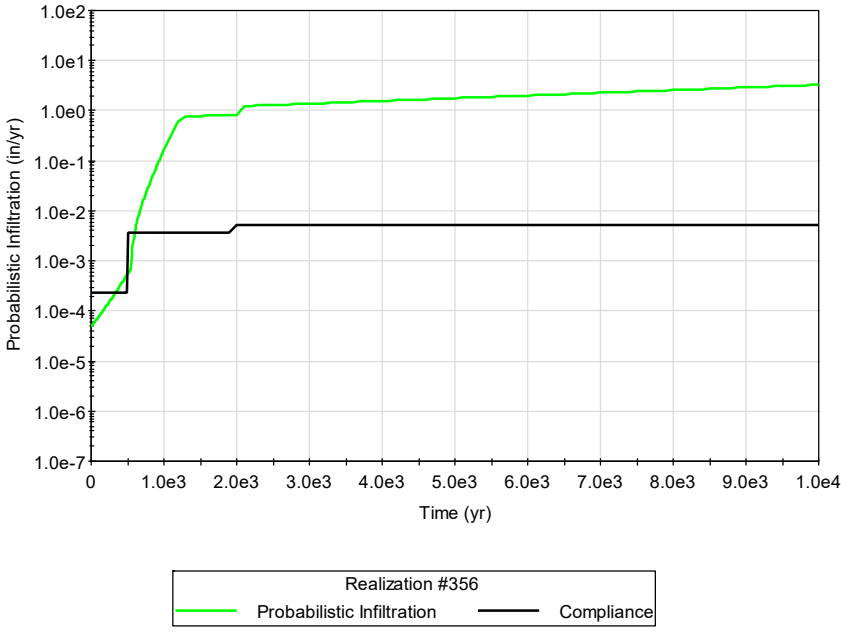
Realization 337 Infiltration Rate:



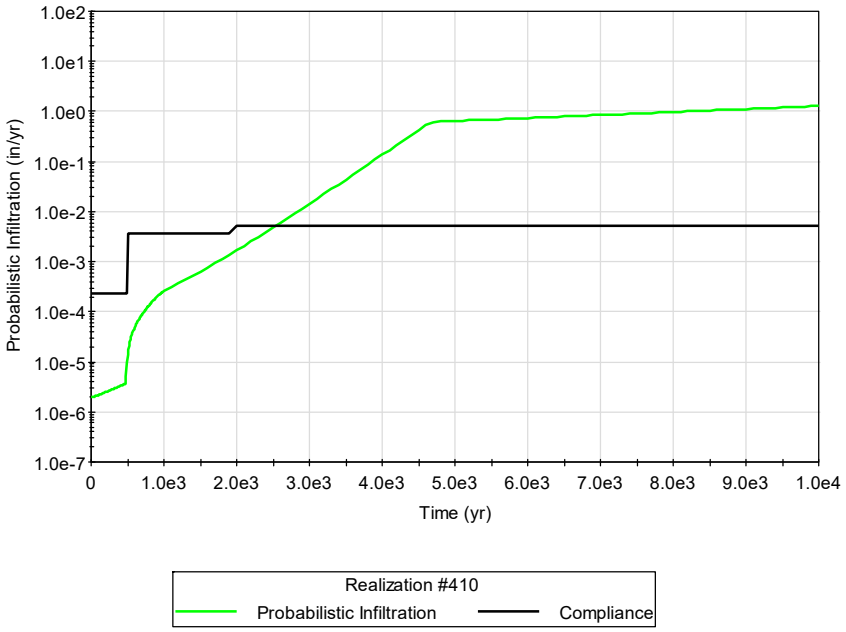
Realization 351 Infiltration Rate:



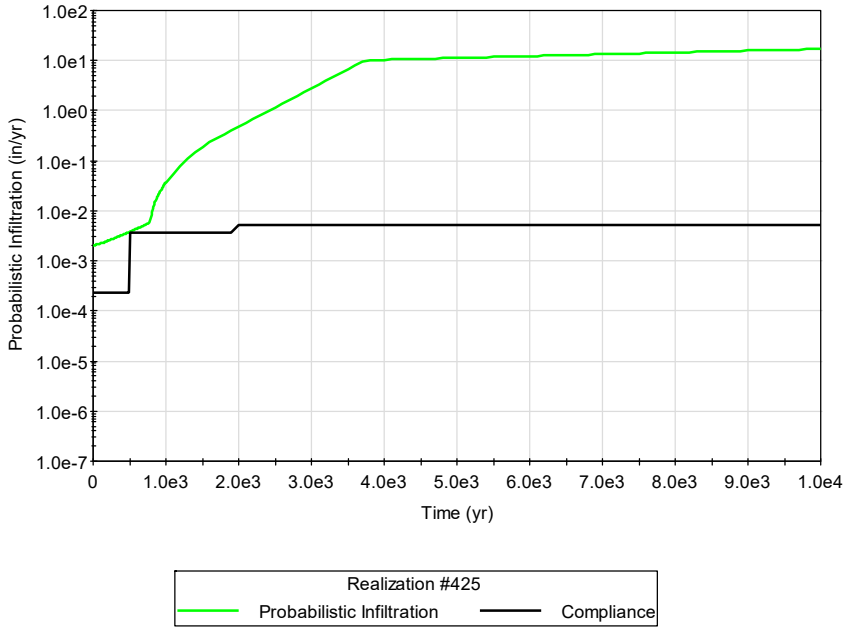
Realization 356 Infiltration Rate:



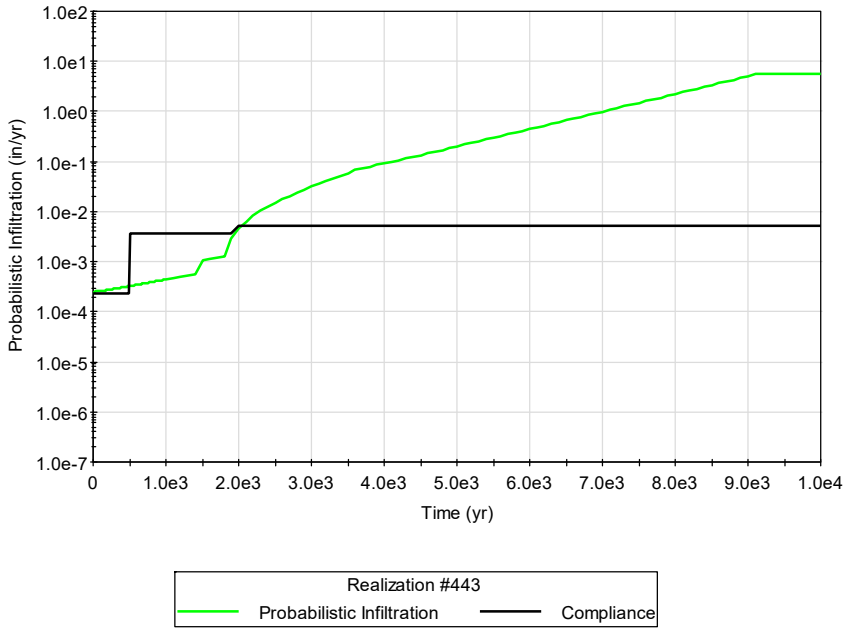
Realization 410 Infiltration Rate:



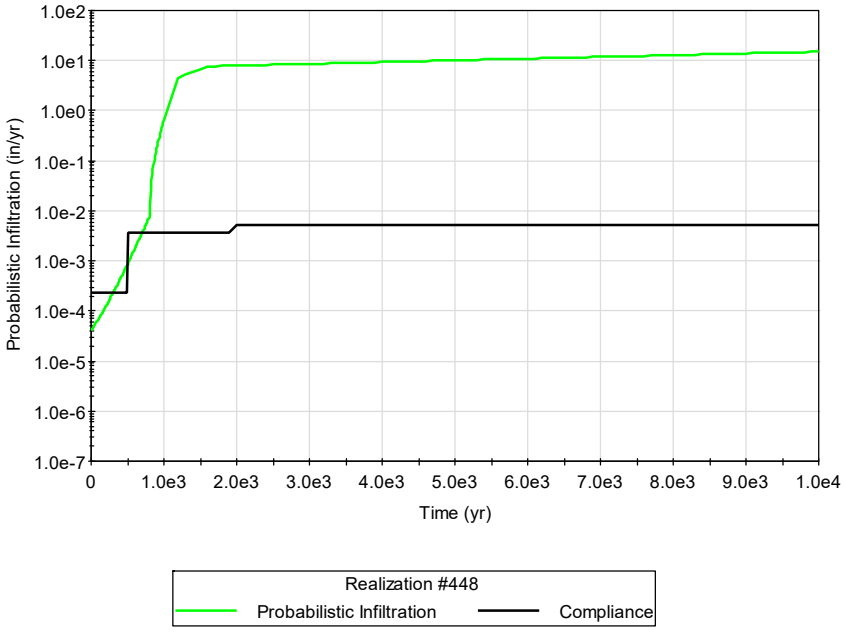
Realization 425 Infiltration Rate:



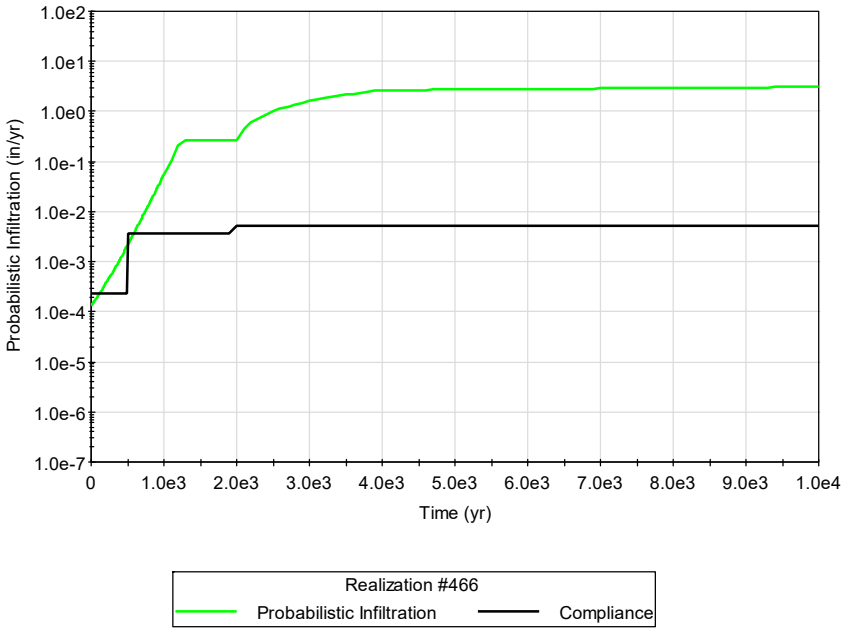
Realization 443 Infiltration Rate:



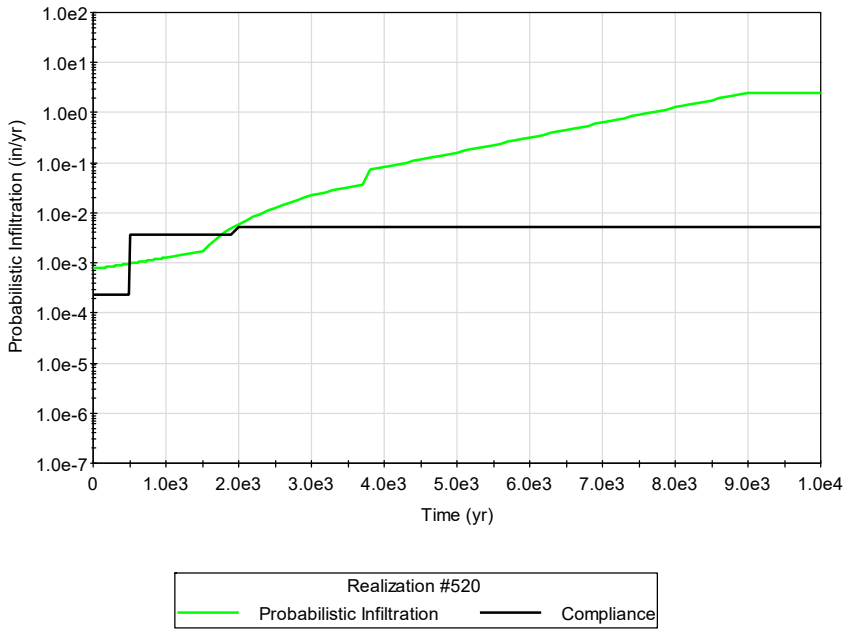
Realization 448 Infiltration Rate:



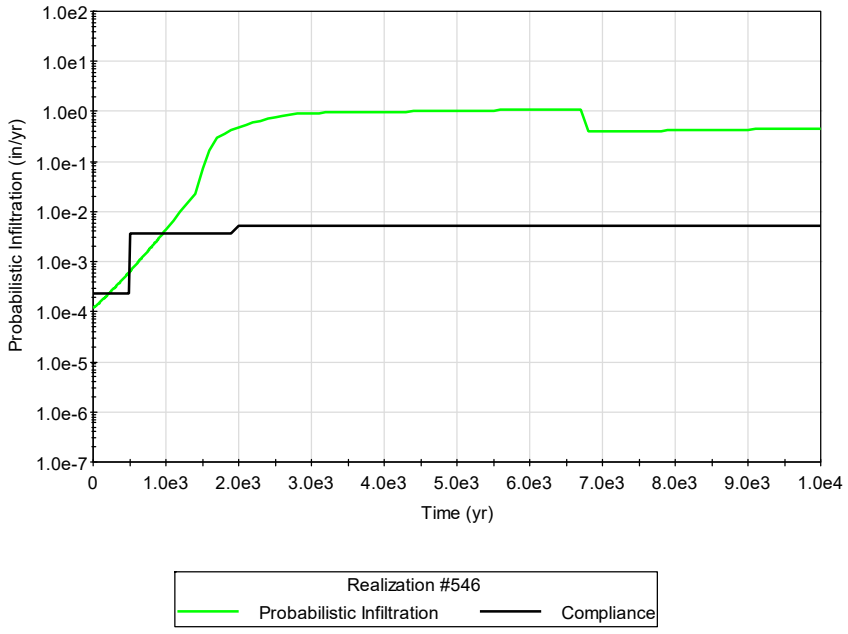
Realization 466 Infiltration Rate:



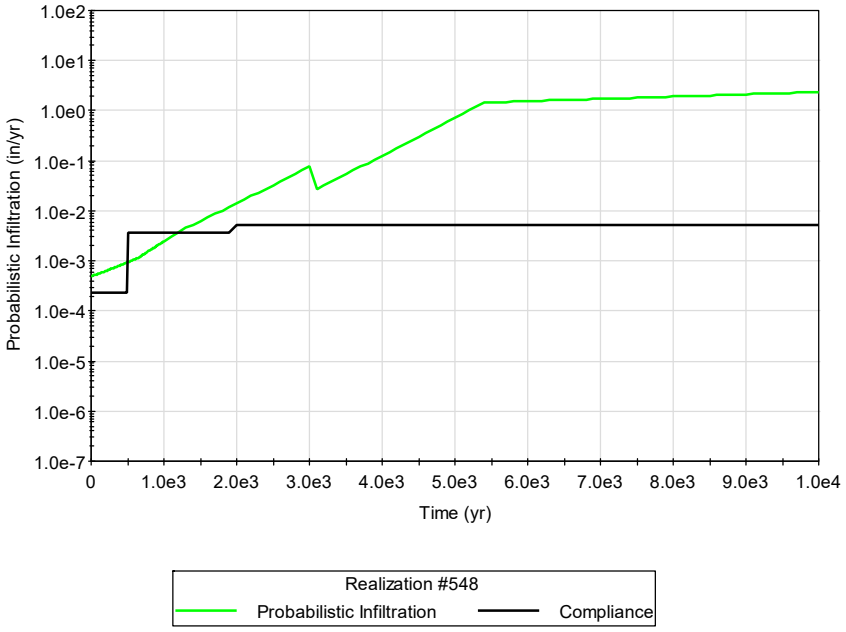
Realization 520 Infiltration Rate:



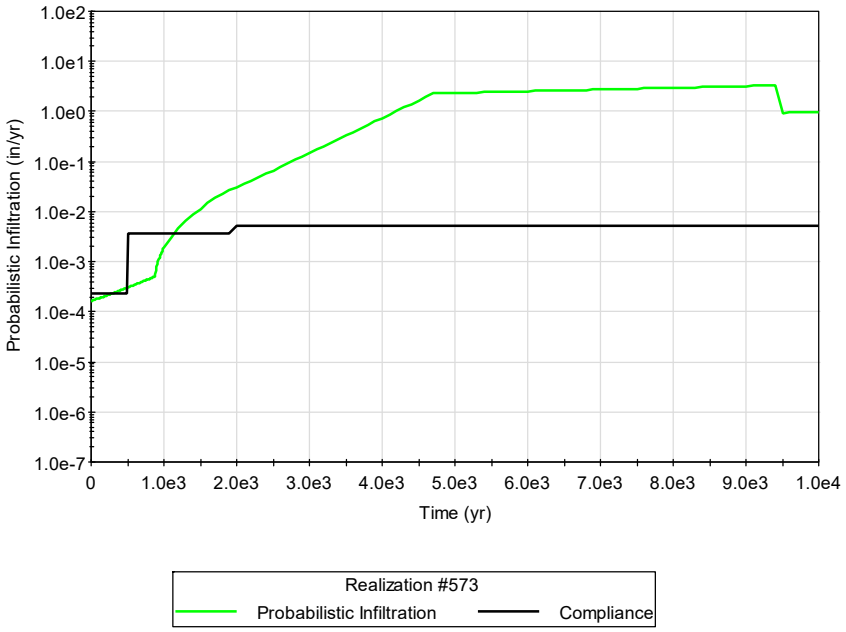
Realization 546 Infiltration Rate:



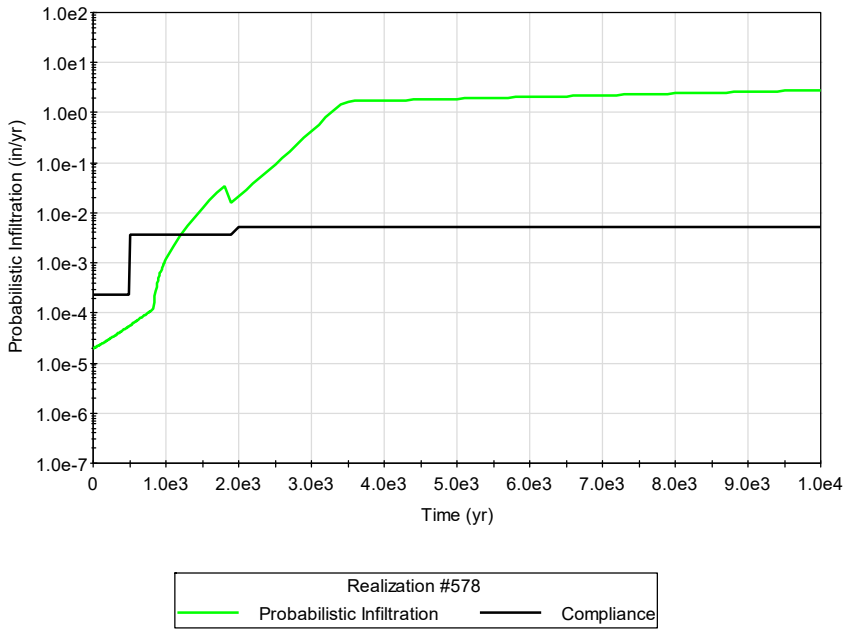
Realization 548 Infiltration Rate:



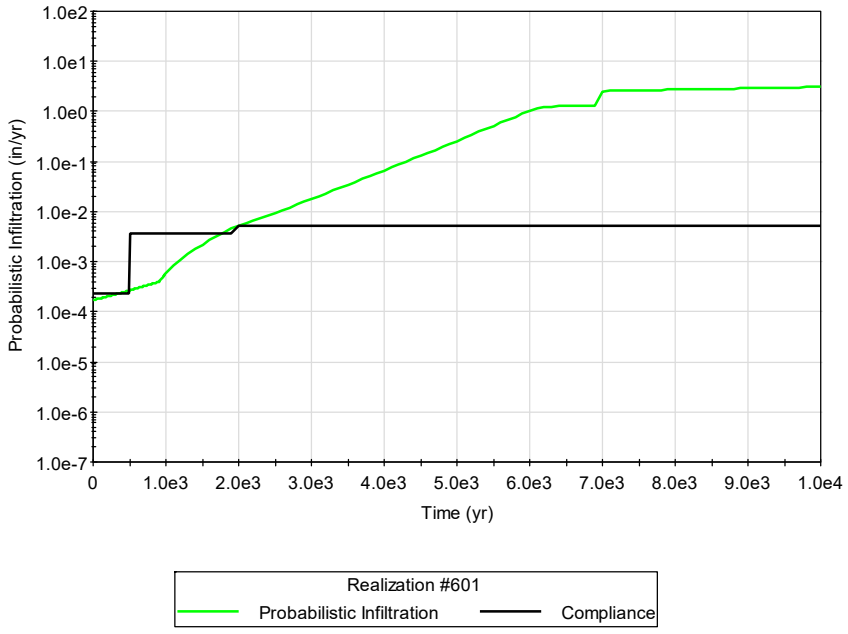
Realization 573 Infiltration Rate:



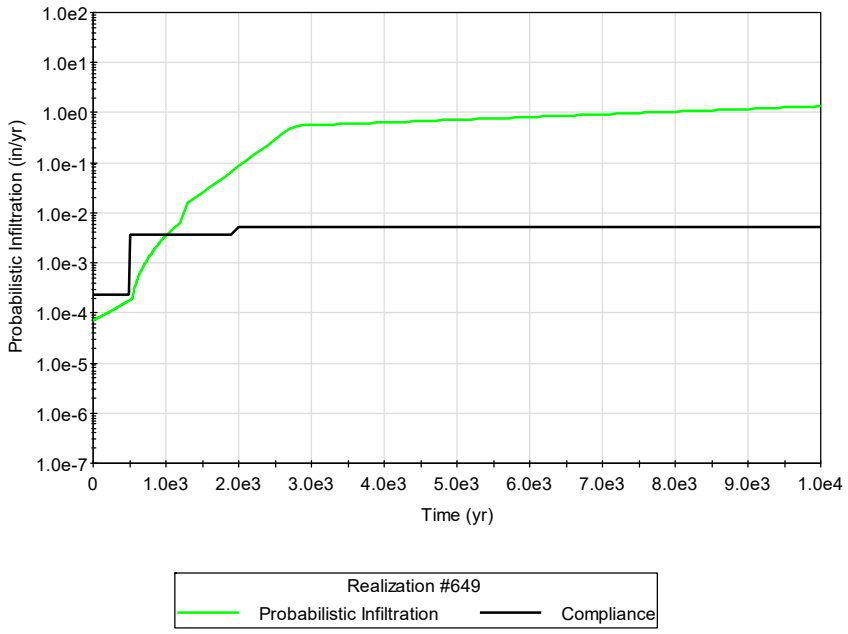
Realization 578 Infiltration Rate:



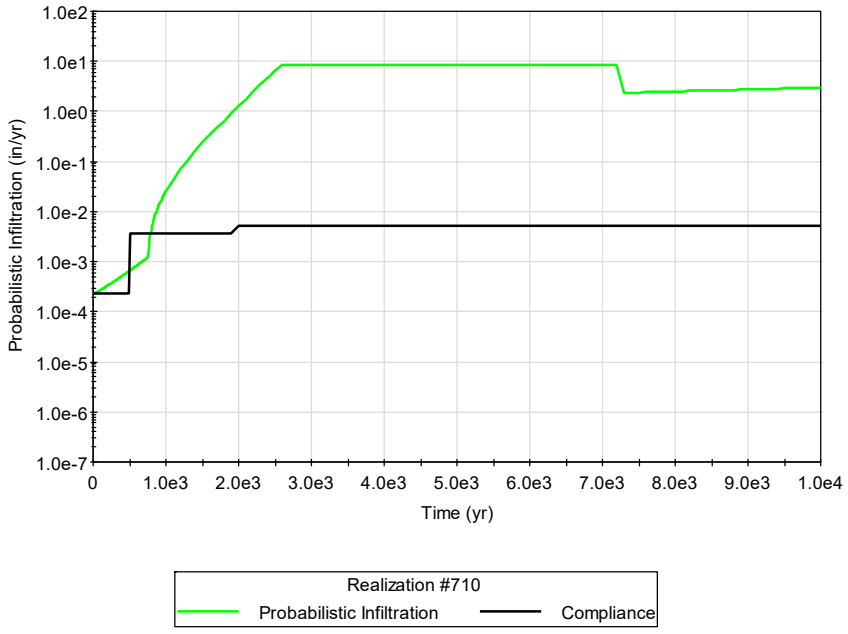
Realization 601 Infiltration Rate:



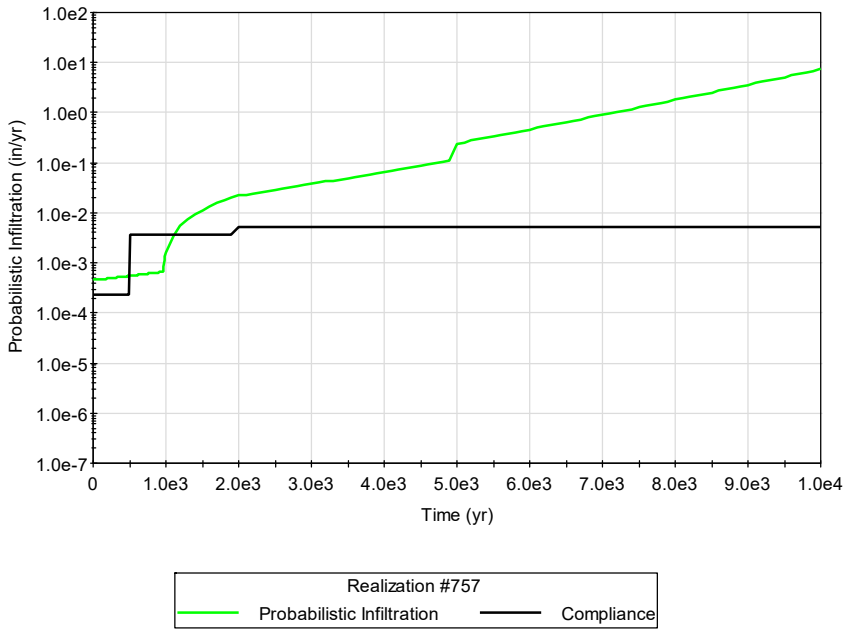
Realization 649 Infiltration Rate:



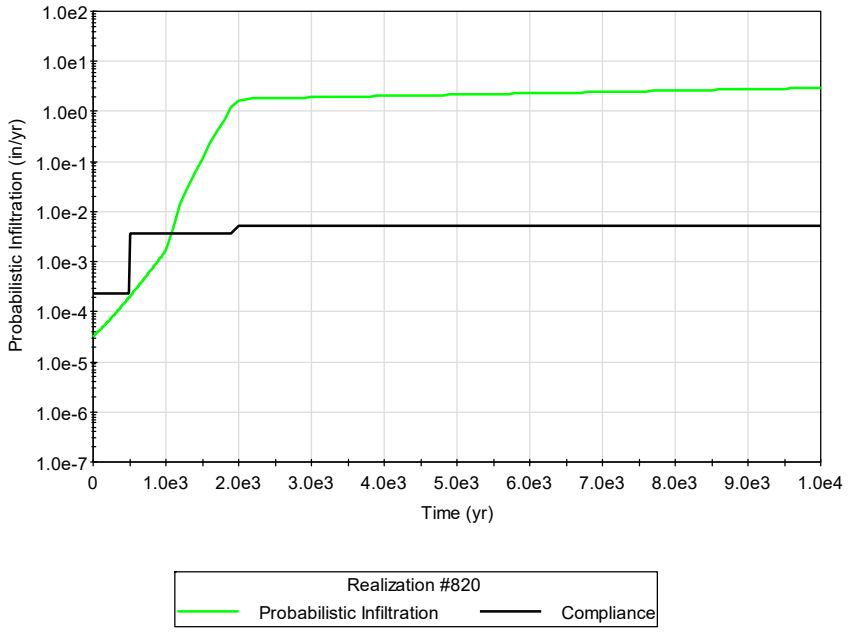
Realization 710 Infiltration Rate:



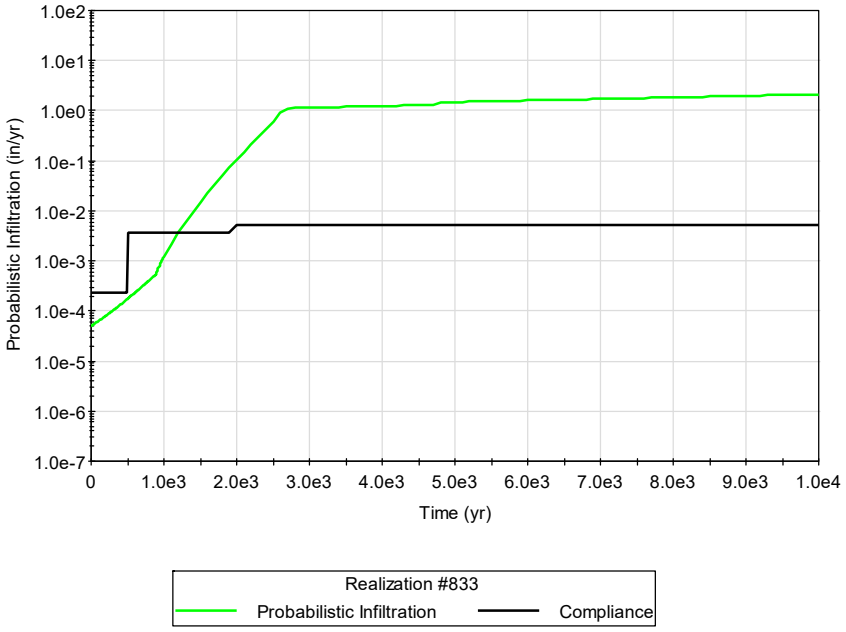
Realization 757 Infiltration Rate:



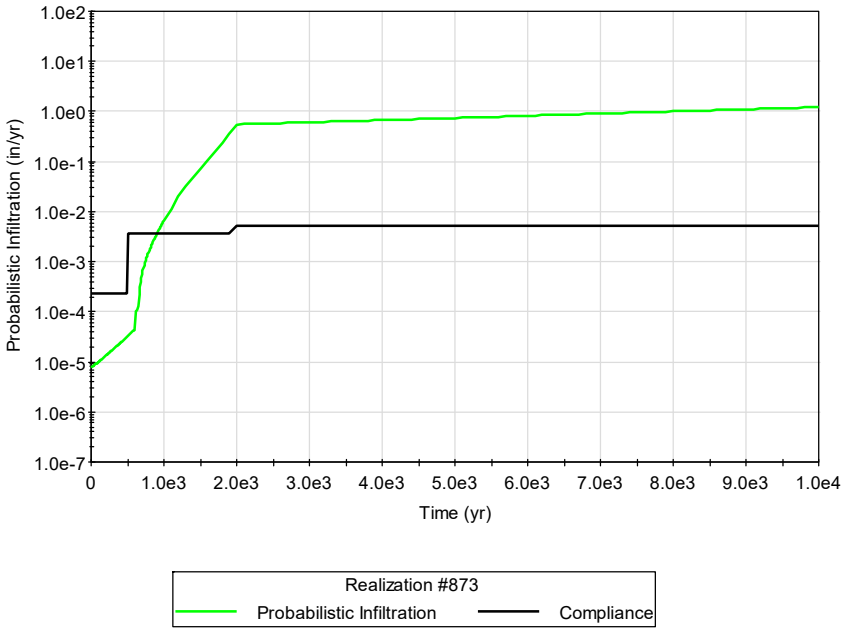
Realization 820 Infiltration Rate:



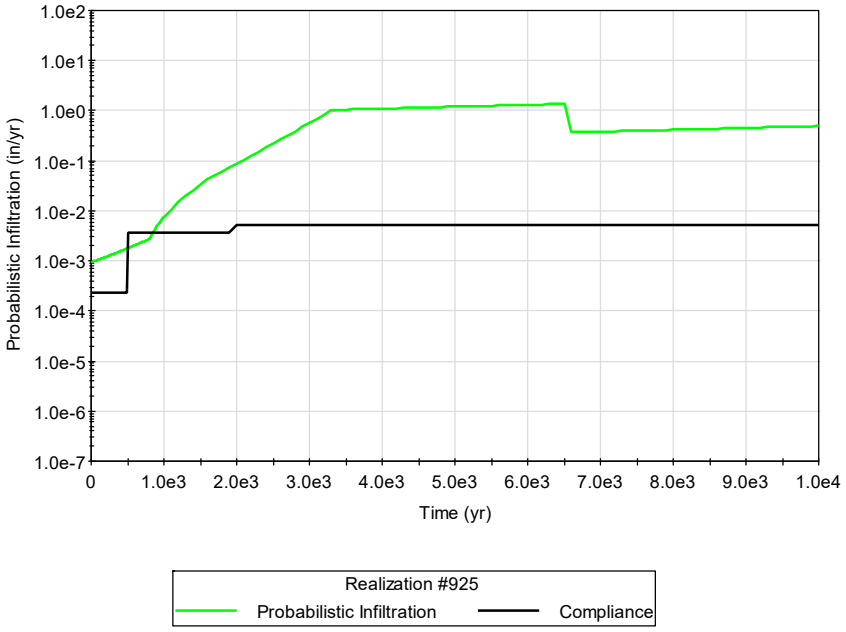
Realization 833 Infiltration Rate:



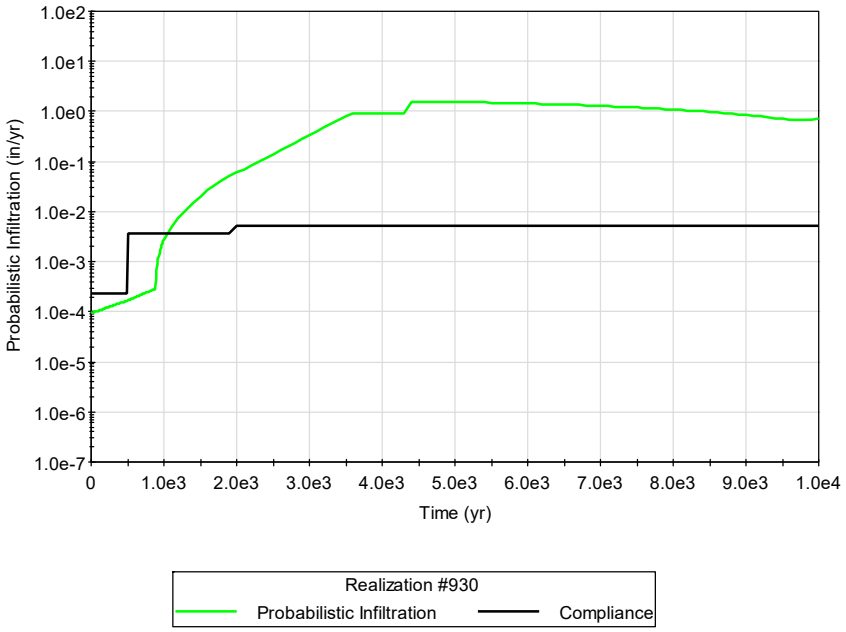
Realization 873 Infiltration Rate:



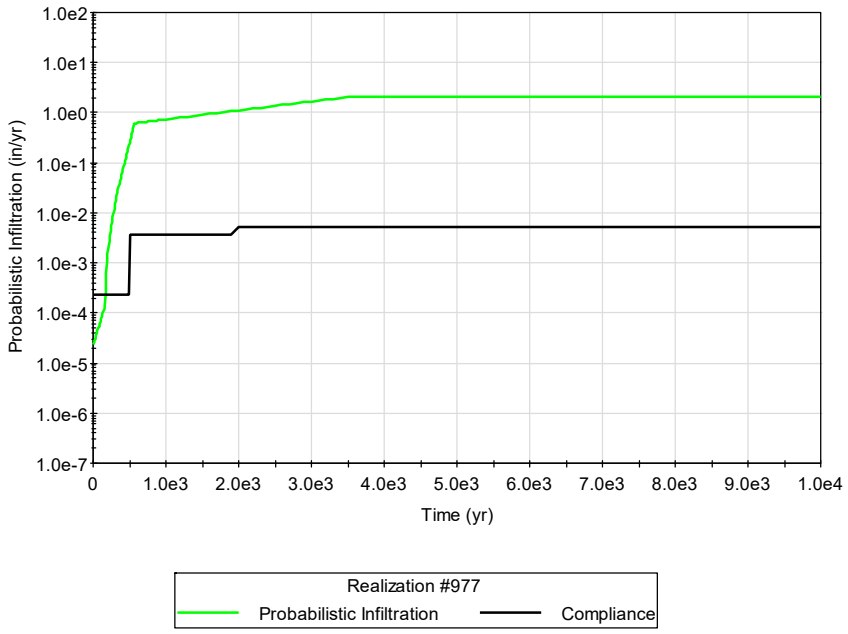
Realization 925 Infiltration Rate:



Realization 930 Infiltration Rate:



Realization 977 Infiltration Rate:

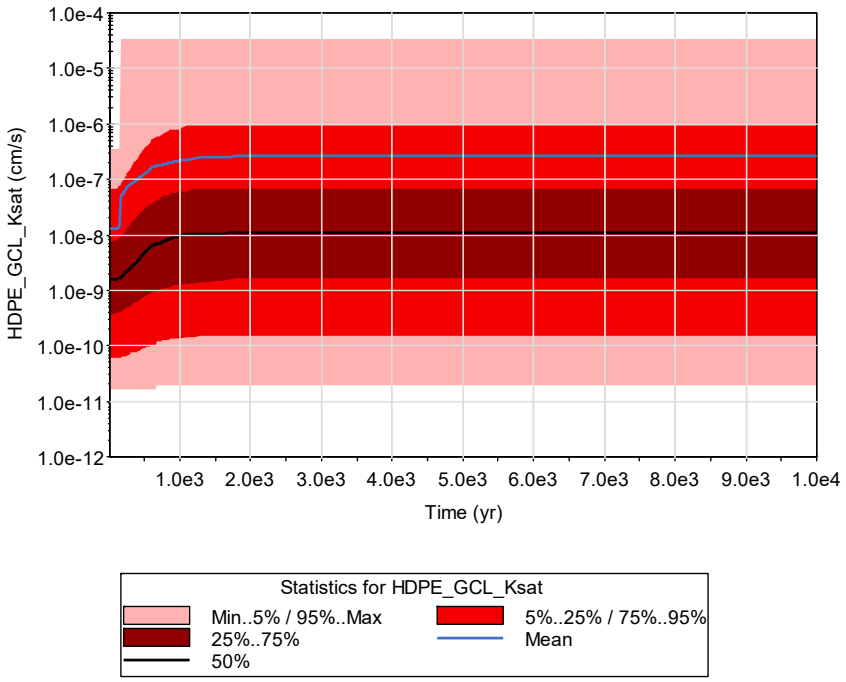


Appendix B. Composite Barrier Degradation Curves

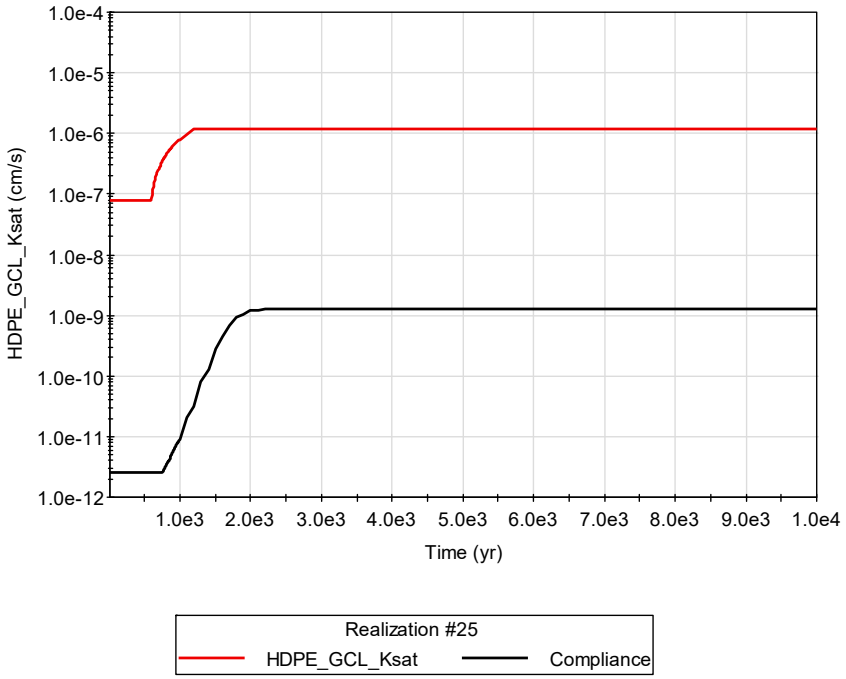
The following figures show the composite barrier (HDPE-GCL) degradation curves that correspond to each of the RSI-1 model realizations. These curves come from the probabilistic saltstone degradation model: *Probabilistic_SaltstoneDeg_Model_v1.001.gsm*, which was described in *Evaluation of the Uncertainties Associated with Long-Term Saltstone Degradation* (SRR-CWDA-2021-00056). These composite barrier degradation curves were used to develop the RSI-1 model realizations. The selected model results correspond to the realizations from Table 1.

For context, the first figure shows the probabilities from using all 1,000 RSI-1 model realizations (i.e., the realizations depicted in this figure have not been screened). This figure shows that the median HDPE-GCL Ksat starts at approximately 1.6E-09 cm/s, then increases by nearly an order of magnitude to approximately 1.1E-08 cm/s over a 10,000-year period. The relatively large difference between the mean curve (blue) and the median curve (black) indicates that the mean curve is not representative of the central tendency of the HDPE-GCL Ksat values. This is because a relatively small number of realizations had extremely high Ksat values that drove up the mean.

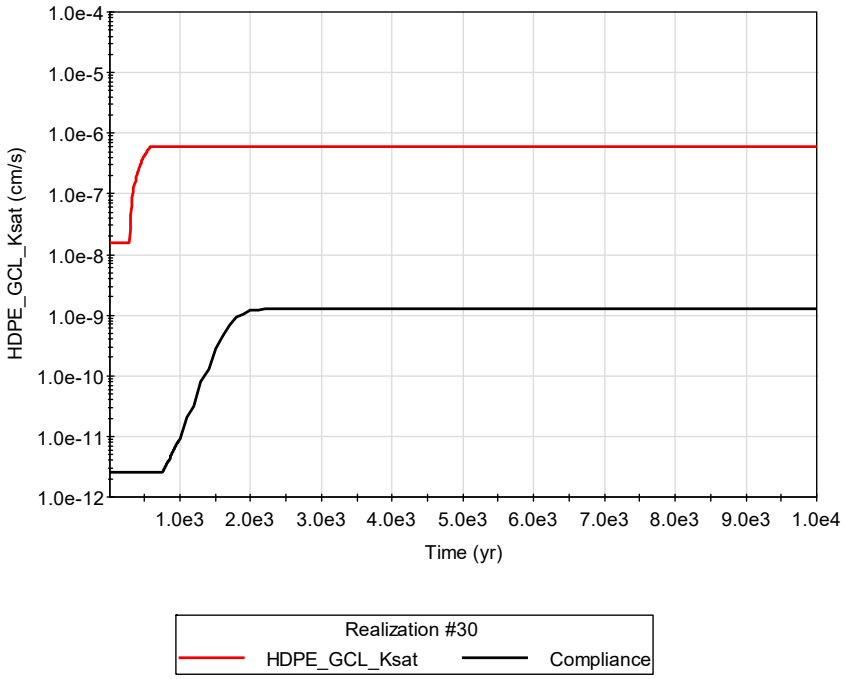
HDPE-GCL Ksat Probabilities:



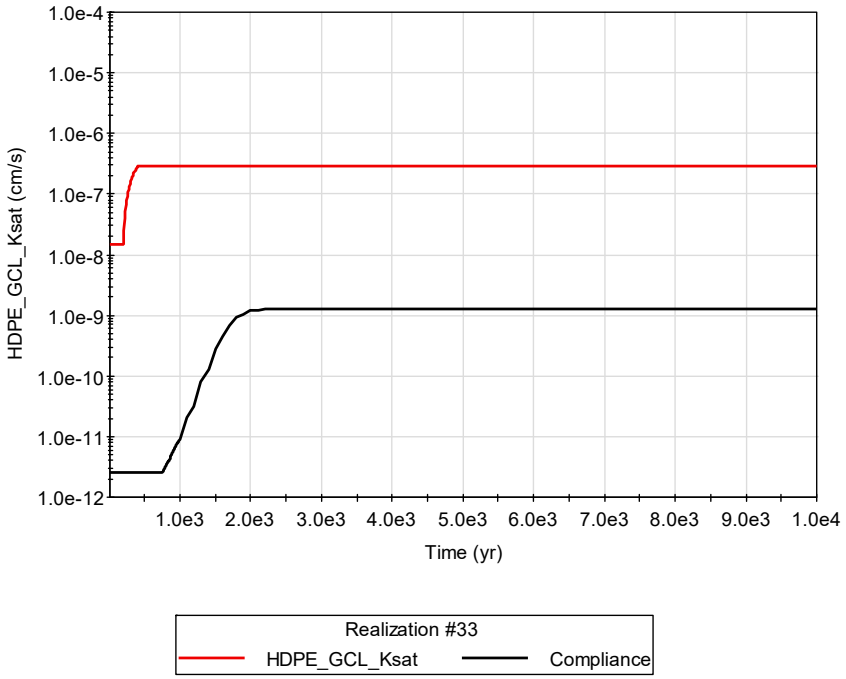
Realization 25 HDPE-GCL Ksat:



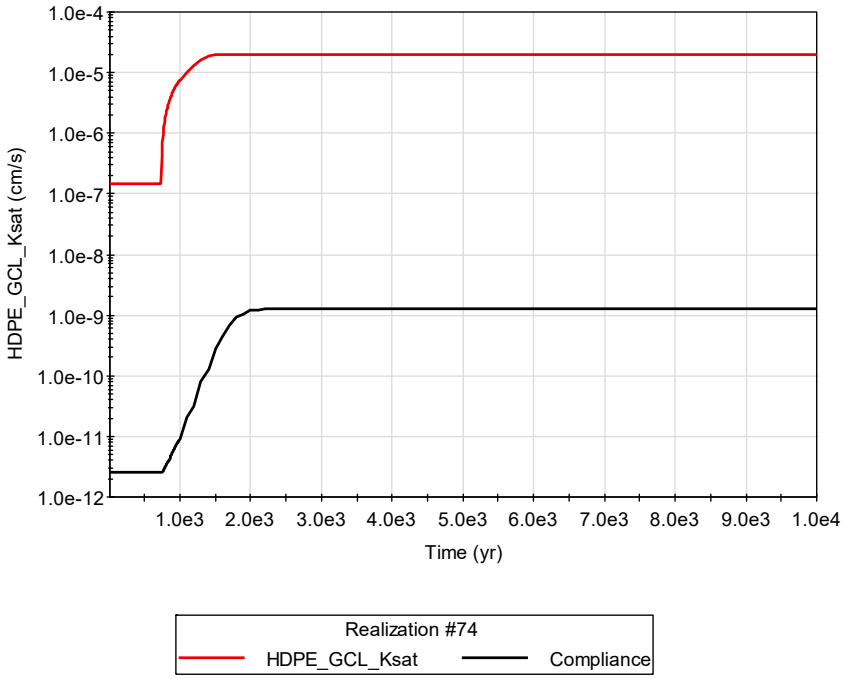
Realization 30 HDPE-GCL Ksat:



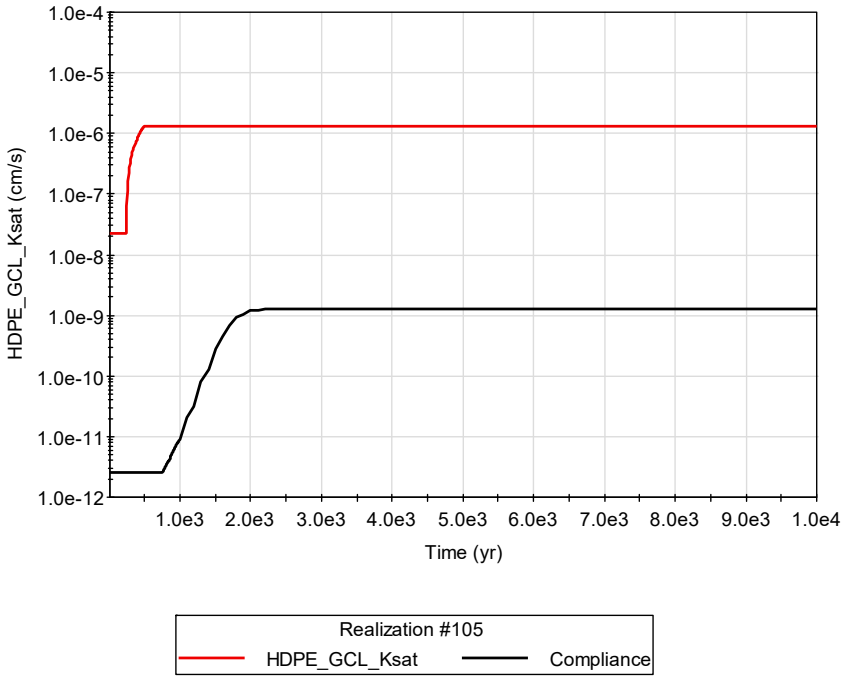
Realization 33 HDPE-GCL Ksat:



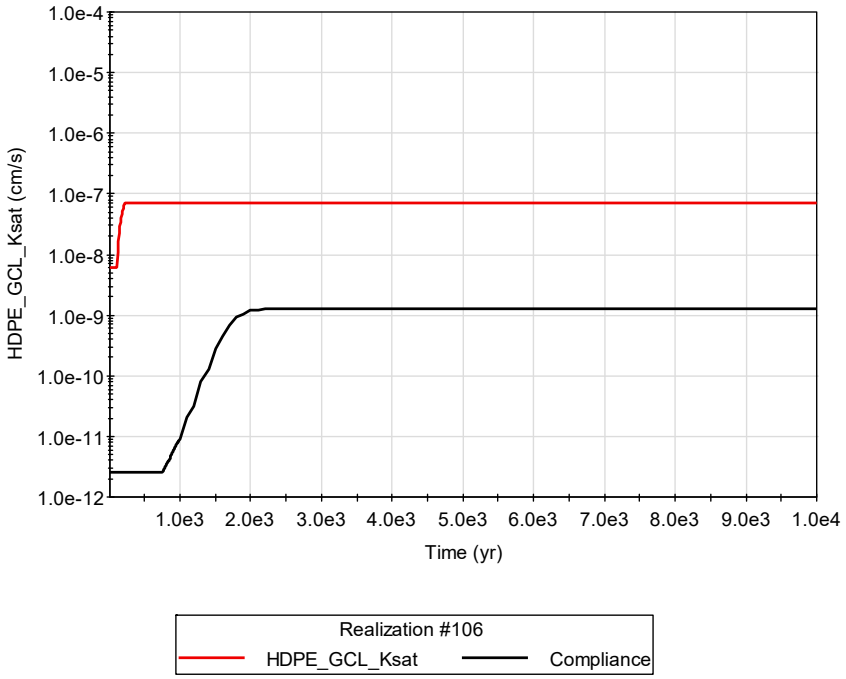
Realization 74 HDPE-GCL Ksat:



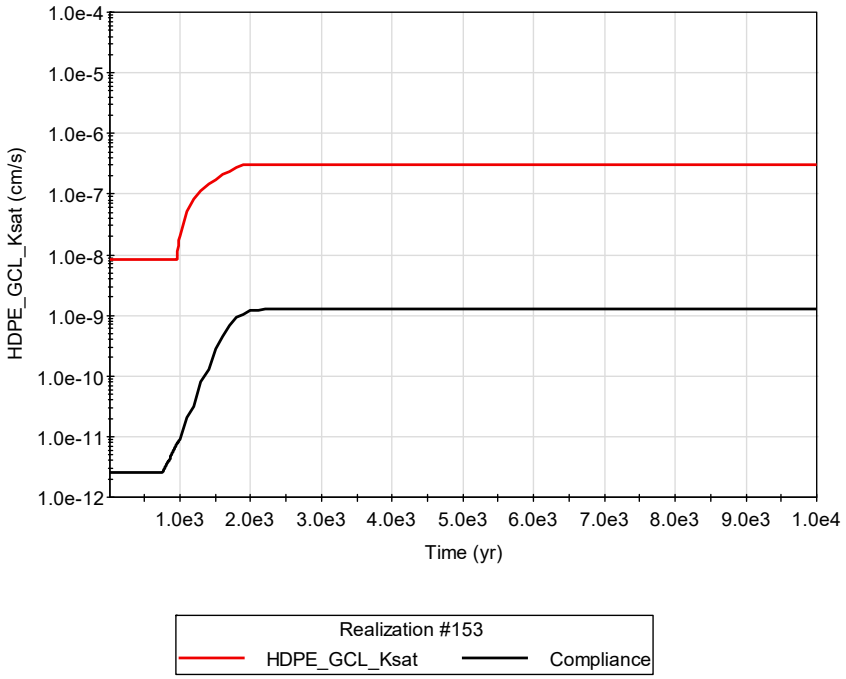
Realization 105 HDPE-GCL Ksat:



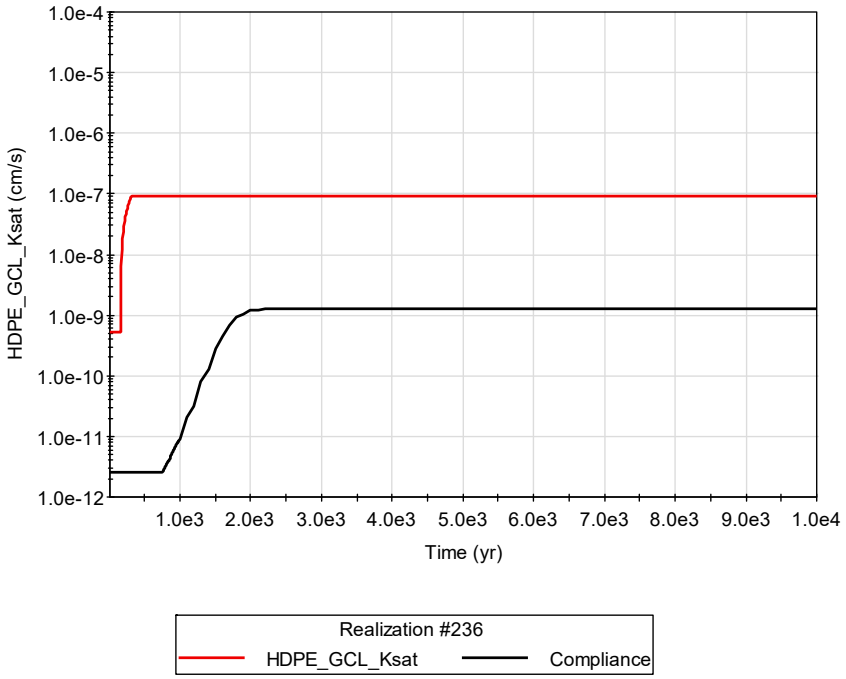
Realization 106 HDPE-GCL Ksat:



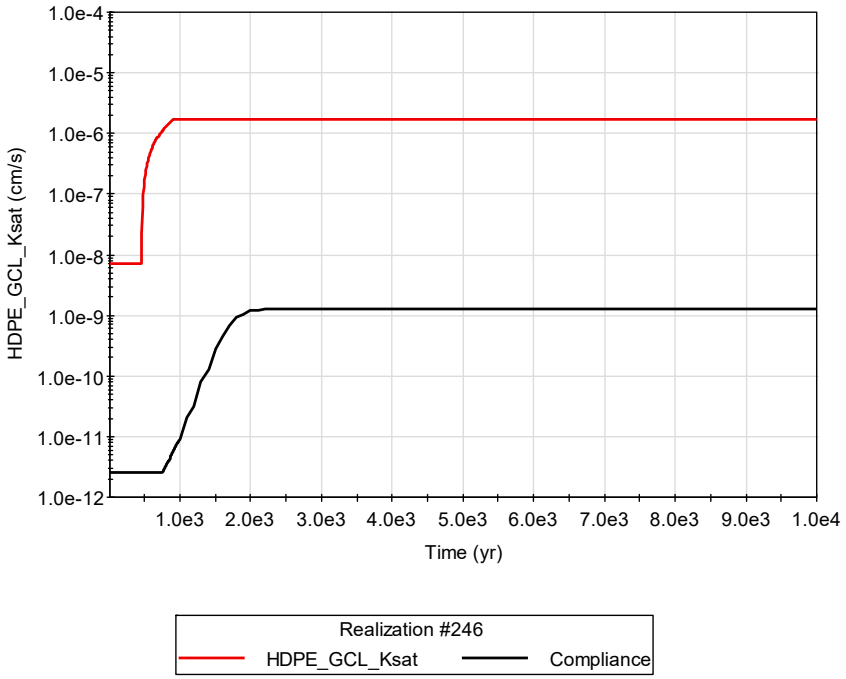
Realization 153 HDPE-GCL Ksat:



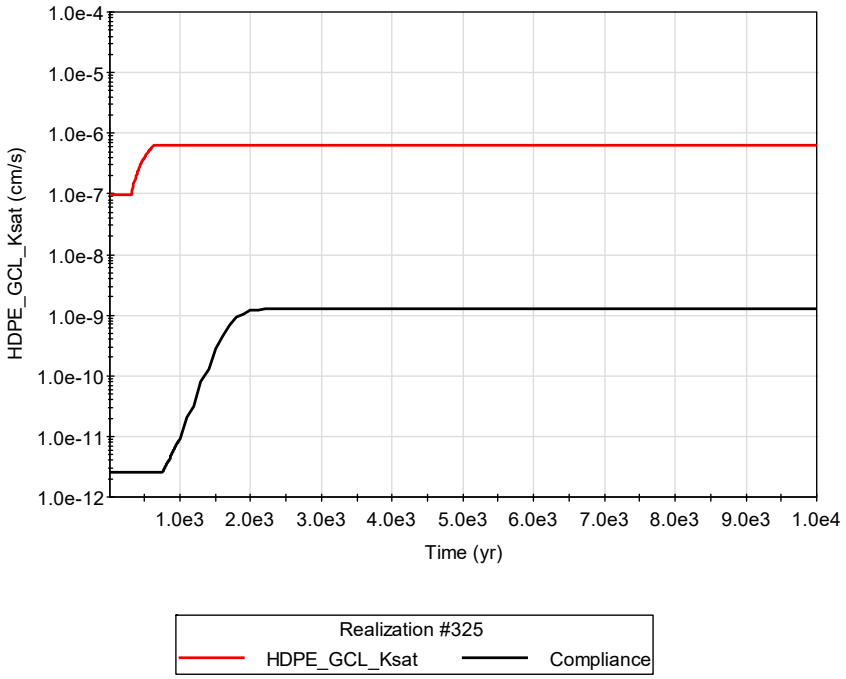
Realization 236 HDPE-GCL Ksat:



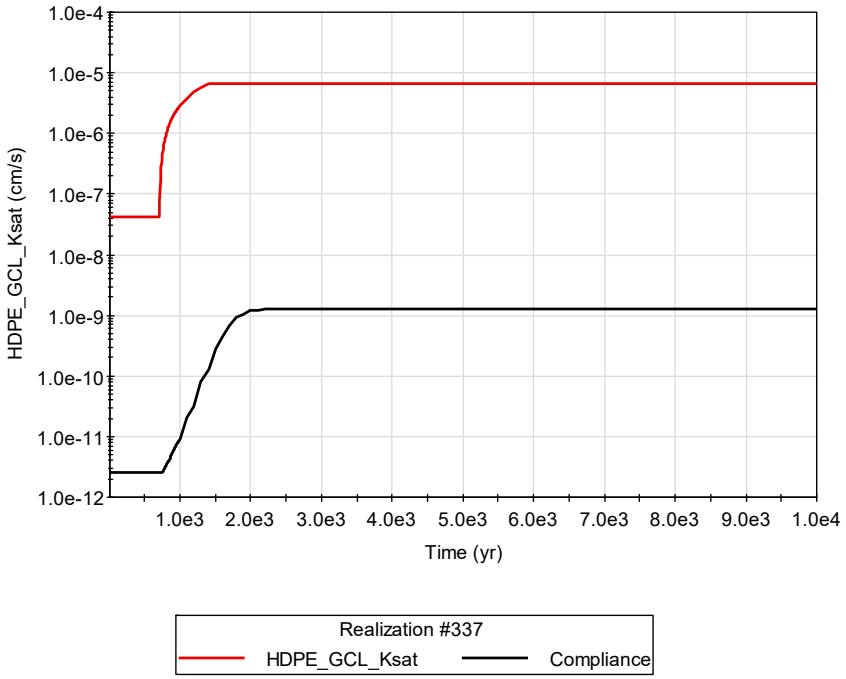
Realization 246 HDPE-GCL Ksat:



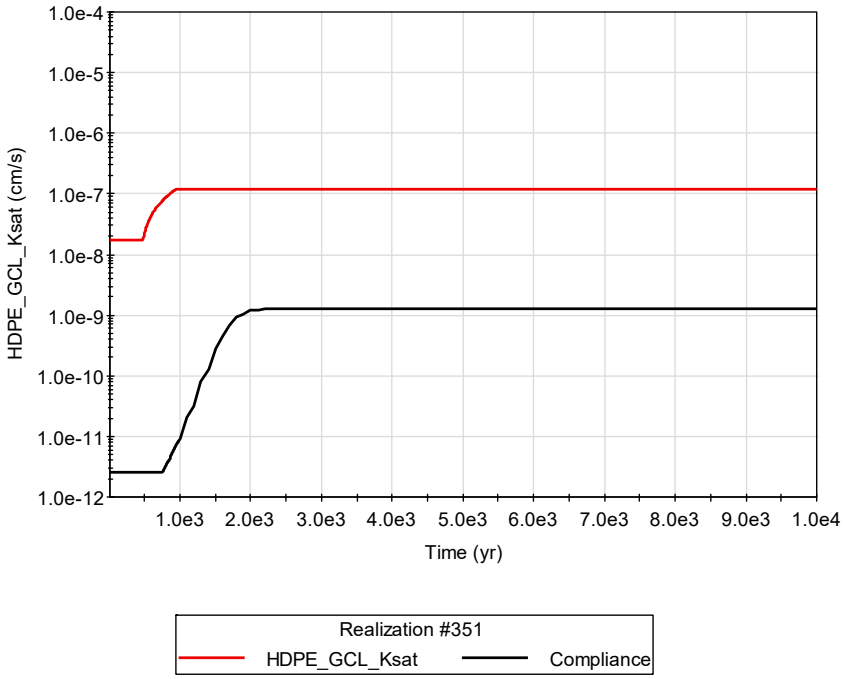
Realization 325 HDPE-GCL Ksat:



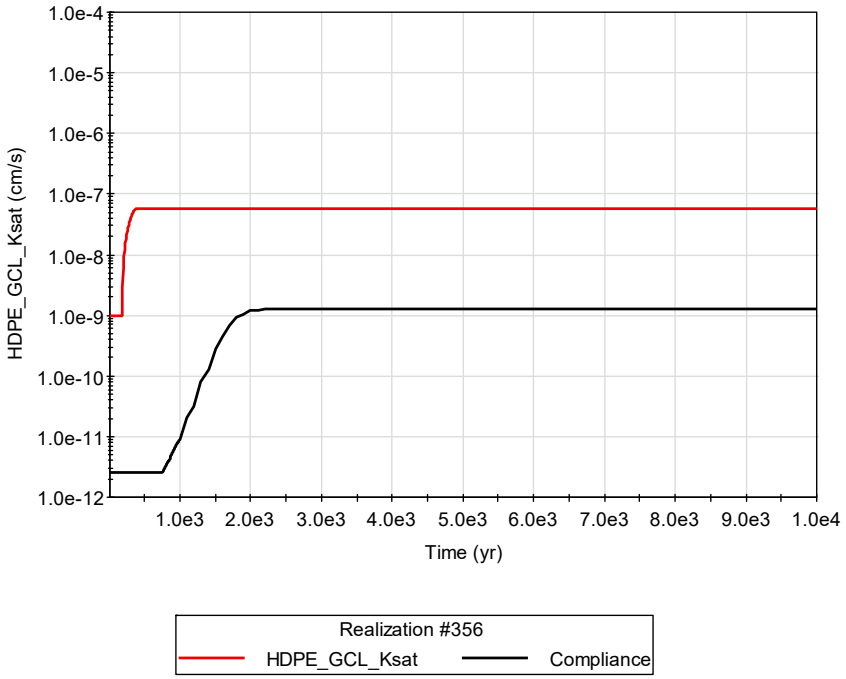
Realization 337 HDPE-GCL Ksat:



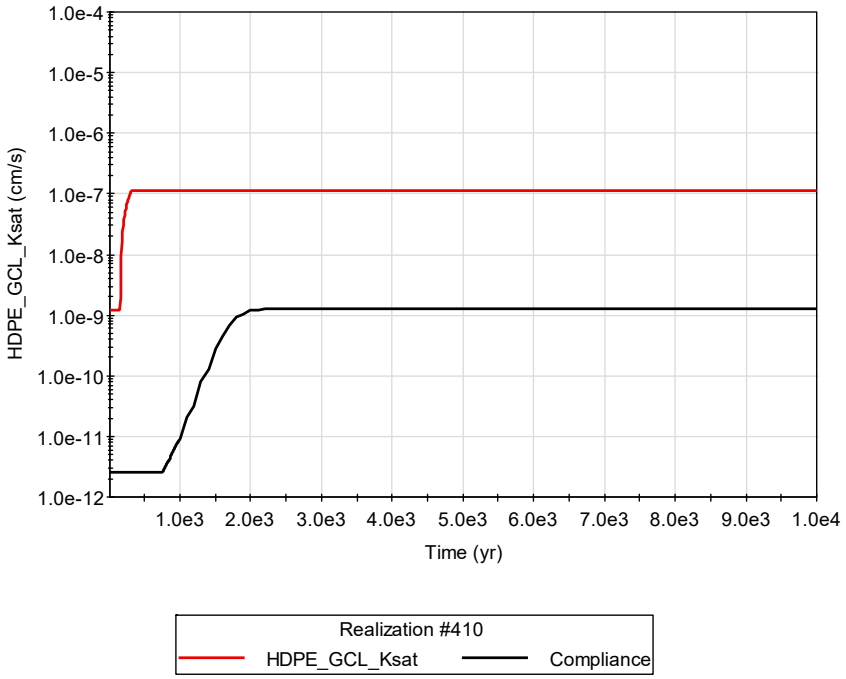
Realization 351 HDPE-GCL Ksat:



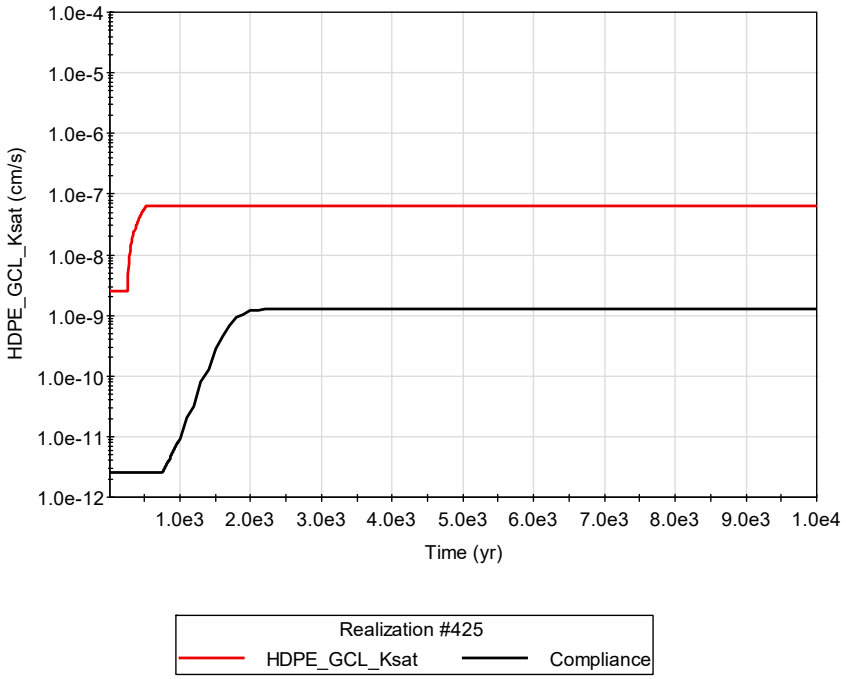
Realization 356 HDPE-GCL Ksat:



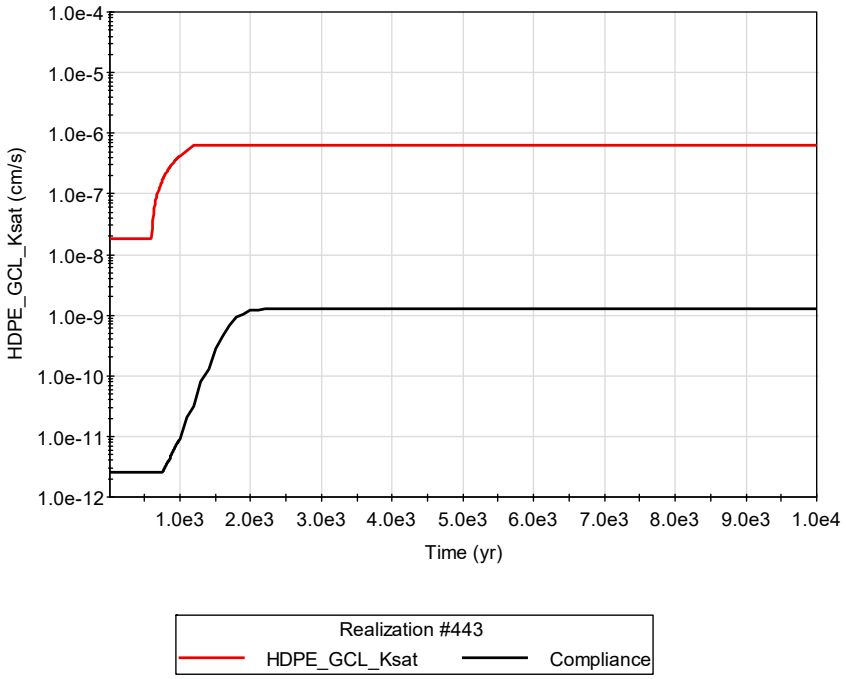
Realization 410 HDPE-GCL Ksat:



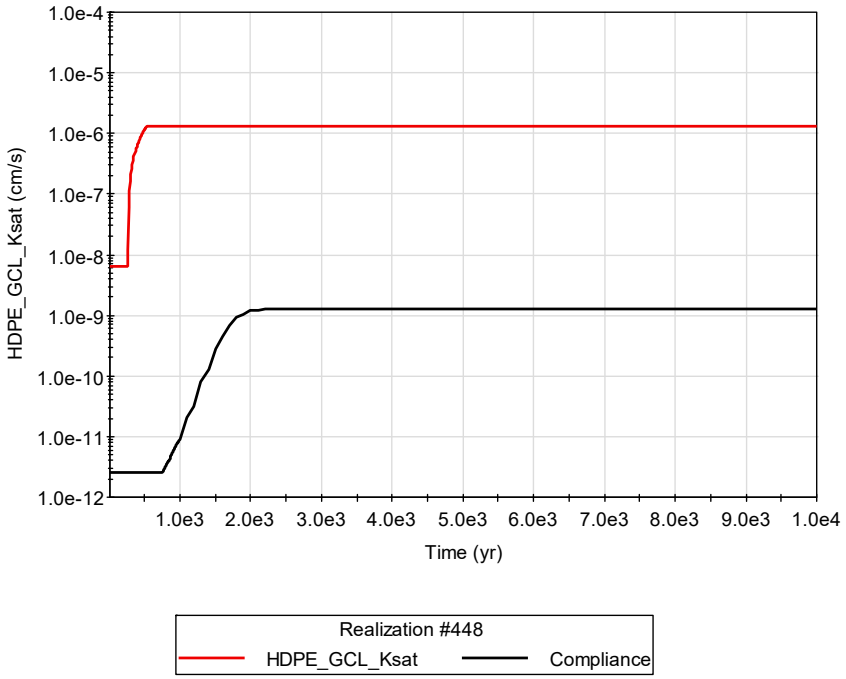
Realization 425 HDPE-GCL Ksat:



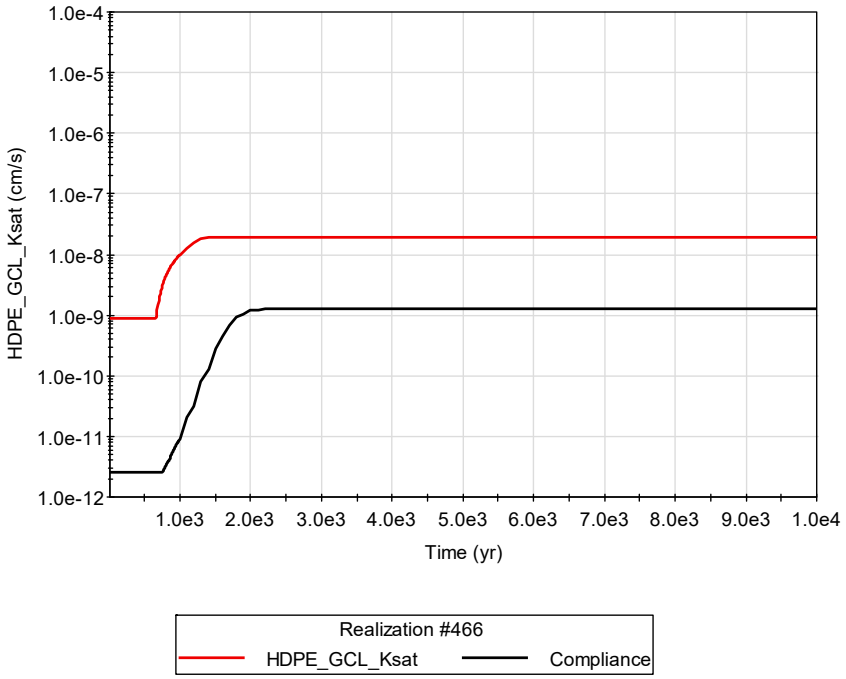
Realization 443 HDPE-GCL Ksat:



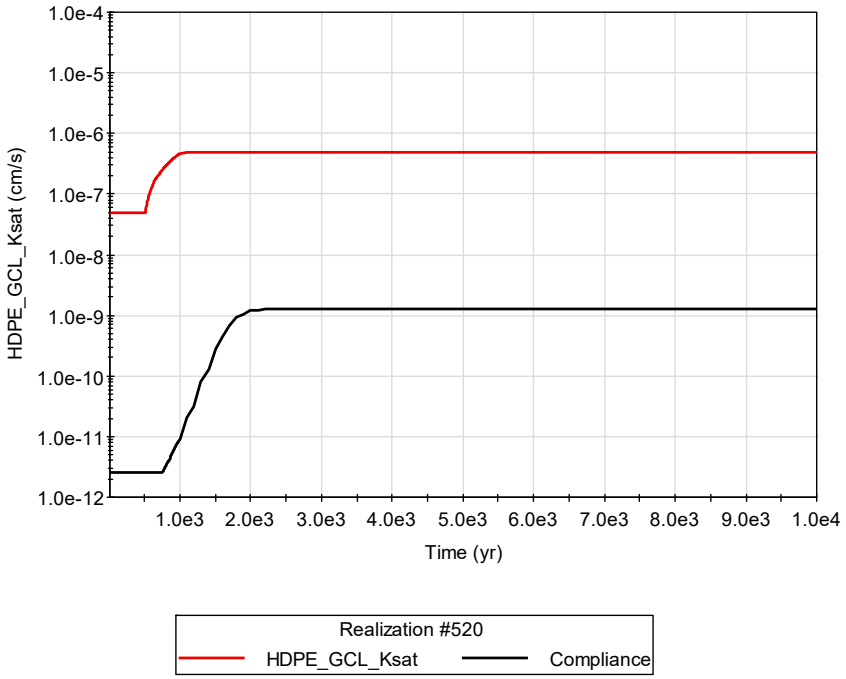
Realization 448 HDPE-GCL Ksat:



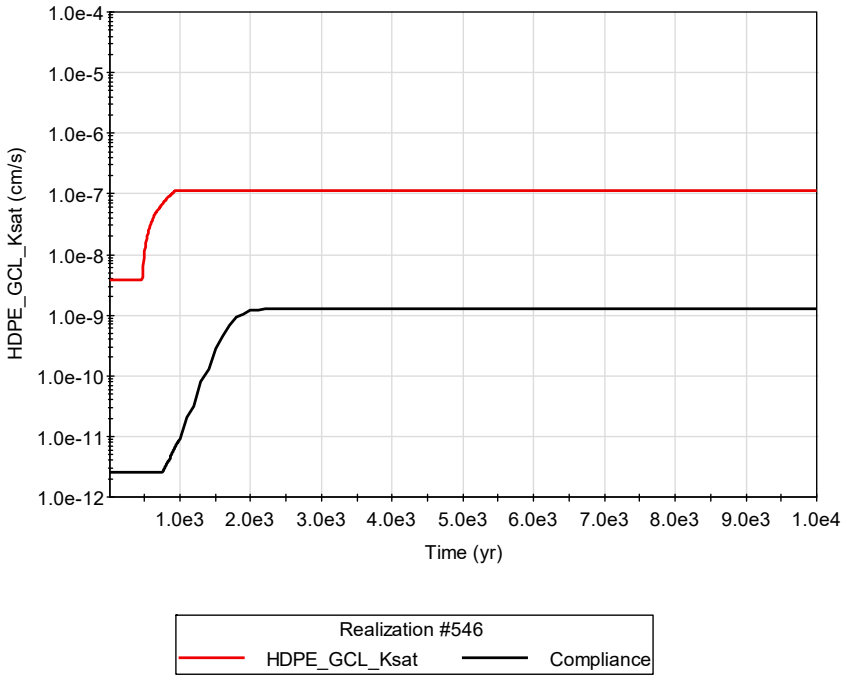
Realization 466 HDPE-GCL Ksat:



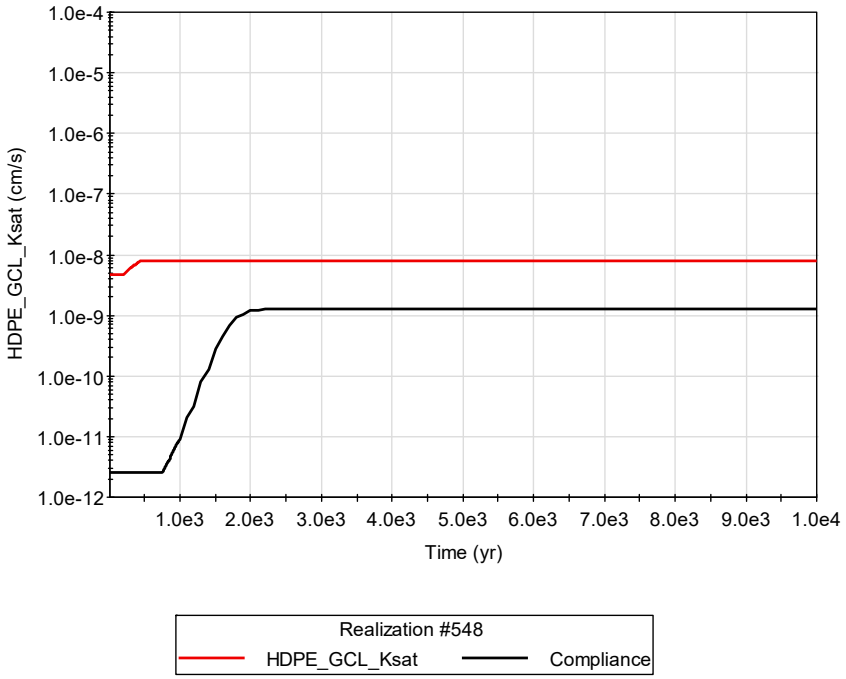
Realization 520 HDPE-GCL Ksat:



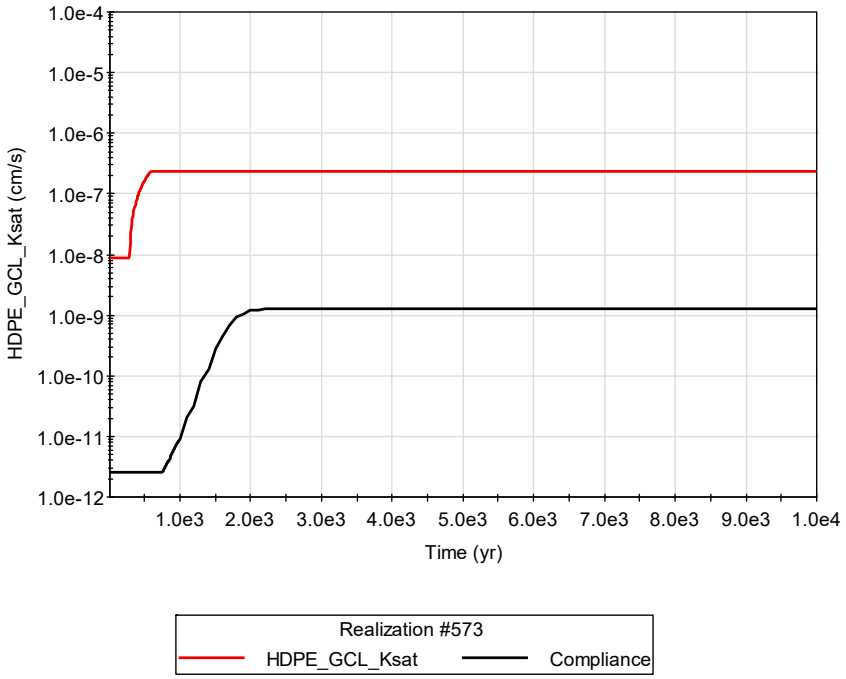
Realization 546 HDPE-GCL Ksat:



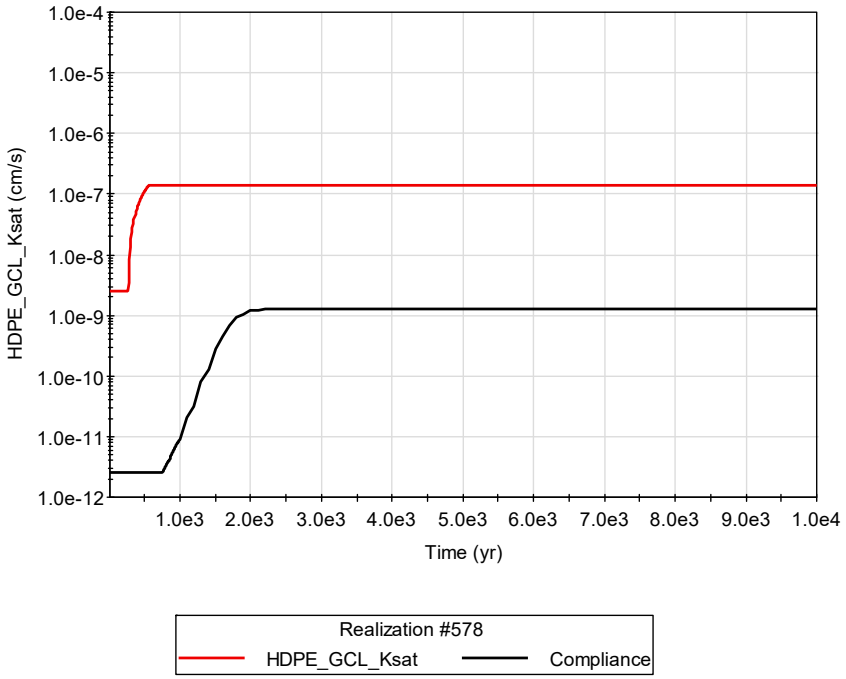
Realization 548 HDPE-GCL Ksat:



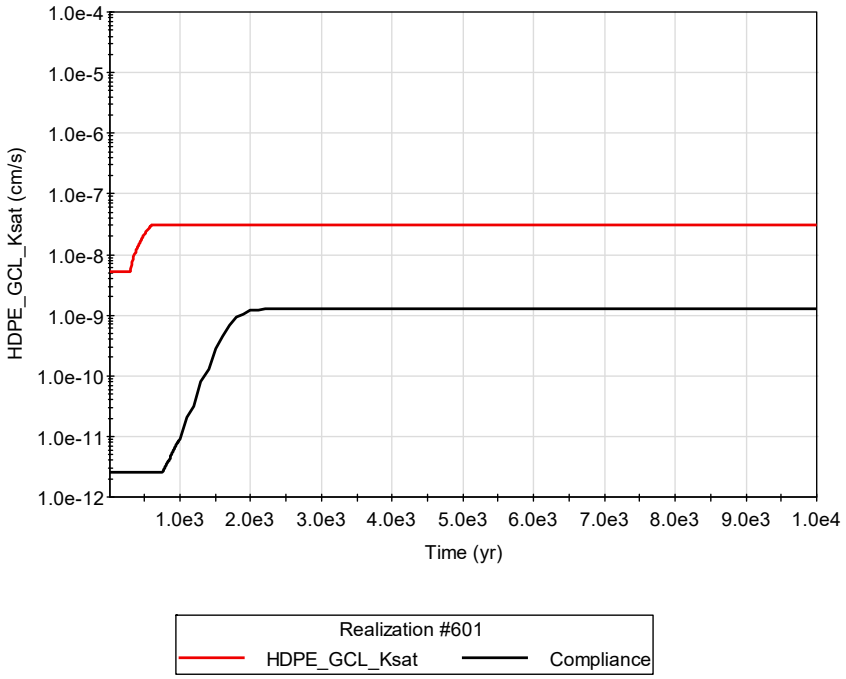
Realization 573 HDPE-GCL Ksat:



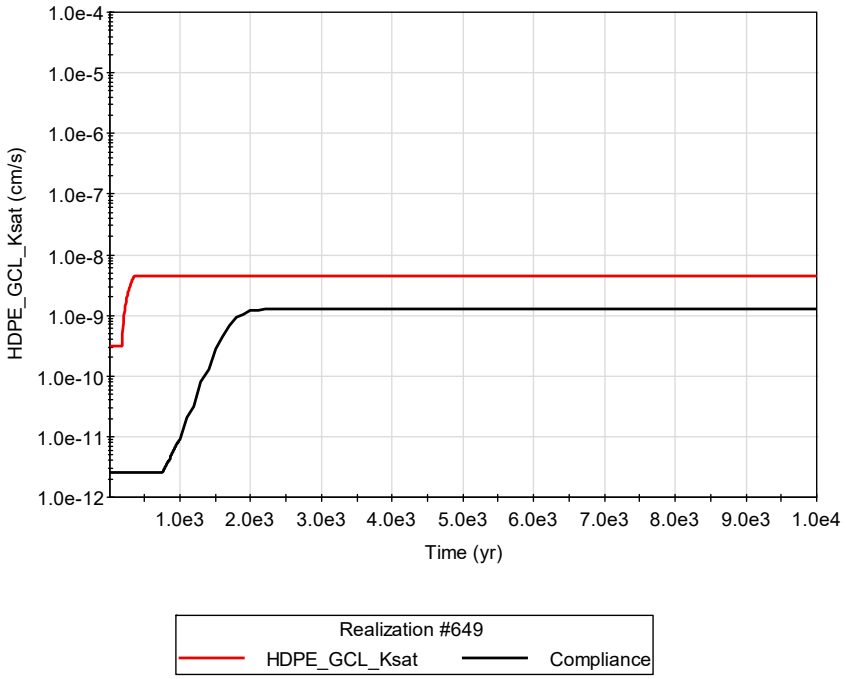
Realization 578 HDPE-GCL Ksat:



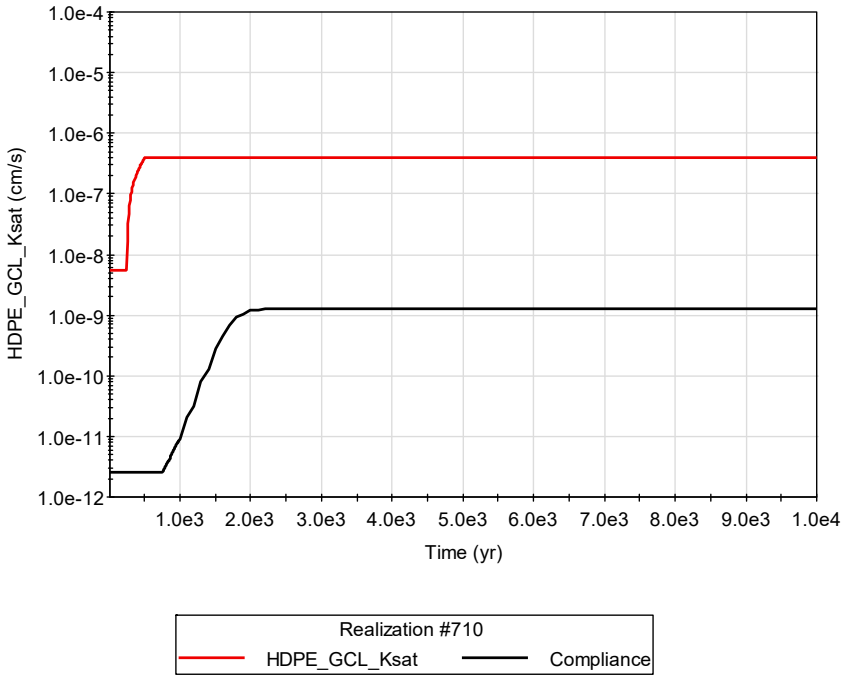
Realization 601 HDPE-GCL Ksat:



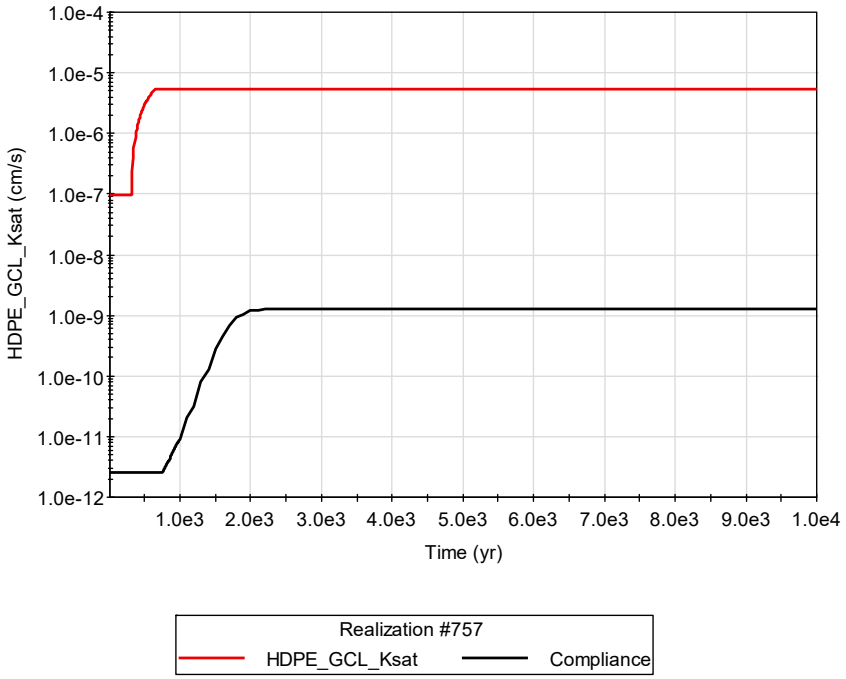
Realization 649 HDPE-GCL Ksat:



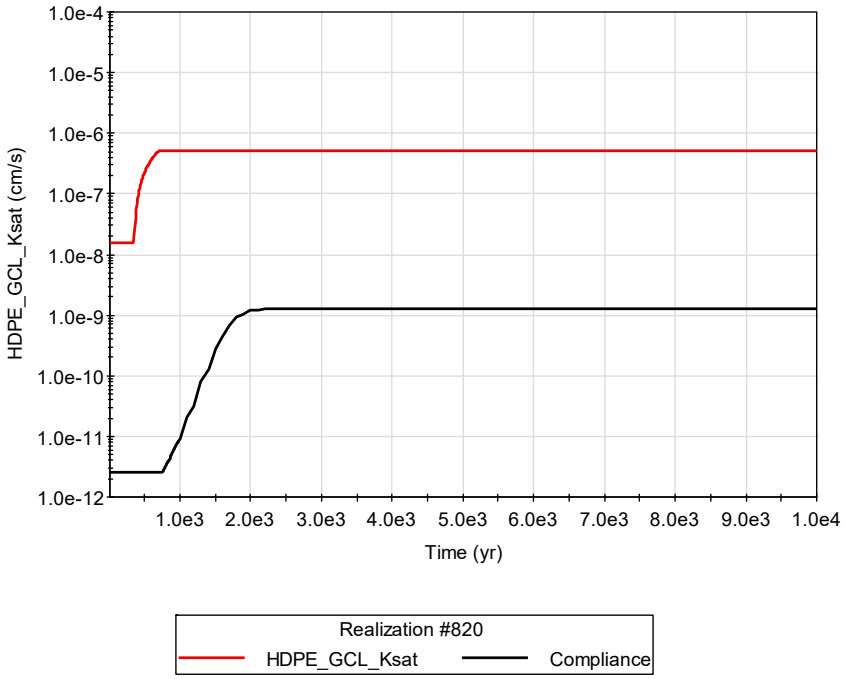
Realization 710 HDPE-GCL Ksat:



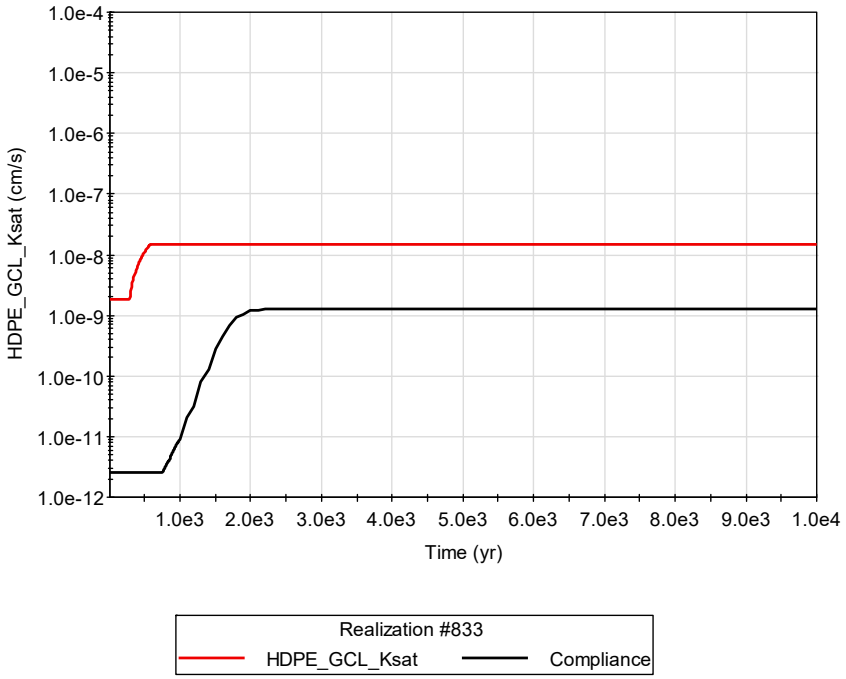
Realization 757 HDPE-GCL Ksat:



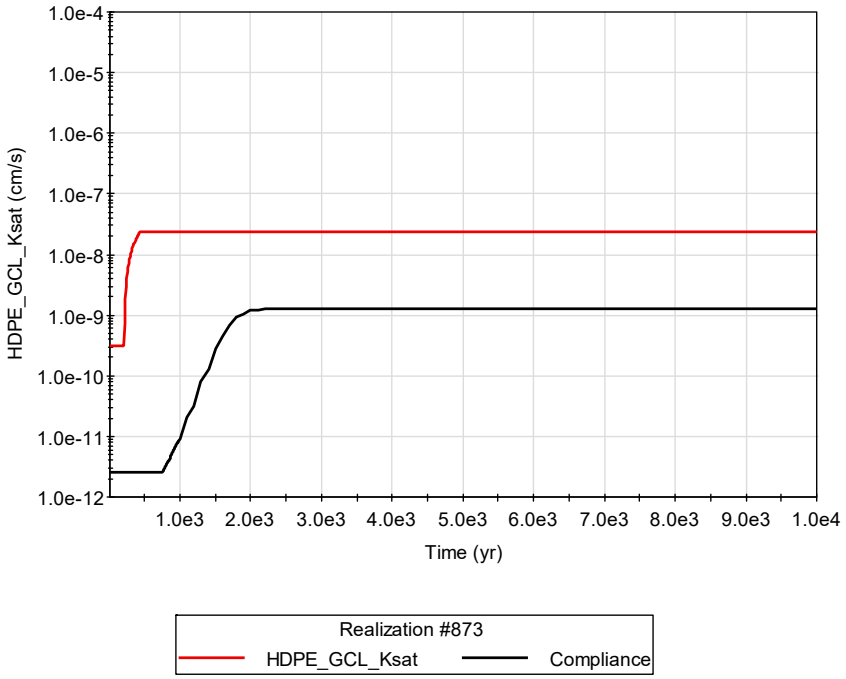
Realization 820 HDPE-GCL Ksat:



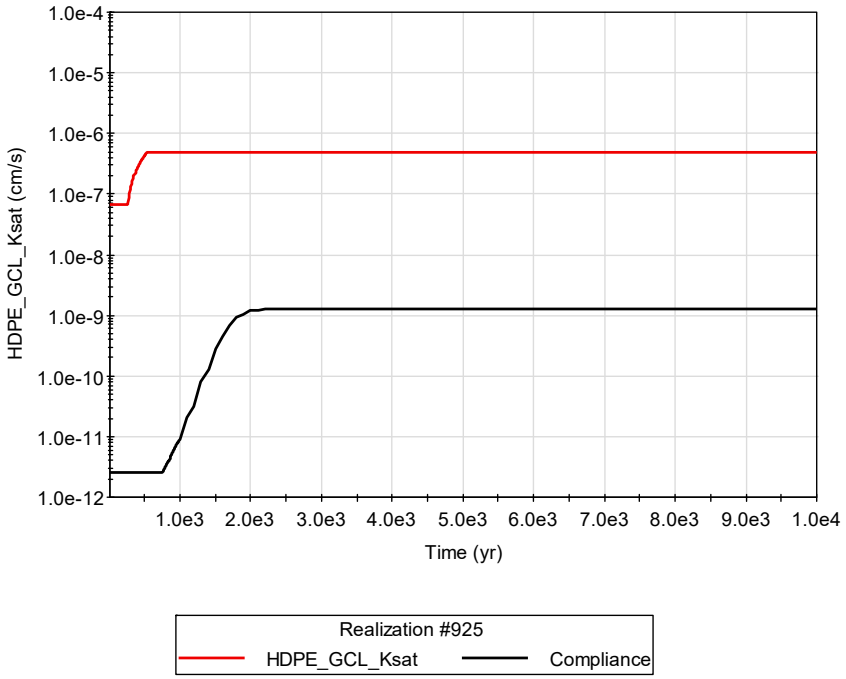
Realization 833 HDPE-GCL Ksat:



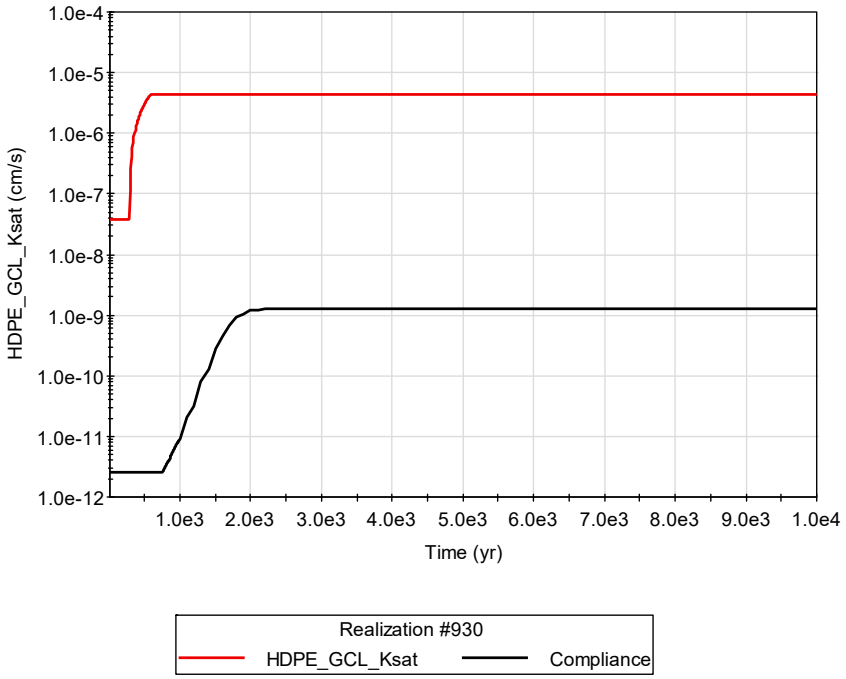
Realization 873 HDPE-GCL Ksat:



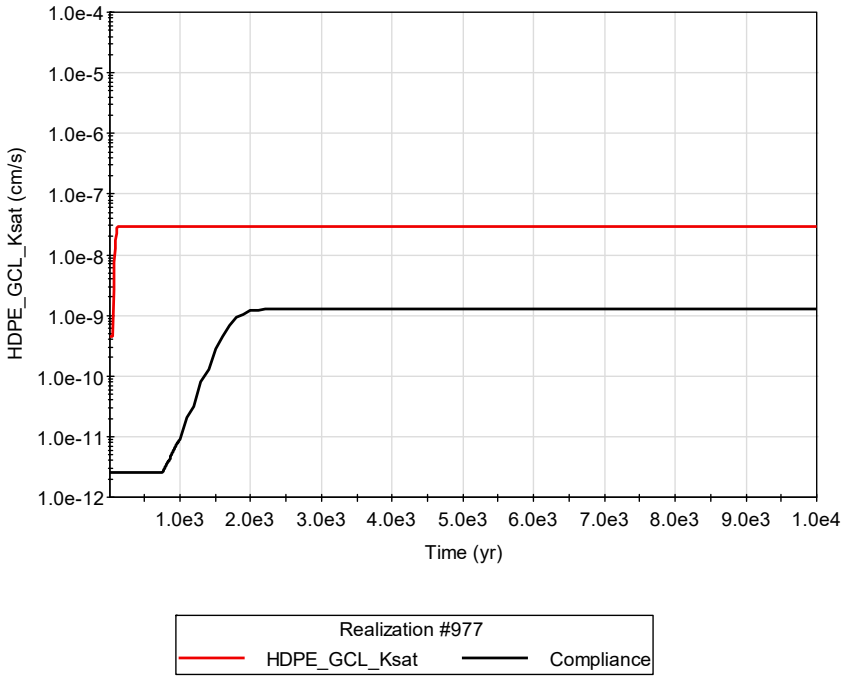
Realization 925 HDPE-GCL Ksat:



Realization 930 HDPE-GCL Ksat:



Realization 977 HDPE-GCL Ksat:

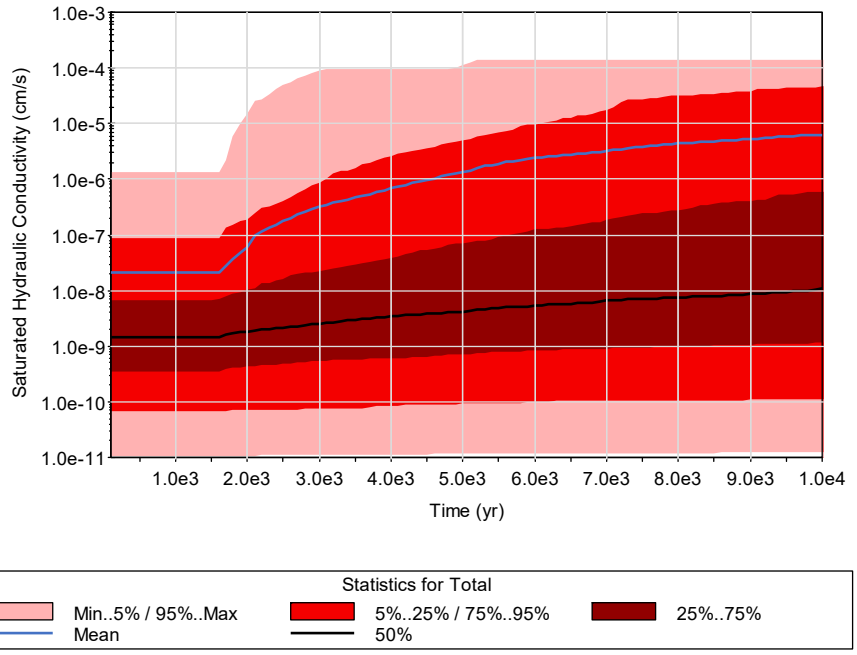


Appendix C. Saltstone Degradation Curves

The following figures show the saltstone degradation curves that correspond to each of the RSI-1 model realizations. These curves come from the probabilistic saltstone degradation model: *Probabilistic_SaltstoneDeg_Model_v1.001.gsm*, which was described in *Evaluation of the Uncertainties Associated with Long-Term Saltstone Degradation* (SRR-CWDA-2021-00056). These saltstone degradation curves were used to develop the RSI-1 model realizations. The selected model results correspond to the realizations from Table 1.

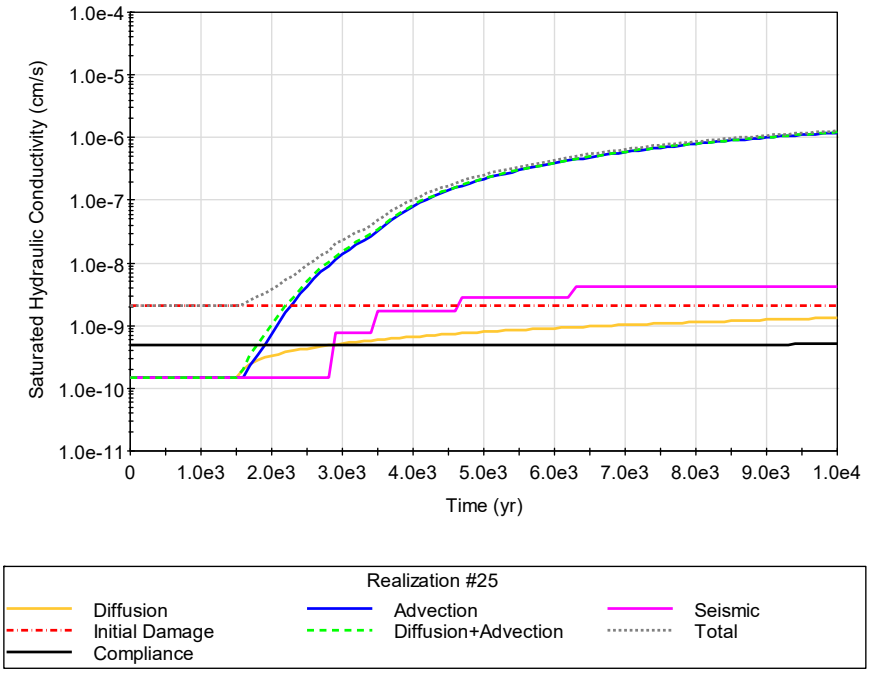
For context, the first figure shows the probabilities from using all 1,000 RSI-1 model realizations (i.e., the realizations depicted in this figure have not been screened). This figure shows that the median saltstone Ksat starts at approximately 1.4E-09 cm/s, then increases by nearly an order of magnitude to approximately 1.1E-08 cm/s over a 10,000-year period. The relatively large difference between the mean curve (blue) and the median curve (black) indicates that the mean curve is not representative of the central tendency of the saltstone Ksat values. This is because a relatively small number of realizations had extremely high Ksat values that drove up the mean.

Saltstone Ksat Probabilities:

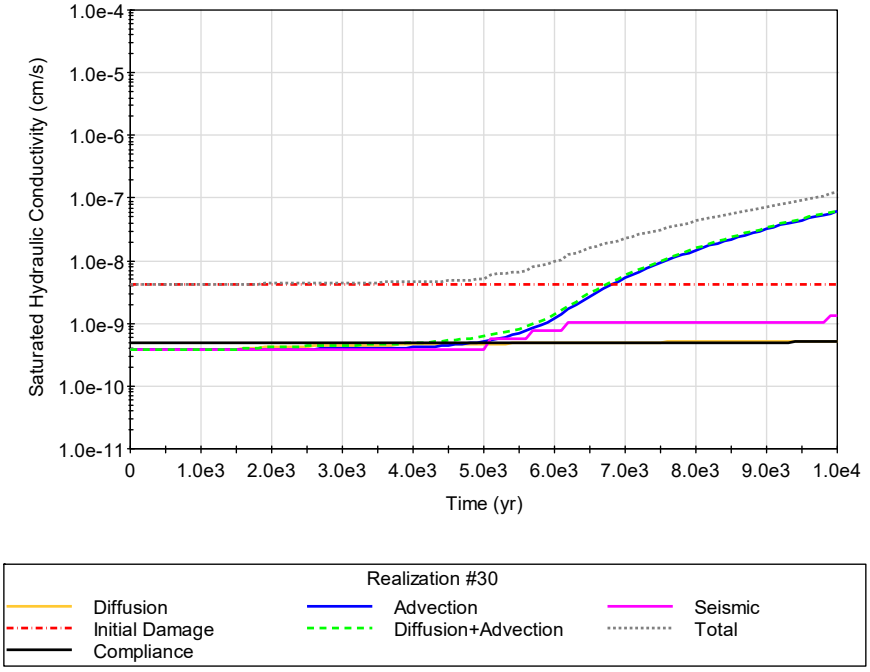


Each of the following saltstone Ksat figures shows six curves: the red curve represents the Ksat upon applying the assumed initial cracking damage, the yellow and blue curves show the influence of diffusive and advective decalcification, respectively, the green curve shows the combined influence of both decalcification processes, the magenta curve shows the influence from assumed seismic damage, and the gray dashed curve shows the combined effects of all the degradation mechanisms. Because the advective decalcification is tied to the infiltration rates, and all of these realizations had infiltration rates greater than 1 in/yr, most of these curves show total Ksat values that are higher than the median curve.

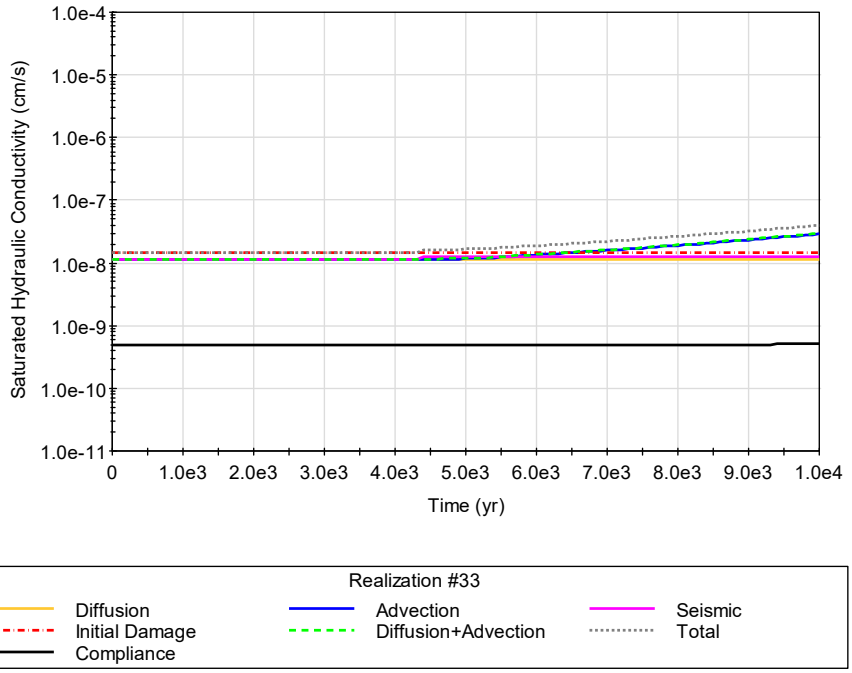
Realization 25 Saltstone Ksat:



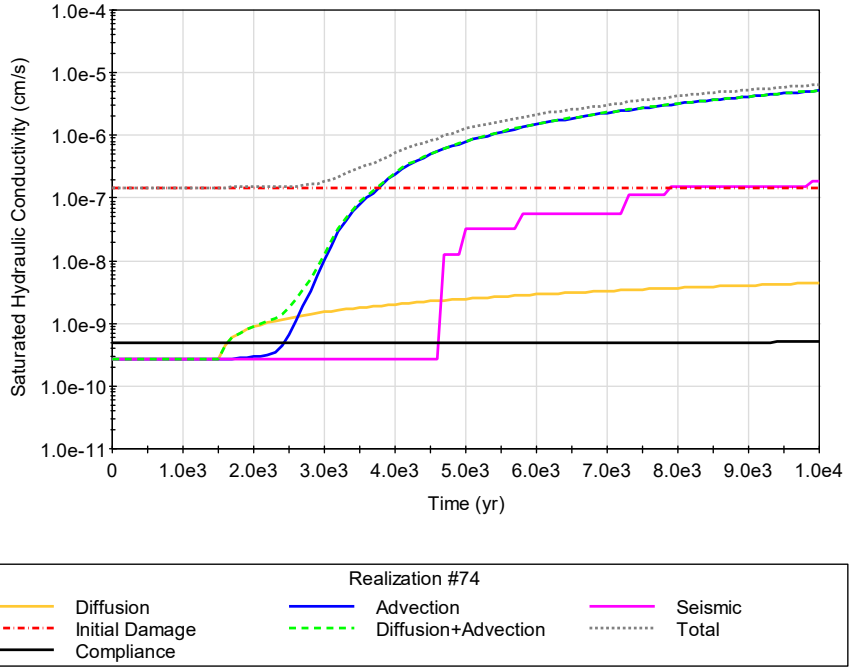
Realization 30 Saltstone Ksat:



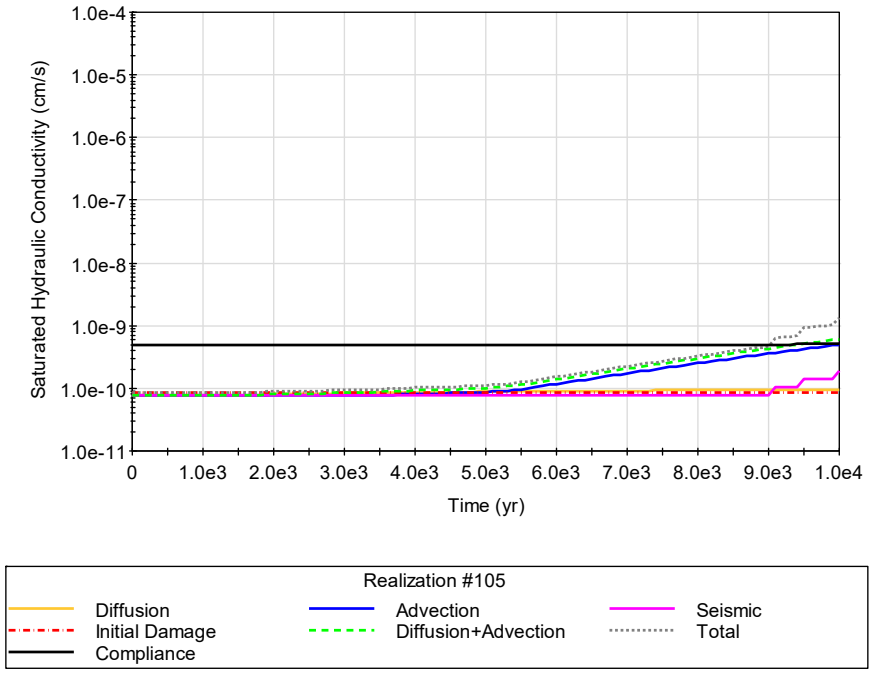
Realization 33 Saltstone Ksat:



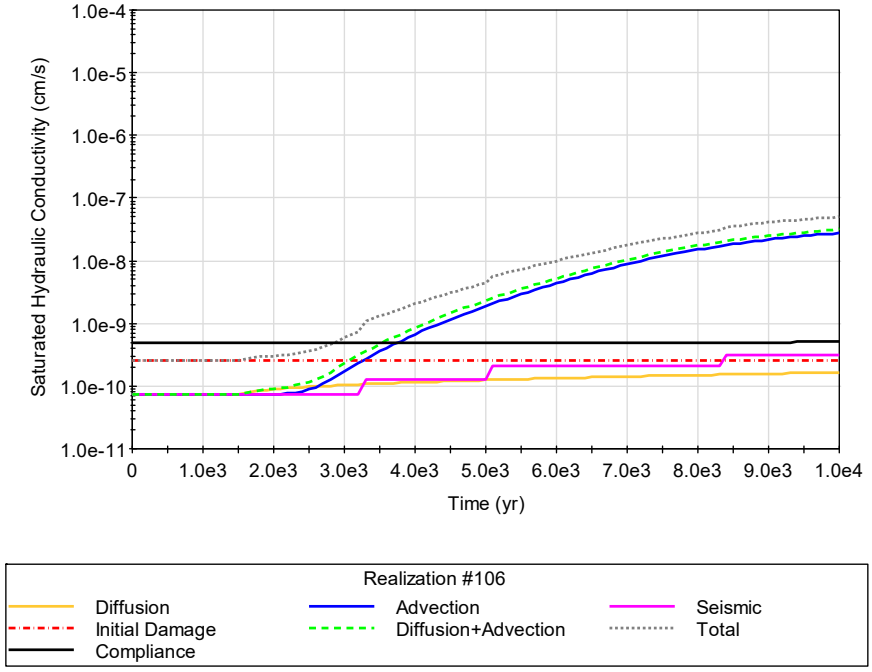
Realization 74 Saltstone Ksat:



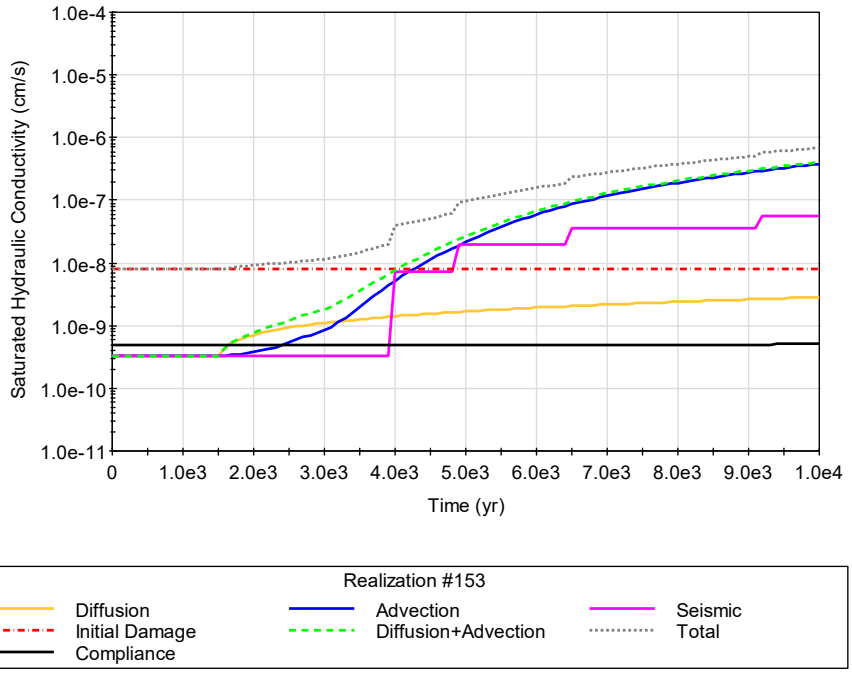
Realization 105 Saltstone Ksat:



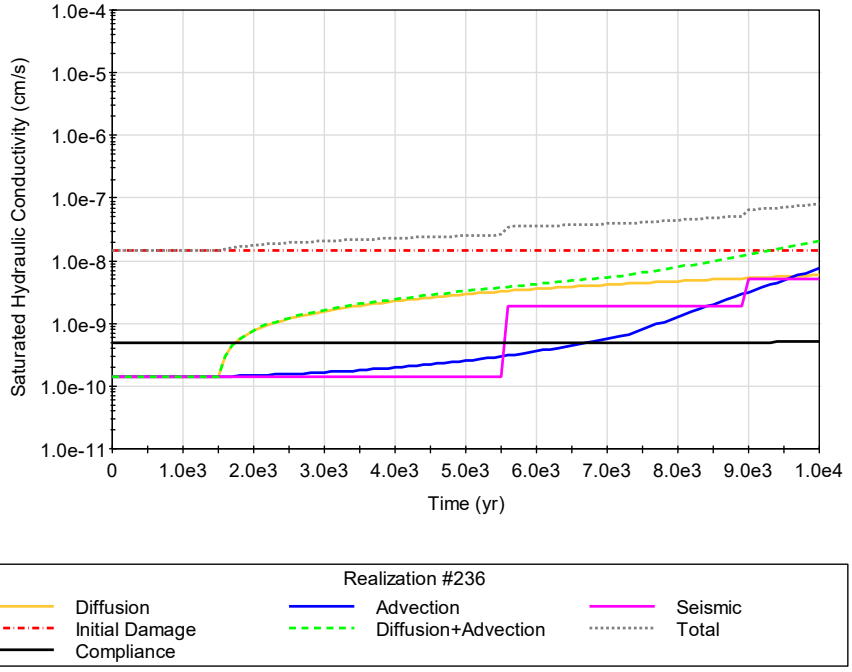
Realization 106 Saltstone Ksat:



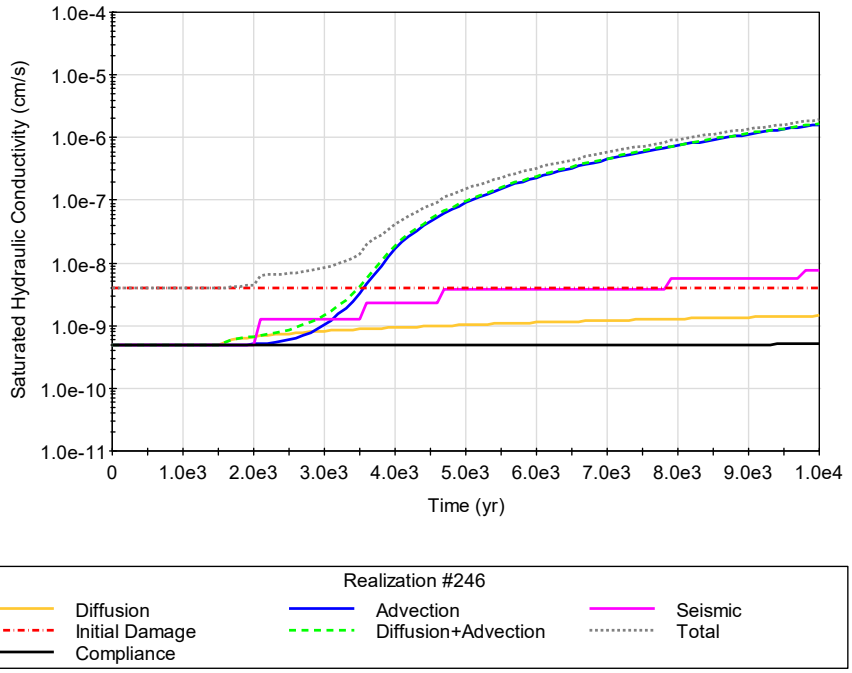
Realization 153 Saltstone Ksat:



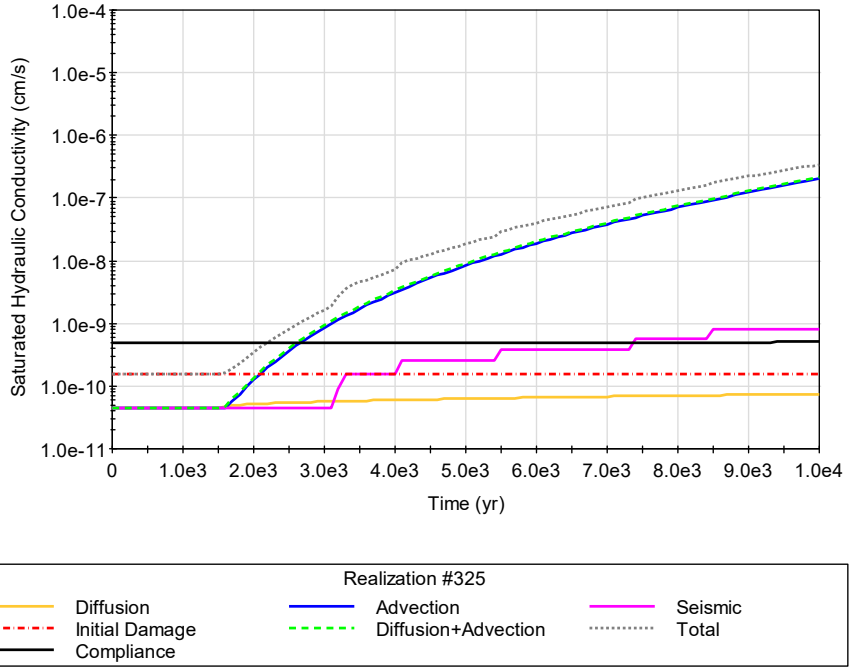
Realization 236 Saltstone Ksat:



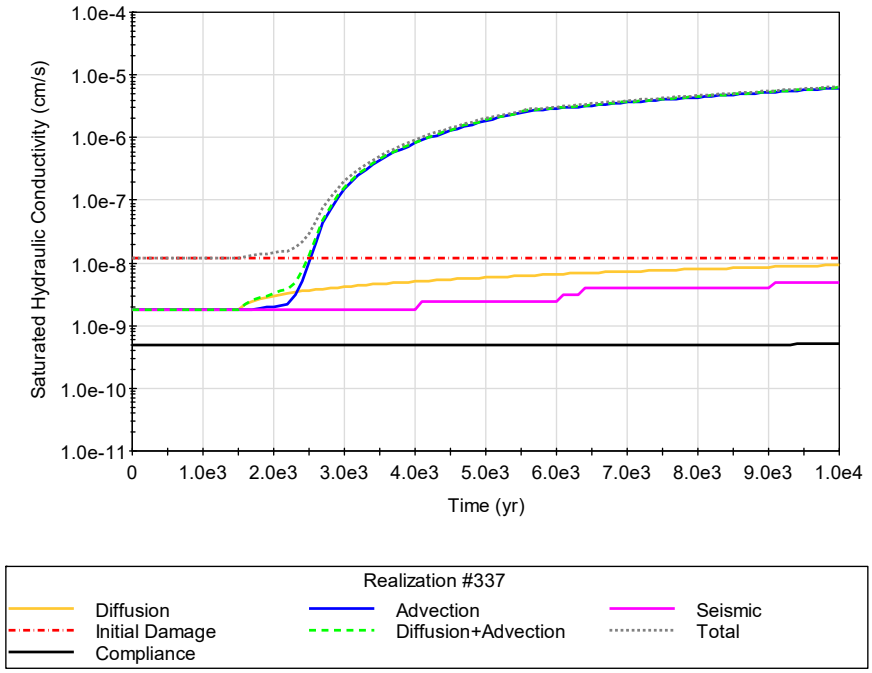
Realization 246 Saltstone Ksat:



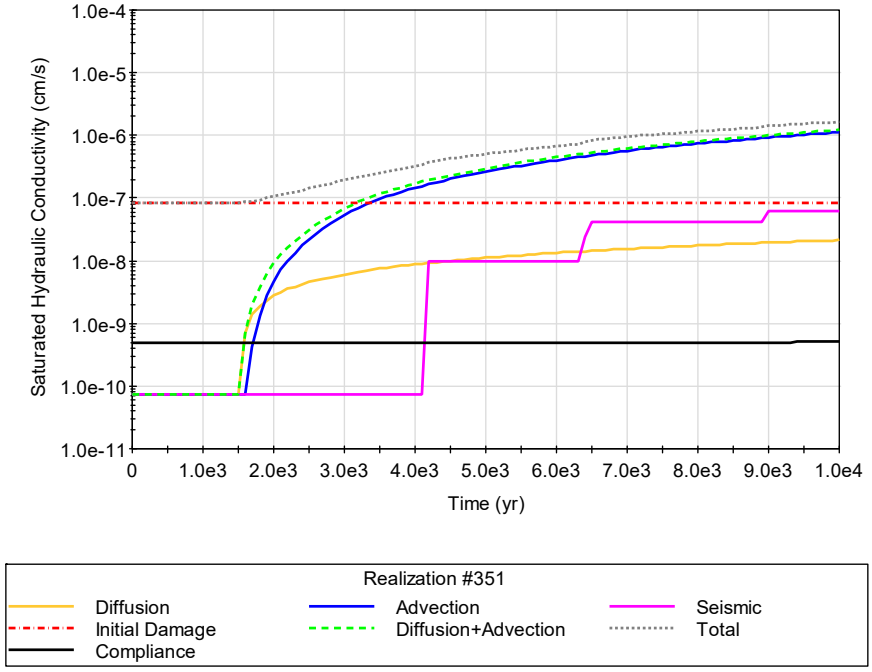
Realization 325 Saltstone Ksat:



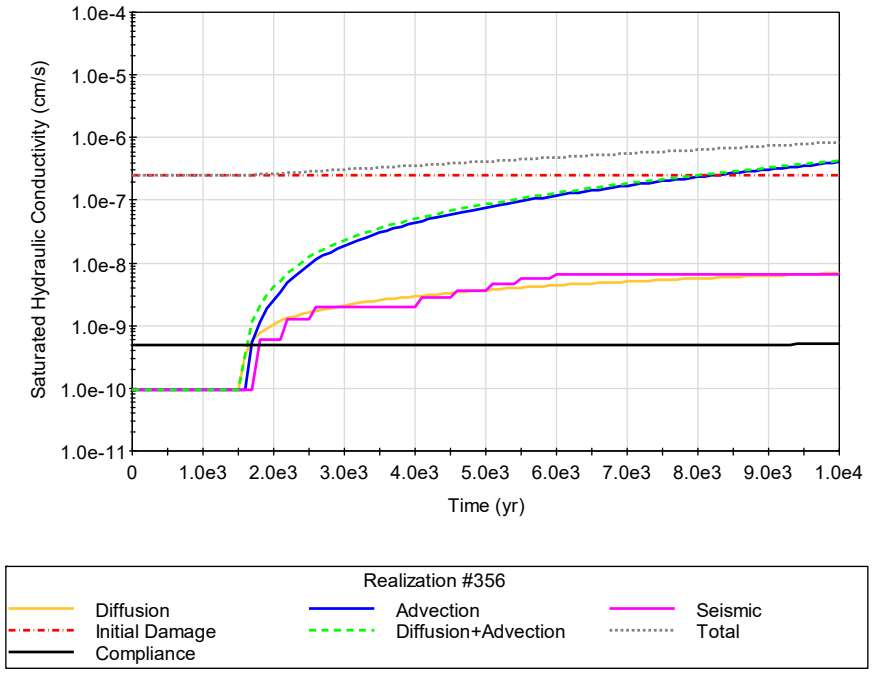
Realization 337 Saltstone Ksat:



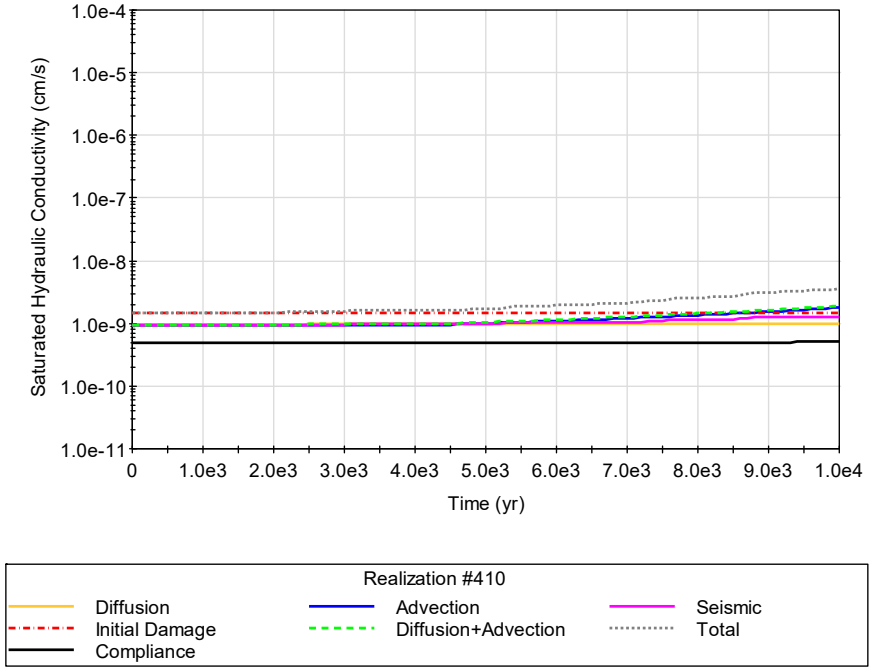
Realization 351 Saltstone Ksat:



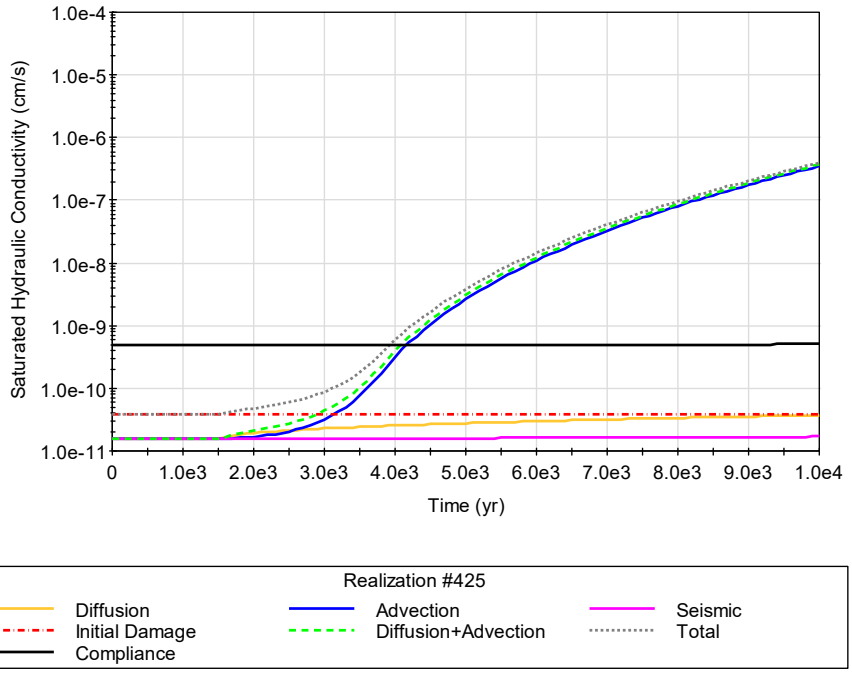
Realization 356 Saltstone Ksat:



Realization 410 Saltstone Ksat:



Realization 425 Saltstone Ksat:



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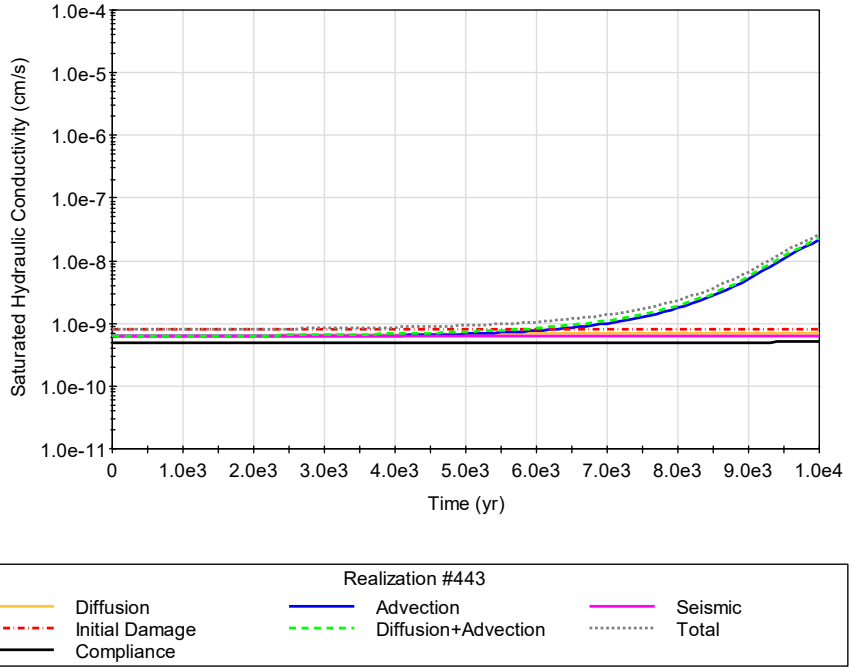

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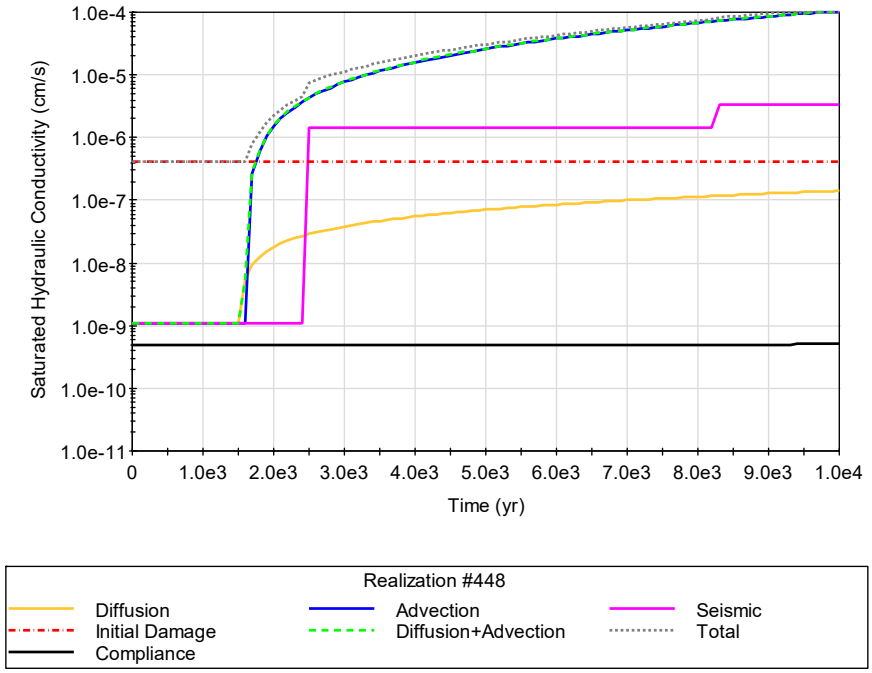

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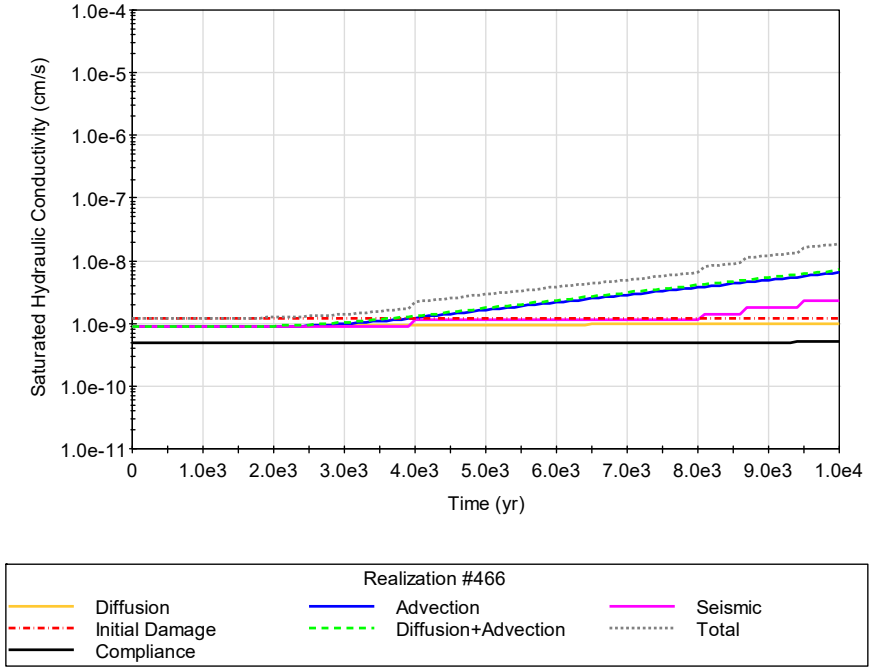

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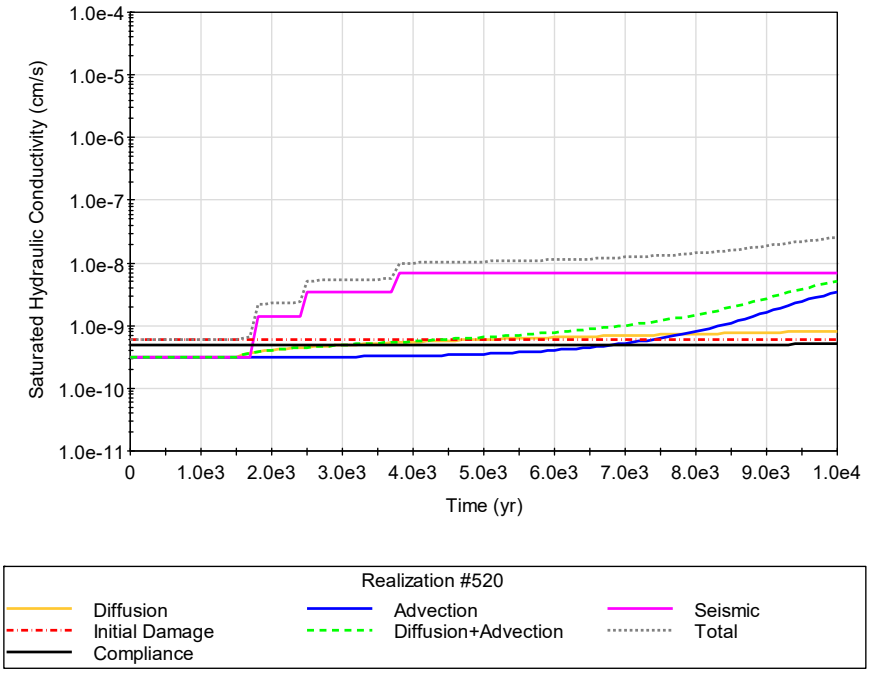

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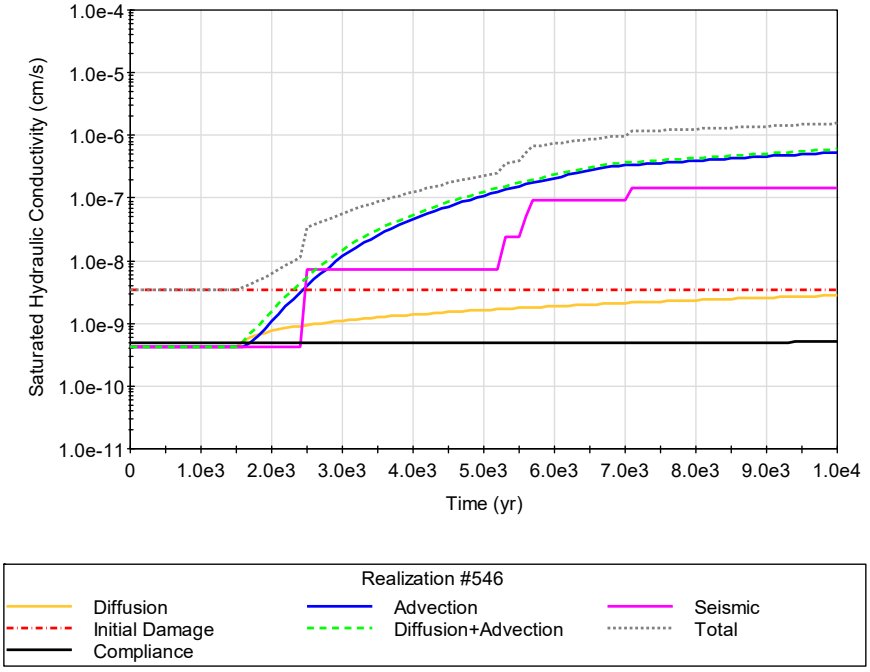

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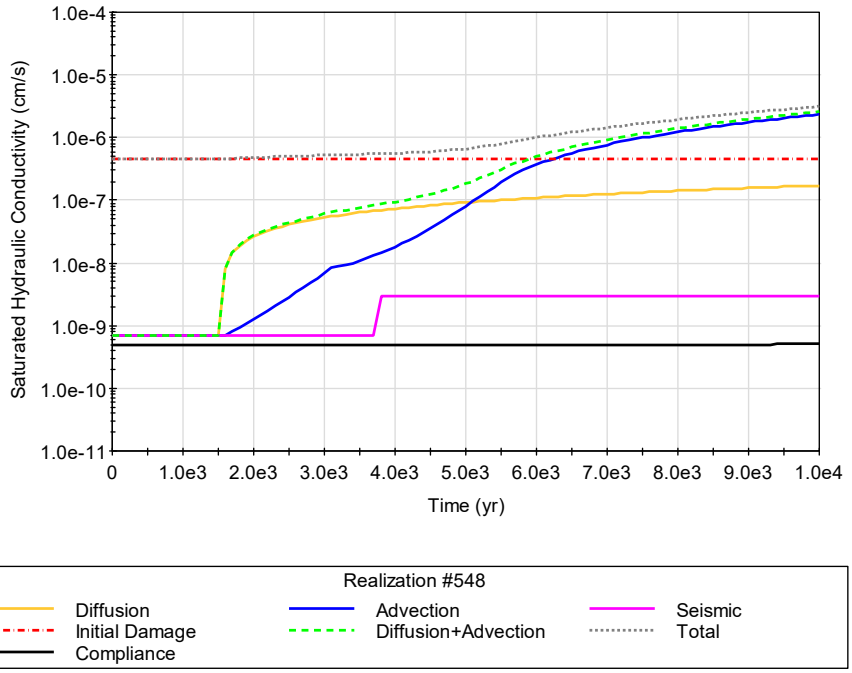

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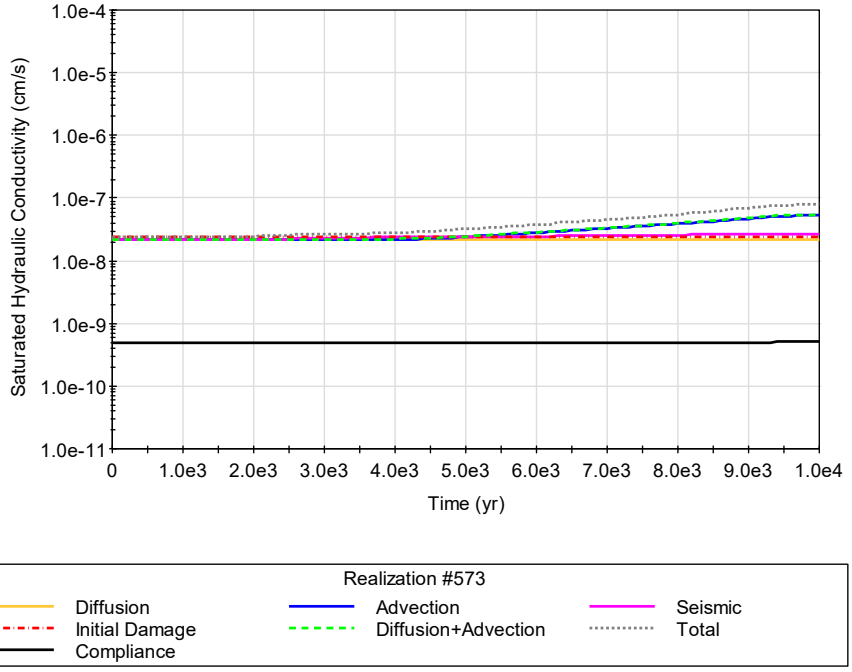

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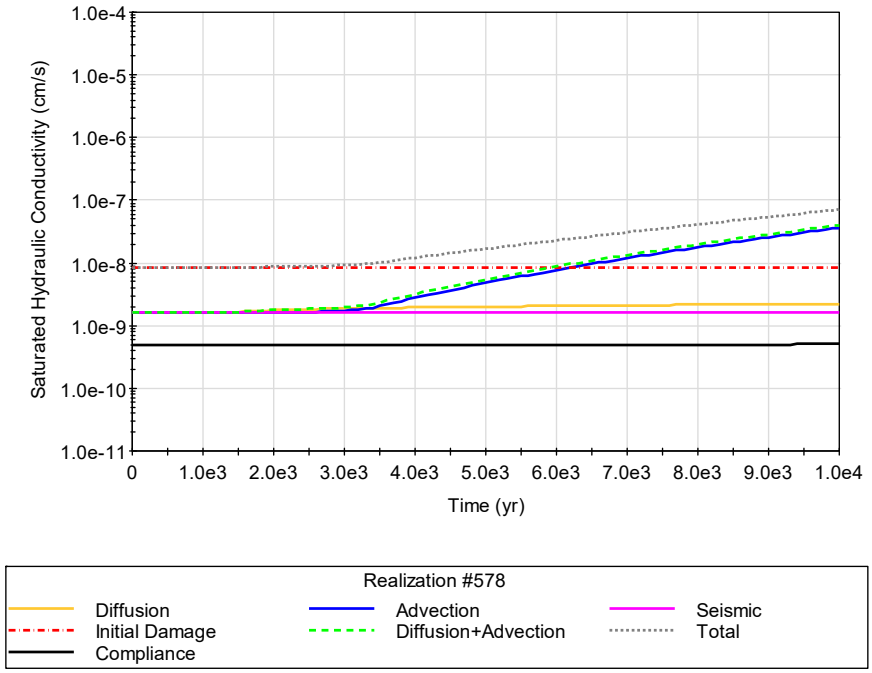

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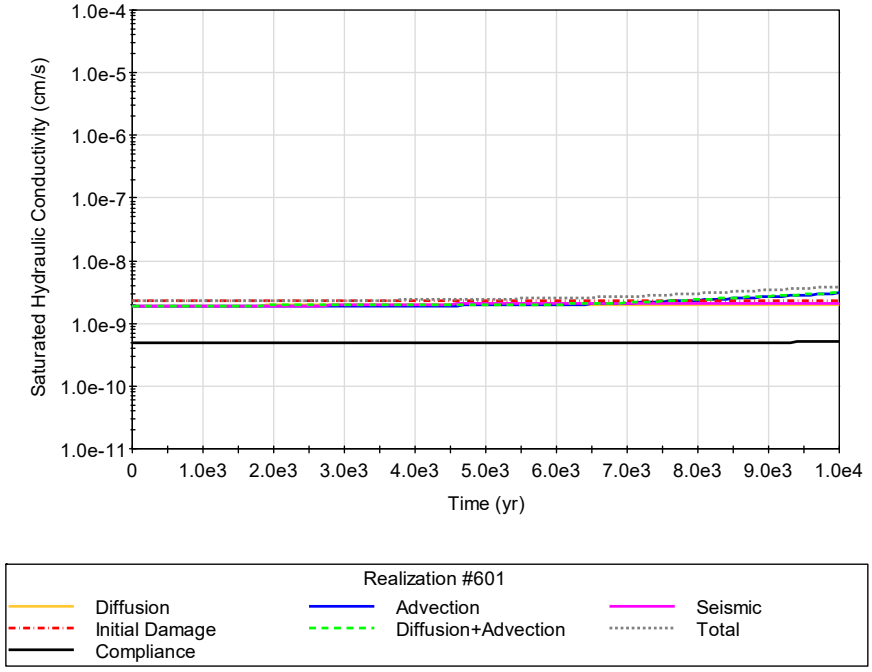

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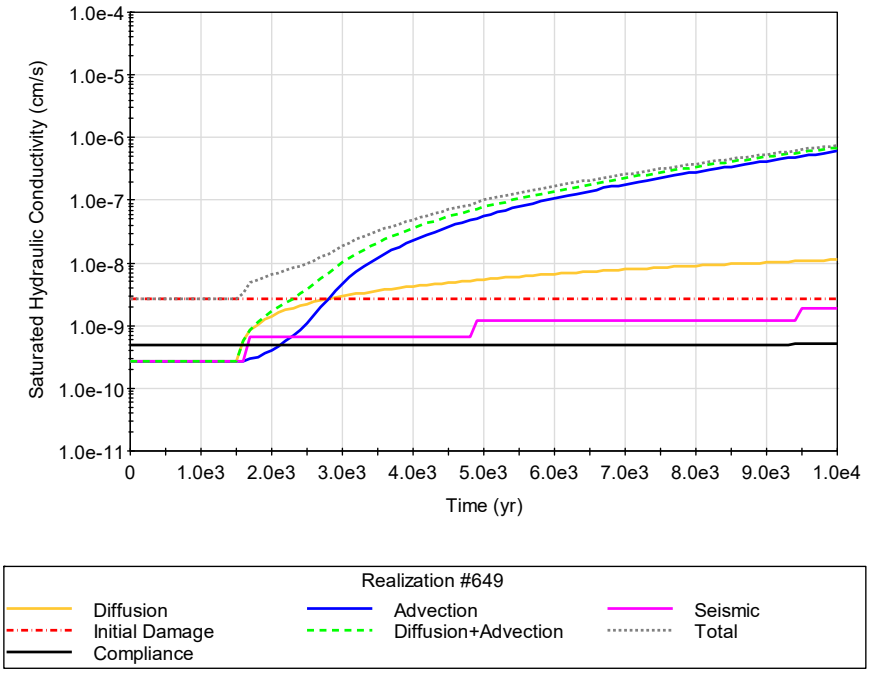

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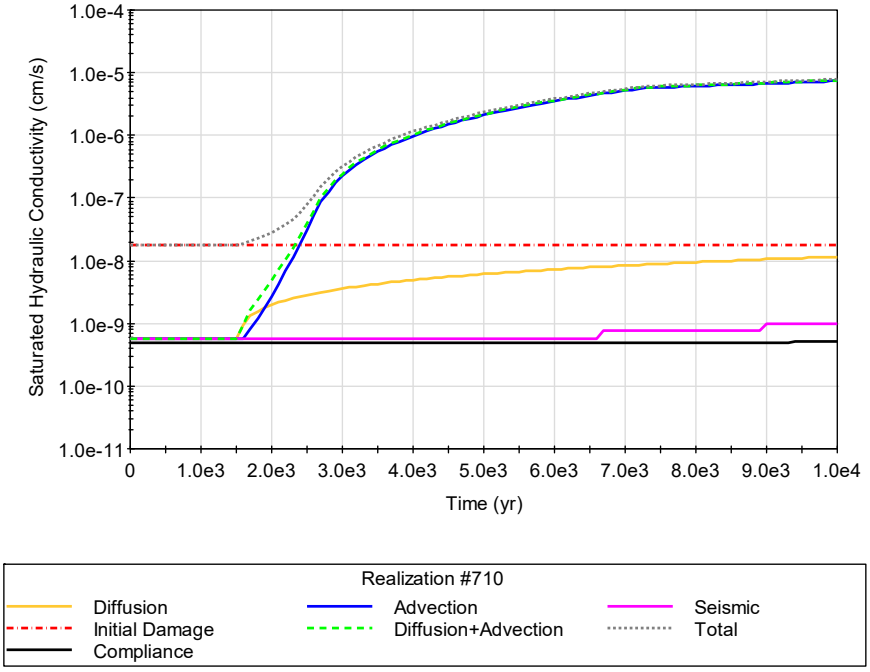

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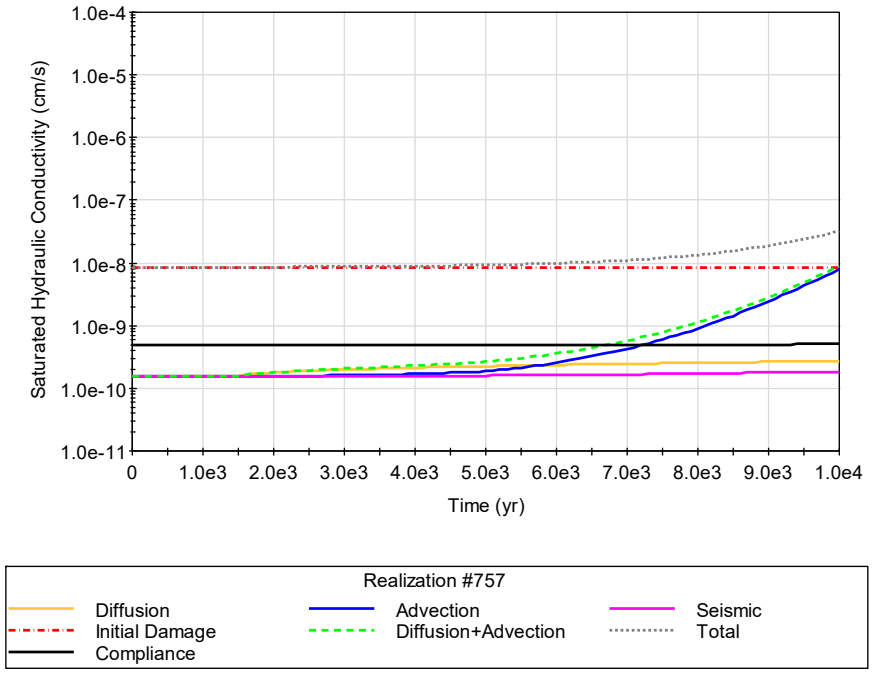

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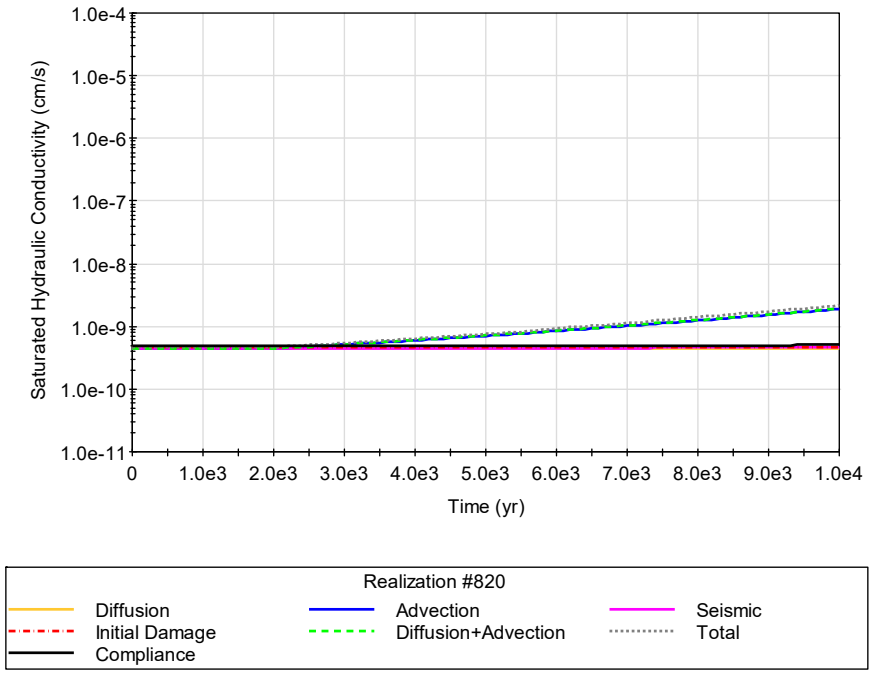

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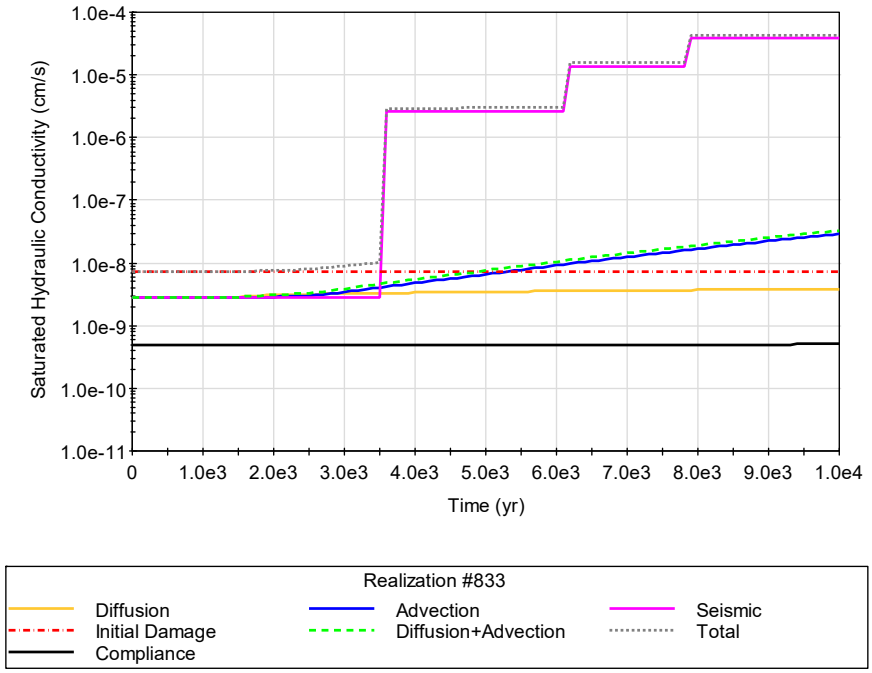

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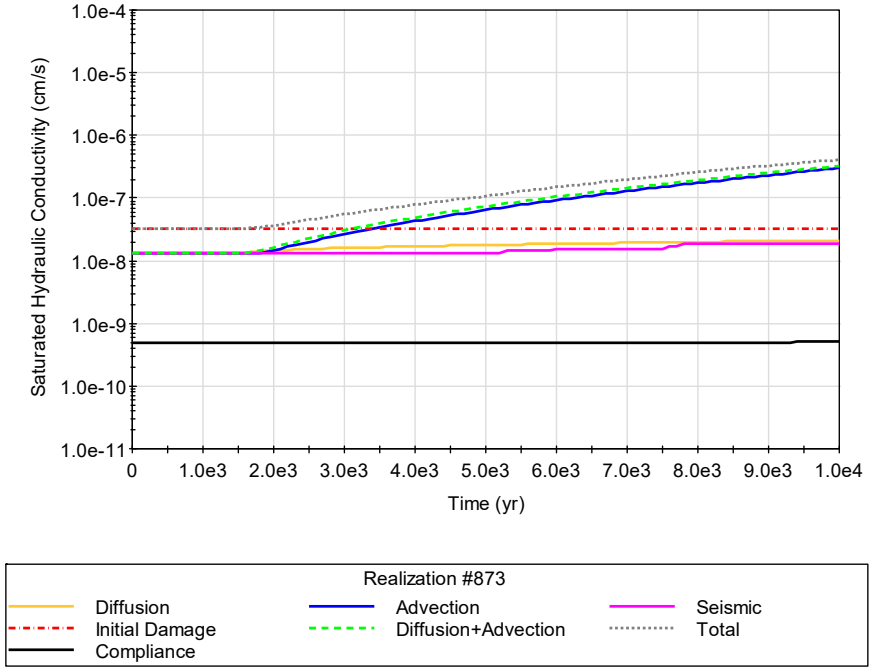
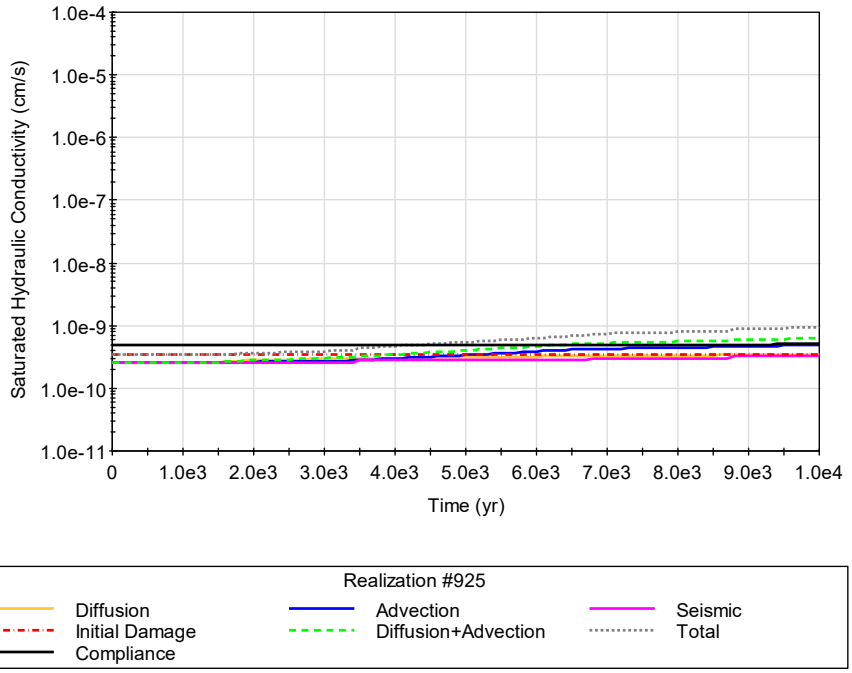


Realization 925 Saltstone Ksat:



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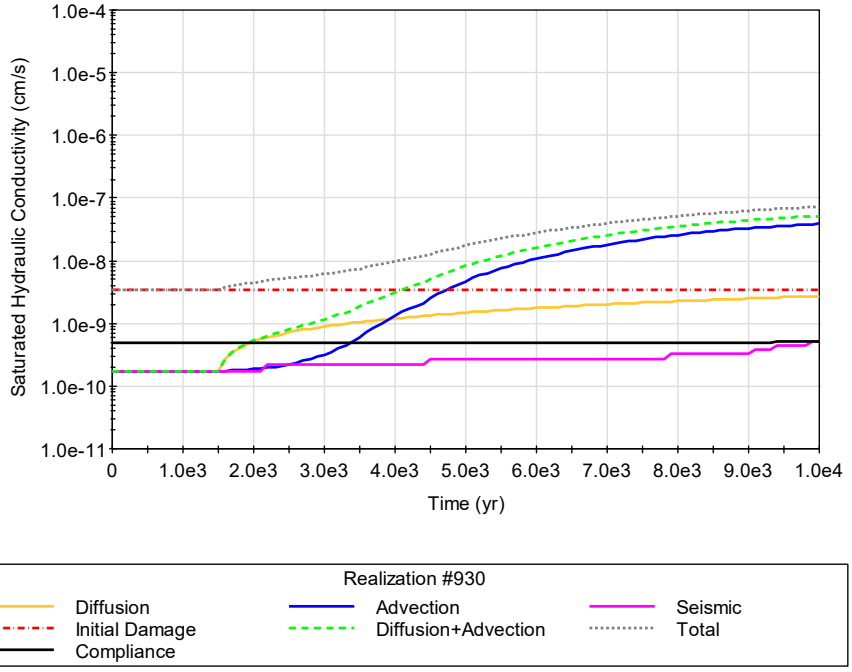

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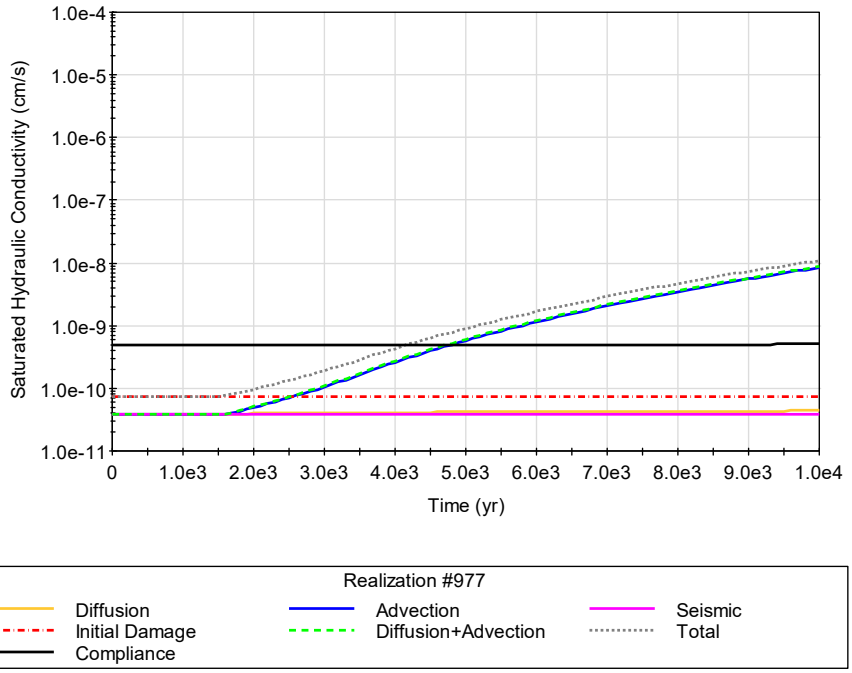

Appendix D. Release of Information Email

Release of Information (PORFLOW and GoldSim Calculations)

John Monahan to: Steven Hommel 05/14/2012 12:59 PM
Dorinda Fountain, Kent Rosenberger, Richard Sheppard, Barry
Cc: Lester, Joann Wingard, Daniel Campbell, George Rodrigues, Michael Burch, Reginald Waltz

Over the past few years, the Classification Office has performed several information release reviews of data files associated with calculations for radiation dose to a theoretical person that builds their house on top of an SRS decommissioned waste tank. These models will be required for each waste tank as we proceed through the decommissioning and closure process. The modeling software and tables containing basic science information for the residual radioisotopes in the tanks are unclassified subject areas.

Updates to the GoldSim and PORFLOW modeling files and programs, used for the calculations described above, do not require further review by the Classification Office. This also applies to modeling data for other waste tanks as we move through the decommissioning and closure process.

As we discussed, please generate a Request for Information Review and Release and attach this email when updates or new tanks are modeled and require submission to the regulators.

NOTE: If any technical discussion of SNM processing or how SNM is used in nuclear weapons is included, then the full document must be reviewed for information security concerns.

John J. Monahan
SRNS Classification Officer