MEMORANDUM

To:	Timothy Leighton, EPA; Kathryn Korthauer, EPA
From:	Jonathan Cohen, ICF
Date:	September 13, 2021
Re:	Supplement to Statistical Review of the AEATF II Immersion Dip Soak Study

5. Contents

This memorandum is a Supplement to the main memo "Statistical Review of the AEATF II Immersion Dip Soak Study," September 11, 2021.

In the main memo we detailed the methods and results for the statistical analysis of the AEATF II Immersion Dip Soak Study using the normalizing factor pesticide concentration times duration for the three scenarios abbreviated as "Bucket," "Sink," and "COP." In Sections 6, 7, 8 of this Supplement we present the results using the normalizing factor pesticide concentration for the same three scenarios. In Sections 9, 10, 11 of this Supplement we present the results using the normalizing factor one (i.e., no normalizing factor) for the same three scenarios; those sections do not include regression modeling results. In Section 12 of the Supplement we describe and present the Threshold analyses that graphically compare the Linear and Lognormal models for each normalizing factor and scenario.

The statistical methods used in the Supplement were detailed in Section 2 of the main memo for the Bucket Scenario using the normalizing factor pesticide concentration times duration and the reader is referred to that Section for the details. The results In the Supplement repeat those analyses for the other two normalizing factors and all three scenarios. As in the main memo, we continue to use the following labeling scheme for the tables and figures. Each Table or Figure is labeled as Table XYn or Figure XYn. The letter X indicates the normalizing factor which is either A for normalizing by concentration times duration, B for normalizing by concentration, or C for normalizing by 1. For the concentration times duration normalizing factor, normalizing factor A is in the main text and normalizing factors B and C are in the Supplement. The letter Y denotes the scenario, which is either B for Bucket, C for COP, or S for Sink. The number n denotes the table or figure number for normalizing factor X and scenario Y. The same sequence of analyses applies for each combination of normalizing factor and scenario. In this manner the first two letters of each Figure or Table identify the normalizing factor and the scenario.

6. Normalizing Factor Concentration, Bucket Scenario

Summary Statistics of Exposure per Concentration

Tables BB1 to BB7 summarize the normalized exposure data (per concentration) with the summary statistics from the 18 (all concentrations), or 6 (specific concentrations) measurements for each concentration group, and each dermal and inhalation exposure route. These analyses assume that the exposure measurements within each subset come from some unspecified distribution for that subset.

Table BB1. Summary statistics for normalized long dermal exposure (mg/(ppm ADBAC)) using empirical sampling model

Statistic	All	Target Quat: 440 ppm	Target Quat: 880 ppm	Target Quat: 1760 ppm
Arithmetic Mean	0.0591	0.0675	0.0659	0.0439
Arithmetic Standard Deviation	0.0407	0.0397	0.0554	0.0239
Geometric Mean	0.0476	0.0569	0.0517	0.0367
Geometric Standard Deviation	2.0106	1.9587	2.0785	2.0902
Min	0.0098	0.0229	0.0239	0.0098
5%	0.0098	0.0229	0.0239	0.0098
10%	0.0229	0.0229	0.0239	0.0098
25%	0.0299	0.0299	0.0300	0.0267
50%	0.0493	0.0632	0.0472	0.0453
75%	0.0755	0.1076	0.0755	0.0576
90%	0.1182	0.1182	0.1715	0.0787
95%	0.1715	0.1182	0.1715	0.0787
Max	0.1715	0.1182	0.1715	0.0787

Table BB2. Summary statistics for normalized short dermal exposure (mg/(ppm ADBAC)) using empirical sampling model

Statistic	All	Target Quat: 440 ppm	Target Quat: 880 ppm	Target Quat: 1760 ppm
Arithmetic Mean	0.0596	0.0679	0.0664	0.0444
Arithmetic Standard Deviation	0.0411	0.0397	0.0561	0.0245
Geometric Mean	0.0480	0.0573	0.0521	0.0371
Geometric Standard Deviation	2.0051	1.9483	2.0794	2.0845
Min	0.0100	0.0233	0.0240	0.0100
5%	0.0100	0.0233	0.0240	0.0100
10%	0.0233	0.0233	0.0240	0.0100

Statistic	All	Target Quat: 440 ppm	Target Quat: 880 ppm	Target Quat: 1760 ppm
25%	0.0301	0.0304	0.0301	0.0269
50%	0.0494	0.0634	0.0476	0.0455
75%	0.0756	0.1085	0.0756	0.0579
90%	0.1185	0.1185	0.1735	0.0808
95%	0.1735	0.1185	0.1735	0.0808
Max	0.1735	0.1185	0.1735	0.0808

Table BB3. Summary statistics for normalized long short dermal exposure (mg/(ppm ADBAC)) using empirical sampling model

Statistic	All	Target Quat: 440 ppm	Target Quat: 880 ppm	Target Quat: 1760 ppm
Arithmetic Mean	0.0593	0.0678	0.0661	0.0442
Arithmetic Standard Deviation	0.0407	0.0396	0.0554	0.0242
Geometric Mean	0.0479	0.0572	0.0519	0.0370
Geometric Standard Deviation	2.0020	1.9486	2.0731	2.0795
Min	0.0100	0.0233	0.0240	0.0100
5%	0.0100	0.0233	0.0240	0.0100
10%	0.0233	0.0233	0.0240	0.0100
25%	0.0301	0.0303	0.0301	0.0269
50%	0.0493	0.0634	0.0475	0.0454
75%	0.0755	0.1079	0.0755	0.0578
90%	0.1183	0.1183	0.1717	0.0799
95%	0.1717	0.1183	0.1717	0.0799
Max	0.1717	0.1183	0.1717	0.0799

Table BB4. Summary statistics for normalized hands only dermal exposure (mg/(ppm ADBAC)) using empirical sampling model

Statistic	All	Target Quat: 440 ppm	Target Quat: 880 ppm	Target Quat: 1760 ppm
Arithmetic Mean	0.0590	0.0674	0.0658	0.0438
Arithmetic Standard Deviation	0.0406	0.0397	0.0553	0.0239
Geometric Mean	0.0475	0.0567	0.0516	0.0366
Geometric Standard Deviation	2.0113	1.9630	2.0783	2.0898

Statistic	All	Target Quat: 440 ppm	Target Quat: 880 ppm	Target Quat: 1760 ppm
Min	0.0098	0.0227	0.0239	0.0098
5%	0.0098	0.0227	0.0239	0.0098
10%	0.0227	0.0227	0.0239	0.0098
25%	0.0298	0.0298	0.0300	0.0267
50%	0.0493	0.0631	0.0471	0.0453
75%	0.0754	0.1074	0.0754	0.0575
90%	0.1181	0.1181	0.1712	0.0785
95%	0.1712	0.1181	0.1712	0.0785
Max	0.1712	0.1181	0.1712	0.0785

Table BB5. Summary statistics for normalized inhalation concentration exposure (mg/m^3/(ppm DDAC)) using empirical sampling model

Statistic	All	Target Quat: 440 ppm	Target Quat: 880 ppm	Target Quat: 1760 ppm
Arithmetic Mean	2.198E-06	1.865E-06	3.479E-06	1.250E-06
Arithmetic Standard Deviation	3.431E-06	1.042E-06	5.913E-06	8.898E-07
Geometric Mean	1.368E-06	1.614E-06	1.609E-06	9.856E-07
Geometric Standard Deviation	2.358E+00	1.861E+00	3.150E+00	2.179E+00
Min	3.839E-07	5.608E-07	7.874E-07	3.839E-07
5%	3.839E-07	5.608E-07	7.874E-07	3.839E-07
10%	4.438E-07	5.608E-07	7.874E-07	3.839E-07
25%	8.210E-07	1.493E-06	8.210E-07	4.438E-07
50%	1.356E-06	1.574E-06	1.037E-06	9.958E-07
75%	2.194E-06	2.332E-06	1.660E-06	2.194E-06
90%	3.655E-06	3.655E-06	1.553E-05	2.486E-06
95%	1.553E-05	3.655E-06	1.553E-05	2.486E-06
Max	1.553E-05	3.655E-06	1.553E-05	2.486E-06

Table BB6. Summary statistics for normalized inhalation dose exposure (mg/(ppm DDAC)) using empirical sampling model

Statistic	All	Target Quat: 440 ppm	Target Quat: 880 ppm	Target Quat: 1760 ppm
Arithmetic Mean	1.227E-06	1.139E-06	1.670E-06	8.720E-07
Arithmetic Standard Deviation	1.317E-06	7.374E-07	2.046E-06	8.781E-07

Statistic	All	Target Quat: 440 ppm	Target Quat: 880 ppm	Target Quat: 1760 ppm
Geometric Mean	8.069E-07	9.570E-07	9.570E-07	5.737E-07
Geometric Standard Deviation	2.571E+00	1.901E+00	3.179E+00	2.817E+00
Min	1.280E-07	5.393E-07	2.737E-07	1.280E-07
5%	1.280E-07	5.393E-07	2.737E-07	1.280E-07
10%	2.737E-07	5.393E-07	2.737E-07	1.280E-07
25%	4.512E-07	5.475E-07	2.756E-07	3.075E-07
50%	8.000E-07	8.895E-07	1.044E-06	5.912E-07
75%	1.633E-06	1.633E-06	1.688E-06	1.087E-06
90%	2.527E-06	2.332E-06	5.694E-06	2.527E-06
95%	5.694E-06	2.332E-06	5.694E-06	2.527E-06
Max	5.694E-06	2.332E-06	5.694E-06	2.527E-06

Table BB7. Summary statistics for normalized inhalation time-weighted average concentration exposure (mg/m^3/(ppm DDAC)) using empirical sampling model

Statistic	All	Target Quat: 440 ppm	Target Quat: 880 ppm	Target Quat: 1760 ppm
Arithmetic Mean	1.534E-07	1.423E-07	2.087E-07	1.090E-07
Arithmetic Standard Deviation	1.646E-07	9.217E-08	2.557E-07	1.098E-07
Geometric Mean	1.009E-07	1.196E-07	1.196E-07	7.172E-08
Geometric Standard Deviation	2.571E+00	1.901E+00	3.179E+00	2.817E+00
Min	1.600E-08	6.741E-08	3.421E-08	1.600E-08
5%	1.600E-08	6.741E-08	3.421E-08	1.600E-08
10%	3.421E-08	6.741E-08	3.421E-08	1.600E-08
25%	5.640E-08	6.843E-08	3.445E-08	3.843E-08
50%	1.000E-07	1.112E-07	1.305E-07	7.391E-08
75%	2.041E-07	2.041E-07	2.110E-07	1.359E-07
90%	3.159E-07	2.916E-07	7.117E-07	3.159E-07
95%	7.117E-07	2.916E-07	7.117E-07	3.159E-07
Max	7.117E-07	2.916E-07	7.117E-07	3.159E-07

The results show the high proportions of the normalized dermal exposure from hands only. For All and for each concentration group, based on the arithmetic means, the overall percentages of normalized exposure from hands only are about 99% of the Long Dermal, Short Dermal, and Long Short Dermal. Similarly, for the unnormalized dermal

exposure, the arithmetic mean hands only exposure is 99% of the arithmetic mean total dermal exposure (defined as the sum of the residues from hand wash, forearm wipe, face/neck wipe, and the inner dosimeters).

Compare Concentration Groups

The results in Tables BB1 to BB7 show some differences between the normalized exposure statistics for the three concentration groups "Target Quat: 440 ppm," "Target Quat: 880 ppm," and "Target Quat: 1760 ppm." To compare these groups, an analysis of variance was performed to test whether the geometric means were statistically significantly different at the 5% significance level.

The p-values for these ANOVA tests are shown in Table BB8. These analyses show that there were no statistically significant differences (at the 5% significance level) between the three concentration groups for any of the exposure modes.

Table BB8. P-values for testing differences in geometric means for different concentration groups

Exposure Route	ANOVA	Welch's ANOVA
Long Dermal	0.548	0.576
Short Dermal	0.552	0.579
Long Short Dermal	0.550	0.577
Hands Only	0.551	0.579
Inhalation Conc	0.547	0.498
Inhalation Dose	0.585	0.607
Inhalation 8-hr TWA	0.585	0.607

Statistical Models

Table BB9 presents the arithmetic mean and 95th percentile estimates from the lognormal simple random sampling model, together with 95% confidence intervals, for each of the exposure routes, for all concentration groups combined. These are the values of AMu and P95u. The other summary statistics are presented in more detail below.

Table BB9. Arithmetic mean and 95th percentile estimates from lognormal simple random sampling model for normalized exposure for All

Exposure Route	Clothing	Arithmetic Mean (95% Confidence Interval)	95th Percentile (95% Confidence Interval)
Dermal (mg/(ppm ADBAC))	Long Dermal	0.0607 (0.0427, 0.0884)	0.1501 (0.0905, 0.2474)
	Short Dermal	0.0612 (0.0430, 0.0889)	0.1508 (0.0911, 0.2481)
	Long Short Dermal	0.0609 (0.0429, 0.0885)	0.1500 (0.0907, 0.2464)
	Hands Only	0.0606 (0.0426, 0.0883)	0.1499 (0.0904, 0.2471)

Exposure Route	Clothing	Arithmetic Mean (95% Confidence Interval)	95th Percentile (95% Confidence Interval)
Inhalation Concentration ((mg/m^3)/ (ppm DDAC))		1.98×10^{-6} (1.26×10^{-6}, 3.22×10^{-6})	5.61×10^{-6} (3.01×10^{-6}, 1.04×10^{-5})
Inhalation Dose (mg/ (ppm DDAC))		1.26×10^{-6} (7.56×10^{-7}, 2.19×10^{-6})	3.81×10^{-6} (1.93×10^{-6}, 7.50×10^{-6})
Inhalation 8-hr TWA ((mg/m^3)/ ppm DDAC))		1.58×10^{-7} (9.45×10^{-8}, 2.73×10^{-7})	4.77×10^{-7} (2.41×10^{-7}, 9.37×10^{-7})

Non-detects

For all the analyses presented in this memorandum except for Table BB10 and BB18, measurements below the LOQ or LOD were replaced by the mid-value, the midpoint of the lowest and highest possible value for that measurement. In Tables BB10 and BB18 we investigated the impact on the summary statistics of the censored values.

Table BB10. Exposure summary statistics calculated using alternative estimated exposures for values below the LOQ

Exposure Route	Method for Substituting Values Below the LOQ	Arithmetic Mean	95th Percentile
Long Dermal (mg/(ppm ADBAC))	Substitute mid value	0.0607 (0.0424, 0.0884)	0.1501 (0.0903, 0.2475)
	Substitute max value	0.0607 (0.0424, 0.0885)	0.1501 (0.0903, 0.2475)
	Substitute min value	0.0607 (0.0424, 0.0884)	0.1501 (0.0902, 0.2475)
	Censored data MLE	0.0599 (0.0423, 0.0861)	0.1453 (0.0887, 0.2363)
Short Dermal (mg/(ppm ADBAC))	Substitute mid value	0.0612 (0.0428, 0.0890)	0.1508 (0.0909, 0.2482)
	Substitute max value	0.0612 (0.0428, 0.0890)	0.1508 (0.0909, 0.2480)
	Substitute min value	0.0611 (0.0427, 0.0890)	0.1508 (0.0909, 0.2483)
	Censored data MLE	0.0604 (0.0427, 0.0866)	0.1460 (0.0893, 0.2370)
Long Short Dermal (mg/(ppm ADBAC))	Substitute mid value	0.0609 (0.0426, 0.0885)	0.1500 (0.0905, 0.2465)
	Substitute max value	0.0609 (0.0426, 0.0885)	0.1500 (0.0905, 0.2465)
	Substitute min value	0.0609 (0.0426, 0.0885)	0.1499 (0.0904, 0.2465)
	Censored data MLE	0.0601 (0.0425, 0.0862)	0.1452 (0.0889, 0.2354)
Hands Only (mg/(ppm ADBAC))	Substitute mid value	0.0606 (0.0423, 0.0883)	0.1499 (0.0901, 0.2472)
	Substitute max value	0.0606 (0.0423, 0.0883)	0.1499 (0.0901, 0.2472)
	Substitute min value	0.0606 (0.0423, 0.0883)	0.1499 (0.0901, 0.2472)
	Censored data MLE	0.0598 (0.0422, 0.0860)	0.1451 (0.0885, 0.2360)
Inhalation Concentration ((mg/m^3)/ (ppm DDAC))	Substitute mid value	1.98×10^{-6} (1.25×10^{-6}, 3.22×10^{-6})	5.61×10^{-6} (3.00×10^{-6}, 1.04×10^{-5})

Exposure Route	Method for Substituting Values Below the LOQ	Arithmetic Mean	95th Percentile
	Substitute max value	2.33×10^{-6} (1.55×10^{-6}, 3.58×10^{-6})	6.18×10^{-6} (3.51×10^{-6}, 1.08×10^{-5})
	Substitute min value	2.62×10^{-6} (1.62×10^{-6}, 4.37×10^{-6})	7.63×10^{-6} (3.99×10^{-6}, 1.45×10^{-5})
	Censored data MLE	1.95×10^{-6} (1.20×10^{-6}, 3.29×10^{-6})	5.75×10^{-6} (2.97×10^{-6}, 1.10×10^{-5})
Inhalation Dose (mg/ (ppm DDAC))	Substitute mid value	1.26×10^{-6} (7.50×10^{-7}, 2.19×10^{-6})	3.81×10^{-6} (1.92×10^{-6}, 7.50×10^{-6})
	Substitute max value	1.36×10^{-6} (9.12×10^{-7}, 2.07×10^{-6})	3.58×10^{-6} (2.05×10^{-6}, 6.18×10^{-6})
	Substitute min value	1.69×10^{-6} (1.11×10^{-6}, 2.61×10^{-6})	4.51×10^{-6} (2.55×10^{-6}, 7.92×10^{-6})
	Censored data MLE	1.26×10^{-6} (7.41×10^{-7}, 2.23×10^{-6})	3.88×10^{-6} (1.92×10^{-6}, 7.75×10^{-6})
Inhalation 8-hr TWA ((mg/m^3)/ ppm DDAC))	Substitute mid value	1.58×10^{-7} (9.37×10^{-8}, 2.73×10^{-7})	4.77×10^{-7} (2.40×10^{-7}, 9.38×10^{-7})
	Substitute max value	1.70×10^{-7} (1.14×10^{-7}, 2.59×10^{-7})	4.47×10^{-7} (2.56×10^{-7}, 7.73×10^{-7})
	Substitute min value	2.11×10^{-7} (1.39×10^{-7}, 3.26×10^{-7})	5.64×10^{-7} (3.18×10^{-7}, 9.90×10^{-7})
	Censored data MLE	1.58×10^{-7} (9.26×10^{-8}, 2.79×10^{-7})	4.85×10^{-7} (2.40×10^{-7}, 9.68×10^{-7})

The results in Table BB10 for dermal exposure show very small impacts of the alternative substitution approaches for treating values below the LOQ on the unit exposure arithmetic mean and 95th percentile. This is mainly because the dermal exposure is dominated by the hand exposures which were all above the LOQ. For inhalation exposure, the results show some larger impiacts of the max and min value substitution methods compared to substituting the mid value, but the results for the censored data MLE are very similar to the results for substituting the mid value.

Detailed Summary Statistics with Confidence Intervals and Fold Relative Accuracy

Tables BB11 to BB17 present the estimates, parametric and non-parametric confidence intervals and fold relative accuracy values for all the summary statistics for the All group. All these analyses use non-detects substituted by the mid-value.

Table BB11. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the normalized long dermal exposure (mg/(ppm ADBAC)) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.0106	1.5936	2.5484	1.26	1.5805	2.4440	1.25
GMs	0.0476	0.0346	0.0663	1.38	0.0349	0.0647	1.36
AMs	0.0591	0.0420	0.0873	1.44	0.0423	0.0785	1.36
AMu	0.0607	0.0427	0.0884	1.44	0.0432	0.0820	1.38
P95s	0.1715	0.0900	0.3829	2.06	0.0787	0.1715	1.59

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
P95u	0.1501	0.0905	0.2474	1.41	0.0914	0.2200	1.56

Table BB12. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the normalized short dermal exposure (mg/(ppm ADBAC)) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.0051	1.5907	2.5391	1.26	1.5783	2.4333	1.25
GMs	0.0480	0.0350	0.0668	1.38	0.0352	0.0653	1.36
AMs	0.0596	0.0424	0.0878	1.44	0.0427	0.0791	1.36
AMu	0.0612	0.0430	0.0889	1.44	0.0435	0.0826	1.38
P95s	0.1735	0.0906	0.3833	2.05	0.0808	0.1735	1.60
P95u	0.1508	0.0911	0.2481	1.65	0.0917	0.2210	1.56

Table BB13. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the normalized long short dermal exposure (mg/(ppm ADBAC)) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.0020	1.5891	2.5338	1.26	1.5775	2.4286	1.25
GMs	0.0479	0.0349	0.0666	1.38	0.0351	0.0650	1.36
AMs	0.0593	0.0422	0.0873	1.44	0.0426	0.0787	1.36
AMu	0.0609	0.0429	0.0885	1.43	0.0434	0.0822	1.38
P95s	0.1717	0.0902	0.3804	2.05	0.0799	0.1717	1.59
P95u	0.1500	0.0907	0.2464	1.65	0.0914	0.2194	1.56

Table BB14. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the normalized hands only exposure (mg/(ppm ADBAC)) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.0113	1.5940	2.5496	1.26	1.5814	2.4443	1.25
GMs	0.0475	0.0346	0.0662	1.38	0.0348	0.0646	1.36
AMs	0.0590	0.0419	0.0871	1.44	0.0423	0.0783	1.36
AMu	0.0606	0.0426	0.0883	1.44	0.0431	0.0819	1.38

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
P95s	0.1712	0.0898	0.3826	2.06	0.0785	0.1712	1.59
P95u	0.1499	0.0904	0.2471	1.65	0.0913	0.2197	1.56

Table BB15. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the normalized inhalation concentration exposure ((mg/m^3)/ (ppm DDAC)) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.36E+00	1.77E+00	3.15E+00	1.33	1.61E+00	3.25E+00	1.44
GMs	1.37E-06	9.26E-07	2.06E-06	1.49	9.47E-07	2.05E-06	1.47
AMs	2.20E-06	1.22E-06	3.16E-06	1.70	1.13E-06	3.92E-06	1.90
AMu	1.98E-06	1.26E-06	3.22E-06	1.60	1.14E-06	3.68E-06	1.80
P95s	1.55E-05	2.99E-06	1.77E-05	4.74	2.33E-06	1.55E-05	6.25
P95u	5.61E-06	3.01E-06	1.04E-05	1.85	2.42E-06	1.24E-05	2.28

Table BB16. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the normalized inhalation dose exposure (mg/ (ppm DDAC)) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.57E+00	1.88E+00	3.54E+00	1.37	1.88E+00	3.29E+00	1.33
GMs	8.07E-07	5.25E-07	1.26E-06	1.55	5.32E-07	1.23E-06	1.52
AMs	1.23E-06	7.32E-07	2.14E-06	1.71	7.34E-07	1.88E-06	1.61
AMu	1.26E-06	7.56E-07	2.19E-06	1.70	7.46E-07	2.03E-06	1.66
P95s	5.69E-06	1.91E-06	1.35E-05	2.84	1.69E-06	5.69E-06	2.44
P95u	3.81E-06	1.93E-06	7.50E-06	1.97	1.90E-06	6.70E-06	1.91

Table BB17. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the normalized inhalation time-weighted average concentration exposure ((mg/m^3)/ (ppm DDAC)) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.57E+00	1.88E+00	3.54E+00	1.37	1.88E+00	3.29E+00	1.33
GMs	1.01E-07	6.57E-08	1.58E-07	1.55	6.65E-08	1.54E-07	1.52
AMs	1.53E-07	9.16E-08	2.68E-07	1.71	9.18E-08	2.35E-07	1.61

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
AMu	1.58E-07	9.45E-08	2.73E-07	1.70	9.32E-08	2.54E-07	1.66
P95s	7.12E-07	2.39E-07	1.69E-06	2.84	2.11E-07	7.12E-07	2.44
P95u	4.77E-07	2.41E-07	9.37E-07	1.97	2.38E-07	8.38E-07	1.91

Tables BB11 to BB17 show that the study benchmark design value of 3 for the fold relative accuracy was met in every case, with the exception of the empirical 95th percentile for the inhalation concentration.

Empirical Quantile Plots

Quantile-quantile plots of the normalized exposure values were used to evaluate whether the data were lognormally distributed, as implied by the assumed statistical lognormal models. These plots were intended to help determine whether the data supported using untransformed normalized exposure values or log-transformed values or neither.

In each case the quantile-quantile plot compared the observed quantiles of the measured values with the corresponding quantiles of a normal or lognormal distribution. A perfect fit would imply that the plotted values lie in a straight line. The quantile-quantile plots for all exposure routes are presented in Figures BB1 to BB14. In all cases the plots seem to show a better fit for the lognormal distributions, supporting the use of the log-transformed exposure values over the untransformed values.

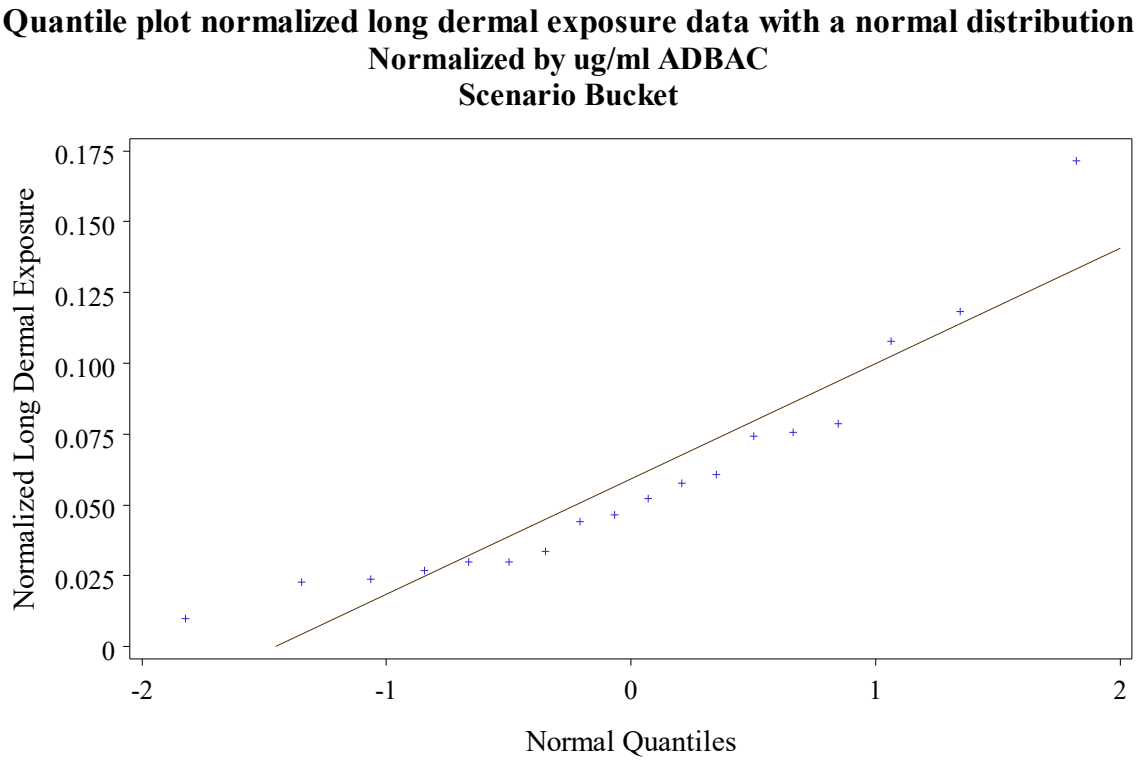


Figure BB1. Empirical quantile plot for Long Dermal, with a normal distribution

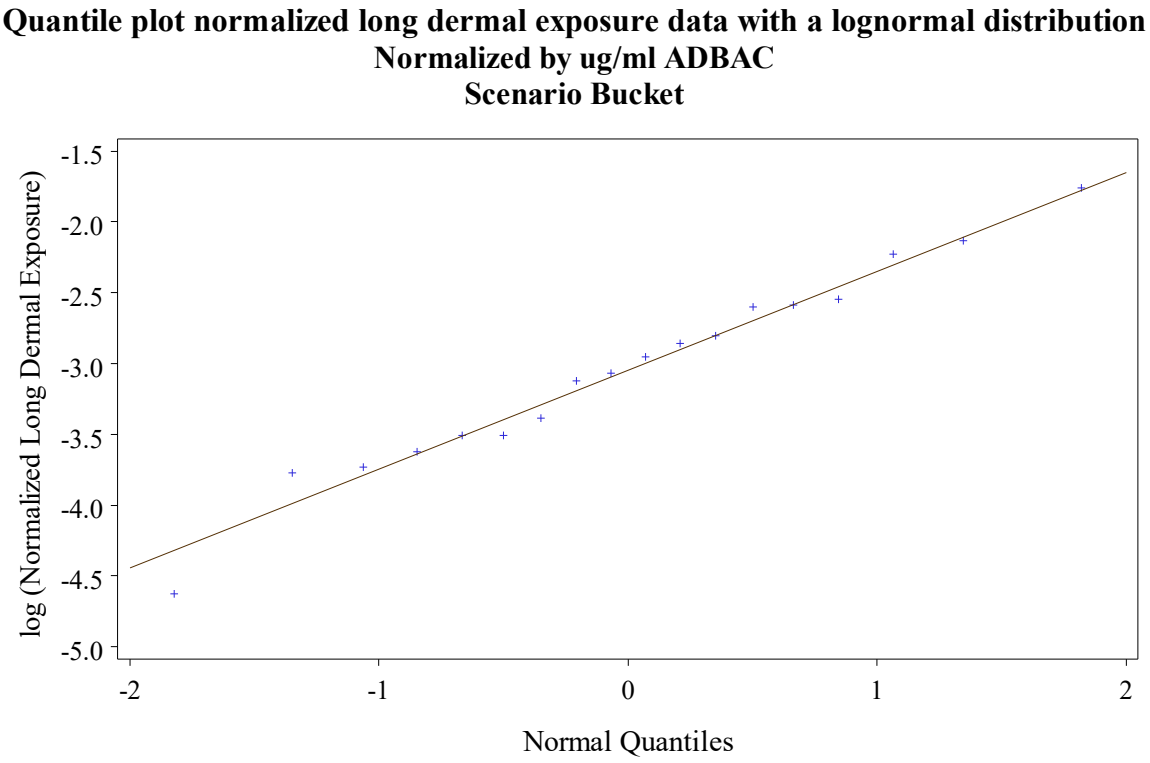


Figure BB2. Empirical quantile plot for Long Dermal, with a lognormal distribution

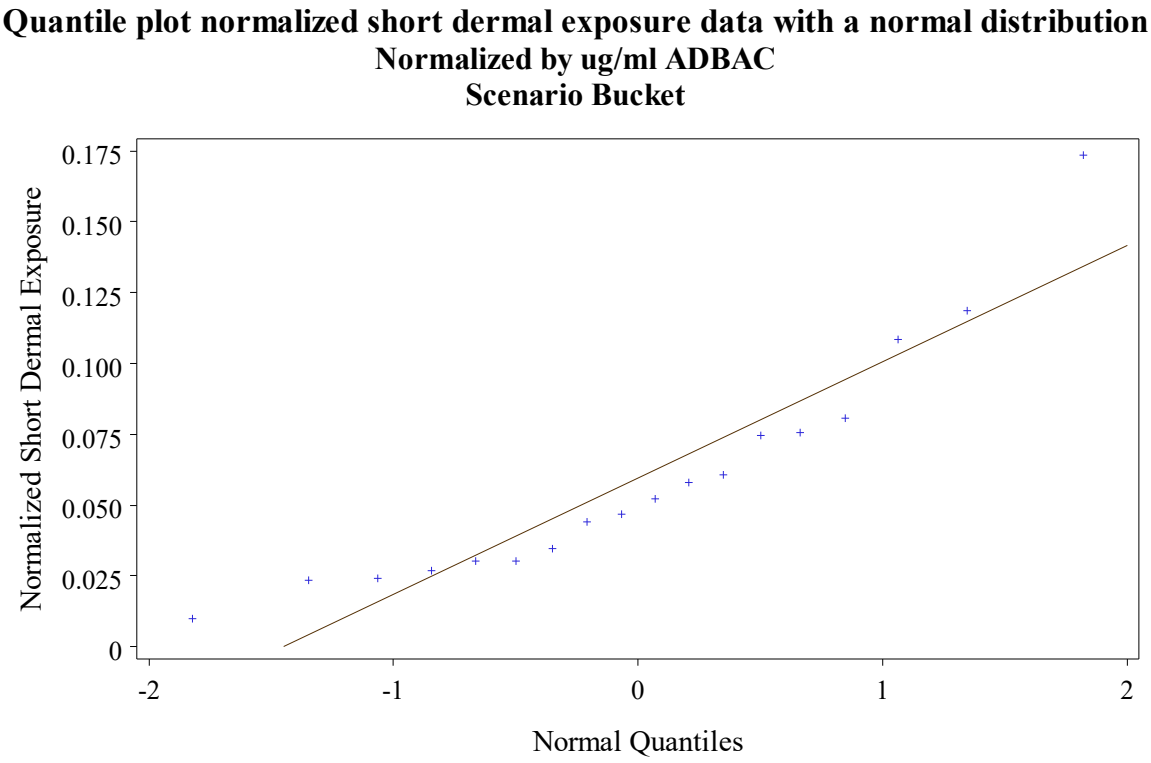


Figure BB3. Empirical quantile plot for Short Dermal, with a normal distribution

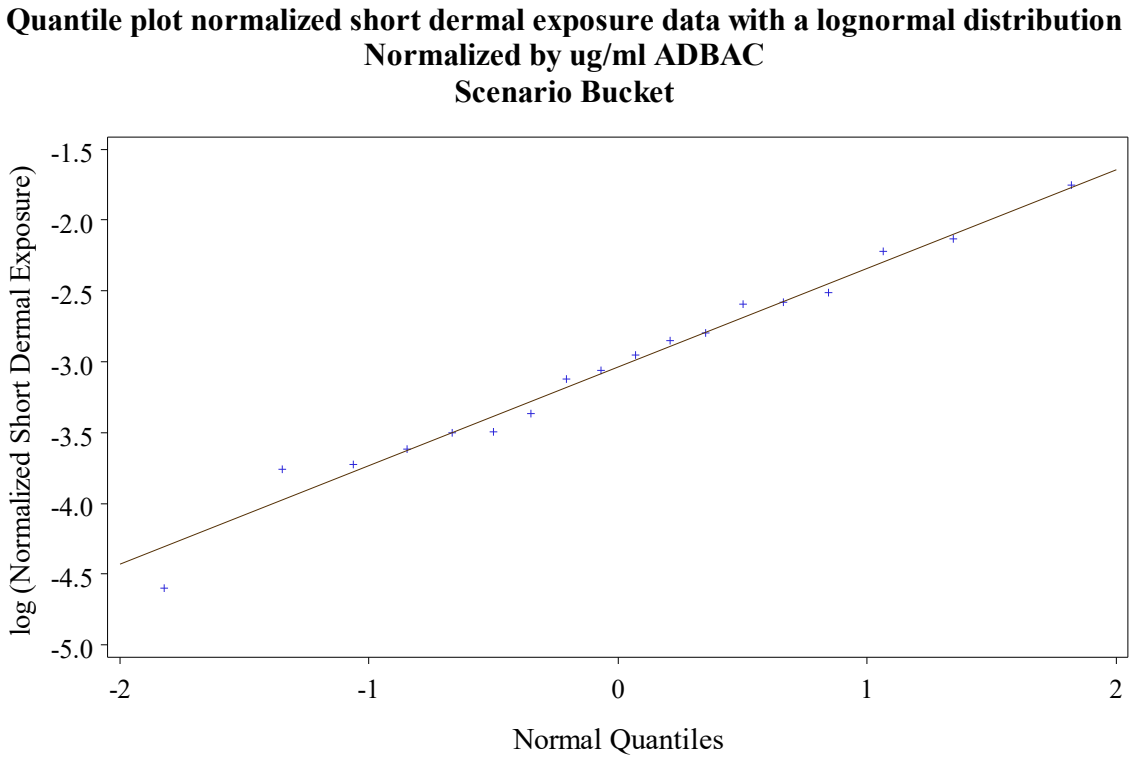


Figure BB4. Empirical quantile plot for Short Dermal, with a lognormal distribution

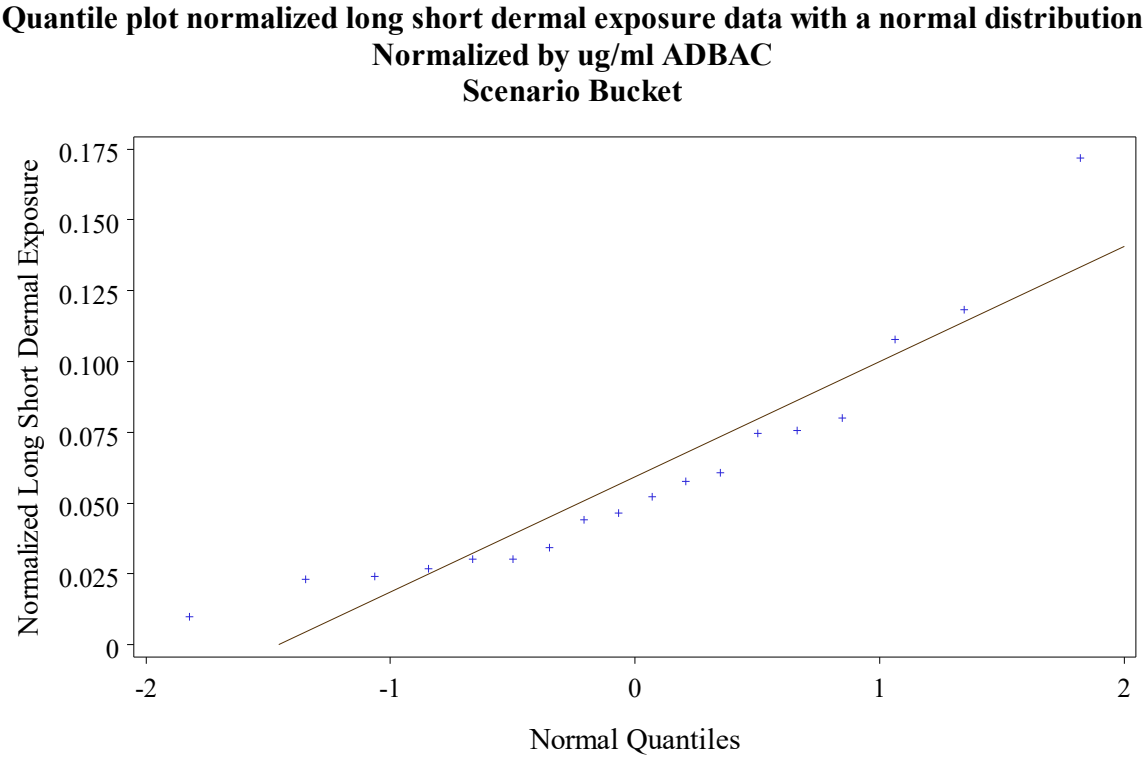


Figure BB5. Empirical quantile plot for Long Short Dermal, with a normal distribution

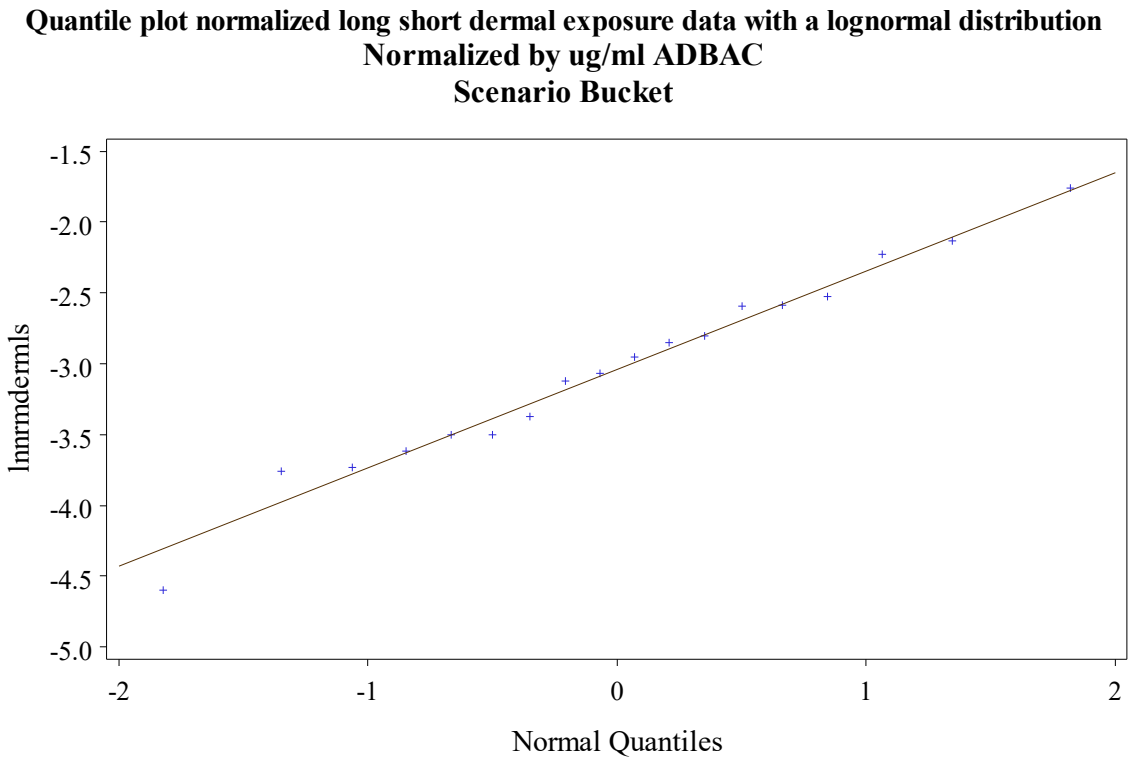


Figure BB6. Empirical quantile plot for Long Short Dermal, with a lognormal distribution

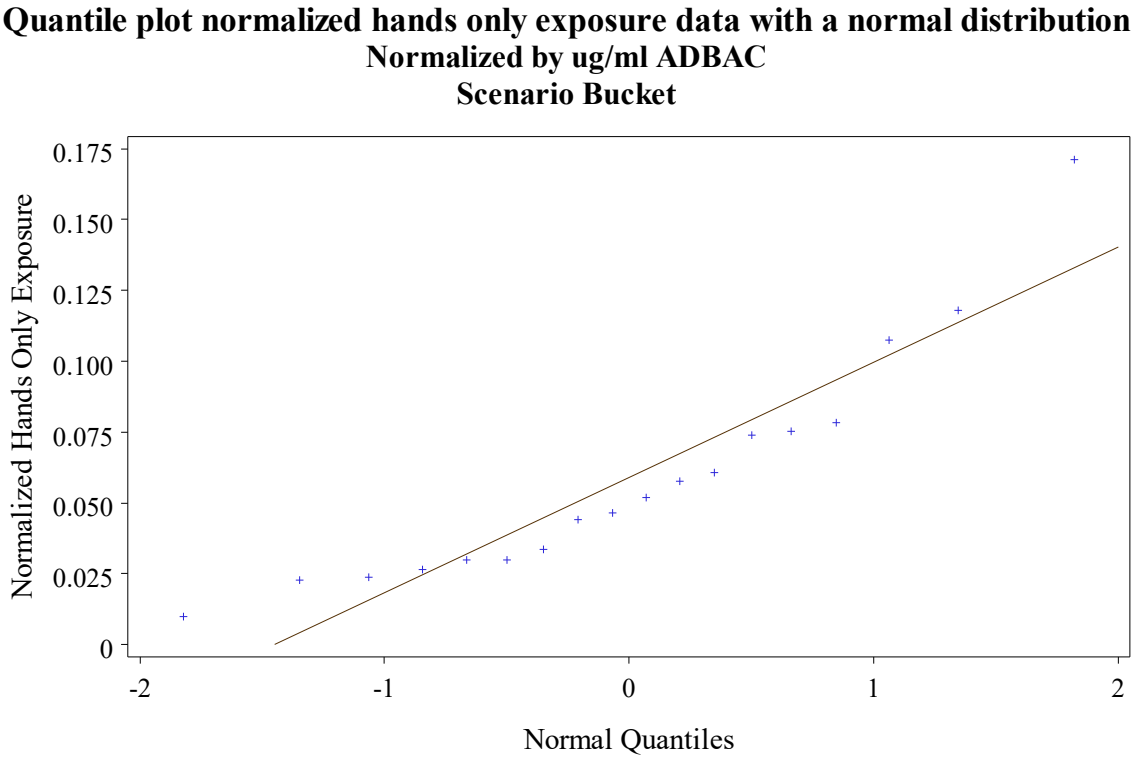


Figure BB7. Empirical quantile plot for Hands Only, with a normal distribution

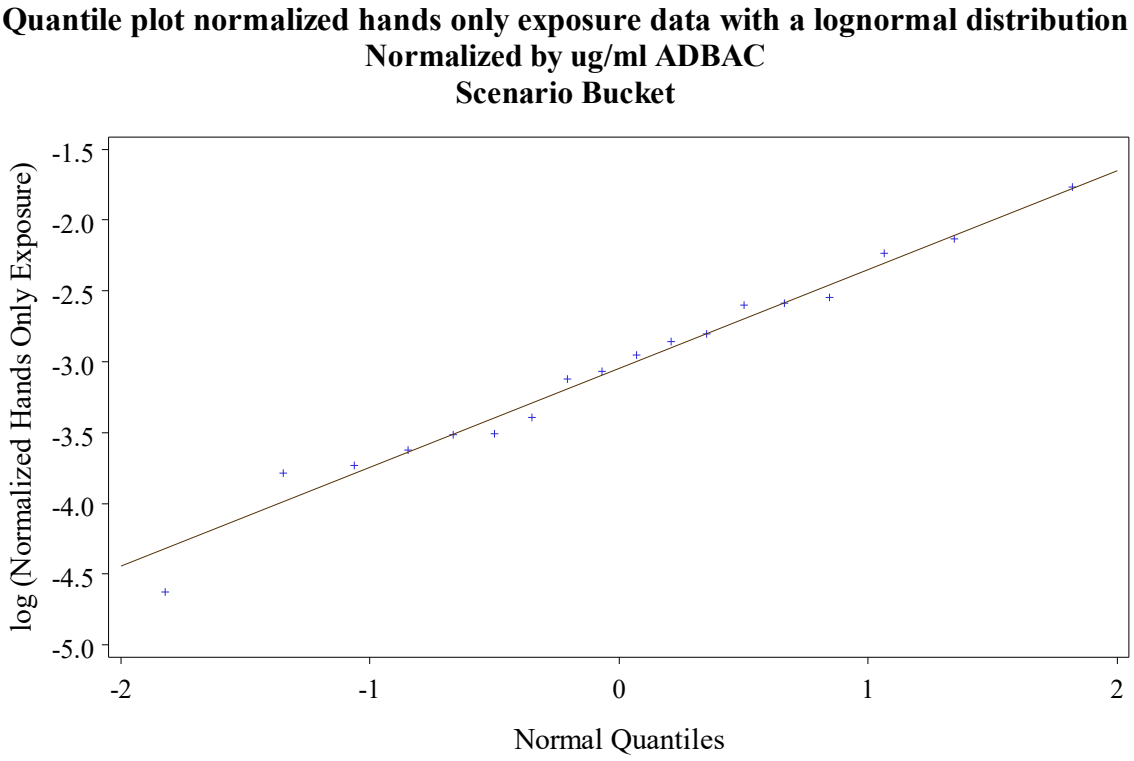


Figure BB8. Empirical quantile plot for Hands Only, with a lognormal distribution

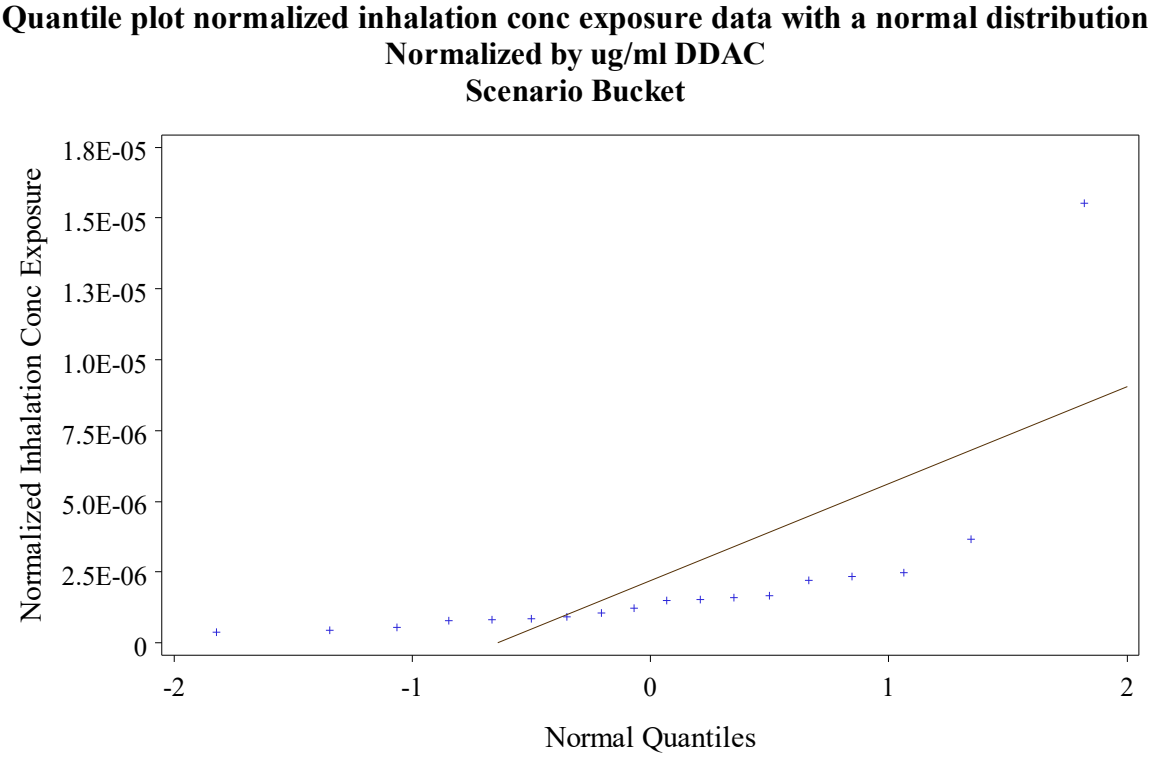


Figure BB9. Empirical quantile plot for Inhalation Concentration, with a normal distribution

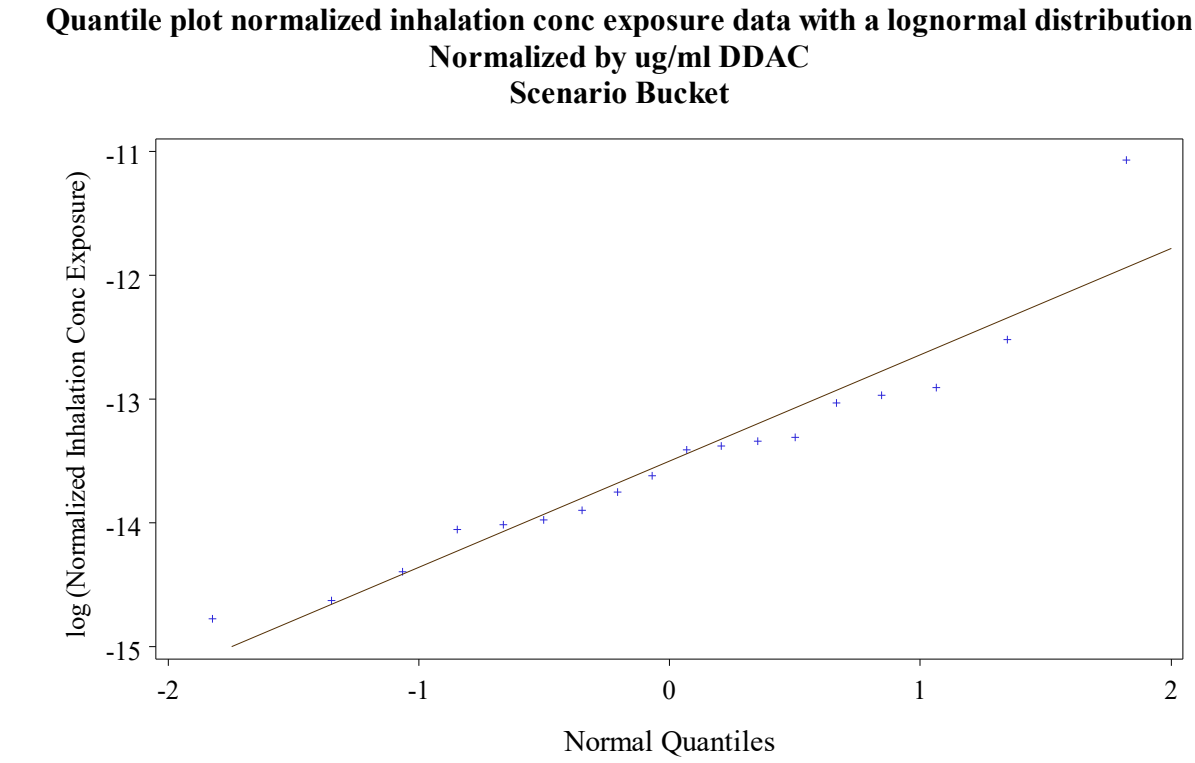


Figure BB10. Empirical quantile plot for Inhalation Concentration, with a lognormal distribution

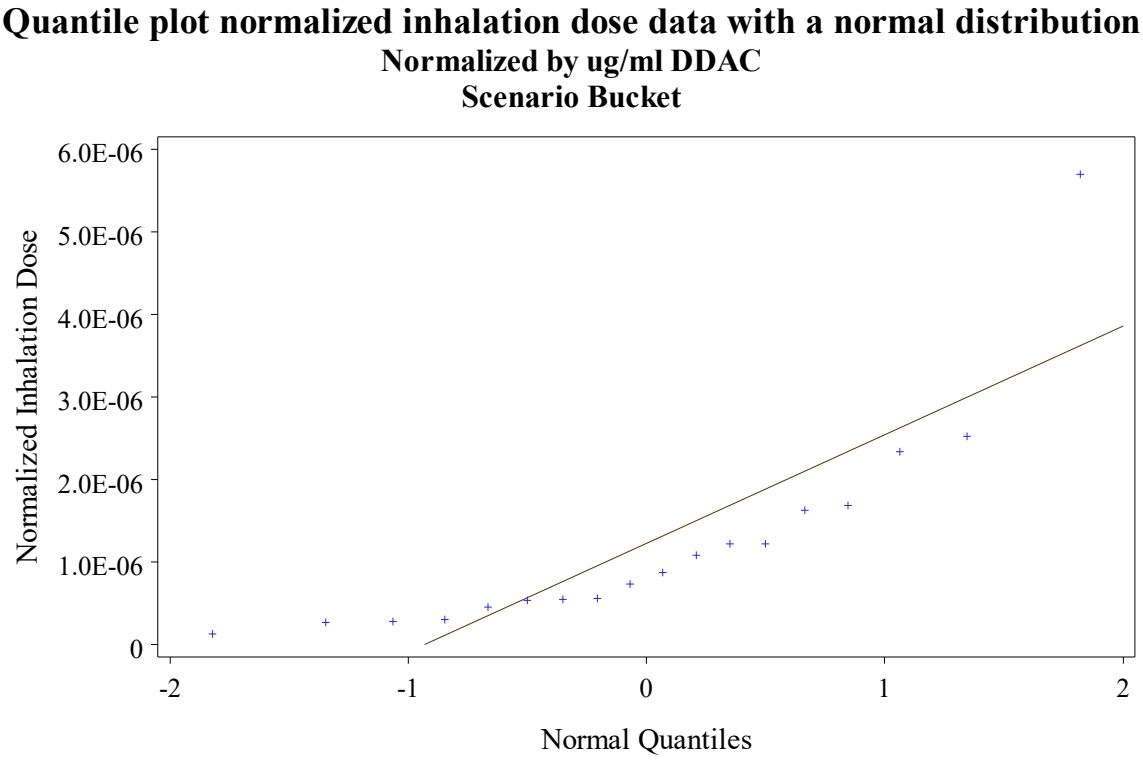


Figure BB11. Empirical quantile plot for Inhalation Dose, with a normal distribution

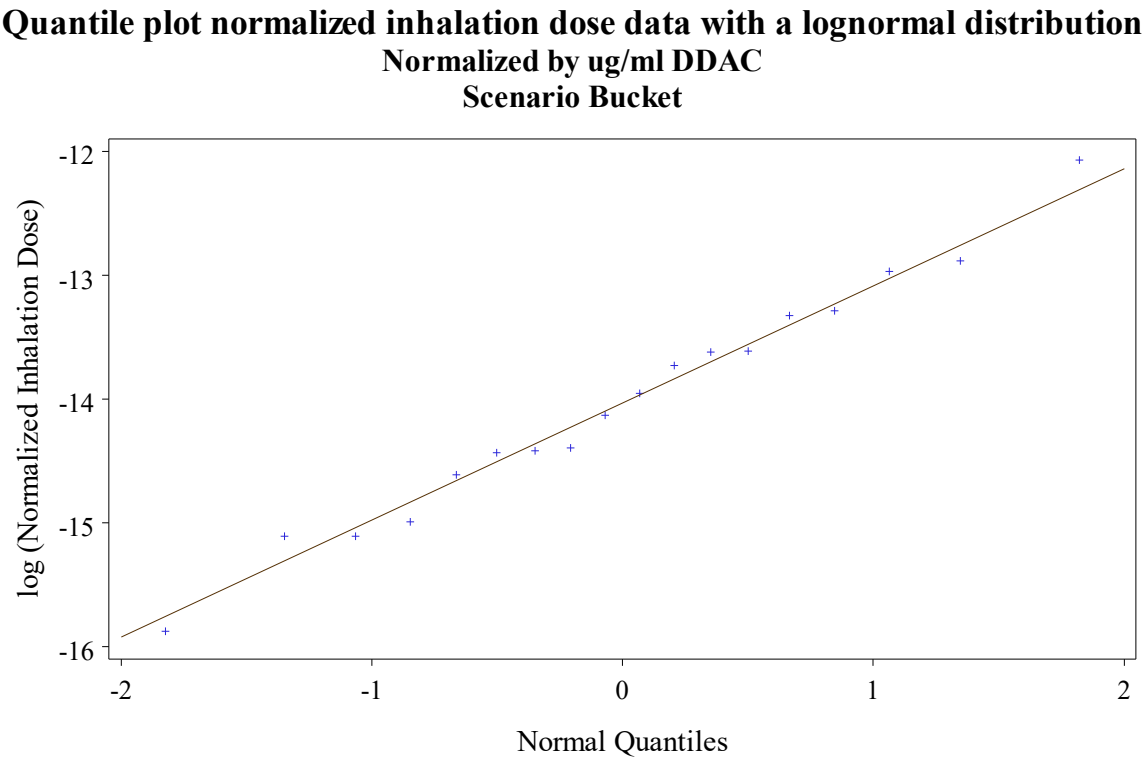


Figure BB12. Empirical quantile plot for Inhalation Dose, with a lognormal distribution

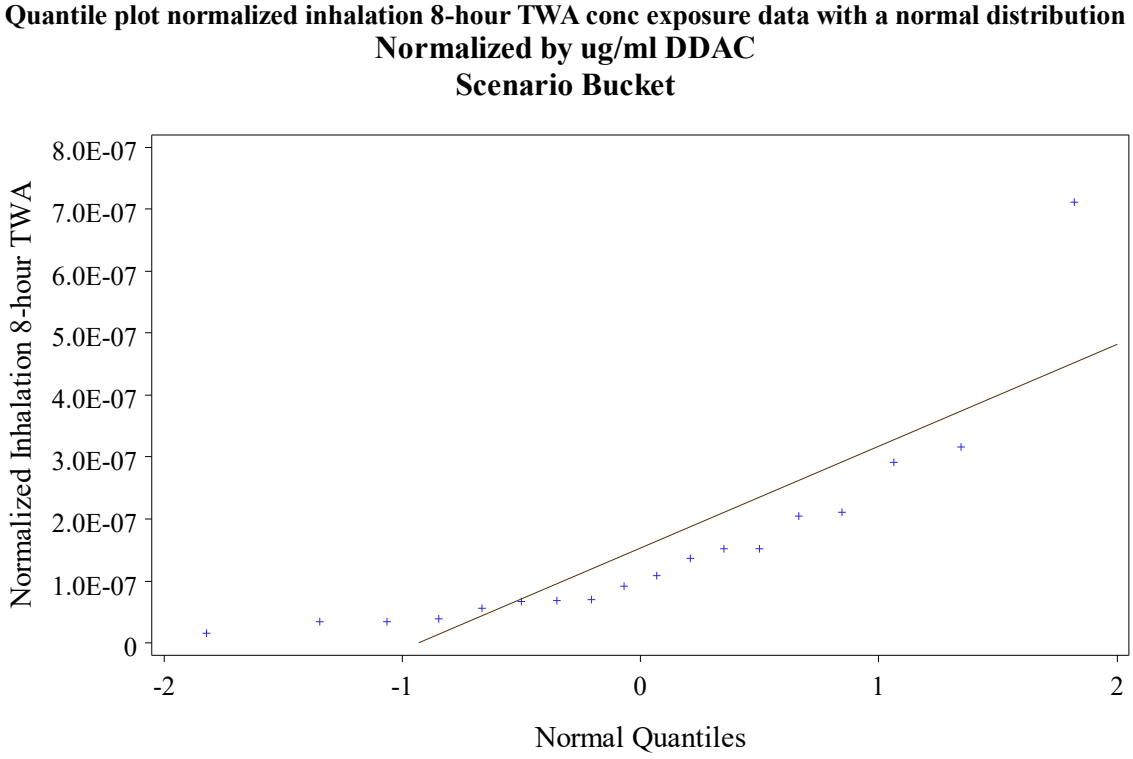


Figure BB13. Empirical quantile plot for Inhalation Time-weighted Average Conc, with a normal distribution

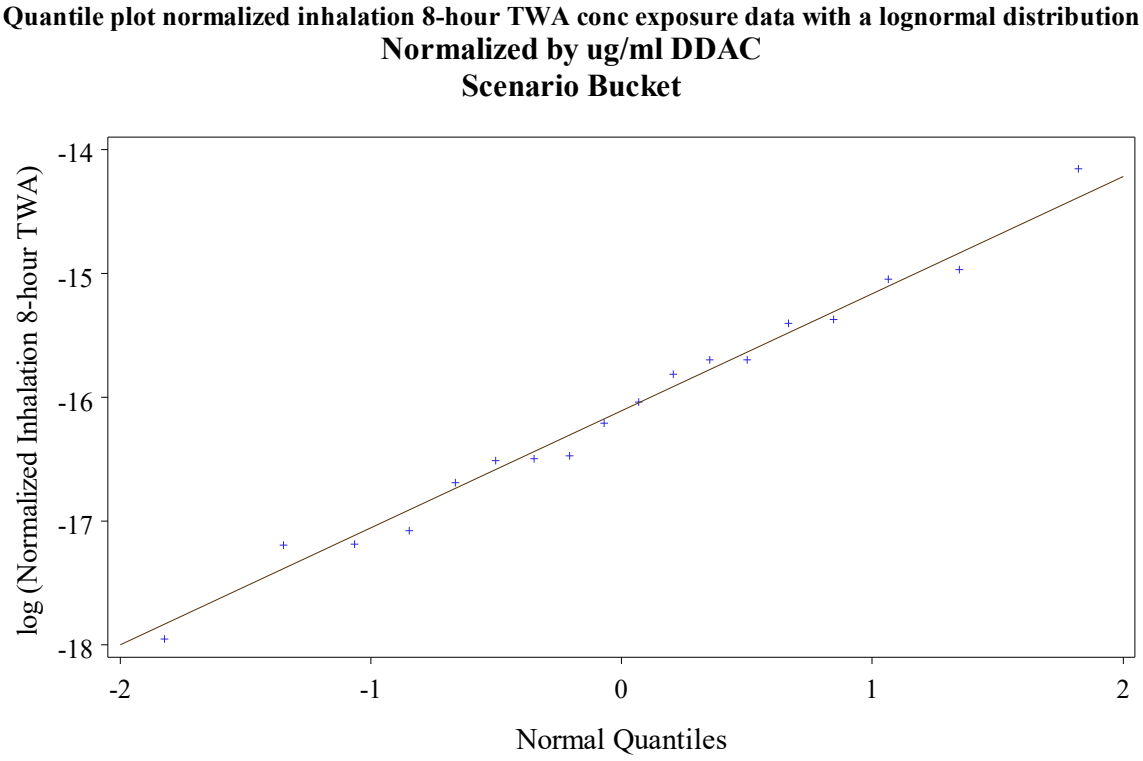


Figure BB14. Empirical quantile plot for Inhalation Time-weighted Average Conc, with a lognormal distribution

Test for log-log-linearity with slope 1

Table BB18 shows the 95% confidence intervals for the slope calculated from the above linear model. A confidence interval that includes one but not zero supports the use of unit exposures. A confidence interval that includes zero but not one suggests that the exposure does not depend on the normalizing factor. A confidence interval that includes both zero and one suggests that either the basic statistical model is incorrect or there are not enough data to statistically infer whether the slope is zero or one. This table also shows the widths of the confidence intervals used to evaluate the second benchmark for post-hoc power discussed in the next sub-section. The table also shows the values of the threshold concentration × duration (case A) or threshold concentration (case B) and the corresponding estimated exposure, to be described and discussed In the Supplement. Threshold values were not computed for the censored data models.

Table BB18. 95 percent confidence intervals for the slope of log exposure versus the log of the normalizing factor.

Exposure Route	Treatment of Non-detects	Estimate	Lower	Upper	Width	Threshold	Exposure
Long Dermal (mg)	Substitute mid value	0.681	0.037	1.324	1.287	170	10.33
	Censored data MLE	0.681	0.120	1.242	1.121		

Exposure Route	Treatment of Non-detects	Estimate	Lower	Upper	Width	Threshold	Exposure
Short Dermal (mg)	Substitute mid value	0.684	0.042	1.325	1.282	170	10.41
	Censored data MLE	0.684	0.125	1.243	1.118		
Long Short Dermal (mg)	Substitute mid value	0.683	0.043	1.323	1.279	170	10.36
	Censored data MLE	0.683	0.126	1.241	1.115		
Hands Only (mg)	Substitute mid value	0.682	0.038	1.326	1.288	170	10.31
	Censored data MLE	0.682	0.121	1.244	1.123		
Inhalation Concentration (mg/m^3)	Substitute mid value	0.688	–0.005	1.381	1.386	194	0.00039
	Censored data MLE	0.752	0.047	1.456	1.409		
Inhalation Dose (mg)	Substitute mid value	0.676	–0.089	1.441	1.530	196	0.00025
	Censored data MLE	0.722	–0.014	1.458	1.472		
Inhalation Time-Weighted Average Concentration (mg/m^3)	Substitute mid value	0.676	–0.089	1.441	1.530	196	0.000031
	Censored data MLE	0.722	–0.014	1.458	1.472		

Table BB18 gives the slopes for all the exposure routes.

For dermal exposures, the slopes range from 0.681 to 0.684, and the confidence intervals include 1 but not 0, supporting the use of the normalized exposures. For inhalation exposures, the slopes range from 0.68 to 0.75, and all but one of the confidence intervals include both 0 and 1, suggesting that there are not enough data to statistically infer whether the slope is zero or one. The lower bounds for the inhalation confidences are only slightly less than zero, suggesting that the proportional assumption is not too unreasonable.

Suppose that the study had a (post-hoc) power of at least 80% for detecting "proportionality" (i.e., log-log-linearity with a slope of 1) under the null hypothesis of independence (slope = 0). It follows that the confidence intervals have an approximate width of 1.4 or less. The results in **Error! Reference source not found.**BB18 show that observed widths are all below 1.4 for dermal exposure but are slightly above 1.4 (maximum 1.53) for inhalation exposure. Therefore, based on the confidence intervals, the secondary objective of meeting the 80% power for detecting proportionality was met for dermal exposures and almost met for inhalation exposures.

Quantile plots for residuals

The quantile-quantile plots of the studentized residuals for all exposure routes are shown below in Figures BB15 to BB21.

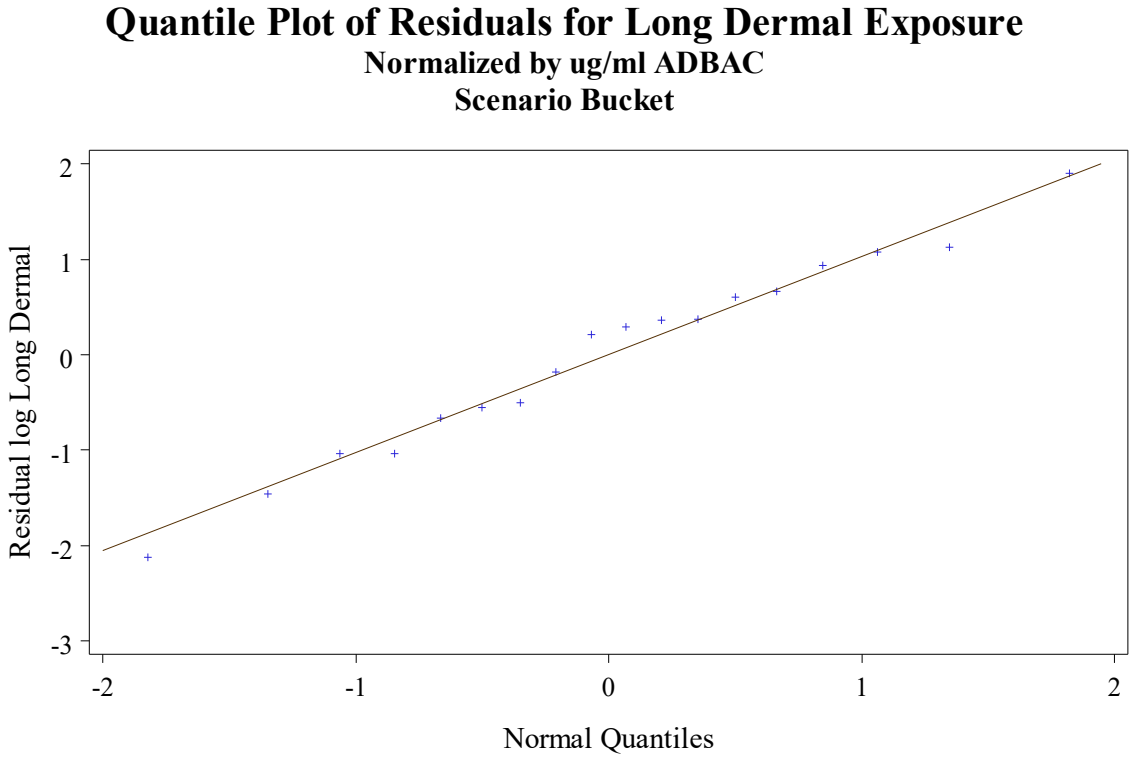


Figure BB15. Quantile plot of residuals from linear model for Long Dermal

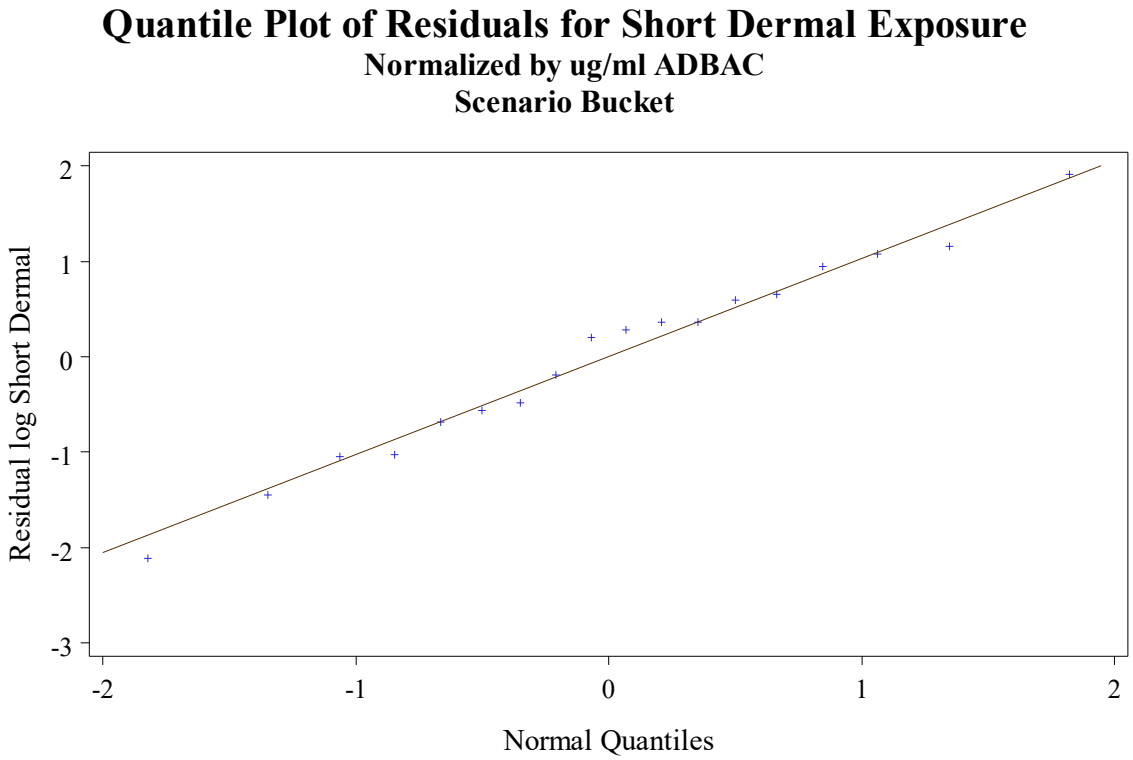


Figure BB16. Quantile plot of residuals from linear model for Short Dermal

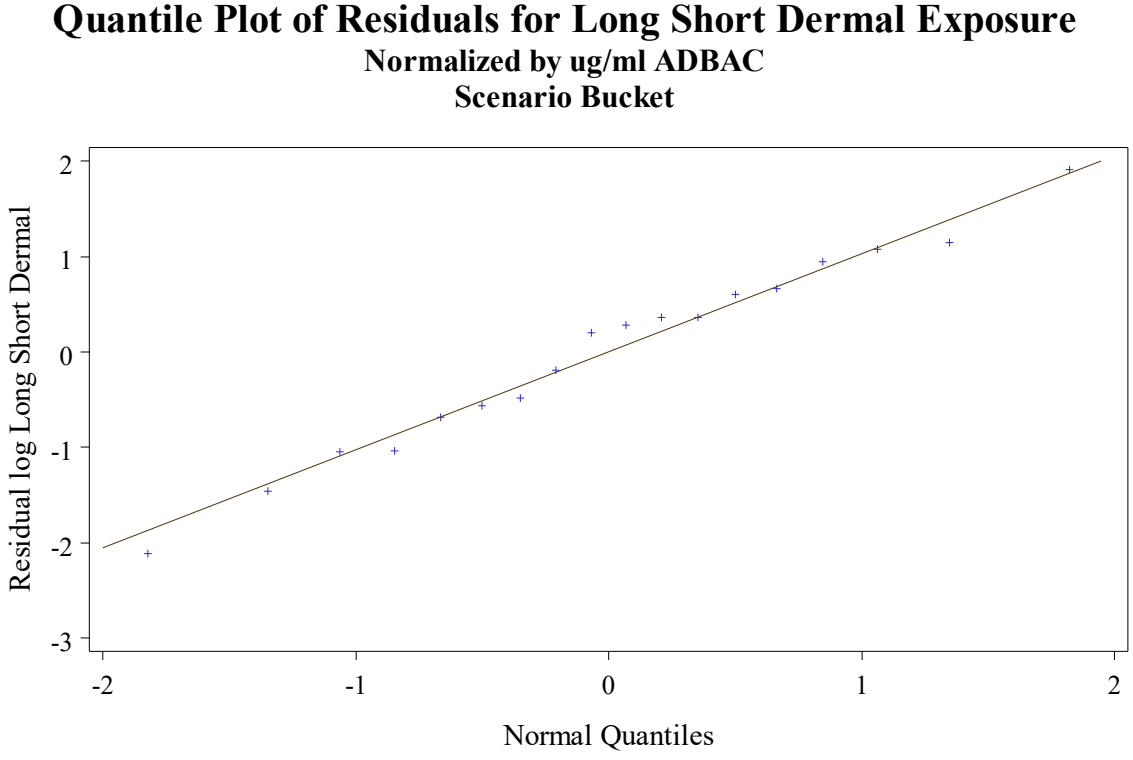


Figure BB17. Quantile plot of residuals from linear model for Long Short Dermal

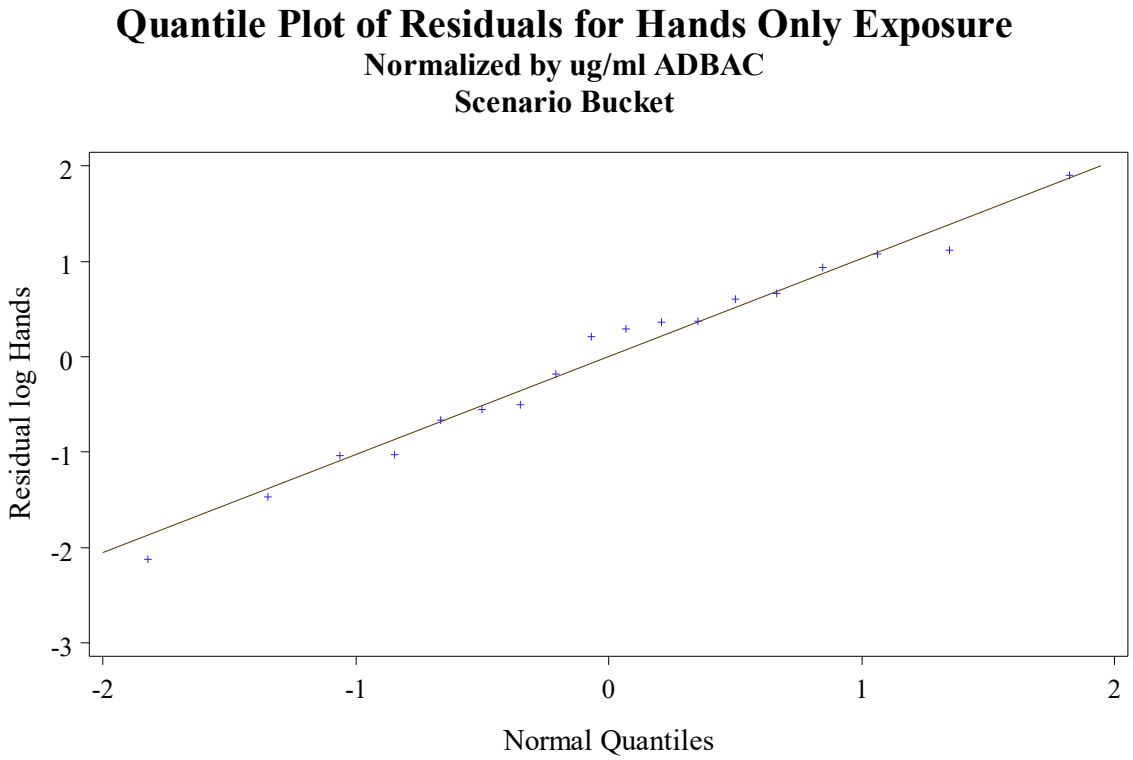


Figure BB18. Quantile plot of residuals from linear model for Hands Only

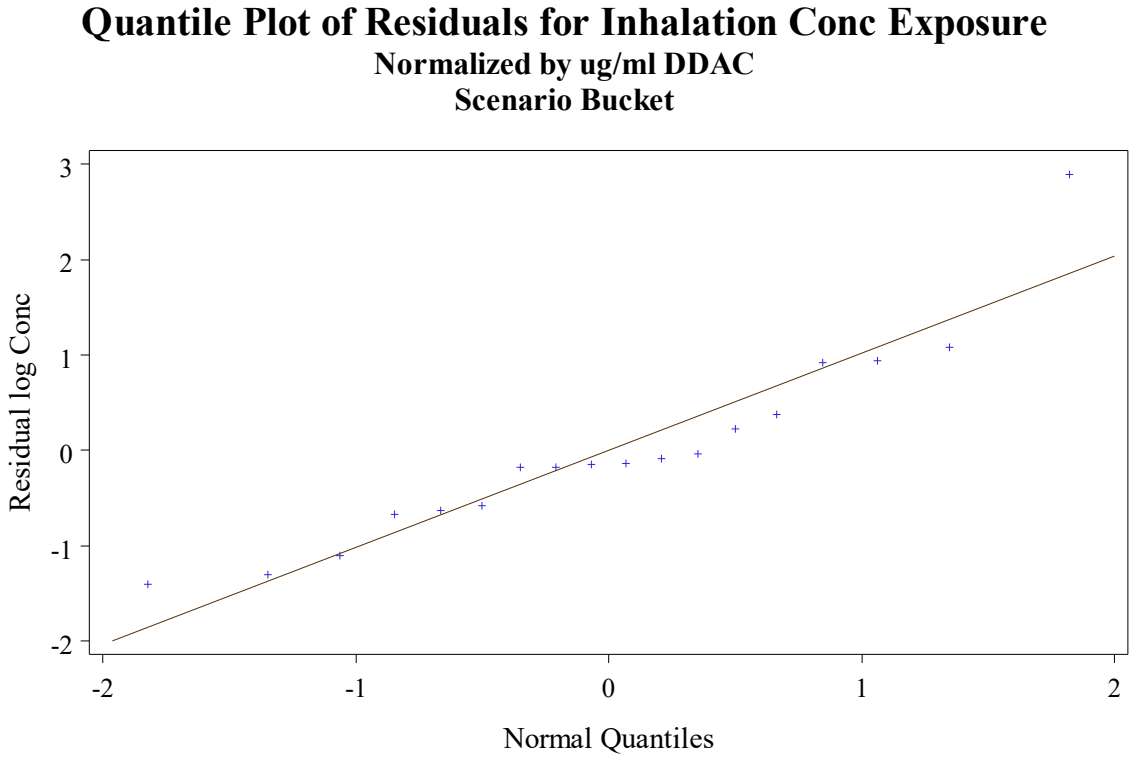


Figure BB19. Quantile plot of residuals from linear model for Inhalation Concentration

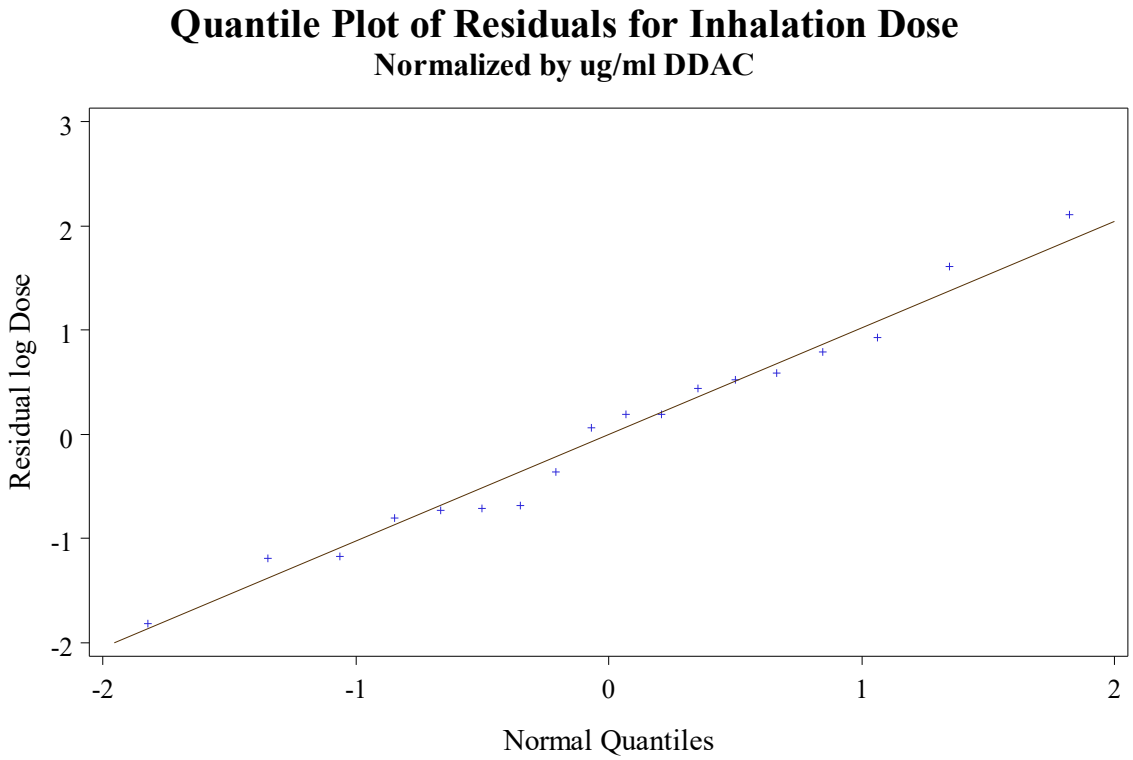


Figure BB20. Quantile plot of residuals from linear model for Inhalation Dose

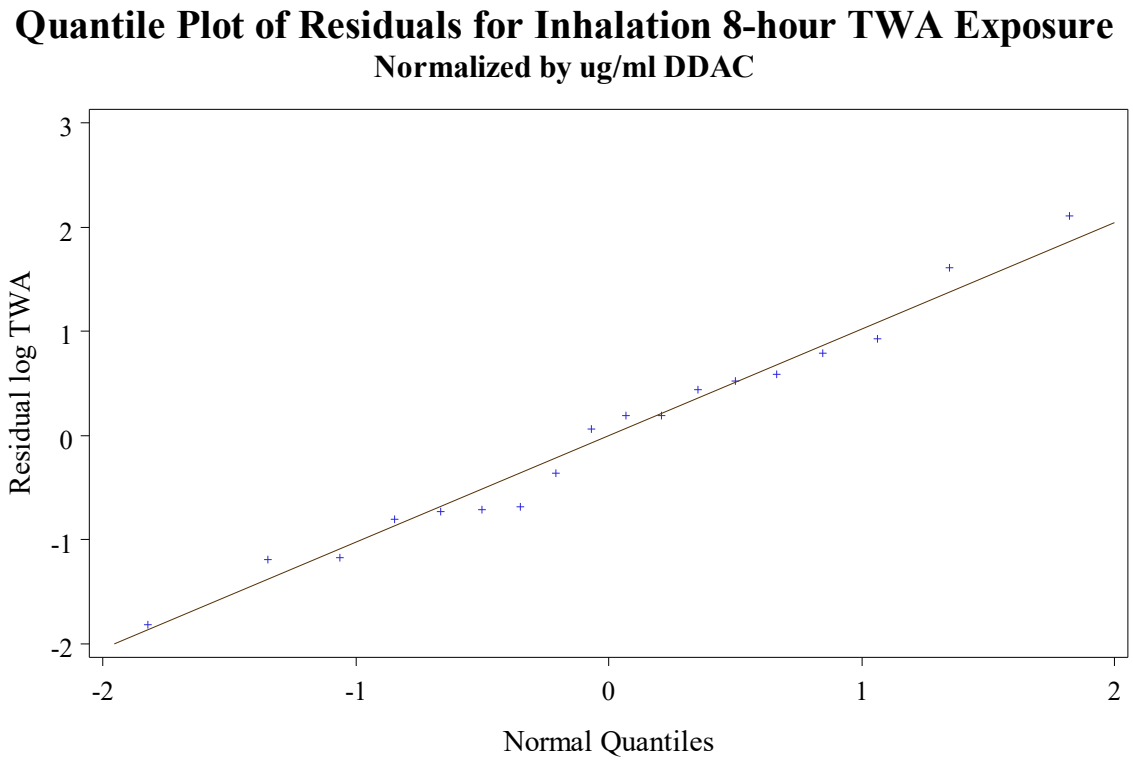


Figure BB21. Quantile plot of residuals from linear model for Inhalation Tine-Weighted Average Concentration

The quantile-quantile plots of the studentized residuals are reasonably close to the straight line except for the inhalation concentration. None of the studentized residuals exceeded the standard outlier cutoff of ±3.

Regression plots

The lognormal linear regression results for all the exposure routes are shown below using the mid value substitution method for non-detect values. The data points are labeled to show the targeted durations.

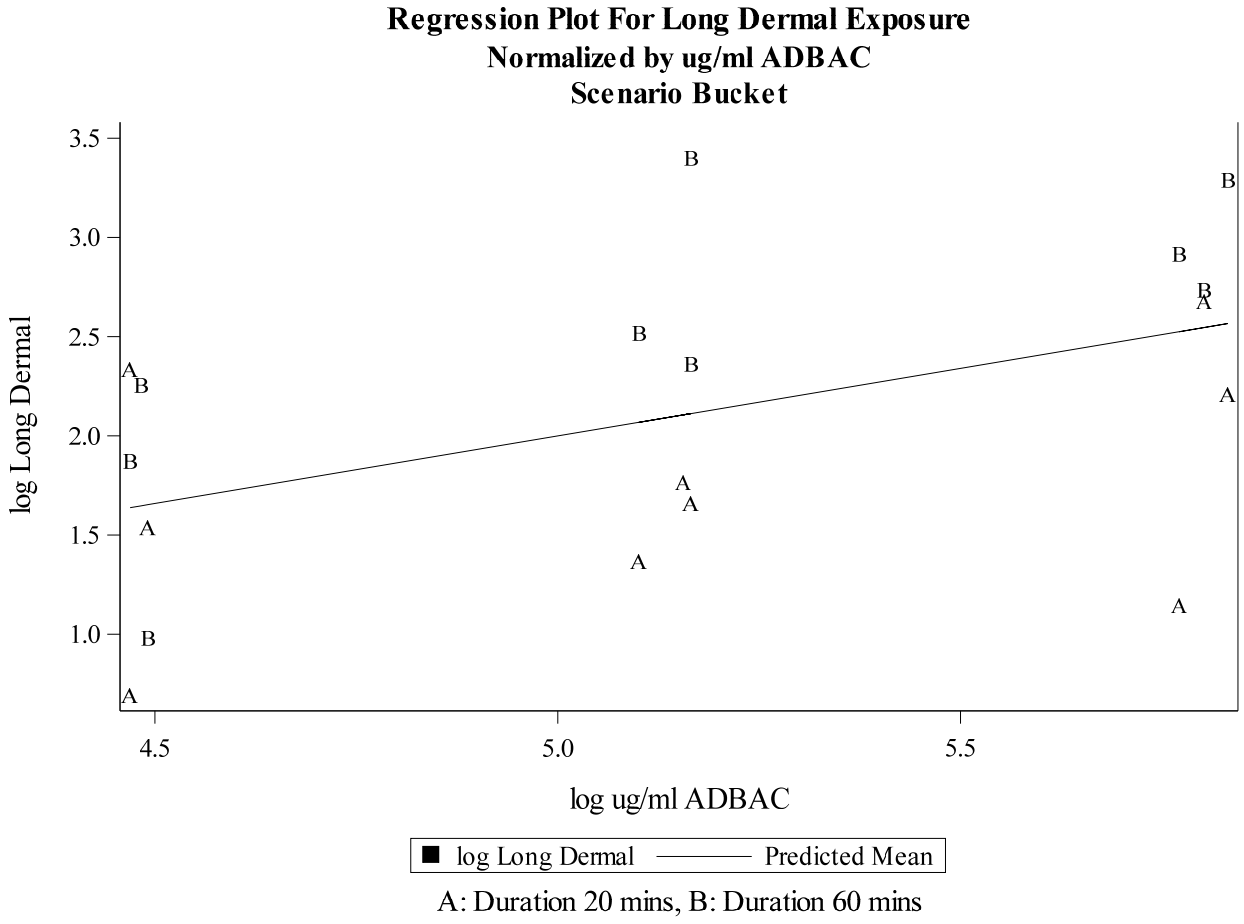


Figure BB22. Regression plot for Long Dermal Exposure (mg)

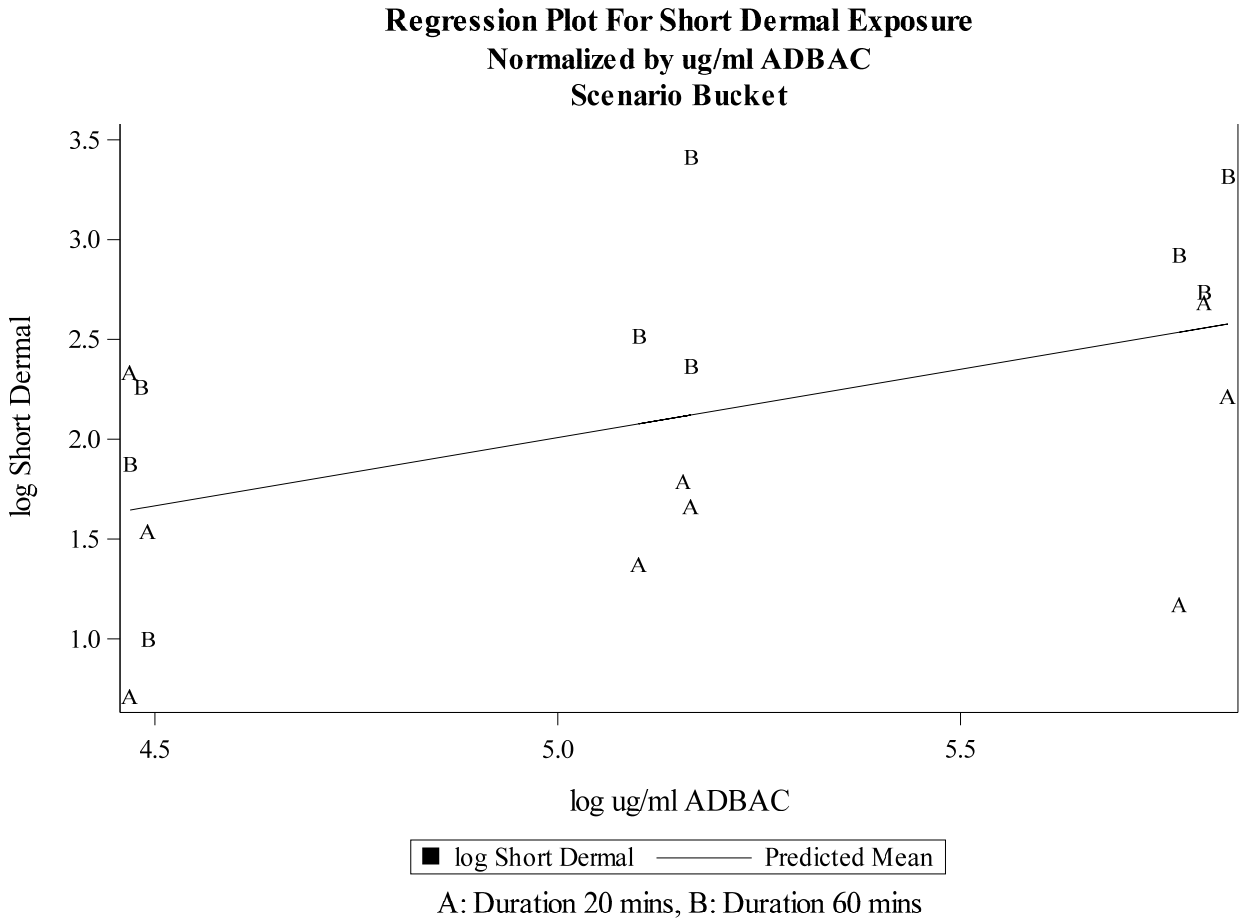


Figure BB23. Regression plot for Short Dermal Exposure (mg)

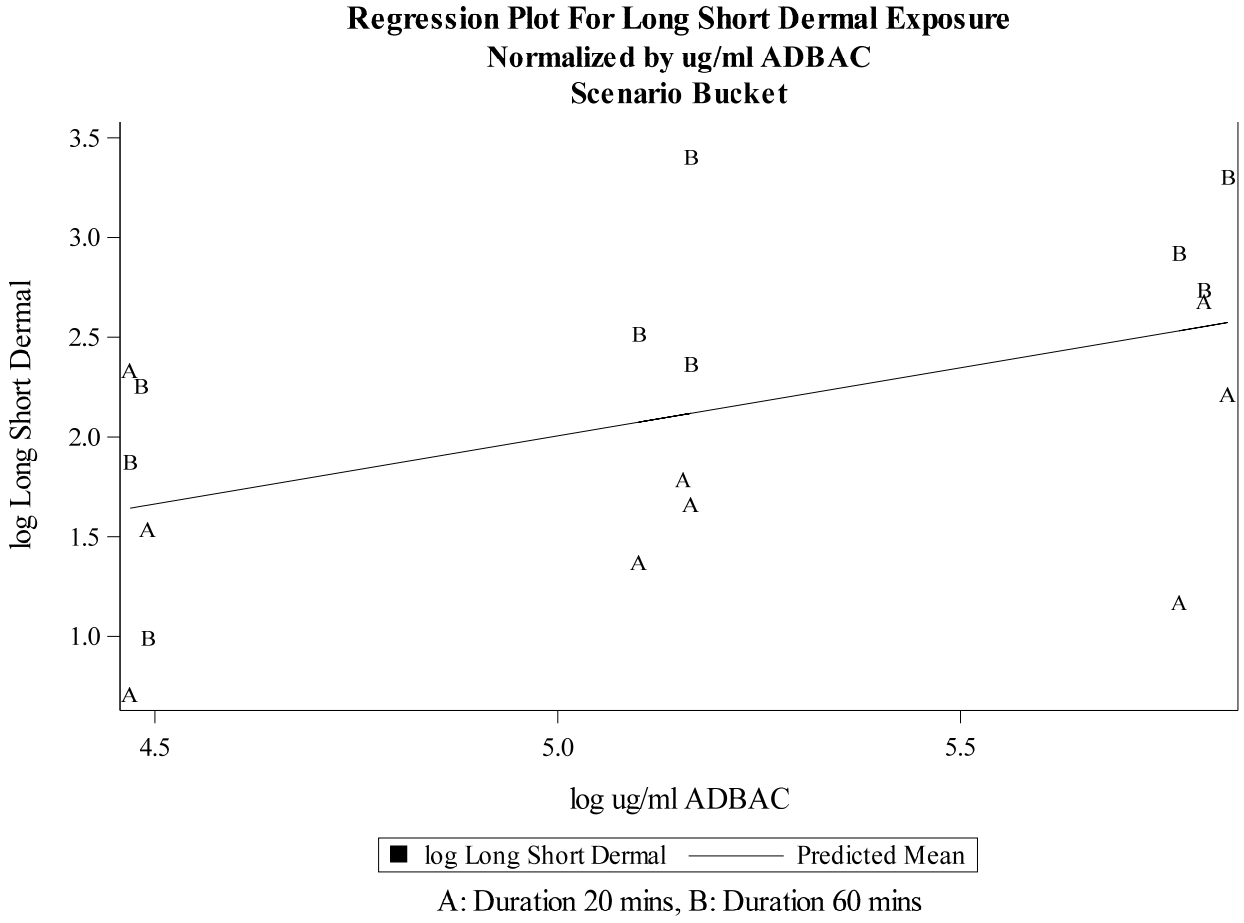


Figure BB24. Regression plot for Long Short Dermal Exposure (mg)

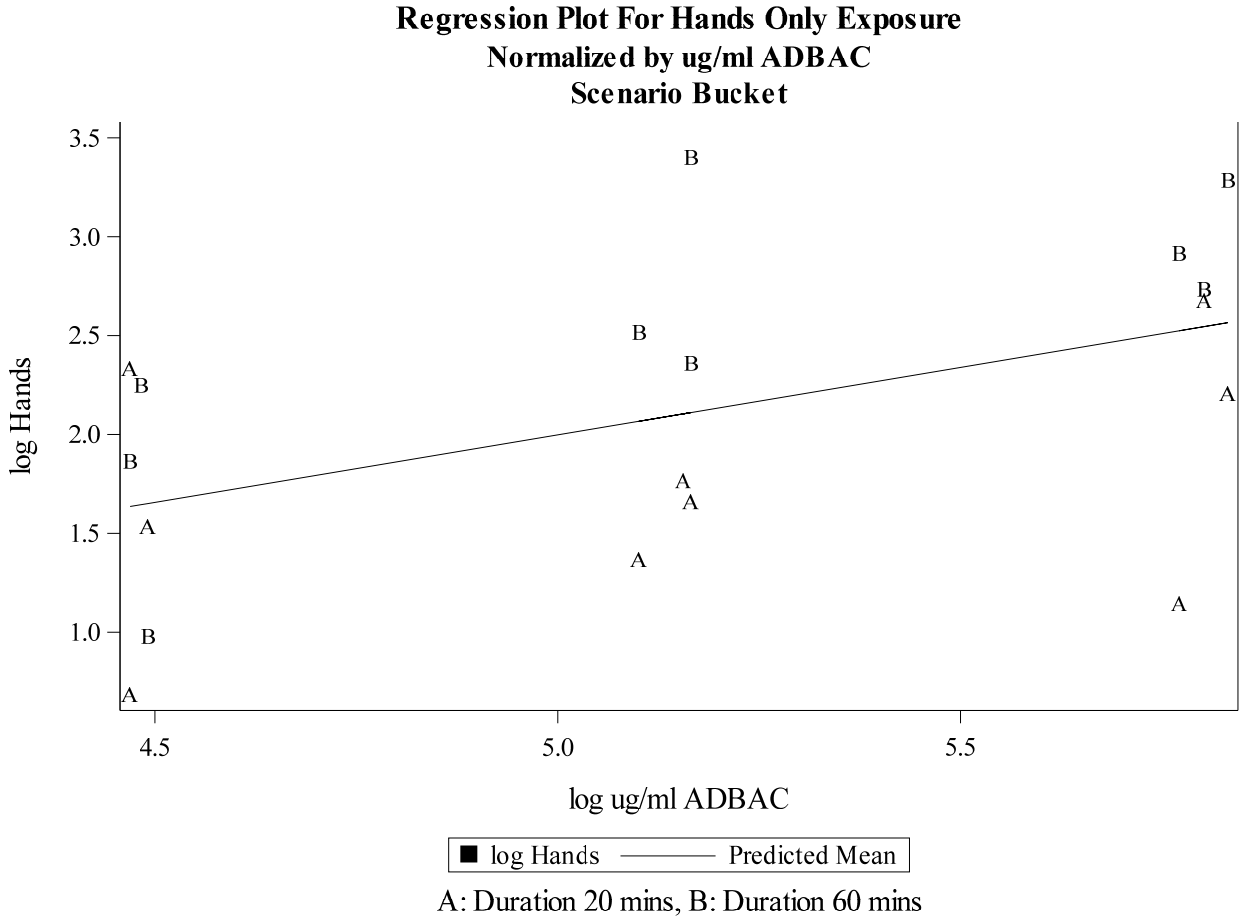


Figure BB25. Regression plot for Hands Only Exposure (mg)

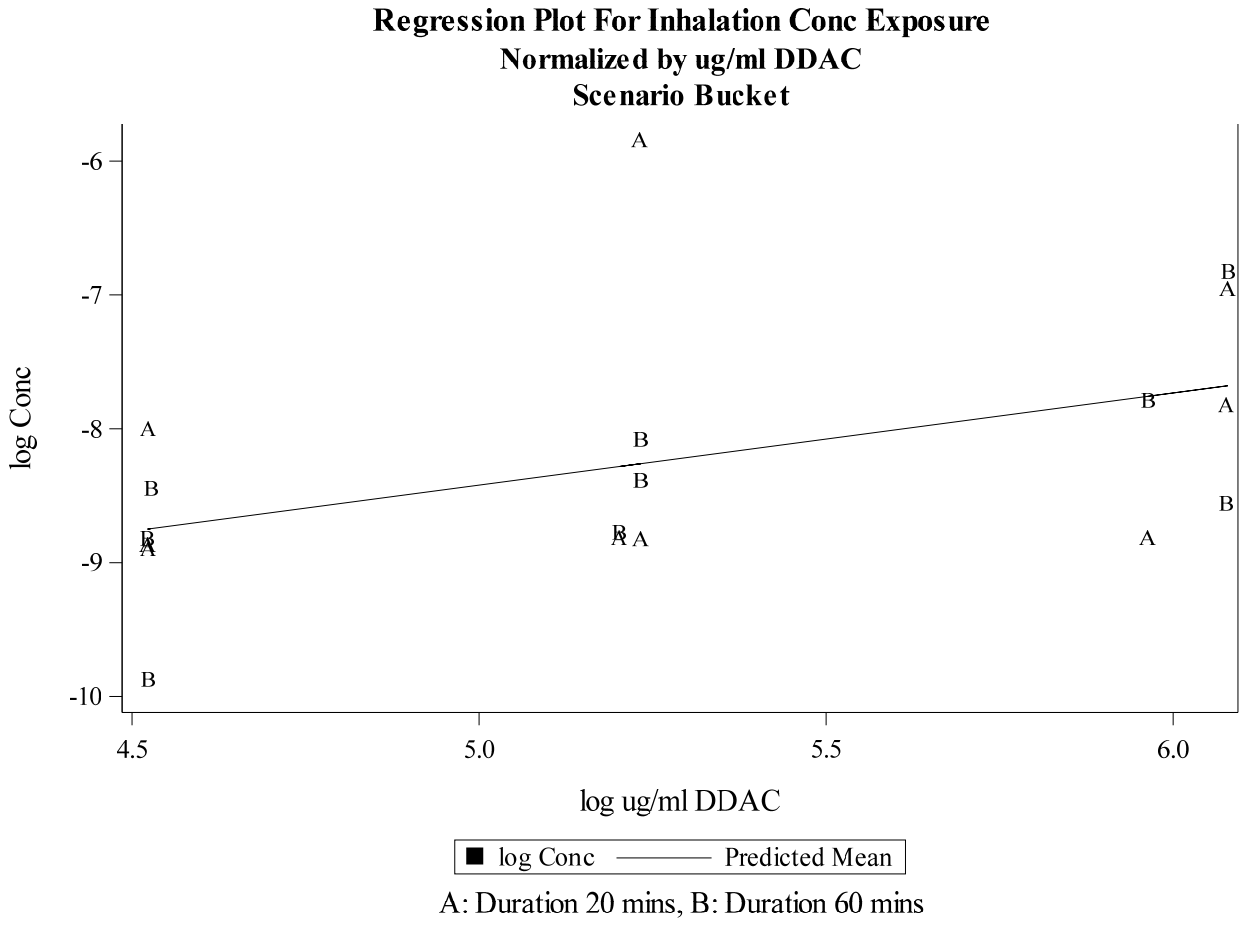


Figure BB26. Regression plot for Inhalation Concentration Exposure (mg/m^3)

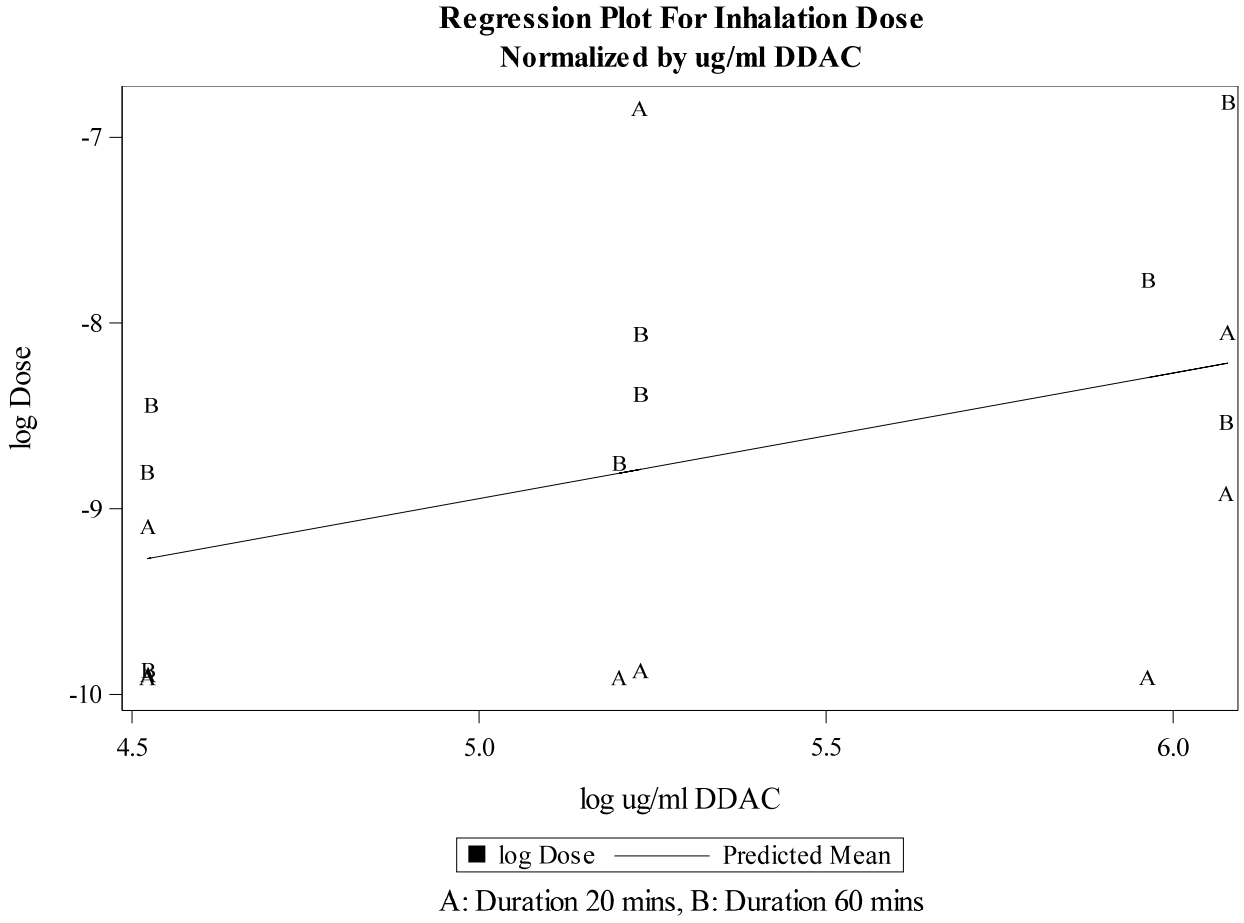


Figure BB27. Regression plot for Inhalation Dose (mg)

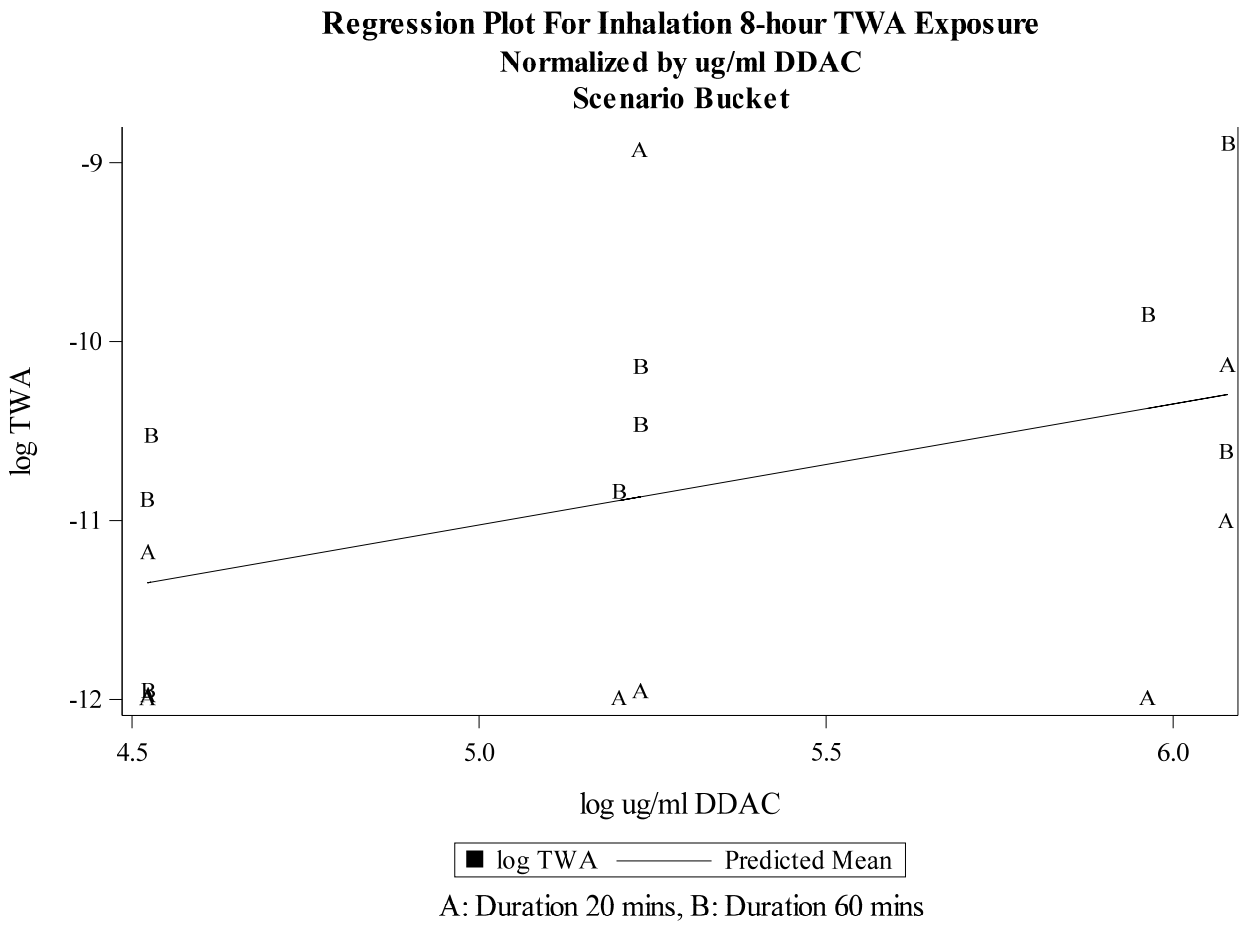


Figure BB28. Regression plot for Inhalation Time-Weighted Average Exposure (mg/m^3)

Quadratic models

Table BB19 presents the quadratic coefficient Quad from the fitted quadratic regression models for all the exposure routes using All data. Coefficients for the Intercept and Slope are shown under model 2 in Tables BB20 to BB26 below.

Table BB19. Quadratic coefficients with 95% confidence intervals for quadratic regression models for the log exposure versus log (Normalizing Factor)

Exposure Route	Estimate	Lower Bound	Upper Bound
Long Dermal	−0.20	−1.94	1.54
Short Dermal	−0.19	−1.93	1.54
Long Short Dermal	−0.19	−1.92	1.54
Hands Only	−0.20	−1.95	1.54
Inhalation Concentration	−0.27	−1.90	1.36

Exposure Route	Estimate	Lower Bound	Upper Bound
Inhalation Dose	−0.29	−2.09	1.50
Inhalation Time-weighted Average	−0.29	−2.09	1.50

Since all the 95% confidence intervals for Quad include zero, the quadratic coefficient is not statistically significant, and the quadratic models are not supported.

Alternative Statistical Approaches

In this section we present and compare some alternative statistical approaches to the linear and quadratic models.

Model Parameters

Table BB20. Alternative fitted statistical models for Long Dermal Exposure (mg)

Model	Parameter	Estimate	Lower Bound	Upper Bound
1. Linear regression of Ln(exposure) on Ln(NF)	μ	-1.404	-4.731	1.922
	β	0.681	0.037	1.324
2. Quadratic regression of Ln(exposure) on Ln(NF)	μ	-6.609	-52.246	39.028
	β	2.728	-15.187	20.644
	γ	-0.199	-1.941	1.542
3. Log-log logistic regression of exposure on NF	**α**	16.908	-7.543	41.359
	γ	10453.800	-269477.493	290385.093
	β	-1.929	-8.123	4.265
4. 3-parameter logistic regression of exposure on NF	**α**			
	c			
	β			
5. Gamma model for exposure	**μ**	-1.238	-4.052	1.575

Model	Parameter	Estimate	Lower Bound	Upper Bound
	β	0.688	0.144	1.233
	ϕ	2.613	1.411	4.839

Table BB21. Alternative fitted statistical models for Short Dermal Exposure (mg)

Model	Parameter	Estimate	Lower Bound	Upper Bound
1. Linear regression of Ln(exposure) on Ln(NF)	μ	-1.410	-4.724	1.905
	β	0.684	0.042	1.325
2. Quadratic regression of Ln(exposure) on Ln(NF)	μ	-6.445	-51.923	39.034
	β	2.664	-15.189	20.518
	γ	-0.193	-1.928	1.543
3. Log-log logistic regression of exposure on NF	**α**	17.227	-8.559	43.013
	γ	9726.029	-249771.181	269223.238
	β	-1.909	-8.092	4.274
4. 3-parameter logistic regression of exposure on NF	**α**			
	c			
	β			
5. Gamma model for exposure	**μ**	-1.255	-4.065	1.554
	β	0.693	0.149	1.237
	ϕ	2.619	1.414	4.850

Table BB22. Alternative fitted statistical models for Long Short Dermal Exposure (mg)

Model	Parameter	Estimate	Lower Bound	Upper Bound
1. Linear regression of Ln(exposure) on Ln(NF)	μ	-1.410	-4.716	1.896
	β	0.683	0.043	1.323

Model	Parameter	Estimate	Lower Bound	Upper Bound
2. Quadratic regression of Ln(exposure) on Ln(NF)	μ	-6.452	-51.816	38.912
	β	2.667	-15.142	20.475
	γ	-0.193	-1.924	1.538
3. Log-log logistic regression of exposure on NF	**α**	17.168	-8.651	42.987
	γ	9277.075	-236492.902	255047.051
	β	-1.898	-8.044	4.248
4. 3-parameter logistic regression of exposure on NF	**α**			
	c			
	β			
5. Gamma model for exposure	**μ**	-1.250	-4.051	1.550
	β	0.691	0.149	1.233
	ϕ	2.635	1.423	4.882

Table BB23. Alternative fitted statistical models for Hands Only Exposure (mg)

Model	Parameter	Estimate	Lower Bound	Upper Bound
1. Linear regression of Ln(exposure) on Ln(NF)	μ	-6.688	-52.362	38.985
	β	2.757	-15.173	20.687
2. Quadratic regression of Ln(exposure) on Ln(NF)	μ	-0.202	-1.945	1.541
	β	-6.688	-52.362	38.985
	γ	2.757	-15.173	20.687
3. Log-log logistic regression of exposure on NF	**α**	16.871	-7.391	41.134
	γ	10672.847	-275083.990	296429.684
	β	-1.934	-8.124	4.257

Model	Parameter	Estimate	Lower Bound	Upper Bound
4. 3-parameter logistic regression of exposure on NF	**α**			
	c			
	β			
5. Gamma model for exposure	**μ**	-1.243	-4.059	1.572
	β	0.689	0.144	1.234
	ϕ	2.610	1.409	4.833

Table BB24. Alternative fitted statistical models for Inhalation Concentration (mg/m^3)

Model	Parameter	Estimate	Lower Bound	Upper Bound
1. Linear regression of Ln(exposure) on Ln(NF)	μ	-11.861	-15.532	-8.191
	β	0.688	-0.005	1.381
2. Quadratic regression of Ln(exposure) on Ln(NF)	μ	-19.357	-64.483	25.770
	β	3.559	-13.680	20.798
	γ	-0.271	-1.898	1.356
3. Log-log logistic regression of exposure on NF	**α**	0.00029	-0.00758	0.00817
	γ	-0.00805	-5.92811	5.91201
	β	0.52798	-103.30233	104.35829
4. 3-parameter logistic regression of exposure on NF	**α**			
	c			
	β			
5. Gamma model for exposure	**μ**	-11.593	-15.787	-7.400
	β	0.725	-0.068	1.518

Model	Parameter	Estimate	Lower Bound	Upper Bound
	ϕ	1.218	0.678	2.186

Table BB25. Alternative fitted statistical models for Inhalation Dose (mg)

Model	Parameter	Estimate	Lower Bound	Upper Bound
1. Linear regression of Ln(exposure) on Ln(NF)	μ	-12.326	-16.379	-8.272
	β	0.676	-0.089	1.441
2. Quadratic regression of Ln(exposure) on Ln(NF)	μ	-20.409	-70.254	29.435
	β	3.772	-15.269	22.814
	γ	-0.292	-2.089	1.504
3. Log-log logistic regression of exposure on NF	**α**	7.32E-01	-5.62E+04	5.62E+04
	γ	1.25E+05	-9.56E+09	9.56E+09
	β	-6.42E-01	-1.40E+01	1.27E+01
4. 3-parameter logistic regression of exposure on NF	**α**			
	c			
	β			
5. Gamma model for exposure	**μ**	-12.686	-16.402	-8.971
	β	0.823	0.121	1.525
	ϕ	1.350	0.748	2.436

Table BB26. Alternative fitted statistical models for Inhalation Time Weighted Average Concentration (mg/m^3)

Model	Parameter	Estimate	Lower Bound	Upper Bound
1. Linear regression of Ln(exposure) on Ln(NF)	μ	-14.4052834	-18.45881815	-10.35174865
	β	0.676123868	-0.088942769	1.441190506

Model	Parameter	Estimate	Lower Bound	Upper Bound
2. Quadratic regression of Ln(exposure) on Ln(NF)	μ	-22.489	-72.333	27.355
	β	3.772	-15.269	22.814
	γ	-0.292	-2.089	1.504
3. Log-log logistic regression of exposure on NF	**α**	1.25E-01	-6.59E+03	6.59E+03
	γ	1.87E+05	-9.82E+09	9.82E+09
	β	-7.05E-01	-1.02E+01	8.82E+00
4. 3-parameter logistic regression of exposure on NF	**α**			
	c			
	β			
5. Gamma model for exposure	**μ**	-14.766	-18.481	-11.050
	β	0.823	0.121	1.525
	ϕ	1.350	0.748	2.436

Model Comparisons

One way to compare the fit of the 7 models presented above is to use the Akaike Information Criterion (AIC), which takes minus twice the log-likelihood and then makes an adjustment or penalty for the number of parameters in the model. The following two tables compare the AIC values for the various Dermal and Inhalation exposure measures. The smaller values of the AIC suggest a better-fitting model. AIC values for models that failed to converge are not shown.

Table BB27. Akaike Information Criteria values for alternative models for Dermal Exposure

Model	Long Dermal	Short Dermal	Long Short Dermal	Hands Only
1. Linear regression of Ln(exposure) on Ln(NF)	41.9	41.8	41.7	42.0
2. Quadratic regression of Ln(exposure) on Ln(NF)	43.9	43.7	43.6	43.9

Model	Long Dermal	Short Dermal	Long Short Dermal	Hands Only
3. Log-log logistic regression of exposure on NF	53.1	53.3	53.0	53.0
4. 3-parameter logistic regression of exposure on NF				
5. Gamma model for exposure	42.1	42.0	41.9	42.1

Table BB28. Akaike Information Criteria values for alternative models for Inhalation Exposure

Model	Inhalation Concentration	Inhalation Dose	Inhalation Time-Weighted Average Concentration
1. Linear regression of Ln(exposure) on Ln(NF)	49.5	53.1	53.1
2. Quadratic regression of Ln(exposure) on Ln(NF)	51.4	55.0	55.0
3. Log-log logistic regression of exposure on NF	92.1	83.0	81.7
4. 3-parameter logistic regression of exposure on NF			
5. Gamma model for exposure	58.3	56.0	56.0

Based on the AIC, the best-fitting models are the linear model for all the exposure routes.

7. Normalizing Factor Concentration, Sink Scenario

Summary Statistics of Exposure per Concentration

Tables BS1 to BS7 summarize the normalized exposure data (per concentration) with the summary statistics from the 18 (all concentrations), or 6 (specific concentrations) measurements for each concentration group, and each dermal and inhalation exposure route. These analyses assume that the exposure measurements within each subset come from some unspecified distribution for that subset.

Table BS1. Summary statistics for normalized long dermal exposure (mg/(ppm ADBAC)) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	0.0491	0.0500	0.0504	0.0469
Arithmetic Standard Deviation	0.0227	0.0301	0.0203	0.0206
Geometric Mean	0.0451	0.0451	0.0470	0.0432
Geometric Standard Deviation	1.5150	1.5687	1.5261	1.5661
Min	0.0247	0.0346	0.0254	0.0247
5%	0.0247	0.0346	0.0254	0.0247
10%	0.0254	0.0346	0.0254	0.0247
25%	0.0346	0.0354	0.0327	0.0278
50%	0.0437	0.0372	0.0526	0.0437
75%	0.0560	0.0449	0.0560	0.0641
90%	0.0832	0.1110	0.0832	0.0776
95%	0.1110	0.1110	0.0832	0.0776
Max	0.1110	0.1110	0.0832	0.0776

Table BS2. Summary statistics for normalized short dermal exposure (mg/(ppm ADBAC)) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	0.0527	0.0542	0.0537	0.0502
Arithmetic Standard Deviation	0.0240	0.0316	0.0218	0.0220
Geometric Mean	0.0485	0.0492	0.0501	0.0463
Geometric Standard Deviation	1.5054	1.5516	1.5164	1.5614
Min	0.0274	0.0368	0.0287	0.0274
5%	0.0274	0.0368	0.0287	0.0274
10%	0.0287	0.0368	0.0287	0.0274

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
25%	0.0368	0.0393	0.0335	0.0292
50%	0.0460	0.0416	0.0545	0.0460
75%	0.0618	0.0480	0.0618	0.0715
90%	0.0892	0.1182	0.0892	0.0813
95%	0.1182	0.1182	0.0892	0.0813
Max	0.1182	0.1182	0.0892	0.0813

Table BS3. Summary statistics for normalized long short dermal exposure (mg/(ppm ADBAC)) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	0.0519	0.0526	0.0533	0.0499
Arithmetic Standard Deviation	0.0242	0.0320	0.0218	0.0220
Geometric Mean	0.0476	0.0473	0.0497	0.0459
Geometric Standard Deviation	1.5159	1.5773	1.5183	1.5684
Min	0.0272	0.0360	0.0284	0.0272
5%	0.0272	0.0360	0.0284	0.0272
10%	0.0284	0.0360	0.0284	0.0272
25%	0.0360	0.0370	0.0334	0.0286
50%	0.0457	0.0388	0.0542	0.0457
75%	0.0608	0.0478	0.0608	0.0712
90%	0.0891	0.1173	0.0891	0.0808
95%	0.1173	0.1173	0.0891	0.0808
Max	0.1173	0.1173	0.0891	0.0808

Table BS4. Summary statistics for normalized hands only dermal exposure (mg/(ppm ADBAC)) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	0.0473	0.0468	0.0483	0.0468
Arithmetic Standard Deviation	0.0237	0.0318	0.0218	0.0207
Geometric Mean	0.0425	0.0408	0.0438	0.0430
Geometric Standard Deviation	1.5970	1.6944	1.6635	1.5720

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Min	0.0189	0.0243	0.0189	0.0246
5%	0.0189	0.0243	0.0189	0.0246
10%	0.0243	0.0243	0.0189	0.0246
25%	0.0312	0.0312	0.0326	0.0274
50%	0.0435	0.0351	0.0497	0.0436
75%	0.0560	0.0448	0.0560	0.0640
90%	0.0830	0.1101	0.0830	0.0776
95%	0.1101	0.1101	0.0830	0.0776
Max	0.1101	0.1101	0.0830	0.0776

Table BS5. Summary statistics for normalized inhalation concentration exposure (mg/m^3/(ppm DDAC)) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	3.303E-06	8.357E-06	1.051E-06	5.018E-07
Arithmetic Standard Deviation	4.123E-06	3.102E-06	1.411E-06	2.019E-07
Geometric Mean	1.300E-06	7.937E-06	5.995E-07	4.618E-07
Geometric Standard Deviation	4.388E+00	1.410E+00	2.941E+00	1.604E+00
Min	1.804E-07	5.224E-06	1.804E-07	2.111E-07
5%	1.804E-07	5.224E-06	1.804E-07	2.111E-07
10%	2.111E-07	5.224E-06	1.804E-07	2.111E-07
25%	3.527E-07	6.583E-06	3.395E-07	3.395E-07
50%	7.117E-07	7.237E-06	4.481E-07	5.183E-07
75%	6.583E-06	1.005E-05	1.022E-06	6.759E-07
90%	1.005E-05	1.381E-05	3.870E-06	7.474E-07
95%	1.381E-05	1.381E-05	3.870E-06	7.474E-07
Max	1.381E-05	1.381E-05	3.870E-06	7.474E-07

Table BS6. Summary statistics for normalized inhalation dose exposure (mg/(ppm DDAC)) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	4.850E-06	1.244E-05	1.364E-06	7.424E-07
Arithmetic Standard Deviation	6.279E-06	5.277E-06	1.453E-06	3.124E-07

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Geometric Mean	1.862E-06	1.141E-05	8.525E-07	6.639E-07
Geometric Standard Deviation	4.474E+00	1.610E+00	2.876E+00	1.790E+00
Min	2.182E-07	5.572E-06	3.395E-07	2.182E-07
5%	2.182E-07	5.572E-06	3.395E-07	2.182E-07
10%	3.395E-07	5.572E-06	3.395E-07	2.182E-07
25%	6.759E-07	7.475E-06	3.527E-07	6.759E-07
50%	1.105E-06	1.349E-05	7.239E-07	7.257E-07
75%	7.475E-06	1.436E-05	2.045E-06	9.861E-07
90%	1.436E-05	2.027E-05	3.999E-06	1.123E-06
95%	2.027E-05	2.027E-05	3.999E-06	1.123E-06
Max	2.027E-05	2.027E-05	3.999E-06	1.123E-06

Table BS7. Summary statistics for normalized inhalation time-weighted average concentration exposure (mg/m^3/(ppm DDAC)) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	6.062E-07	1.555E-06	1.705E-07	9.280E-08
Arithmetic Standard Deviation	7.849E-07	6.596E-07	1.817E-07	3.905E-08
Geometric Mean	2.328E-07	1.426E-06	1.066E-07	8.299E-08
Geometric Standard Deviation	4.474E+00	1.610E+00	2.876E+00	1.790E+00
Min	2.727E-08	6.966E-07	4.244E-08	2.727E-08
5%	2.727E-08	6.966E-07	4.244E-08	2.727E-08
10%	4.244E-08	6.966E-07	4.244E-08	2.727E-08
25%	8.449E-08	9.343E-07	4.408E-08	8.449E-08
50%	1.381E-07	1.686E-06	9.049E-08	9.071E-08
75%	9.343E-07	1.795E-06	2.556E-07	1.233E-07
90%	1.795E-06	2.534E-06	4.999E-07	1.403E-07
95%	2.534E-06	2.534E-06	4.999E-07	1.403E-07
Max	2.534E-06	2.534E-06	4.999E-07	1.403E-07

The results show the high proportions of the normalized dermal exposure from hands only. For All and for each concentration group, based on the arithmetic means, the overall percentages of the normalized exposure from hands only are between 93 and 100% of the Long Dermal, between 86 and 93% of the Short Dermal, and between 89 and 94% of the Long Short Dermal. Similarly, for the unnormalized dermal exposure, the arithmetic mean hands only exposure is

92% of the arithmetic mean total dermal exposure (defined as the sum of the residues from hand wash, forearm wipe, face/neck wipe, and the inner dosimeters).

Compare Concentration Groups

The results in Tables BS1 to BS7 show some differences between the normalized exposure statistics for the three concentration groups "Target Quat: 100 ppm," "Target Quat: 600 ppm," and "Target Quat: 1000 ppm." To compare these groups, an analysis of variance was performed to test whether the geometric means were statistically significantly different at the 5% significance level.

The p-values for these ANOVA tests are shown in Table BS8. These analyses show that there were no statistically significant differences (at the 5% significance level) between the three concentration groups for the dermal exposure modes, but very significant differences for the inhalation modes.

Table BS8. P-values for testing differences in geometric means for different concentration groups

Exposure Route	ANOVA	Welch's ANOVA
Long Dermal	0.949	0.951
Short Dermal	0.947	0.951
Long Short Dermal	0.952	0.953
Hands Only	0.966	0.971
Inhalation Conc	0.000	0.000
Inhalation Dose	0.000	0.000
Inhalation 8-hr TWA	0.000	0.000

Statistical Models

Table BS9 presents the arithmetic mean and 95th percentile estimates from the lognormal simple random sampling model, together with 95% confidence intervals, for each of the exposure routes, for all concentration groups combined. These are the values of AMu and P95u. The other summary statistics are presented in more detail below.

Table BS9. Arithmetic mean and 95th percentile estimates from lognormal simple random sampling model for normalized exposure for All

Exposure Route	Clothing	Arithmetic Mean (95% Confidence Interval)	95th Percentile (95% Confidence Interval)
Dermal (mg/(ppm ADBAC))	Long Dermal	0.0491 (0.0403, 0.0603)	0.0893 (0.0661, 0.1202)
	Short Dermal	0.0527 (0.0434, 0.0644)	0.0950 (0.0707, 0.1273)
	Long Short Dermal	0.0519 (0.0426, 0.0637)	0.0944 (0.0698, 0.1271)
	Hands Only	0.0474 (0.0379, 0.0699)	0.0918 (0.0654, 0.1283)

Exposure Route	Clothing	Arithmetic Mean (95% Confidence Interval)	95th Percentile (95% Confidence Interval)
Inhalation Concentration ((mg/m^3)/ (ppm DDAC))		3.88×10^{-6} (1.51×10^{-6}, 1.15×10^{-5})	1.48×10^{-5} (5.07×10^{-6}, 4.27×10^{-5})
Inhalation Dose (mg/ (ppm DDAC))		5.72×10^{-6} (2.20×10^{-6}, 1.74×10^{-5})	2.19×10^{-5} (7.40×10^{-6}, 6.40×10^{-5})
Inhalation 8-hr TWA ((mg/m^3)/ ppm DDAC))		7.15×10^{-7} (2.74×10^{-7}, 2.18×10^{-6})	2.74×10^{-6} (9.25×10^{-7}, 7.99×10^{-6})

Non-detects

For all the analyses presented in this memorandum except for Table BS10 and BS18, measurements below the LOQ or LOD were replaced by the mid-value, the midpoint of the lowest and highest possible value for that measurement. In Tables BS10 and BS18 we investigated the impact on the summary statistics of the censored values.

Table BS10. Exposure summary statistics calculated using alternative estimated exposures for values below the LOQ

Exposure Route	Method for Substituting Values Below the LOQ	Arithmetic Mean	95th Percentile
Long Dermal (mg/(ppm ADBAC))	Substitute mid value	0.0491 (0.0402, 0.0603)	0.0893 (0.0660, 0.1202)
	Substitute max value	0.0492 (0.0402, 0.0604)	0.0893 (0.0660, 0.1203)
	Substitute min value	0.0491 (0.0401, 0.0603)	0.0892 (0.0659, 0.1202)
	Censored data MLE	0.0489 (0.0402, 0.0597)	0.0892 (0.0659, 0.1202)
Short Dermal (mg/(ppm ADBAC))	Substitute mid value	0.0527 (0.0432, 0.0645)	0.0950 (0.0705, 0.1273)
	Substitute max value	0.0528 (0.0433, 0.0646)	0.0951 (0.0706, 0.1274)
	Substitute min value	0.0526 (0.0432, 0.0644)	0.0949 (0.0705, 0.1273)
	Censored data MLE	0.0525 (0.0433, 0.0638)	0.0932 (0.0698, 0.1239)
Long Short Dermal (mg/(ppm ADBAC))	Substitute mid value	0.0519 (0.0424, 0.0638)	0.0944 (0.0697, 0.1271)
	Substitute max value	0.0520 (0.0425, 0.0638)	0.0944 (0.0698, 0.1272)
	Substitute min value	0.0519 (0.0424, 0.0637)	0.0943 (0.0697, 0.1271)
	Censored data MLE	0.0517 (0.0425, 0.0630)	0.0926 (0.0690, 0.1237)
Hands Only (mg/(ppm ADBAC))	Substitute mid value	0.0474 (0.0377, 0.0600)	0.0918 (0.0653, 0.1284)
	Substitute max value	0.0474 (0.0377, 0.0600)	0.0918 (0.0653, 0.1284)
	Substitute min value	0.0474 (0.0377, 0.0600)	0.0918 (0.0653, 0.1284)
	Censored data MLE	0.0471 (0.0378, 0.0592)	0.0899 (0.0645, 0.1245)
Inhalation Concentration ((mg/m^3)/ (ppm DDAC))	Substitute mid value	3.88×10^{-6} (1.50×10^{-6}, 1.14×10^{-5})	1.48×10^{-5} (5.04×10^{-6}, 4.27×10^{-5})

Exposure Route	Method for Substituting Values Below the LOQ	Arithmetic Mean	95th Percentile
	Substitute max value	3.64×10^{-6} (1.61×10^{-6}, 8.98×10^{-5})	1.34×10^{-5} (5.10×10^{-6}, $3,45 \times 10^{-5}$)
	Substitute min value	5.09×10^{-6} (2.22×10^{-6}, 1.29×10^{-5})	1.88×10^{-5} (7.07×10^{-6}, 4.93×10^{-5})
	Censored data MLE	4.09×10^{-6} (1.47×10^{-6}, 1.32×10^{-5})	1.57×10^{-5} (5.07×10^{-6}, 4.80×10^{-5})
Inhalation Dose (mg/ (ppm DDAC))	Substitute mid value	5.72×10^{-6} (2.17×10^{-6}, 1.73×10^{-5})	2.19×10^{-5} (7.36×10^{-6}, 6.40×10^{-5})
	Substitute max value	5.21×10^{-6} (2.31×10^{-6}, 1.29×10^{-5})	1.91×10^{-5} (7.30×10^{-6}, 4.93×10^{-5})
	Substitute min value	7.11×10^{-6} (3.25×10^{-6}, 1.69×10^{-5})	2.58×10^{-5} (1.01×10^{-6}, 6.49×10^{-5})
	Censored data MLE	6.02×10^{-6} (2.14×10^{-6}, 1.97×10^{-5})	2.32×10^{-5} (7.42×10^{-6}, 7.14×10^{-5})
Inhalation 8-hr TWA ((mg/m^3)/ ppm DDAC))	Substitute mid value	7.15×10^{-7} (2.71×10^{-7}, 2.16×10^{-6})	2.74×10^{-6} (9.19×10^{-7}, 8.00×10^{-6})
	Substitute max value	6.51×10^{-7} (2.89×10^{-7}, 1.61×10^{-6})	2.39×10^{-6} (9.13×10^{-7}, 6.17×10^{-6})
	Substitute min value	8.89×10^{-7} (4.06×10^{-7}, 2.11×10^{-6})	3.23×10^{-6} (1.26×10^{-6}, 8.11×10^{-6})
	Censored data MLE	7.53×10^{-7} (2.67×10^{-7}, 2.46×10^{-6})	2.90×10^{-6} (9.27×10^{-7}, 8.92×10^{-6})

The results in Table BS10 for dermal exposure show very small impacts of the alternative substitution approaches for treating values below the LOQ on the unit exposure arithmetic mean and 95th percentile. This is mainly because the dermal exposure is dominated by the hand exposures which were all above the LOQ. For inhalation exposure, the results show some large impacts of the max and min value substitution methods compared to substituting the mid value, but the results for the censored data MLE are very similar to the results for substituting the mid value.

Detailed Summary Statistics with Confidence Intervals and Fold Relative Accuracy

Tables BS11 to BS17 present the estimates, parametric and non-parametric confidence intervals and fold relative accuracy values for all the summary statistics for the All group. All these analyses use non-detects substituted by the mid-value.

Table BS11. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the normalized long dermal exposure (mg/(ppm ADBAC)) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	1.5150	1.3194	1.7444	1.15	1.3101	1.6741	1.14
GMs	0.0451	0.0373	0.0549	1.21	0.0376	0.0546	1.20
AMs	0.0491	0.0401	0.0600	1.22	0.0397	0.0600	1.23
AMu	0.0491	0.0403	0.0603	1.22	0.0396	0.0604	1.23
P95s	0.1110	0.0659	0.1558	1.63	0.0641	0.1110	1.43

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
P95u	0.0893	0.0661	0.1202	1.35	0.0618	0.1177	1.40

Table BS12. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the normalized short dermal exposure (mg/(ppm ADBAC)) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	1.5054	1.3138	1.7296	1.15	1.3048	1.6574	1.13
GMs	0.0485	0.0403	0.0589	1.21	0.0405	0.0586	1.20
AMs	0.0527	0.0432	0.0641	1.22	0.0427	0.0643	1.23
AMu	0.0527	0.0434	0.0644	1.22	0.0426	0.0645	1.23
P95s	0.1182	0.0704	0.1644	1.63	0.0715	0.1182	1.46
P95u	0.0950	0.0707	0.1273	1.34	0.0658	0.1250	1.39

Table BS13. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the normalized long short dermal exposure (mg/(ppm ADBAC)) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	1.5159	1.3199	1.7457	1.15	1.3115	1.6683	1.13
GMs	0.0476	0.0394	0.0580	1.21	0.0397	0.0578	1.21
AMs	0.0519	0.0424	0.0634	1.22	0.0418	0.0635	1.23
AMu	0.0519	0.0426	0.0637	1.22	0.0418	0.0639	1.24
P95s	0.1173	0.0696	0.1649	1.63	0.0712	0.1173	1.45
P95u	0.0944	0.0698	0.1271	1.35	0.0648	0.1244	1.40

Table BS14. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the normalized hands only exposure (mg/(ppm ADBAC)) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	1.5970	1.3666	1.8720	1.17	1.3711	1.7801	1.15
GMs	0.0425	0.0344	0.0531	1.24	0.0345	0.0525	1.23
AMs	0.0473	0.0377	0.0595	1.26	0.0372	0.0586	1.25
AMu	0.0474	0.0379	0.0599	1.26	0.0373	0.0592	1.26

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
P95s	0.1101	0.0652	0.1720	1.66	0.0640	0.1101	1.42
P95u	0.0918	0.0654	0.1283	1.40	0.0629	0.1220	1.41

Table BS15. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the normalized inhalation concentration exposure ((mg/m^3)/ (ppm DDAC)) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	4.39E+00	2.68E+00	7.25E+00	1.64	3.07E+00	5.33E+00	1.34
GMs	1.30E-06	6.64E-07	2.63E-06	1.99	6.80E-07	2.54E-06	1.94
AMs	3.30E-06	1.36E-06	1.01E-05	2.69	1.58E-06	5.25E-06	1.84
AMu	3.88E-06	1.51E-06	1.15E-05	2.74	1.37E-06	7.82E-06	2.41
P95s	1.38E-05	5.01E-06	1.08E-04	5.82	7.12E-06	1.38E-05	1.88
P95u	1.48E-05	5.07E-06	4.27E-05	2.90	4.67E-06	2.99E-05	2.58

Table BS16. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the normalized inhalation dose exposure (mg/ (ppm DDAC)) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	4.47E+00	2.72E+00	7.44E+00	1.66	3.07E+00	5.61E+00	1.38
GMs	1.86E-06	9.43E-07	3.80E-06	2.01	9.58E-07	3.63E-06	1.95
AMs	4.85E-06	1.96E-06	1.51E-05	2.74	2.27E-06	7.91E-06	1.89
AMu	5.72E-06	2.20E-06	1.74E-05	2.79	1.97E-06	1.23E-05	2.50
P95s	2.03E-05	7.31E-06	1.63E-04	6.00	1.32E-05	2.03E-05	1.47
P95u	2.19E-05	7.40E-06	6.40E-05	2.94	6.87E-06	4.71E-05	2.66

Table BS17. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the normalized inhalation time-weighted average concentration exposure ((mg/m^3)/ (ppm DDAC)) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	4.47E+00	2.72E+00	7.44E+00	1.66	3.07E+00	5.61E+00	1.38
GMs	2.33E-07	1.18E-07	4.74E-07	2.01	1.20E-07	4.54E-07	1.95
AMs	6.06E-07	2.46E-07	1.89E-06	2.74	2.83E-07	9.89E-07	1.89

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
AMu	7.15E-07	2.74E-07	2.18E-06	2.79	2.47E-07	1.53E-06	2.50
P95s	2.53E-06	9.13E-07	2.04E-05	6.00	1.65E-06	2.53E-06	1.47
P95u	2.74E-06	9.25E-07	7.99E-06	2.94	8.58E-07	5.89E-06	2.66

Tables BS11 to BS17 show that the study benchmark design value of 3 for the fold relative accuracy was met in every case, with the exception of the parametric bootstrap empirical 95th percentile for the inhalation concentration, dose, and time-weighted average concentration.

Empirical Quantile Plots

Quantile-quantile plots of the normalized exposure values were used to evaluate whether the data were lognormally distributed, as implied by the assumed statistical lognormal models. These plots were intended to help determine whether the data supported using untransformed normalized exposure values or log-transformed values or neither. The plots are not intended to evaluate the fitted regression models for the un-normalized exposure to be described below, for which the residual quantile plots were developed.

In each case the quantile-quantile plot compared the observed quantiles of the measured values with the corresponding quantiles of a normal or lognormal distribution. A perfect fit would imply that the plotted values lie in a straight line. The quantile-quantile plots for all exposure routes are presented in Figures BS1 to BS14. In all cases the plots seem to show a better fit for the lognormal distributions, supporting the use of the log-transformed exposure values over the untransformed values.

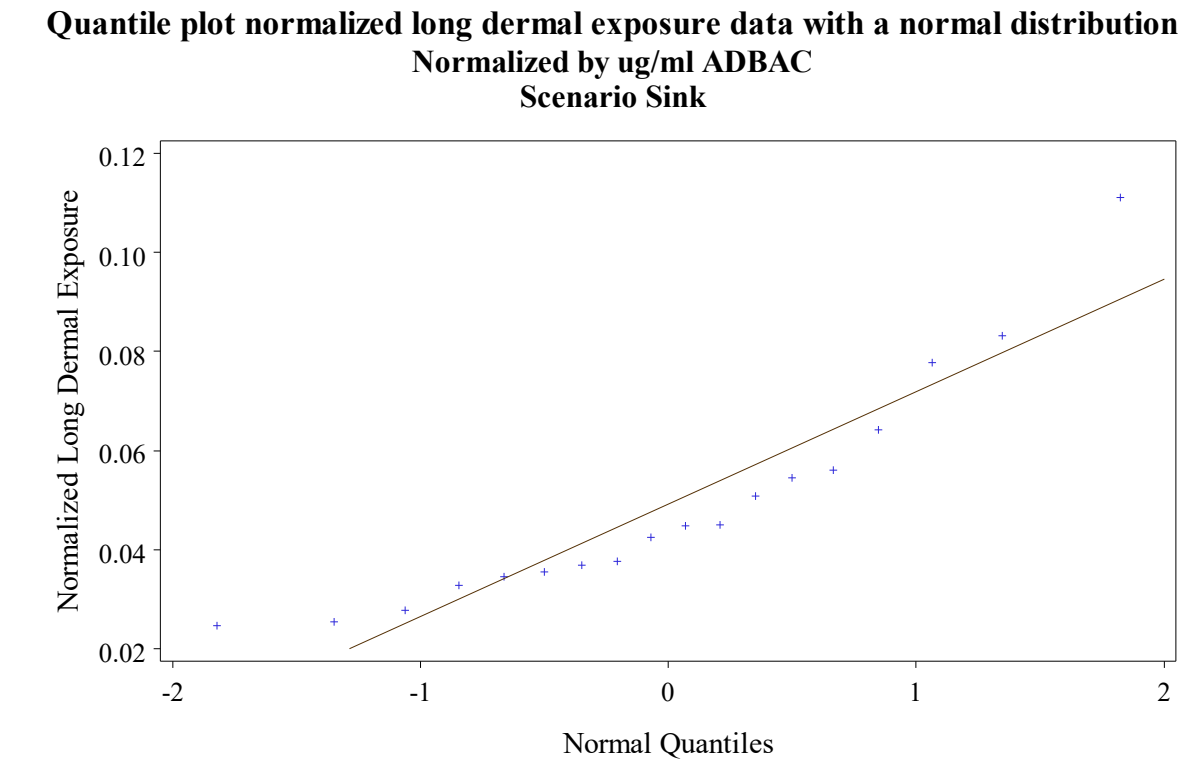


Figure BS1. Empirical quantile plot for Long Dermal, with a normal distribution

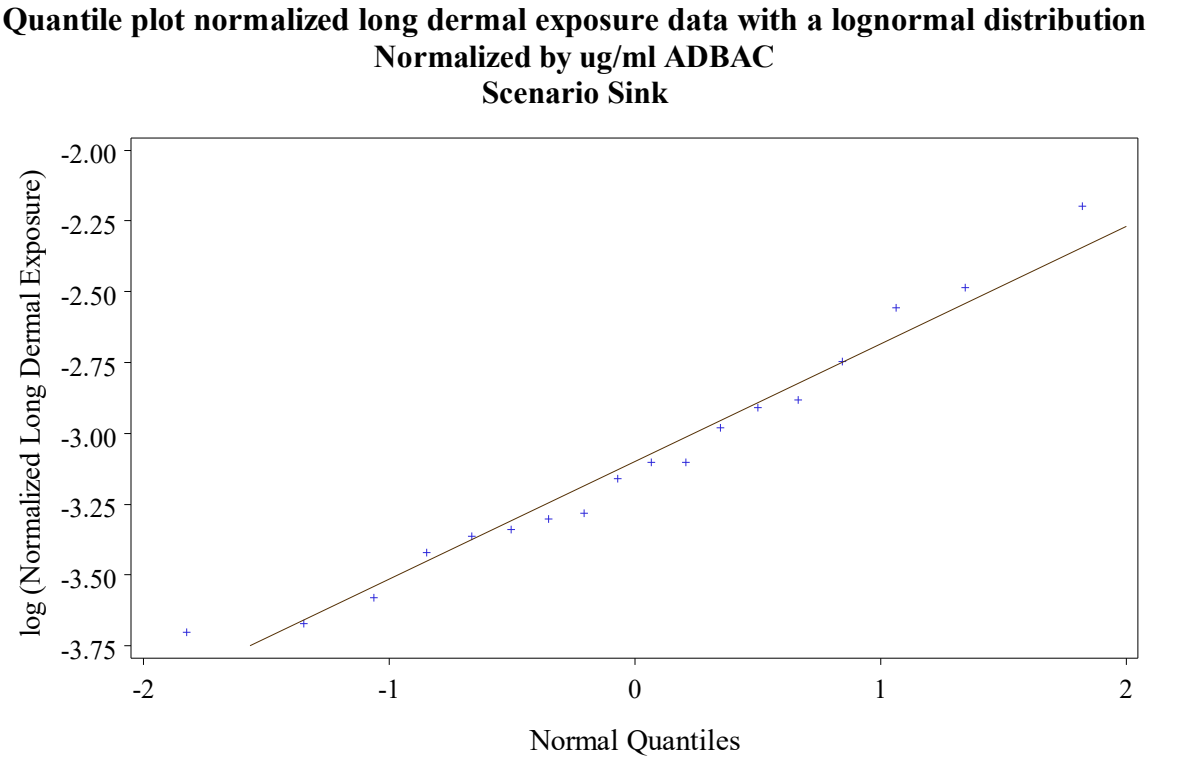


Figure BS2. Empirical quantile plot for Long Dermal, with a lognormal distribution

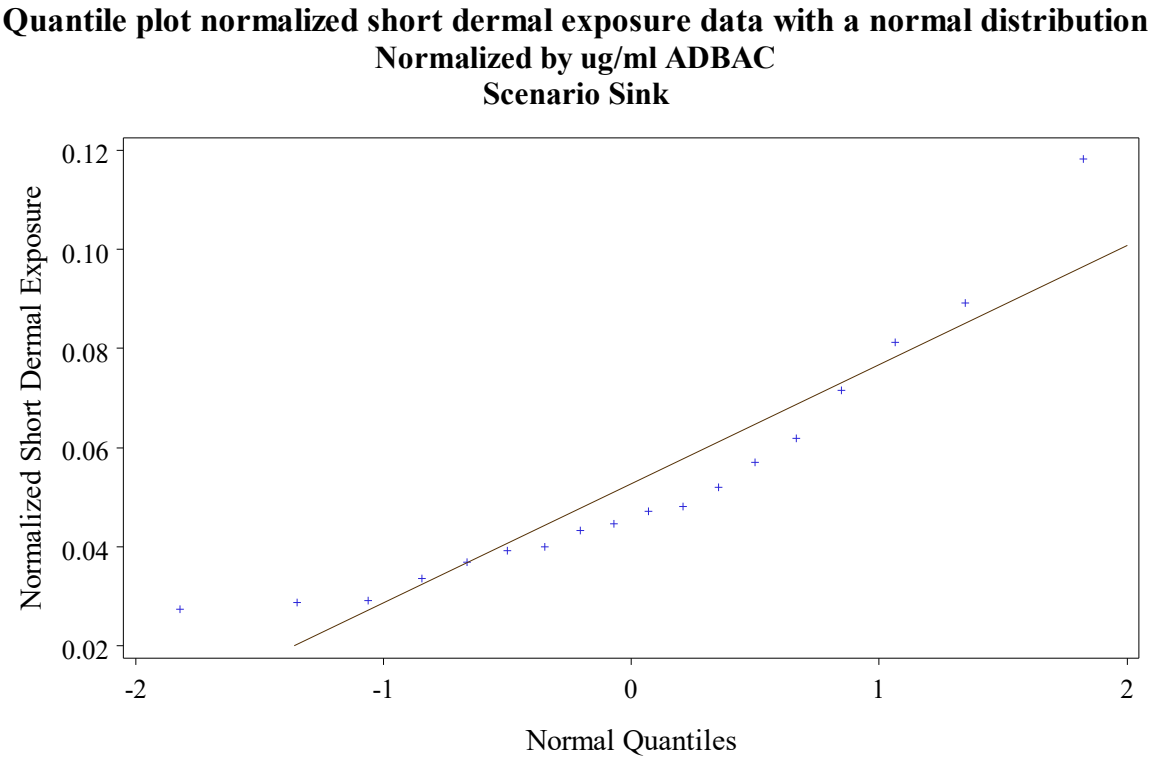


Figure BS3. Empirical quantile plot for Short Dermal, with a normal distribution

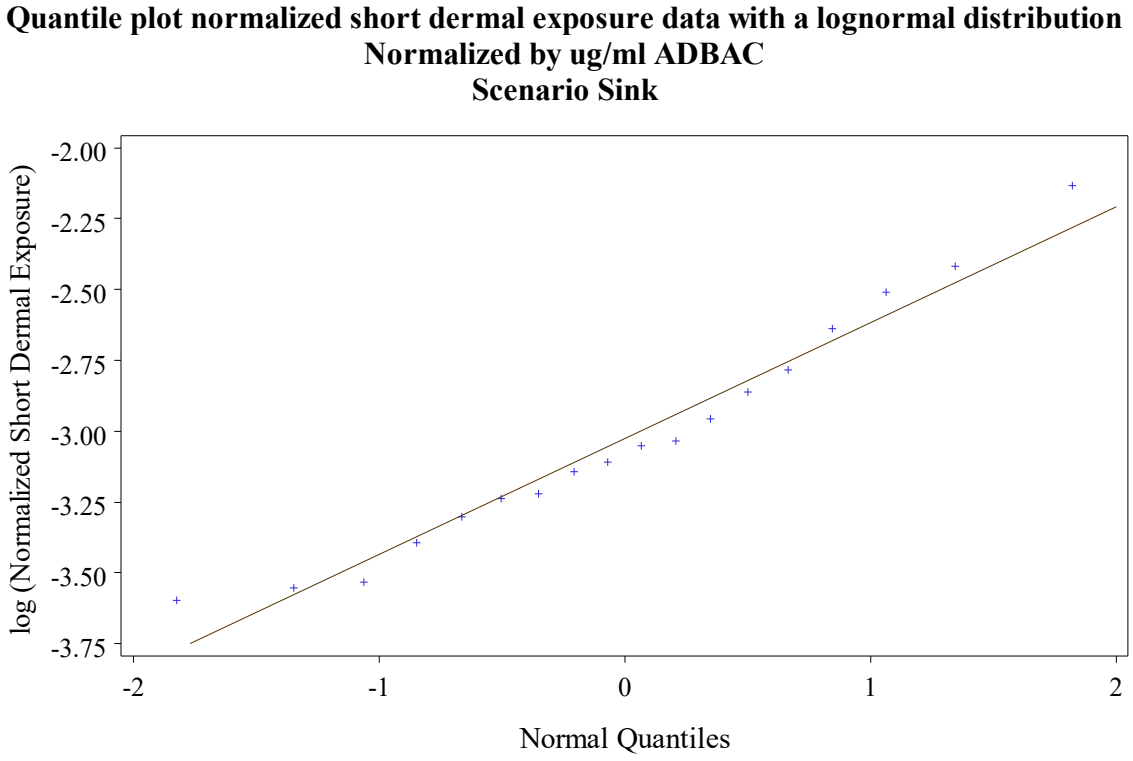


Figure BS4. Empirical quantile plot for Short Dermal, with a lognormal distribution

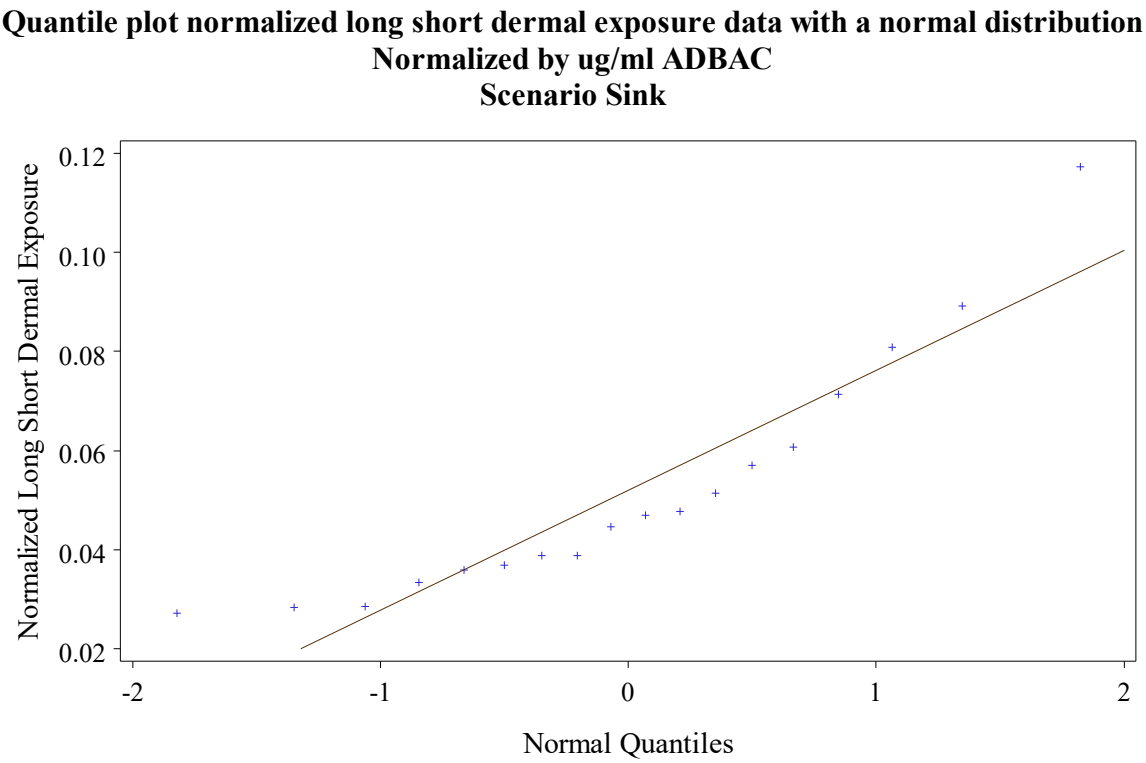


Figure BS5. Empirical quantile plot for Long Short Dermal, with a normal distribution

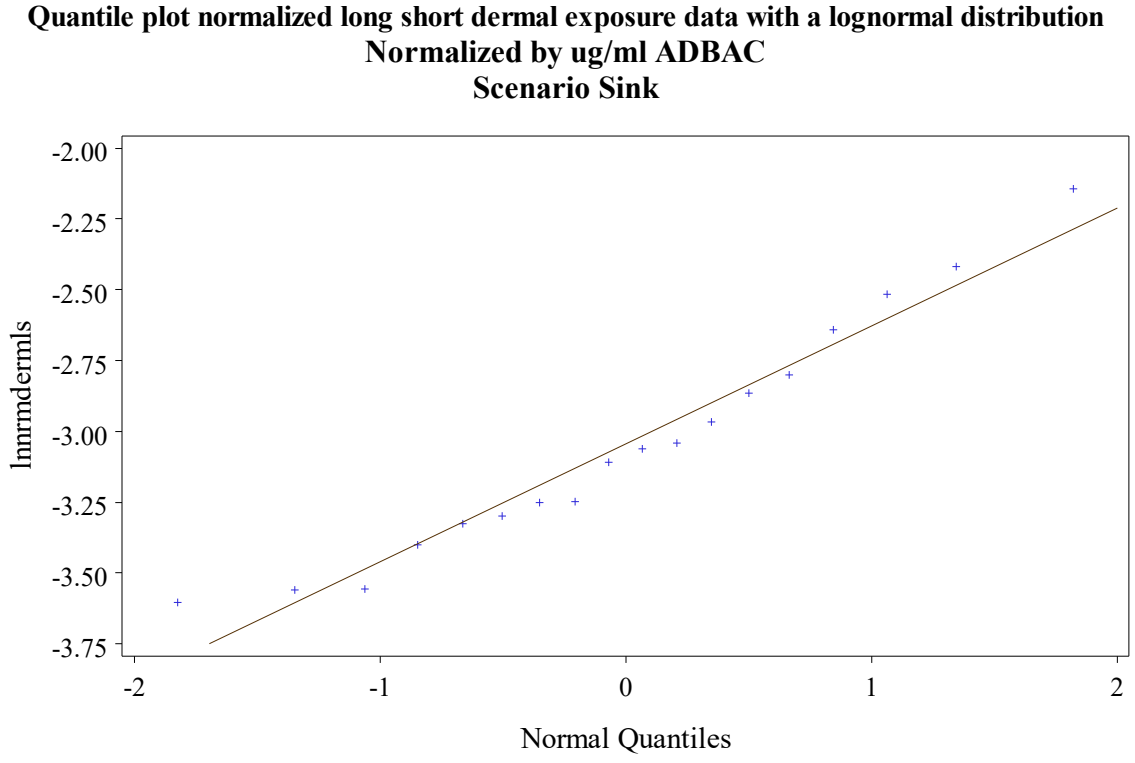


Figure BS6. Empirical quantile plot for Long Short Dermal, with a lognormal distribution

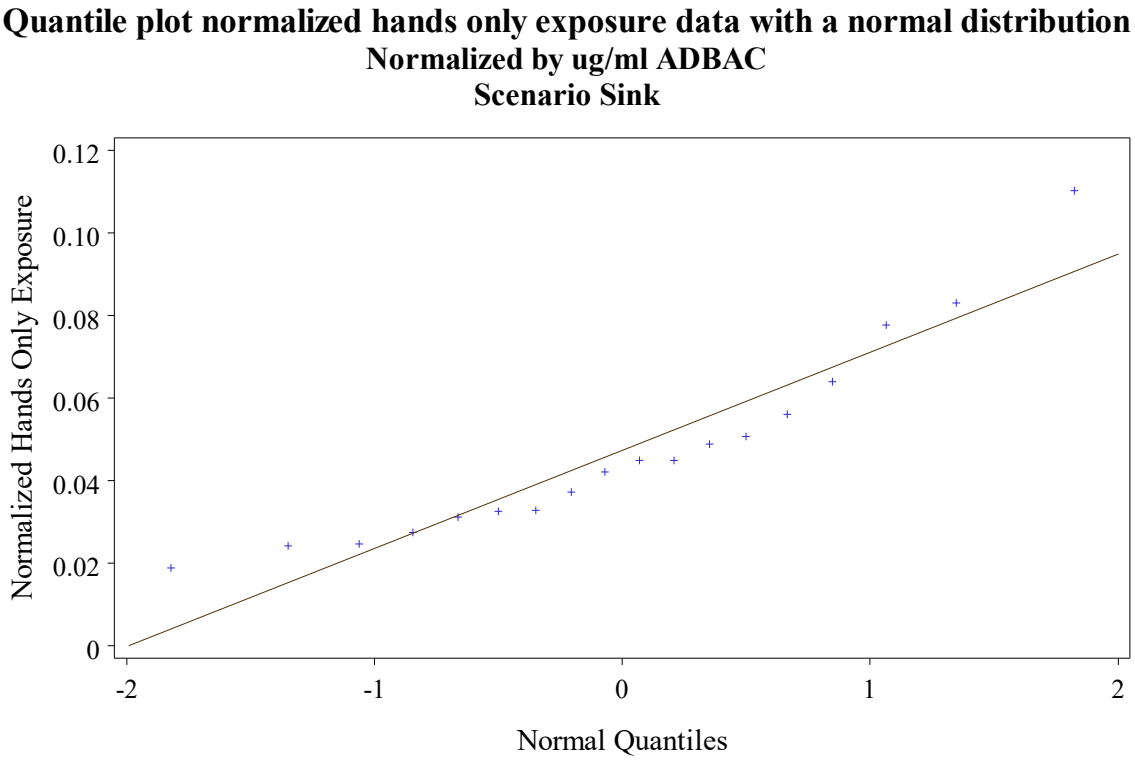


Figure BS7. Empirical quantile plot for Hands Only, with a normal distribution

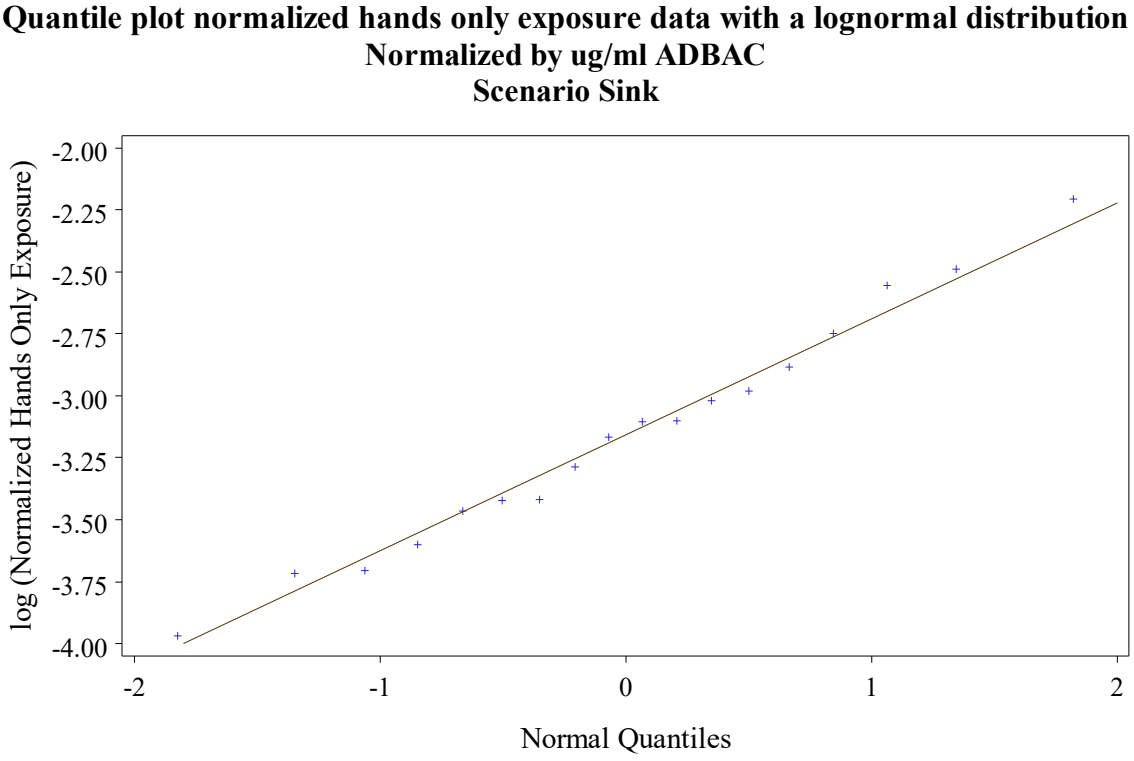


Figure BS8. Empirical quantile plot for Hands Only, with a lognormal distribution

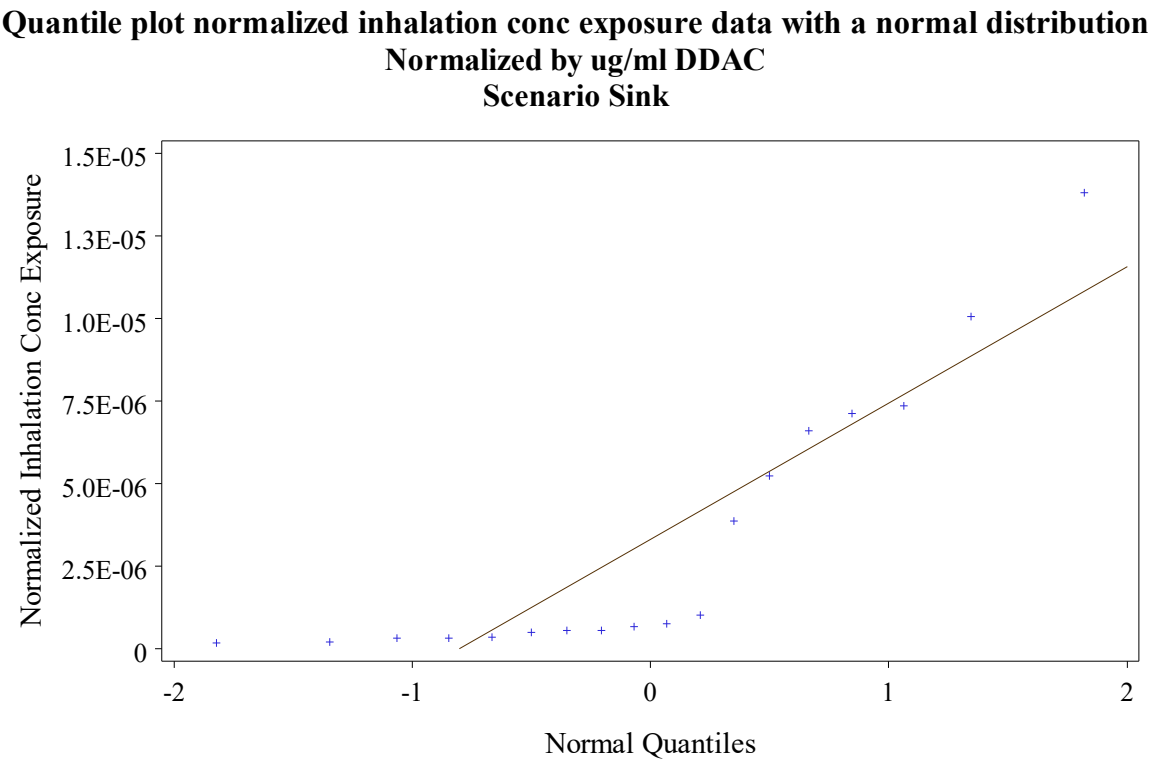


Figure BS9. Empirical quantile plot for Inhalation Concentration, with a normal distribution

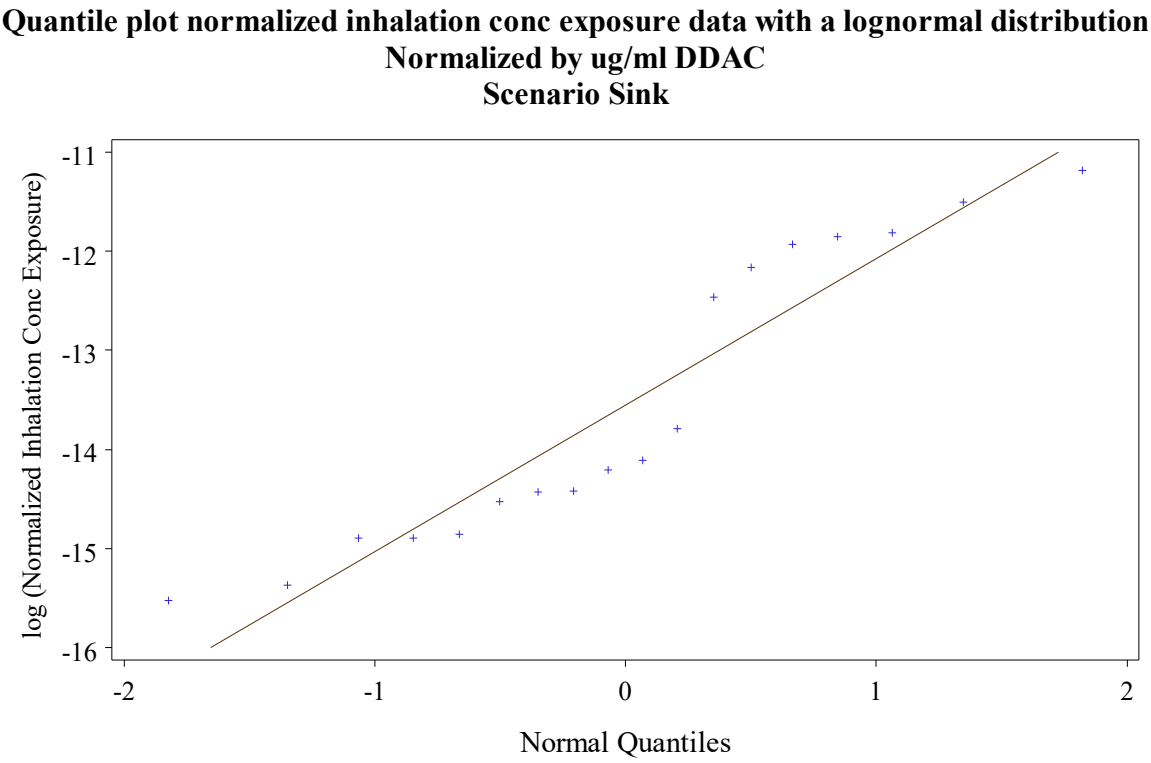


Figure BS10. Empirical quantile plot for Inhalation Concentration, with a lognormal distribution

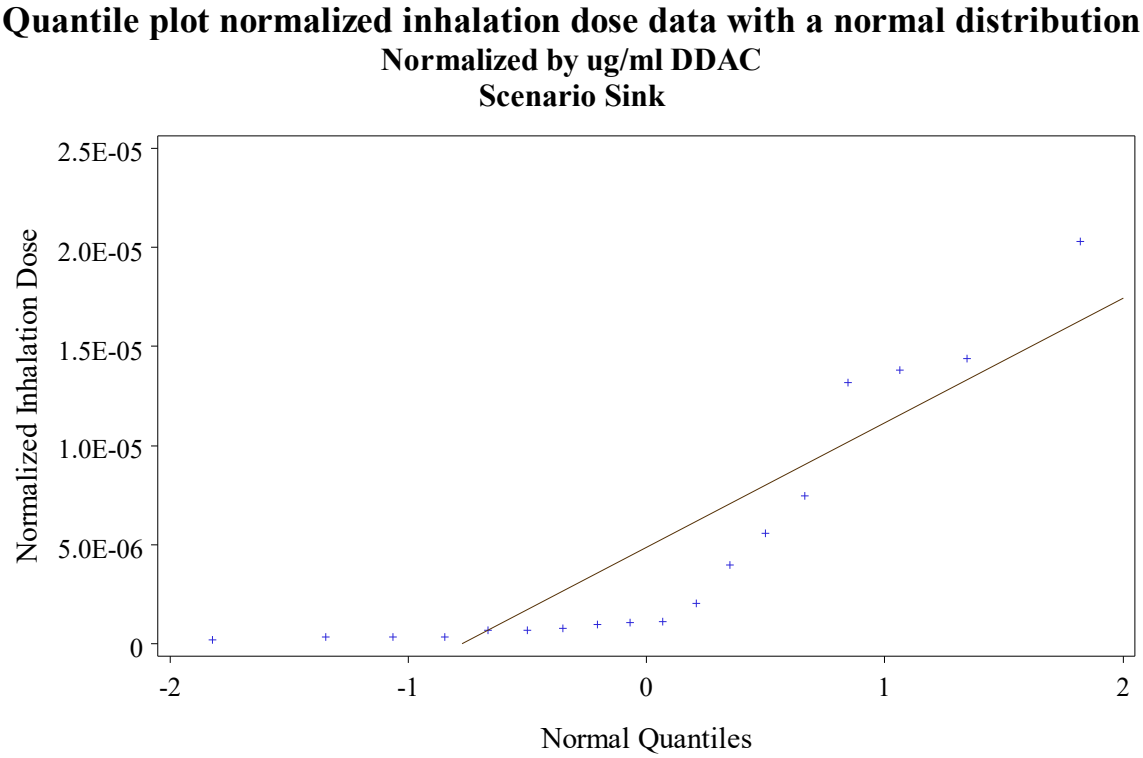


Figure BS11. Empirical quantile plot for Inhalation Dose, with a normal distribution

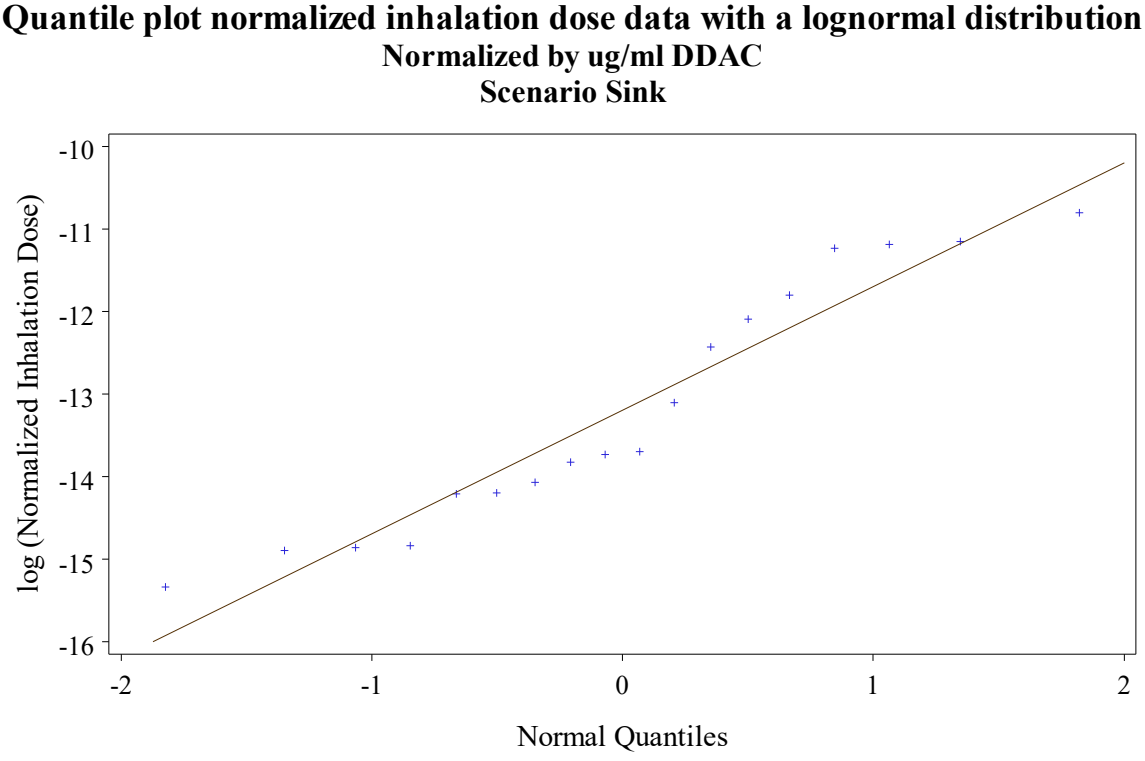


Figure BS12. Empirical quantile plot for Inhalation Dose, with a lognormal distribution

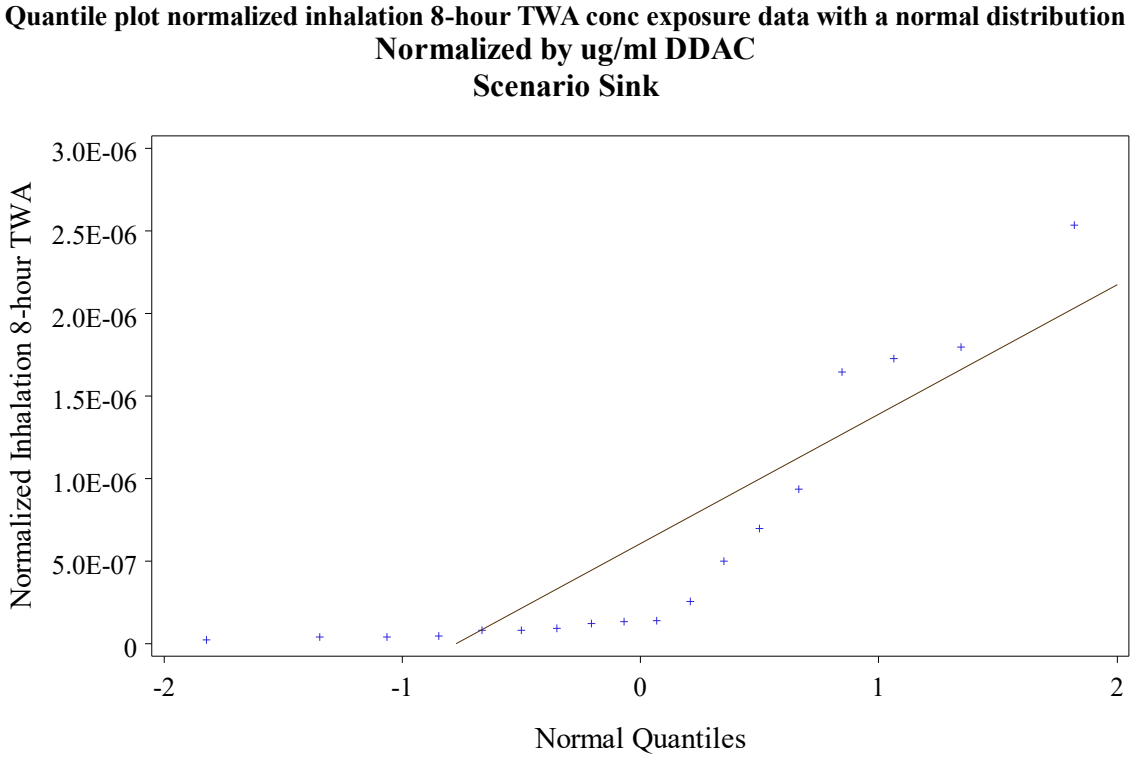


Figure BS13. Empirical quantile plot for Inhalation Time-weighted Average Conc, with a normal distribution

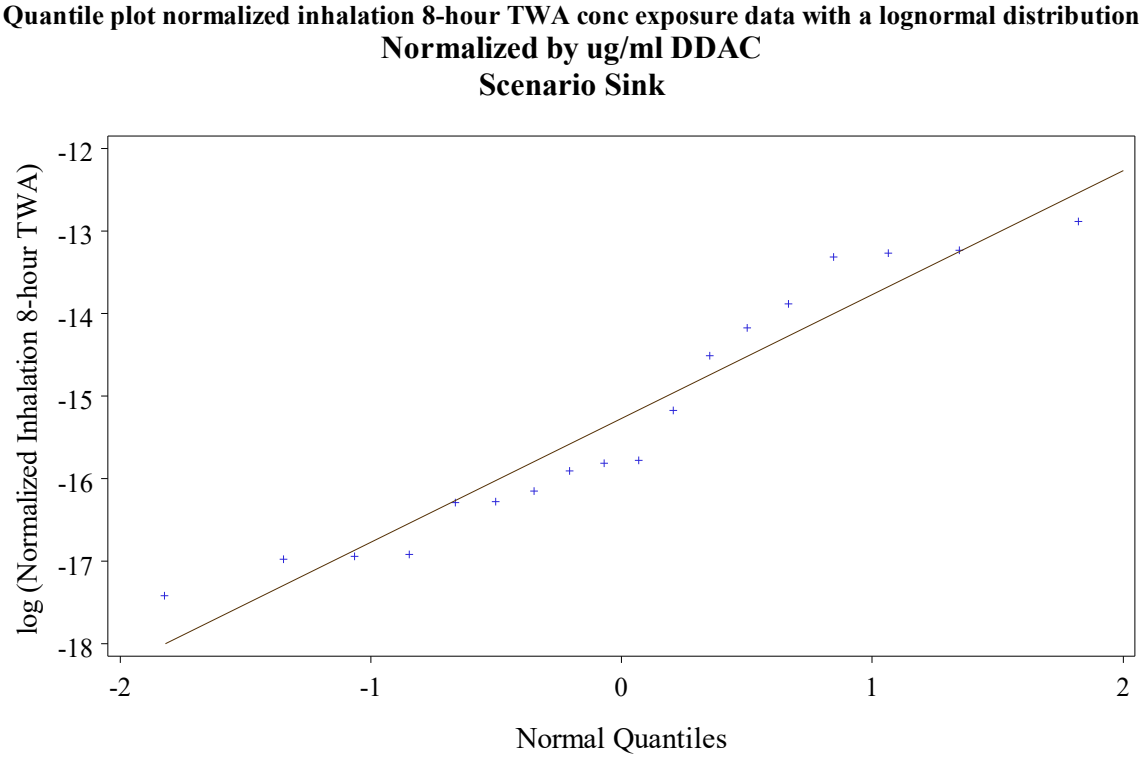


Figure BS14. Empirical quantile plot for Inhalation Time-weighted Average Conc, with a lognormal distribution

Test for log-log-linearity with slope 1

Table BS18 shows the 95% confidence intervals for the slope calculated from the above linear model. A confidence interval that includes one but not zero supports the use of unit exposures. A confidence interval that includes zero but not one suggests that the exposure does not depend on the normalizing factor. A confidence interval that includes both zero and one suggests that either the basic statistical model is incorrect or there are not enough data to statistically infer whether the slope is zero or one. This table also shows the widths of the confidence intervals used to evaluate the second benchmark for post-hoc power discussed in the next sub-section. The table also shows the values of the threshold concentration × duration (case A) or threshold concentration (case B) and the corresponding estimated exposure, to be described and discussed In the Supplement. Threshold values were not computed for the censored data models.

Table BS18. 95 percent confidence intervals for the slope of log exposure versus the log of the normalizing factor.

Exposure Route	Treatment of Non-detects	Estimate	Lower	Upper	Width	Threshold	Exposure
Long Dermal (mg)	Substitute mid value	0.989	0.773	1.205	0.432	127	6.25
	Censored data MLE	0.989	0.800	1.177	0.377		
Short Dermal (mg)	Substitute mid value	0.979	0.767	1.192	0.425	100	5.28
	Censored data MLE	0.979	0.794	1.165	0.371		
Long Short Dermal (mg)	Substitute mid value	0.994	0.777	1.210	0.433	183	9.52
	Censored data MLE	0.994	0.805	1.182	0.378		
Hands Only (mg)	Substitute mid value	1.025	0.782	1.268	0.487	61	2.88
	Censored data MLE	1.025	0.813	1.237	0.424		
Inhalation Concentration (mg/m^3)	Substitute mid value	–0.265	–0.621	0.091	0.711	47	0.00018
	Censored data MLE	–0.231	–0.515	0.054	0.568		
Inhalation Dose (mg)	Substitute mid value	–0.270	–0.642	0.101	0.742	47	0.00027
	Censored data MLE	–0.227	–0.510	0.056	0.566		
Inhalation Time-Weighted Average Concentration (mg/m^3)	Substitute mid value	–0.270	–0.642	0.101	0.742	47	0.000034
	Censored data MLE	–0.227	–0.510	0.056	0.566		

Table BS18 gives the slopes for all the exposure routes.

For dermal exposures, the slopes range from 0.98 to 1.03, and the confidence intervals include 1 but not 0. For inhalation exposures, the slopes are all negative and the confidence intervals include 0 but not 1. Thus for dermal exposure the assumption of independence was rejected and the assumption of log-log-linearity with slope 1 was supported. However, for inhalation exposure the assumption of independence was supported and the assumption of log-log-linearity with slope 1 was rejected. The results for inhalation exposure seem to be counterintuitive.

Suppose that the study had a (post-hoc) power of at least 80% for detecting "proportionality" (i.e., log-log-linearity with a slope of 1) under the null hypothesis of independence (slope = 0). It follows that the confidence intervals have an approximate width of 1.4 or less. The results in **Error! Reference source not found.**AS18 show that observed widths are all below 1.4. The maximum width was about 0.7. Therefore, based on the confidence intervals, the secondary objective of meeting the 80% power for detecting proportionality was met.

Quantile plots for residuals

The quantile-quantile plots of the studentized residuals for all exposure routes are shown below in Figures BS15 to BS21.

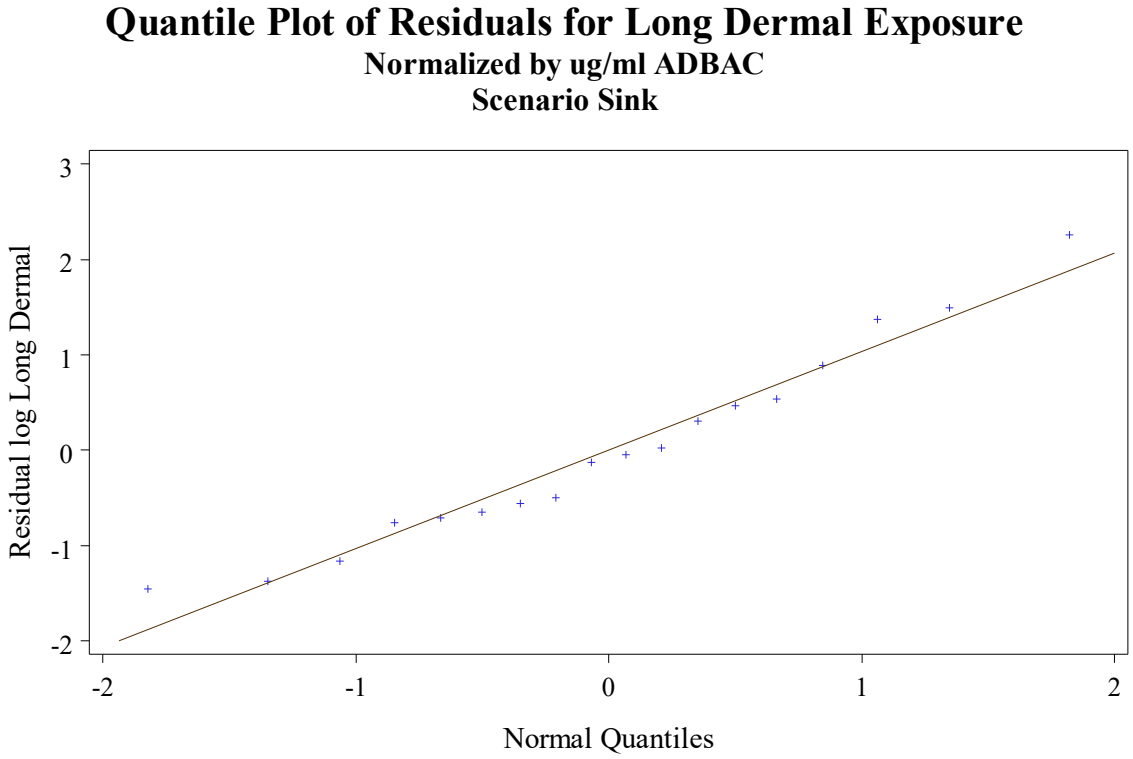


Figure BS15. Quantile plot of residuals from linear model for Long Dermal

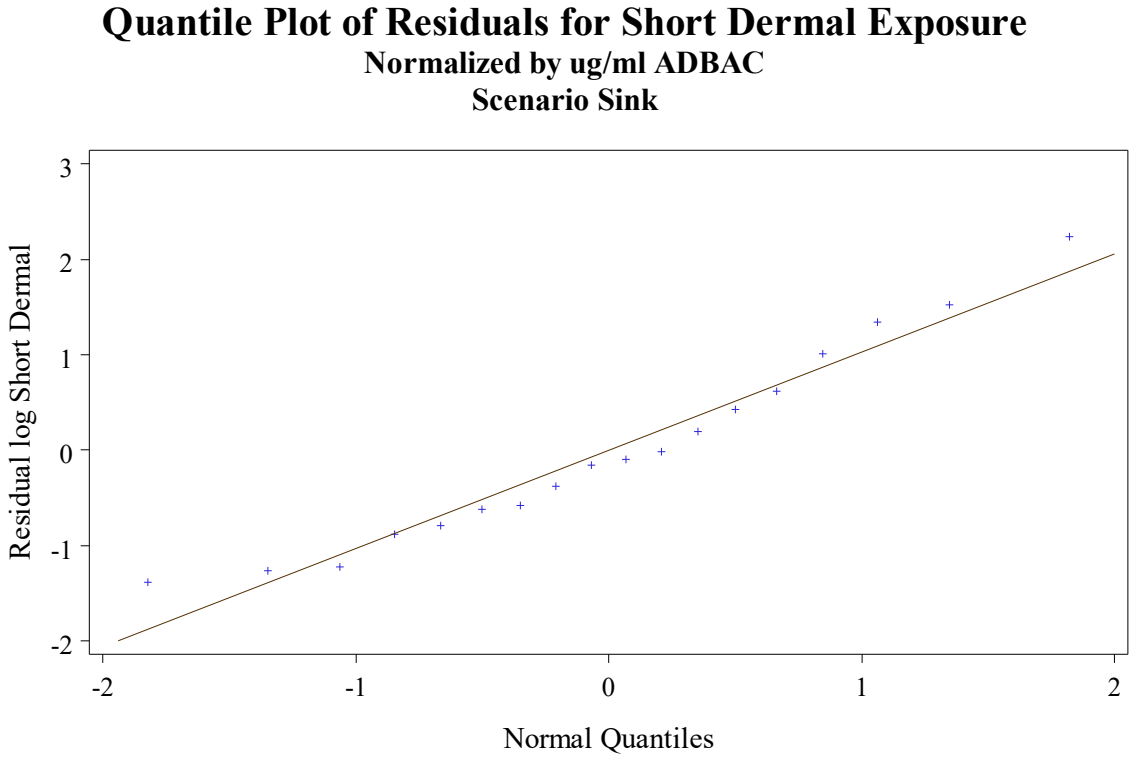


Figure BS16. Quantile plot of residuals from linear model for Short Dermal

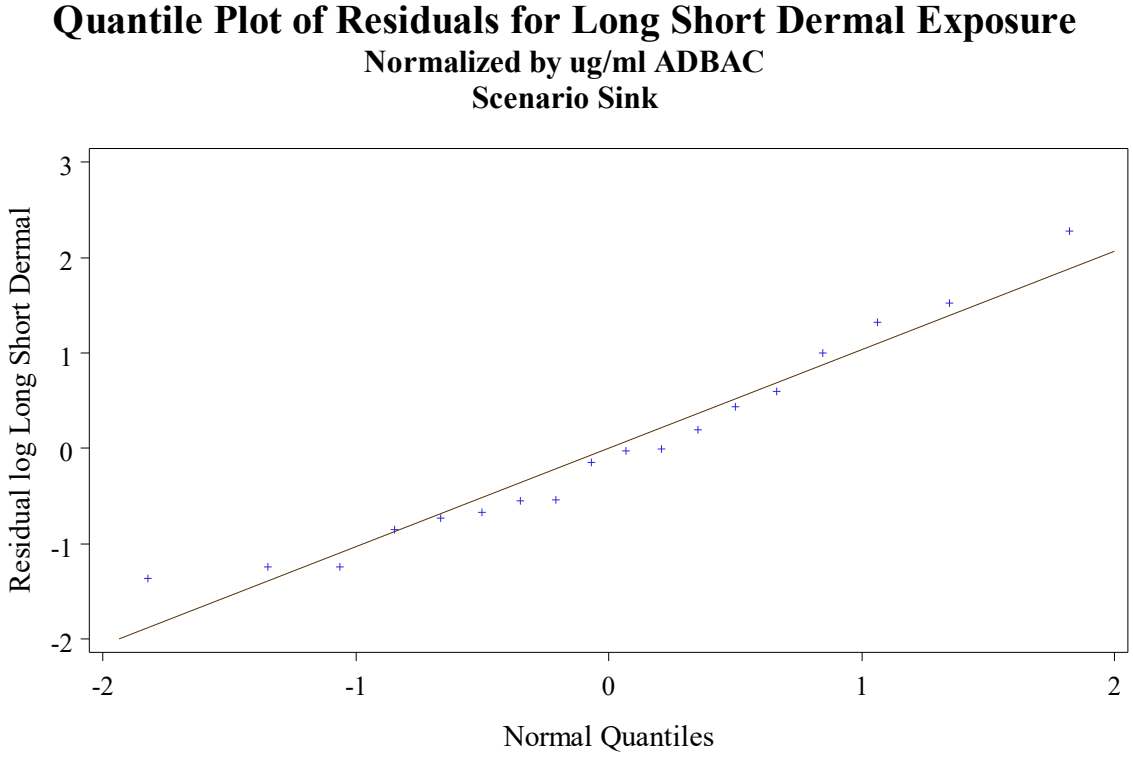


Figure BS17. Quantile plot of residuals from linear model for Long Short Dermal

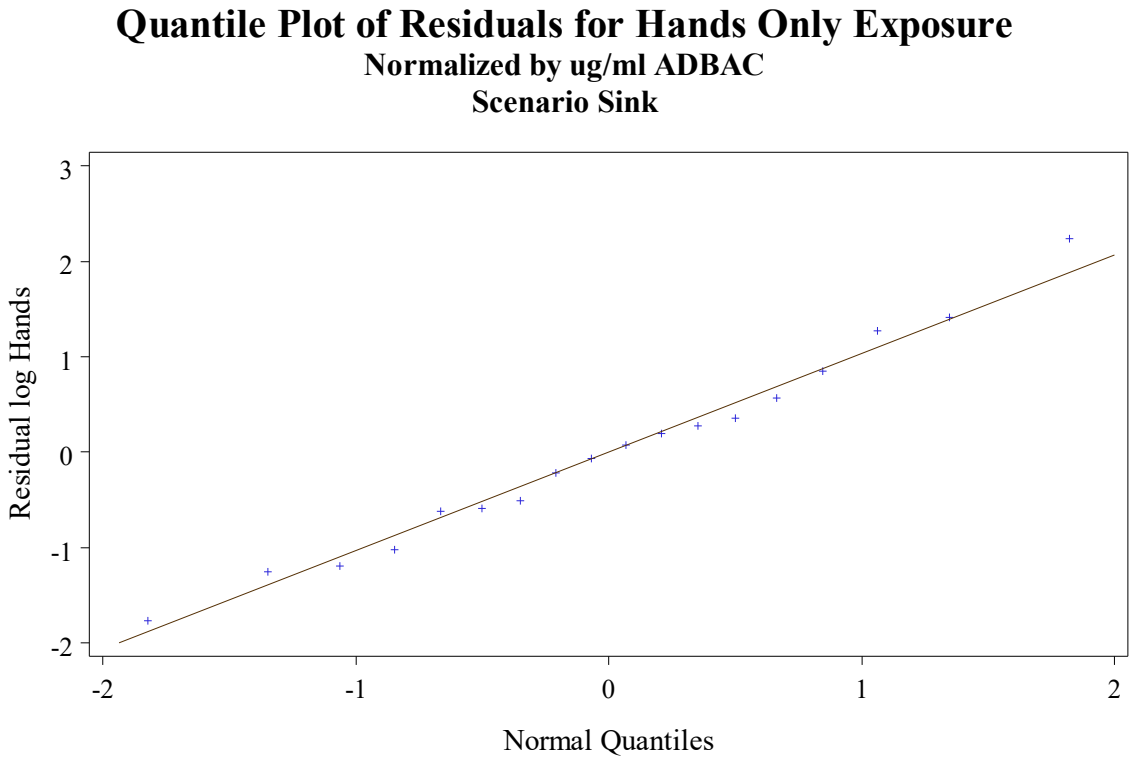


Figure BS18. Quantile plot of residuals from linear model for Hands Only

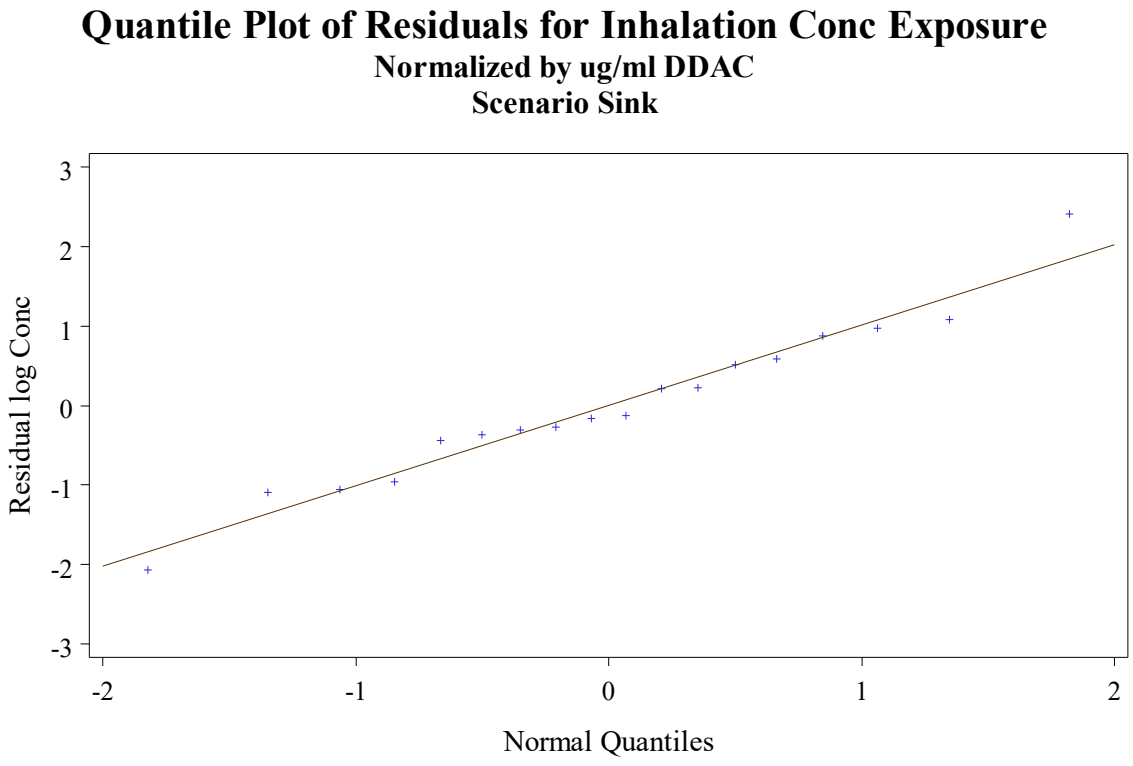


Figure BS19. Quantile plot of residuals from linear model for Inhalation Concentration

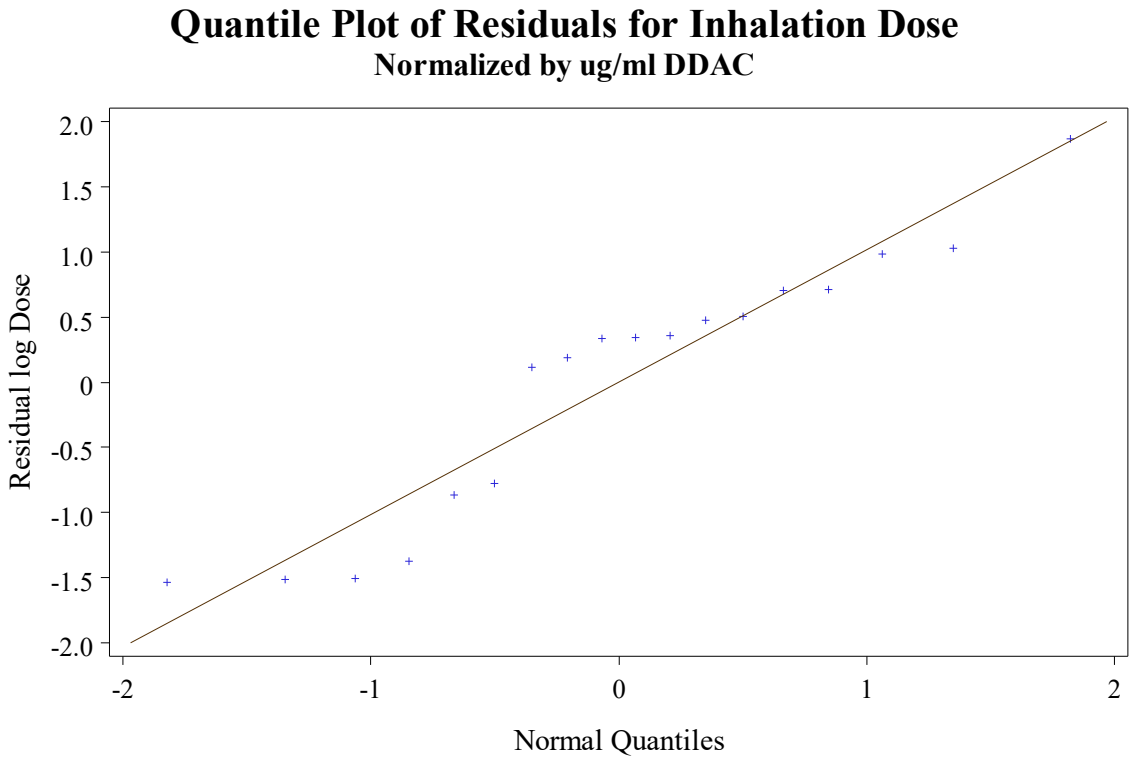


Figure BS20. Quantile plot of residuals from linear model for Inhalation Dose

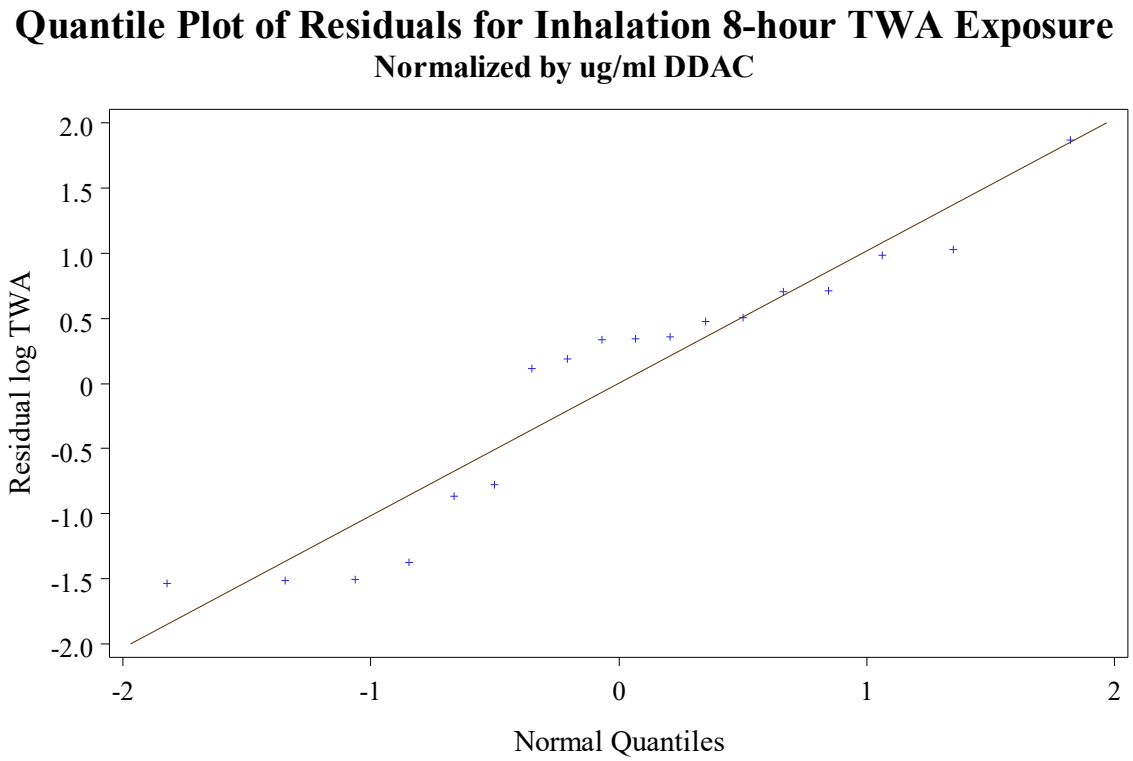


Figure BS21. Quantile plot of residuals from linear model for Inhalation Tine-Weighted Average Concentration

The quantile-quantile plots of the studentized residuals are reasonably close to the straight line except for the inhalation dose and the inhalation time-weighted average concentration. None of the studentized residuals exceeded the standard outlier cutoff of ±3.

Regression plots

The lognormal linear regression results for all the exposure routes are shown below using the mid value substitution method for non-detect values. The data points are labeled to show the targeted durations.

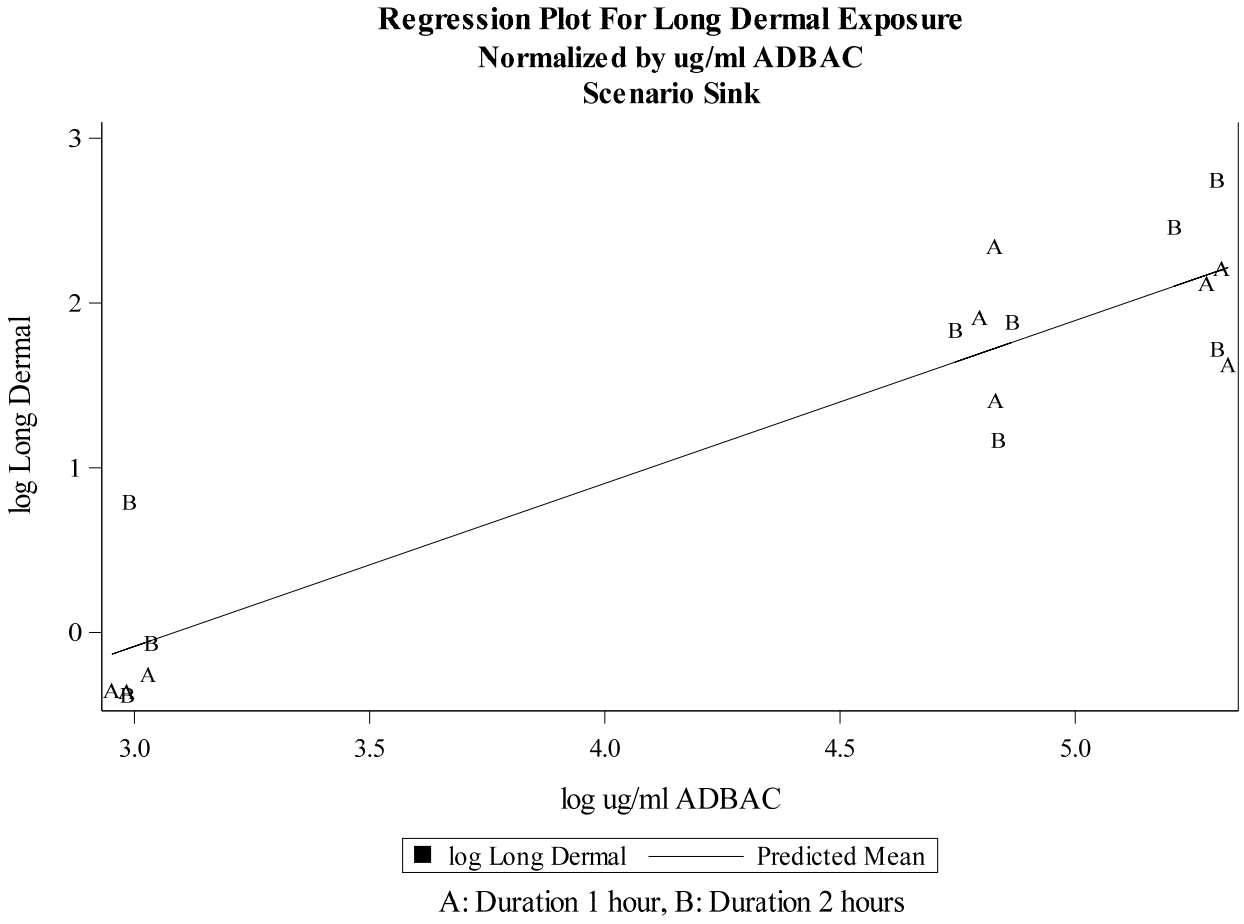


Figure BS22. Regression plot for Long Dermal Exposure (mg)

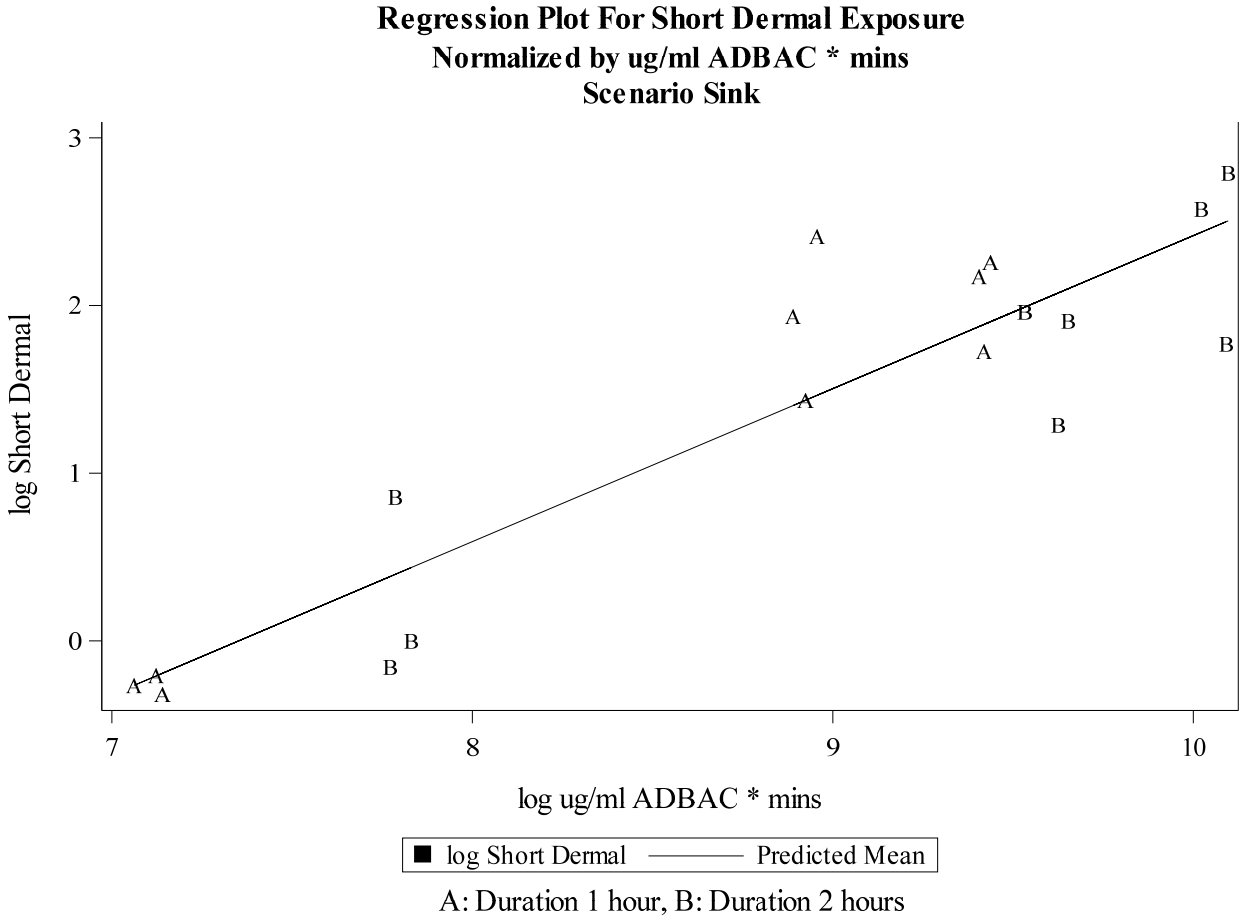


Figure BS23. Regression plot for Short Dermal Exposure (mg)

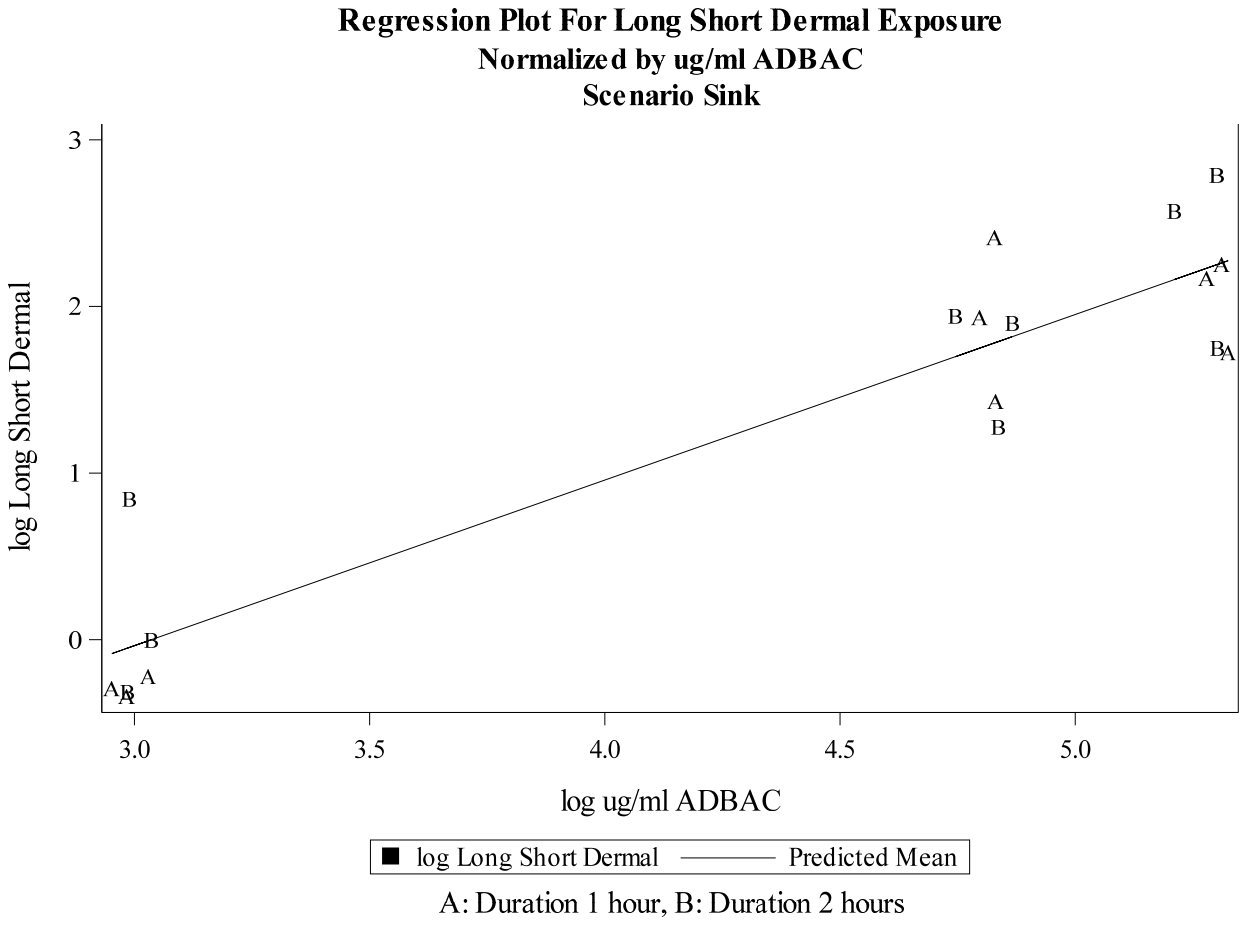


Figure BS24. Regression plot for Long Short Dermal Exposure (mg)

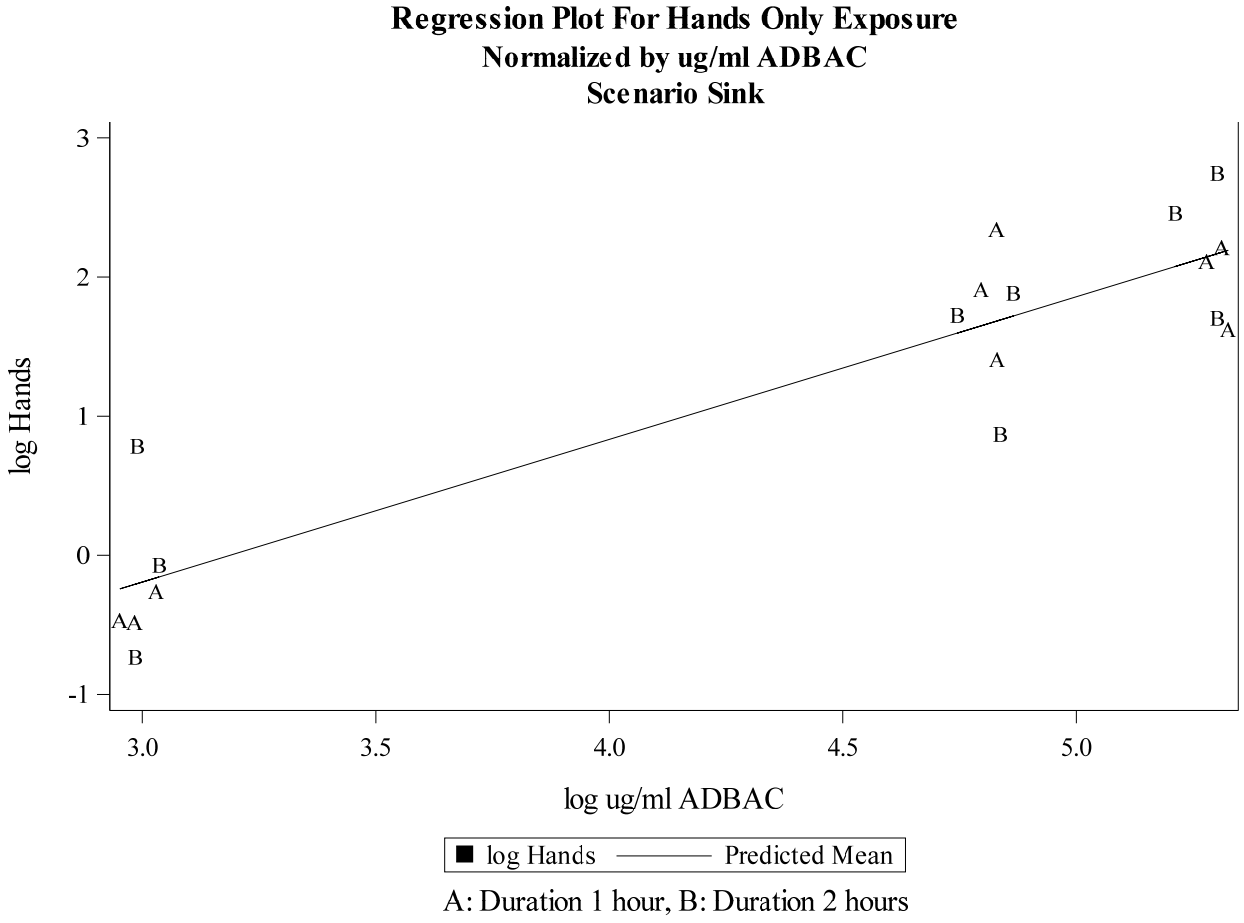


Figure BS25. Regression plot for Hands Only Exposure (mg)

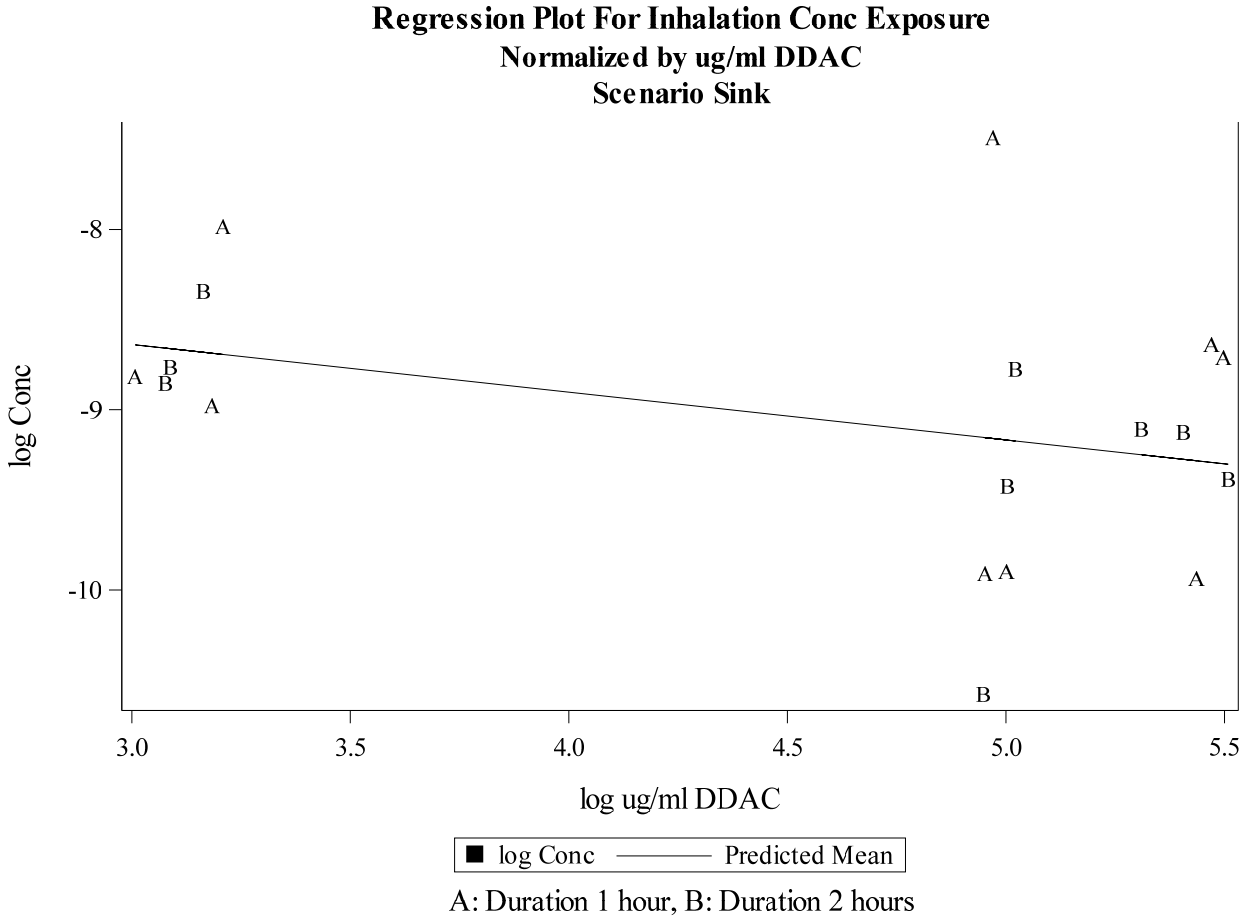


Figure BS26. Regression plot for Inhalation Concentration Exposure (mg/m^3)

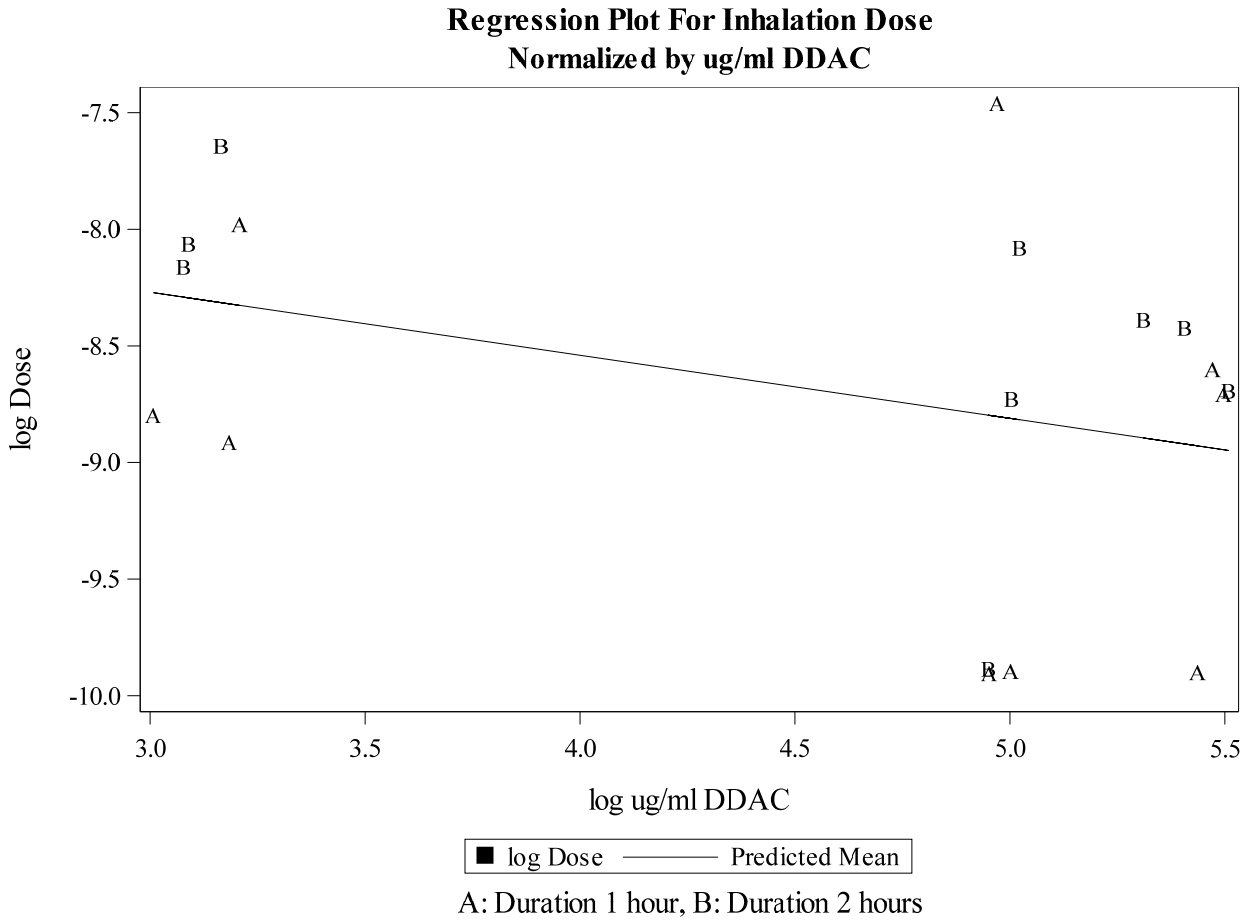


Figure BS27. Regression plot for Inhalation Dose (mg)

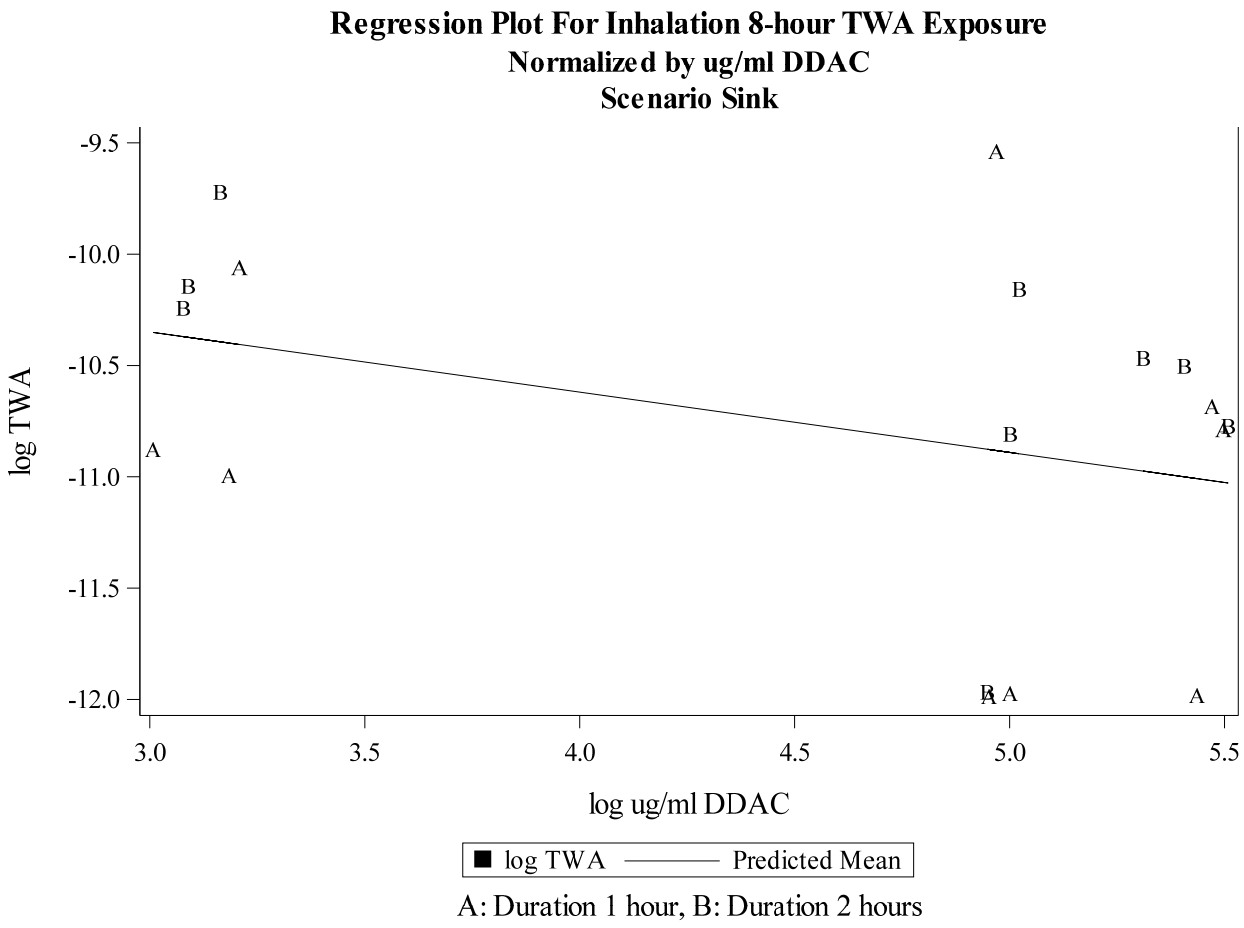


Figure BS28. Regression plot for Inhalation Time-Weighted Average Exposure (mg/m^3)

Quadratic models

Table BS19 presents the quadratic coefficient Quad from the fitted quadratic regression models for all the exposure routes using All data. Coefficients for the Intercept and Slope are shown under model 2 in Tables BS20 to BS26 below.

Table BS19. Quadratic coefficients with 95% confidence intervals for quadratic regression models for the log exposure versus log (Normalizing Factor)

Exposure Route	Estimate	Lower Bound	Upper Bound
Long Dermal	–0.14	–0.71	0.43
Short Dermal	–0.13	–0.69	0.42
Long Short Dermal	–0.14	–0.71	0.42
Hands Only	–0.10	–0.74	0.54

Exposure Route	Estimate	Lower Bound	Upper Bound
Inhalation Concentration	0.29	−0.62	1.21
Inhalation Dose	0.28	−0.68	1.23
Inhalation Time-weighted Average	0.28	−0.68	1.23

Since all the 95% confidence intervals for Quad include zero, the quadratic coefficient is not statistically significant, and the quadratic models are not supported.

Alternative Statistical Approaches

In this section we present and compare some alternative statistical approaches to the linear and quadratic models.

Model Parameters

Table BS20. Alternative fitted statistical models for Long Dermal Exposure (mg)

Model	Parameter	Estimate	Lower Bound	Upper Bound
1. Linear regression of Ln(exposure) on Ln(NF)	μ	-3.051	-4.019	-2.083
	β	0.989	0.773	1.205
2. Quadratic regression of Ln(exposure) on Ln(NF)	μ	-5.221	-14.072	3.630
	β	2.126	-2.488	6.740
	γ	-0.139	-0.705	0.426
3. Log-log logistic regression of exposure on NF	**α**			
	γ			
	β			
4. 3-parameter logistic regression of exposure on NF	**α**	2.798	-0.463	6.058
	c	9.712	5.593	13.831
	β	-0.028	-0.062	0.006

Model	Parameter	Estimate	Lower Bound	Upper Bound
5. Gamma model for exposure	**μ**	-2.917	-3.779	-2.054
	β	0.978	0.785	1.171
	ϕ	5.976	3.164	11.286

Table BS21. Alternative fitted statistical models for Short Dermal Exposure (mg)

Model	Parameter	Estimate	Lower Bound	Upper Bound
1. Linear regression of Ln(exposure) on Ln(NF)	μ	-2.936	-3.888	-1.983
	β	0.979	0.767	1.192
2. Quadratic regression of Ln(exposure) on Ln(NF)	μ	-5.012	-13.723	3.699
	β	2.067	-2.474	6.609
	γ	-0.133	-0.690	0.423
3. Log-log logistic regression of exposure on NF	**α**			
	γ			
	β			
4. 3-parameter logistic regression of exposure on NF	**α**	2.774	-0.422	5.969
	c	10.362	5.959	14.765
	β	-0.028	-0.061	0.005
5. Gamma model for exposure	**μ**	-2.813	-3.663	-1.963
	β	0.970	0.780	1.160
	ϕ	6.150	3.255	11.622

Table BS22. Alternative fitted statistical models for Long Short Dermal Exposure (mg)

Model	Parameter	Estimate	Lower Bound	Upper Bound
1. Linear regression of Ln(exposure) on Ln(NF)	μ	-3.017	-3.986	-2.047

Model	Parameter	Estimate	Lower Bound	Upper Bound
	β	0.994	0.777	1.210
2. Quadratic regression of Ln(exposure) on Ln(NF)	μ	-5.248	-14.109	3.612
	β	2.163	-2.456	6.783
	γ	-0.143	-0.709	0.422
3. Log-log logistic regression of exposure on NF	**α**			
	γ			
	β			
4. 3-parameter logistic regression of exposure on NF	**α**	2.809	-0.494	6.113
	c	10.277	5.928	14.625
	β	-0.028	-0.062	0.006
5. Gamma model for exposure	**μ**	-2.877	-3.744	-2.010
	β	0.982	0.788	1.175
	ϕ	5.914	3.132	11.169

Table BS23. Alternative fitted statistical models for Hands Only Exposure (mg)

Model	Parameter	Estimate	Lower Bound	Upper Bound
1. Linear regression of Ln(exposure) on Ln(NF)	μ	-3.267	-4.357	-2.177
	β	1.025	0.782	1.268
2. Quadratic regression of Ln(exposure) on Ln(NF)	μ	-4.785	-14.804	5.235
	β	1.820	-3.403	7.044
	γ	-0.098	-0.737	0.542
3. Log-log logistic regression of exposure on NF	**α**			
	γ			

Model	Parameter	Estimate	Lower Bound	Upper Bound
	β			
4. 3-parameter logistic regression of exposure on NF	**α**	2.923	-0.735	6.581
	c	9.753	5.254	14.252
	β	-0.028	-0.065	0.009
5. Gamma model for exposure	**μ**	-3.063	-4.017	-2.108
	β	1.003	0.789	1.216
	ϕ	4.857	2.581	9.140

Table BS24. Alternative fitted statistical models for Inhalation Concentration (mg/m^3)

Model	Parameter	Estimate	Lower Bound	Upper Bound
1. Linear regression of Ln(exposure) on Ln(NF)	μ	-7.843	-9.488	-6.198
	β	-0.265	-0.621	0.091
2. Quadratic regression of Ln(exposure) on Ln(NF)	μ	-2.921	-18.185	12.343
	β	-2.755	-10.439	4.929
	γ	0.295	-0.615	1.206
3. Log-log logistic regression of exposure on NF	**α**			
	γ			
	β			
4. 3-parameter logistic regression of exposure on NF	**α**	3.237	-51870.276	51876.750
	c	0.364	-18844.174	18844.903
	β	0.200	-4.778	5.177
5. Gamma model for exposure	**μ**	-7.973	-9.429	-6.517

Model	Parameter	Estimate	Lower Bound	Upper Bound
	β	-0.182	-0.498	0.133
	ϕ	2.217	1.204	4.083

Table BS25. Alternative fitted statistical models for Inhalation Dose (mg)

Model	Parameter	Estimate	Lower Bound	Upper Bound
1. Linear regression of Ln(exposure) on Ln(NF)	μ	-7.459	-9.175	-5.743
	β	-0.270	-0.642	0.101
2. Quadratic regression of Ln(exposure) on Ln(NF)	μ	-2.837	-18.812	13.139
	β	-2.609	-10.650	5.433
	γ	0.277	-0.676	1.231
3. Log-log logistic regression of exposure on NF	**α**			
	γ			
	β			
4. 3-parameter logistic regression of exposure on NF	**α**			
	c			
	β			
5. Gamma model for exposure	**μ**	-7.492	-8.887	-6.098
	β	-0.213	-0.515	0.088
	ϕ	2.381	1.290	4.396

Table BS26. Alternative fitted statistical models for Inhalation Time Weighted Average Concentration (mg/m^3)

Model	Parameter	Estimate	Lower Bound	Upper Bound
1. Linear regression of Ln(exposure) on Ln(NF)	μ	-9.538	-11.255	-7.822
	β	-0.270	-0.642	0.101

Model	Parameter	Estimate	Lower Bound	Upper Bound
2. Quadratic regression of Ln(exposure) on Ln(NF)	μ	-4.916	-20.891	11.059
	β	-2.609	-10.650	5.433
	γ	0.277	-0.676	1.231
3. Log-log logistic regression of exposure on NF	**α**	1.192	-98219.685	98222.069
	γ	24.048	-1981971.023	1982019.120
	β	1.998	-9.591	13.586
4. 3-parameter logistic regression of exposure on NF	**α**	-6.940	-288.891	275.010
	c	0.000	-0.001	0.001
	β	0.307	-9.475	10.090
5. Gamma model for exposure	**μ**	-9.572	-10.966	-8.177
	β	-0.213	-0.515	0.088
	ϕ	2.381	1.290	4.396

Model Comparisons

One way to compare the fit of the 7 models presented above is to use the Akaike Information Criterion (AIC), which takes minus twice the log-likelihood and then makes an adjustment or penalty for the number of parameters in the model. The following two tables compare the AIC values for the various Dermal and Inhalation exposure measures. The smaller values of the AIC suggest a better-fitting model. AIC values for models that failed to converge are not shown.

Table BS27. Akaike Information Criteria values for alternative models for Dermal Exposure

Model	Long Dermal	Short Dermal	Long Short Dermal	Hands Only
1. Linear regression of Ln(exposure) on Ln(NF)	24.4	23.8	24.5	28.7
2. Quadratic regression of Ln(exposure) on Ln(NF)	26.1	25.5	26.1	30.5

Model	Long Dermal	Short Dermal	Long Short Dermal	Hands Only
3. Log-log logistic regression of exposure on NF				
4. 3-parameter logistic regression of exposure on NF	46.8	46.4	47.0	49.8
5. Gamma model for exposure	25.9	25.4	26.1	29.9

Table BS28. Akaike Information Criteria values for alternative models for Inhalation Exposure

Model	Inhalation Concentration	Inhalation Dose	Inhalation Time-Weighted Average Concentration
1. Linear regression of Ln(exposure) on Ln(NF)	42.9	44.4	44.4
2. Quadratic regression of Ln(exposure) on Ln(NF)	44.3	45.9	45.9
3. Log-log logistic regression of exposure on NF			85.9
4. 3-parameter logistic regression of exposure on NF	72.1		68.4
5. Gamma model for exposure	45.4	44.0	44.0

Based on the AIC, the best-fitting models are the linear model for the Dermal models and the inhalation concentration model, and the gamma model for the inhalation dose, and the time-weighted average concentration.

8. Normalizing Factor Concentration, COP Scenario

Summary Statistics of Exposure per Concentration

Tables BC1 to BC7 summarize the normalized exposure data (per concentration) with the summary statistics from the 18 (all concentrations), or 6 (specific concentrations) measurements for each concentration group, and each dermal and inhalation exposure route. These analyses assume that the exposure measurements within each subset come from some unspecified distribution for that subset.

Table BC1. Summary statistics for normalized long dermal exposure (mg/(ppm ADBAC)) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	1.140E-03	2.664E-03	5.394E-04	2.163E-04
Arithmetic Standard Deviation	1.372E-03	1.433E-03	3.007E-04	1.167E-04
Geometric Mean	5.862E-04	2.285E-03	4.667E-04	1.888E-04
Geometric Standard Deviation	3.340E+00	1.903E+00	1.835E+00	1.790E+00
Min	1.070E-04	8.596E-04	1.987E-04	1.070E-04
5%	1.070E-04	8.596E-04	1.987E-04	1.070E-04
10%	1.117E-04	8.596E-04	1.987E-04	1.070E-04
25%	2.923E-04	1.589E-03	3.163E-04	1.117E-04
50%	4.872E-04	2.790E-03	4.841E-04	2.040E-04
75%	1.589E-03	3.965E-03	7.844E-04	3.146E-04
90%	3.965E-03	3.990E-03	9.687E-04	3.566E-04
95%	3.990E-03	3.990E-03	9.687E-04	3.566E-04
Max	3.990E-03	3.990E-03	9.687E-04	3.566E-04

Table BC2. Summary statistics for normalized short dermal exposure (mg/(ppm ADBAC)) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	3.635E-03	5.852E-03	3.083E-03	1.970E-03
Arithmetic Standard Deviation	3.219E-03	4.357E-03	1.602E-03	2.021E-03
Geometric Mean	2.442E-03	4.893E-03	2.592E-03	1.148E-03
Geometric Standard Deviation	2.867E+00	1.865E+00	2.040E+00	3.556E+00
Min	1.640E-04	2.165E-03	9.134E-04	1.640E-04
5%	1.640E-04	2.165E-03	9.134E-04	1.640E-04
10%	4.422E-04	2.165E-03	9.134E-04	1.640E-04

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
25%	1.301E-03	3.917E-03	1.195E-03	4.422E-04
50%	3.798E-03	4.579E-03	3.798E-03	1.501E-03
75%	4.587E-03	5.450E-03	4.206E-03	2.496E-03
90%	5.714E-03	1.442E-02	4.587E-03	5.714E-03
95%	1.442E-02	1.442E-02	4.587E-03	5.714E-03
Max	1.442E-02	1.442E-02	4.587E-03	5.714E-03

Table BC3. Summary statistics for normalized long short dermal exposure (mg/(ppm ADBAC)) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	2.971E-03	4.996E-03	2.239E-03	1.679E-03
Arithmetic Standard Deviation	2.924E-03	4.041E-03	1.396E-03	1.795E-03
Geometric Mean	1.837E-03	3.869E-03	1.836E-03	8.733E-04
Geometric Standard Deviation	3.156E+00	2.226E+00	2.048E+00	4.124E+00
Min	1.378E-04	1.119E-03	8.073E-04	1.378E-04
5%	1.378E-04	1.119E-03	8.073E-04	1.378E-04
10%	1.872E-04	1.119E-03	8.073E-04	1.378E-04
25%	9.939E-04	2.683E-03	9.939E-04	1.872E-04
50%	2.465E-03	4.274E-03	2.275E-03	1.276E-03
75%	3.669E-03	4.917E-03	3.524E-03	2.247E-03
90%	4.949E-03	1.271E-02	3.558E-03	4.949E-03
95%	1.271E-02	1.271E-02	3.558E-03	4.949E-03
Max	1.271E-02	1.271E-02	3.558E-03	4.949E-03

Table BC4. Summary statistics for normalized hands only dermal exposure (mg/(ppm ADBAC)) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	8.858E-04	2.180E-03	3.531E-04	1.248E-04
Arithmetic Standard Deviation	1.242E-03	1.450E-03	3.023E-04	8.577E-05
Geometric Mean	3.422E-04	1.703E-03	2.303E-04	1.022E-04
Geometric Standard Deviation	4.388E+00	2.270E+00	3.061E+00	2.001E+00

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Min	4.560E-05	6.186E-04	4.634E-05	4.560E-05
5%	4.560E-05	6.186E-04	4.634E-05	4.560E-05
10%	4.634E-05	6.186E-04	4.634E-05	4.560E-05
25%	8.383E-05	7.294E-04	8.383E-05	5.920E-05
50%	2.724E-04	2.296E-03	2.724E-04	9.117E-05
75%	7.726E-04	3.431E-03	6.711E-04	2.117E-04
90%	3.431E-03	3.708E-03	7.726E-04	2.501E-04
95%	3.708E-03	3.708E-03	7.726E-04	2.501E-04
Max	3.708E-03	3.708E-03	7.726E-04	2.501E-04

Table BC5. Summary statistics for normalized inhalation concentration exposure (mg/m^3/(ppm DDAC)) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	6.532E-05	1.627E-04	2.135E-05	1.187E-05
Arithmetic Standard Deviation	1.227E-04	1.835E-04	1.770E-05	8.362E-06
Geometric Mean	2.403E-05	8.956E-05	1.609E-05	9.636E-06
Geometric Standard Deviation	3.737E+00	3.353E+00	2.268E+00	2.031E+00
Min	4.262E-06	2.869E-05	6.682E-06	4.262E-06
5%	4.262E-06	2.869E-05	6.682E-06	4.262E-06
10%	5.083E-06	2.869E-05	6.682E-06	4.262E-06
25%	8.767E-06	3.332E-05	8.767E-06	5.083E-06
50%	2.218E-05	6.806E-05	1.395E-05	8.774E-06
75%	3.756E-05	3.141E-04	3.359E-05	1.970E-05
90%	3.141E-04	4.642E-04	5.116E-05	2.466E-05
95%	4.642E-04	4.642E-04	5.116E-05	2.466E-05
Max	4.642E-04	4.642E-04	5.116E-05	2.466E-05

Table BC6. Summary statistics for normalized inhalation dose exposure (mg/(ppm DDAC)) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	1.118E-04	2.745E-04	3.994E-05	2.088E-05
Arithmetic Standard Deviation	2.114E-04	3.189E-04	4.533E-05	1.665E-05

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Geometric Mean	3.972E-05	1.482E-04	2.629E-05	1.609E-05
Geometric Standard Deviation	3.899E+00	3.361E+00	2.610E+00	2.229E+00
Min	5.186E-06	4.194E-05	7.351E-06	5.186E-06
5%	5.186E-06	4.194E-05	7.351E-06	5.186E-06
10%	7.351E-06	4.194E-05	7.351E-06	5.186E-06
25%	1.711E-05	6.360E-05	1.934E-05	1.101E-05
50%	3.597E-05	9.692E-05	2.068E-05	1.444E-05
75%	7.720E-05	5.571E-04	4.199E-05	3.000E-05
90%	5.571E-04	7.905E-04	1.296E-04	5.023E-05
95%	7.905E-04	7.905E-04	1.296E-04	5.023E-05
Max	7.905E-04	7.905E-04	1.296E-04	5.023E-05

Table BC7. Summary statistics for normalized inhalation time-weighted average concentration exposure (mg/m^3/(ppm DDAC)) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	1.397E-05	3.431E-05	4.993E-06	2.611E-06
Arithmetic Standard Deviation	2.642E-05	3.986E-05	5.666E-06	2.081E-06
Geometric Mean	4.965E-06	1.852E-05	3.287E-06	2.011E-06
Geometric Standard Deviation	3.899E+00	3.361E+00	2.610E+00	2.229E+00
Min	6.482E-07	5.242E-06	9.188E-07	6.482E-07
5%	6.482E-07	5.242E-06	9.188E-07	6.482E-07
10%	9.188E-07	5.242E-06	9.188E-07	6.482E-07
25%	2.138E-06	7.950E-06	2.418E-06	1.376E-06
50%	4.496E-06	1.211E-05	2.585E-06	1.805E-06
75%	9.650E-06	6.964E-05	5.249E-06	3.750E-06
90%	6.964E-05	9.881E-05	1.620E-05	6.279E-06
95%	9.881E-05	9.881E-05	1.620E-05	6.279E-06
Max	9.881E-05	9.881E-05	1.620E-05	6.279E-06

The results show fairly high proportions of the normalized Long Dermal exposure from hands only, but not as high as for the Bucket and Sink scenarios. For All and for each concentration group, based on the arithmetic means, the overall percentages of the normalized exposure from hands only range from 58 to 82% of the Long Dermal and is 78% for All, Similarly, for the unnormalized dermal exposure, the arithmetic mean hands only exposure is 69% of the arithmetic

mean total dermal exposure (defined in the study report as the sum of the residues from hand wash, face/neck wipe, and the inner dosimeters, which is the definition of Long Dermal used in this memorandum). (The percentages are much lower if you include the outer dosimeters.)

Compare Concentration Groups

The results in Tables BC1 to BC7 show some differences between the normalized exposure statistics for the three concentration groups "Target Quat: 100 ppm," "Target Quat: 600 ppm," and "Target Quat: 1000 ppm." To compare these groups, an analysis of variance was performed to test whether the geometric means were statistically significantly different at the 5% significance level.

The p-values for these ANOVA tests are shown in Table AC8. These analyses show that there were statistically significant differences (at the 5% significance level) between the three concentration groups for Long Dermal, Hands Only, and the inhalation exposures.

Table BC8. P-values for testing differences in geometric means for different concentration groups

Exposure Route	ANOVA	Welch's ANOVA
Long Dermal	0.001	0.000
Short Dermal	0.113	0.114
Long Short Dermal	0.158	0.184
Hands Only	0.004	0.000
Inhalation Conc	0.015	0.017
Inhalation Dose	0.021	0.024
Inhalation 8-hr TWA	0.021	0.024

Statistical Models

Table BC9 presents the arithmetic mean and 95th percentile estimates from the lognormal simple random sampling model, together with 95% confidence intervals, for each of the exposure routes, for all concentration groups combined. These are the values of AMu and P95u. The other summary statistics are presented in more detail below.

Table BC9. Arithmetic mean and 95th percentile estimates from lognormal simple random sampling model for normalized exposure for All

Exposure Route	Clothing	Arithmetic Mean (95% Confidence Interval)	95th Percentile (95% Confidence Interval)
Dermal (mg/(ppm ADBAC))	Long Dermal	1.21×10^{-3} (6.00×10^{-4}, 2.67×10^{-3})	4.26×10^{-3} (1.78×10^{-3}, 1.01×10^{-2})
	Short Dermal	4.25×10^{-3} (2.37×10^{-3}, 8.06×10^{-3})	1.38×10^{-2} (6.44×10^{-3}, 2.93×10^{-2})
	Long Short Dermal	3.56×10^{-3} (1.84×10^{-3}, 7.40×10^{-3})	1.22×10^{-2} (5.29×10^{-3}, 2.77×10^{-2})

Exposure Route	Clothing	Arithmetic Mean (95% Confidence Interval)	95th Percentile (95% Confidence Interval)
	Hands Only	1.02×10^{-3} (3.98×10^{-4}, 3.03×10^{-3})	3.90×10^{-3} (1.34×10^{-3}, 1.12×10^{-2})
Inhalation Concentration ((mg/m^3)/ (ppm DDAC))		5.73×10^{-5} (2.58×10^{-5}, 1.41×10^{-4})	2.10×10^{-4} (8.09×10^{-5}, 5.40×10^{-4})
Inhalation Dose (mg/ (ppm DDAC))		1.00×10^{-4} (4.34×10^{-5}, 2.61×10^{-4})	3.72×10^{-4} (1.39×10^{-4}, 9.86×10^{-4})
Inhalation 8-hr TWA ((mg/m^3)/ ppm DDAC))		1.25×10^{-5} (5.42×10^{-6}, 3.26×10^{-5})	4.66×10^{-5} (1.74×10^{-5}, 1.23×10^{-4})

Non-detects

For all the analyses presented in this memorandum except for Table BC10 and BC18, measurements below the LOQ or LOD were replaced by the mid-value, the midpoint of the lowest and highest possible value for that measurement. In Tables BC10 and BC18 we investigated the impact on the summary statistics of the censored values.

Table BC10. Exposure summary statistics calculated using alternative estimated exposures for values below the LOQ

Exposure Route	Method for Substituting Values Below the LOQ	Arithmetic Mean	95th Percentile
Long Dermal (mg/(ppm ADBAC))	Substitute mid value	1.21×10^{-3} (5.93×10^{-4}, 2.66×10^{-3})	4.26×10^{-3} (1.77×10^{-3}, 1.01×10^{-2})
	Substitute max value	1.31×10^{-3} (6.56×10^{-4}, 2.78×10^{-3})	4.52×10^{-3} (1.93×10^{-3}, 1.05×10^{-2})
	Substitute min value	1.14×10^{-3} (5.27×10^{-4}, 2.66×10^{-3})	4.11×10^{-3} (1.63×10^{-3}, 1.02×10^{-2})
	Censored data MLE	1.16×10^{-3} (5.81×10^{-4}, 2.47×10^{-3})	4.02×10^{-3} (1.71×10^{-3}, 9.32×10^{-3})
Short Dermal (mg/(ppm ADBAC))	Substitute mid value	4.25×10^{-3} (2.34×10^{-3}, 8.06×10^{-3})	1.38×10^{-2} (6.41×10^{-3}, 2.94×10^{-2})
	Substitute max value	4.33×10^{-3} (2.45×10^{-3}, 7.95×10^{-3})	1.37×10^{-2} (6.56×10^{-3}, 2.84×10^{-2})
	Substitute min value	4.23×10^{-3} (2.23×10^{-3}, 8.48×10^{-3})	1.42×10^{-2} (6.32×10^{-3}, 3.15×10^{-2})
	Censored data MLE	4.10×10^{-3} (2.32×10^{-3}, 7.56×10^{-3})	1.31×10^{-2} (6.21×10^{-3}, 2.71×10^{-2})
Long Short Dermal (mg/(ppm ADBAC))	Substitute mid value	3.56×10^{-3} (1.82×10^{-3}, 7.38×10^{-3})	1.22×10^{-2} (5.27×10^{-3}, 2.77×10^{-2})
	Substitute max value	3.63×10^{-3} (1.91×10^{-3}, 7.27×10^{-3})	1.22×10^{-2} (5.43×10^{-3}, 2.70×10^{-2})
	Substitute min value	3.52×10^{-3} (1.72×10^{-3}, 7.74×10^{-3})	1.24×10^{-2} (5.14×10^{-3}, 2.94×10^{-2})
	Censored data MLE	3.42×10^{-3} (1.79×10^{-3}, 6.92×10^{-3})	1.15×10^{-2} (5.11×10^{-3}, 2.57×10^{-2})
Hands Only (mg/(ppm ADBAC))	Substitute mid value	1.02×10^{-3} (3.94×10^{-4}, 3.01×10^{-3})	3.90×10^{-3} (1.33×10^{-3}, 1.12×10^{-2})
	Substitute max value	1.02×10^{-3} (3.94×10^{-4}, 3.01×10^{-3})	3.90×10^{-3} (1.33×10^{-3}, 1.12×10^{-2})
	Substitute min value	1.02×10^{-3} (3.94×10^{-4}, 3.01×10^{-3})	3.90×10^{-3} (1.33×10^{-3}, 1.12×10^{-2})
	Censored data MLE	9.61×10^{-4} (3.85×10^{-4}, 2.70×10^{-3})	3.64×10^{-3} (1.28×10^{-3}, 1.02×10^{-2})

Exposure Route	Method for Substituting Values Below the LOQ	Arithmetic Mean	95th Percentile
Inhalation Concentration ((mg/m^3)/ (ppm DDAC))	Substitute mid value	5.73×10^{-5} (2.55×10^{-5}, 1.41×10^{-4})	2.10×10^{-4} (8.05×10^{-5}, 5.40×10^{-4})
	Substitute max value	5.73×10^{-5} (2.55×10^{-5}, 1.41×10^{-4})	2.10×10^{-4} (8.05×10^{-5}, 5.40×10^{-4})
	Substitute min value	5.73×10^{-5} (2.55×10^{-5}, 1.41×10^{-4})	2.10×10^{-4} (8.05×10^{-5}, 5.40×10^{-4})
	Censored data MLE	5.46×10^{-5} (2.51×10^{-5}, 1.29×10^{-4})	1.98×10^{-4} (7.78×10^{-5}, 4.95×10^{-4})
Inhalation Dose (mg/ (ppm DDAC))	Substitute mid value	1.00×10^{-4} (4.31×10^{-5}, 2.59×10^{-4})	3.72×10^{-4} (1.38×10^{-4}, 9.87×10^{-4})
	Substitute max value	1.00×10^{-4} (4.31×10^{-5}, 2.59×10^{-4})	3.72×10^{-4} (1.38×10^{-4}, 9.87×10^{-4})
	Substitute min value	1.00×10^{-4} (4.31×10^{-5}, 2.59×10^{-4})	3.72×10^{-4} (1.38×10^{-4}, 9.87×10^{-4})
	Censored data MLE	9.52×10^{-5} (4.23×10^{-5}, 2.35×10^{-4})	3.50×10^{-4} (1.34×10^{-4}, 9.02×10^{-4})
Inhalation 8-hr TWA ((mg/m^3)/ ppm DDAC))	Substitute mid value	1.25×10^{-5} (5.38×10^{-6}, 3.23×10^{-5})	4.66×10^{-5} (1.73×10^{-5}, 1.23×10^{-4})
	Substitute max value	1.25×10^{-5} (5.38×10^{-6}, 3.23×10^{-5})	4.66×10^{-5} (1.73×10^{-5}, 1.23×10^{-4})
	Substitute min value	1.25×10^{-5} (5.38×10^{-6}, 3.23×10^{-5})	4.66×10^{-5} (1.73×10^{-5}, 1.23×10^{-4})
	Censored data MLE	1.19×10^{-5} (5.28×10^{-6}, 2.94×10^{-5})	4.37×10^{-5} (1.67×10^{-5}, 1.13×10^{-4})

The results in Table BC10 show very small impacts of the alternative substitution approaches for treating values below the LOQ on the unit exposure arithmetic mean and 95th percentile.

Detailed Summary Statistics with Confidence Intervals and Fold Relative Accuracy

Tables BC11 to BC17 present the estimates, parametric and non-parametric confidence intervals and fold relative accuracy values for all the summary statistics for the All group. All these analyses use non-detects substituted by the mid-value.

Table BC11. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the normalized long dermal exposure (mg/(ppm ADBAC)) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	3.34E+00	2.24E+00	5.03E+00	1.50	2.34E+00	4.19E+00	1.36
GMs	5.86E-04	3.39E-04	1.04E-03	1.75	3.45E-04	1.01E-03	1.71
AMs	1.14E-03	5.63E-04	2.52E-03	2.10	5.88E-04	1.79E-03	1.78
AMu	1.21E-03	6.00E-04	2.67E-03	2.11	5.68E-04	2.24E-03	2.01
P95s	3.99E-03	1.76E-03	2.15E-02	4.25	1.70E-03	3.99E-03	1.03
P95u	4.26E-03	1.78E-03	1.01E-02	2.38	1.67E-03	8.22E-03	2.27

Table BC12. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the normalized short dermal exposure (mg/(ppm ADBAC)) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.87E+00	2.02E+00	4.10E+00	1.43	1.77E+00	4.00E+00	1.54
GMs	2.44E-03	1.51E-03	4.03E-03	1.63	1.50E-03	3.79E-03	1.59
AMs	3.63E-03	2.26E-03	7.86E-03	1.93	2.40E-03	5.19E-03	1.48
AMu	4.25E-03	2.37E-03	8.06E-03	1.85	2.73E-03	6.26E-03	1.52
P95s	1.44E-02	6.38E-03	5.67E-02	3.23	5.19E-03	1.44E-02	2.65
P95u	1.38E-02	6.44E-03	2.93E-02	2.13	7.19E-03	2.22E-02	1.81

Table BC13. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the normalized long short dermal exposure (mg/(ppm ADBAC)) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	3.16E+00	2.15E+00	4.66E+00	1.47	1.91E+00	4.39E+00	1.56
GMs	1.84E-03	1.09E-03	3.17E-03	1.71	1.07E-03	2.99E-03	1.67
AMs	2.97E-03	1.74E-03	7.11E-03	2.10	1.86E-03	4.37E-03	1.54
AMu	3.56E-03	1.84E-03	7.40E-03	2.01	2.14E-03	5.55E-03	1.62
P95s	1.27E-02	5.24E-03	5.68E-02	3.60	4.88E-03	1.27E-02	2.58
P95u	1.22E-02	5.29E-03	2.77E-02	2.29	6.04E-03	2.03E-02	1.87

Table BC14. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the normalized hands only exposure (mg/(ppm ADBAC)) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	4.39E+00	2.68E+00	7.25E+00	1.64	2.92E+00	5.71E+00	1.42
GMs	3.42E-04	1.75E-04	6.91E-04	1.99	1.78E-04	6.70E-04	1.94
AMs	8.86E-04	3.58E-04	2.65E-03	2.67	3.86E-04	1.48E-03	2.00
AMu	1.02E-03	3.98E-04	3.03E-03	2.74	3.74E-04	2.22E-03	2.47
P95s	3.71E-03	1.32E-03	2.83E-02	5.71	1.28E-03	3.71E-03	1.12
P95u	3.90E-03	1.34E-03	1.12E-02	2.90	1.27E-03	8.52E-03	2.64

Table BC15. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the normalized inhalation concentration exposure ((mg/m³)/ (ppm DDAC)) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	3.74E+00	2.41E+00	5.85E+00	1.56	2.17E+00	5.31E+00	1.61
GMs	2.40E-05	1.32E-05	4.50E-05	1.85	1.38E-05	4.43E-05	1.79
AMs	6.53E-05	2.38E-05	1.30E-04	2.52	2.04E-05	1.26E-04	2.80
AMu	5.73E-05	2.58E-05	1.41E-04	2.33	2.08E-05	1.50E-04	2.70
P95s	4.64E-04	8.00E-05	1.23E-03	5.15	5.12E-05	4.64E-04	4.71
P95u	2.10E-04	8.09E-05	5.40E-04	2.58	5.62E-05	5.77E-04	3.29

Table BC16. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the normalized inhalation dose exposure (mg/ (ppm DDAC)) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	3.90E+00	2.48E+00	6.19E+00	1.58	2.26E+00	5.58E+00	1.62
GMs	3.97E-05	2.14E-05	7.58E-05	1.88	2.23E-05	7.39E-05	1.82
AMs	1.12E-04	3.99E-05	2.35E-04	2.60	3.44E-05	2.16E-04	2.86
AMu	1.00E-04	4.34E-05	2.61E-04	2.42	3.55E-05	2.64E-04	2.74
P95s	7.90E-04	1.37E-04	2.31E-03	5.13	1.17E-04	7.90E-04	6.10
P95u	3.72E-04	1.39E-04	9.86E-04	2.66	1.01E-04	1.01E-03	3.29

Table BC17. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the normalized inhalation time-weighted average concentration exposure ((mg/m³)/ (ppm DDAC)) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	3.90E+00	2.48E+00	6.19E+00	1.58	2.26E+00	5.58E+00	1.62
GMs	4.96E-06	2.68E-06	9.48E-06	1.88	2.78E-06	9.23E-06	1.82
AMs	1.40E-05	4.99E-06	2.94E-05	2.60	4.30E-06	2.70E-05	2.86
AMu	1.25E-05	5.42E-06	3.26E-05	2.42	4.44E-06	3.29E-05	2.74
P95s	9.88E-05	1.72E-05	2.89E-04	5.13	1.46E-05	9.88E-05	6.10
P95u	4.66E-05	1.74E-05	1.23E-04	2.66	1.26E-05	1.27E-04	3.29

Tables BC11 to BC17 show that the study benchmark design value of 3 for the fold relative accuracy was met in every case, with the exception of the parametric bootstrap estimated empirical 95th percentile (P95s) for all exposure routes, the non-parametric bootstrap estimated empirical 95th percentile (P95s) for inhalation exposure routes, and the non-parametric bootstrap estimated lognormal simple random sampling model 95th percentile (P95u) for inhalation exposure routes.

Empirical Quantile Plots

Quantile-quantile plots of the normalized exposure values were used to evaluate whether the data were lognormally distributed, as implied by the assumed statistical lognormal models. These plots were intended to help determine whether the data supported using untransformed normalized exposure values or log-transformed values or neither. The plots are not intended to evaluate the fitted regression models for the un-normalized exposure to be described below, for which the residual quantile plots were developed.

In each case the quantile-quantile plot compared the observed quantiles of the measured values with the corresponding quantiles of a normal or lognormal distribution. A perfect fit would imply that the plotted values lie in a straight line. The quantile-quantile plots for all exposure routes are presented in Figures BC1 to BC14. In all cases the plots seem to show a better fit for the lognormal distributions, supporting the use of the log-transformed exposure values over the untransformed values.

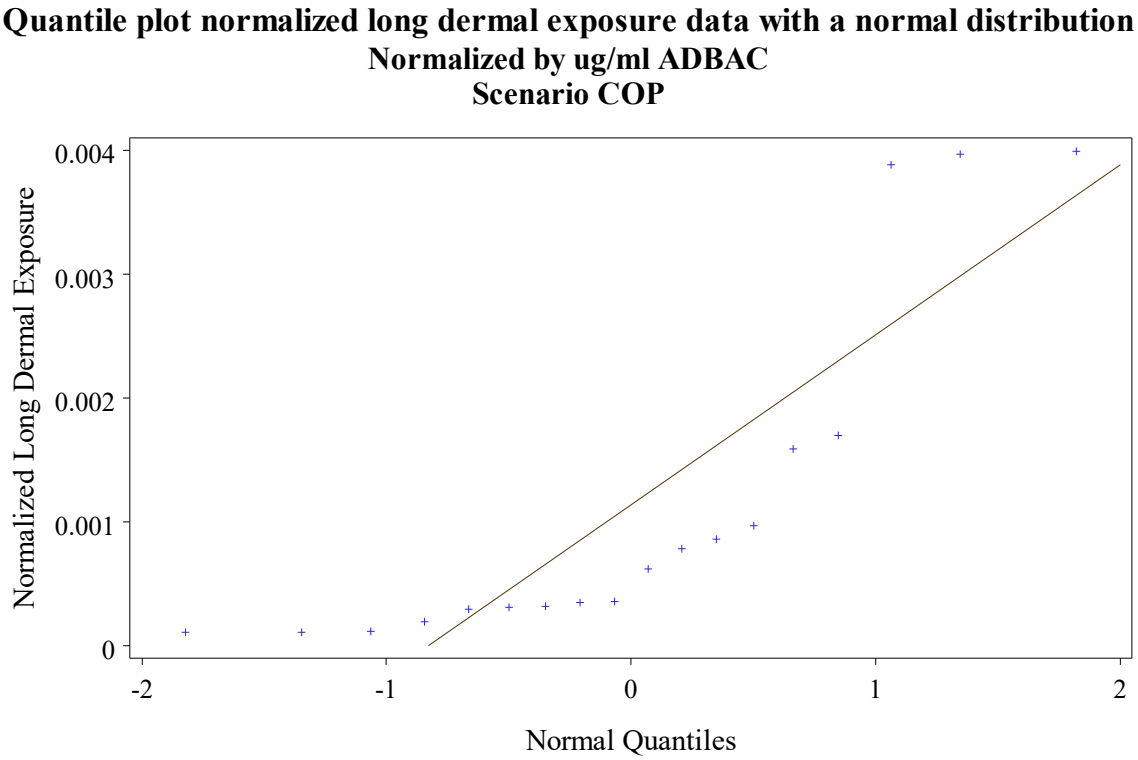


Figure BC1. Empirical quantile plot for Long Dermal, with a normal distribution

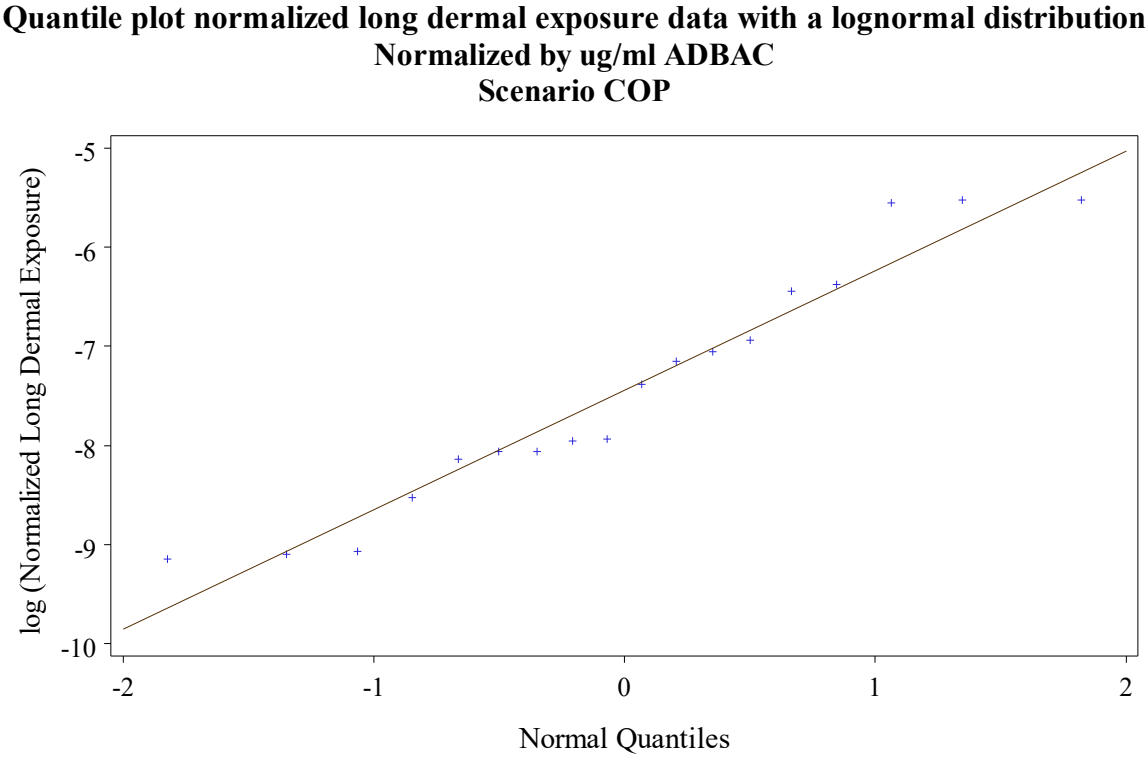


Figure BC2. Empirical quantile plot for Long Dermal, with a lognormal distribution

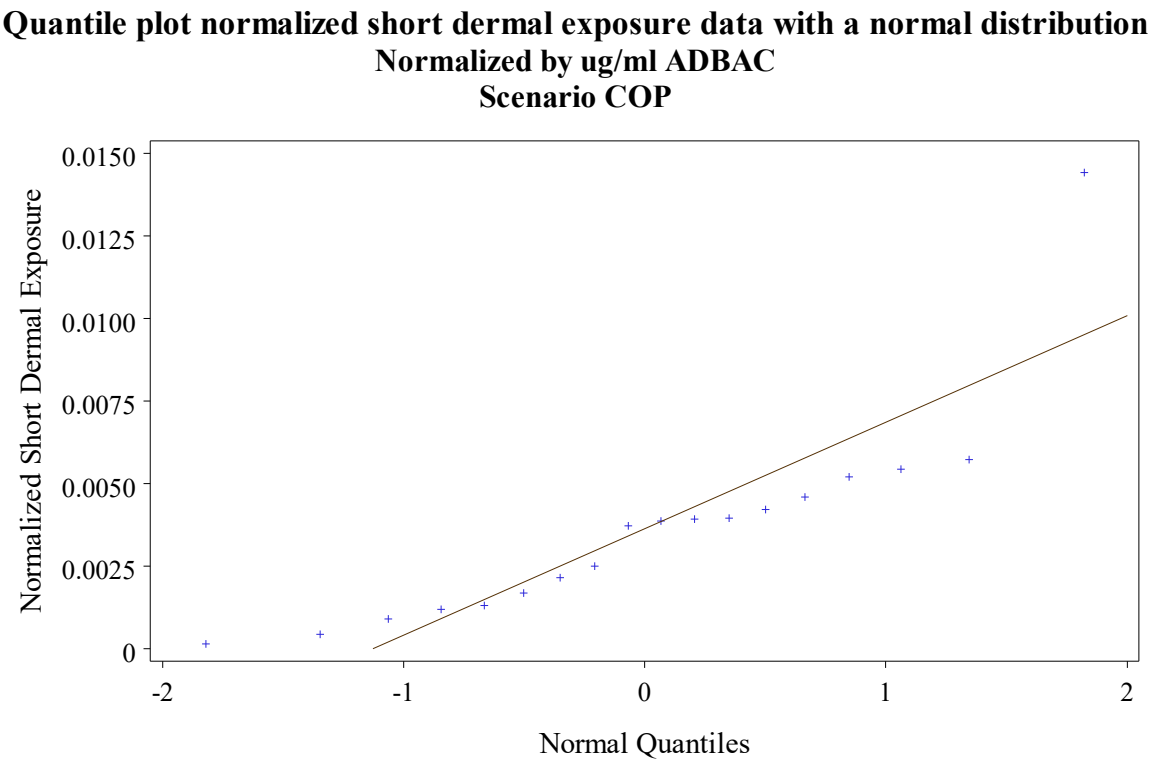


Figure BC3. Empirical quantile plot for Short Dermal, with a normal distribution

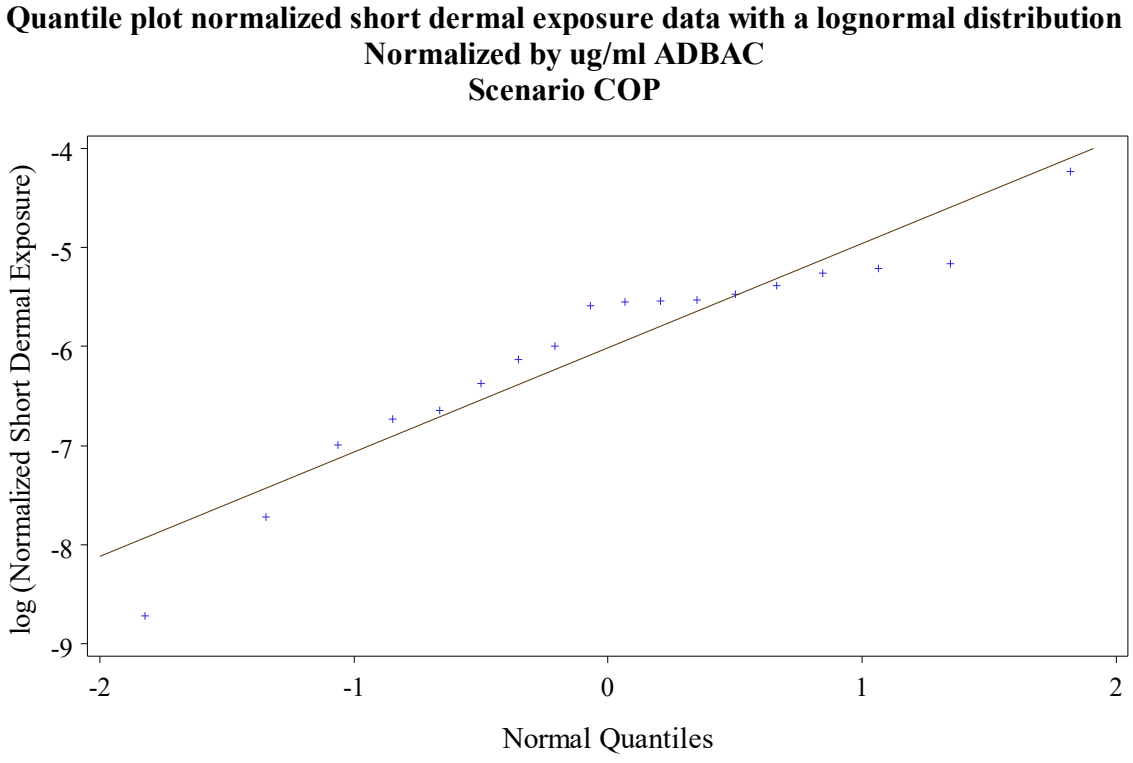


Figure BC4. Empirical quantile plot for Short Dermal, with a lognormal distribution

Quantile plot normalized long short dermal exposure data with a normal distribution
Normalized by ug/ml ADBAC
Scenario COP

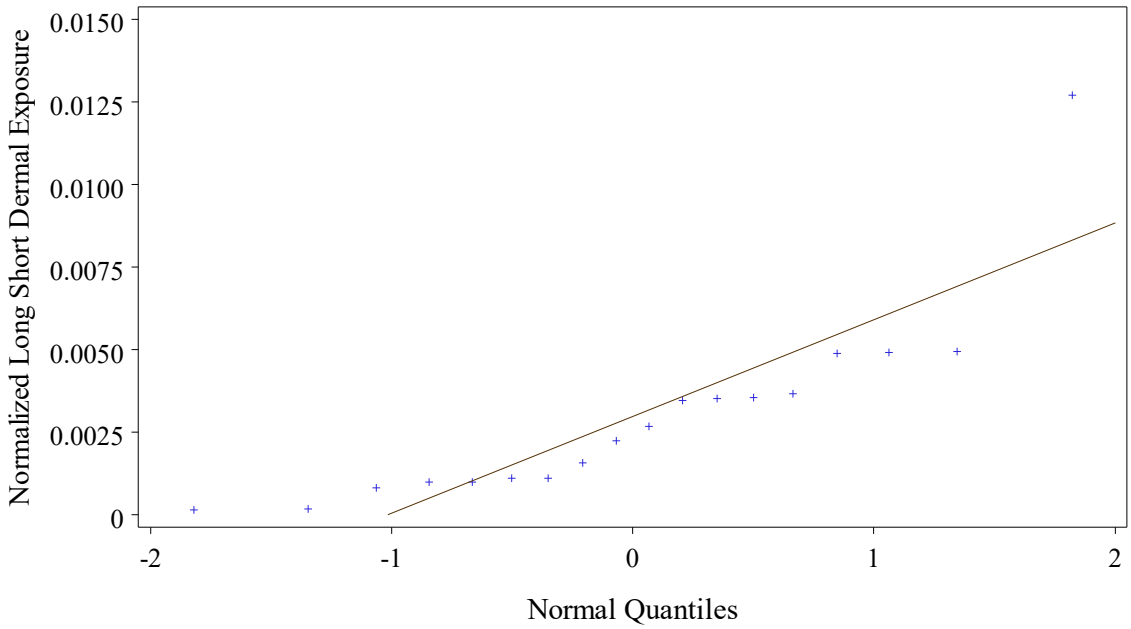


Figure BC5. Empirical quantile plot for Long Short Dermal, with a normal distribution

Quantile plot normalized long short dermal exposure data with a lognormal distribution
Normalized by ug/ml ADBAC
Scenario COP

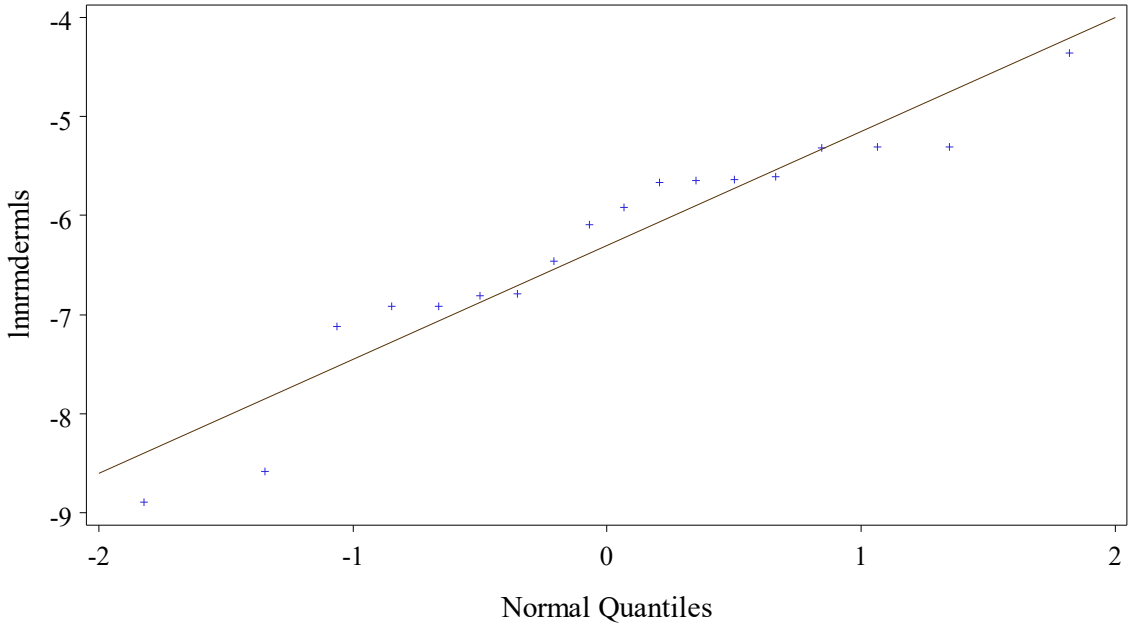


Figure BC6. Empirical quantile plot for Long Short Dermal, with a lognormal distribution

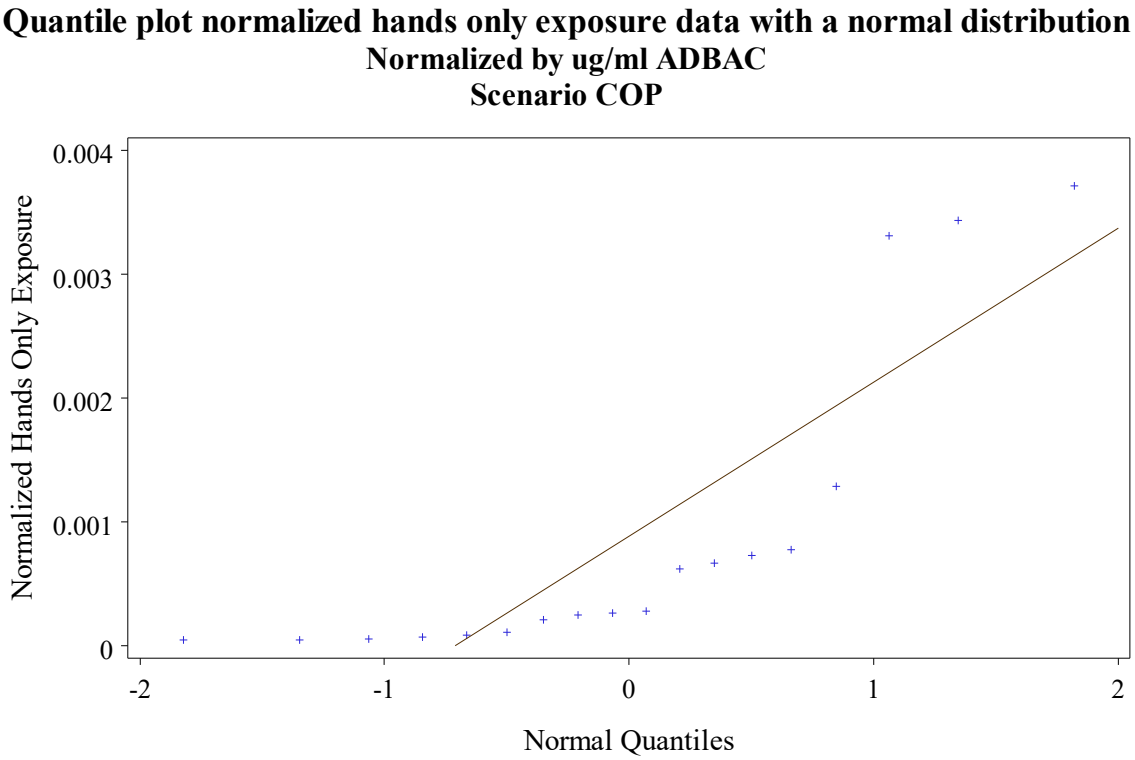


Figure BC7. Empirical quantile plot for Hands Only, with a normal distribution

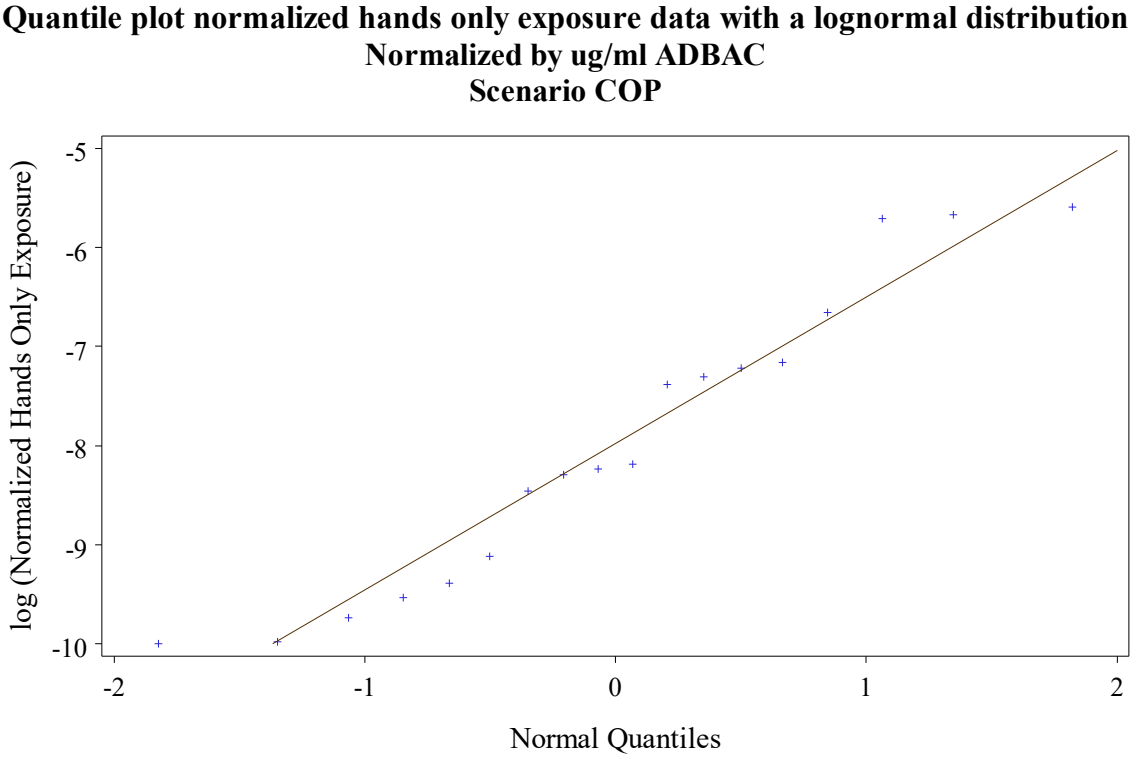


Figure BC8. Empirical quantile plot for Hands Only, with a lognormal distribution

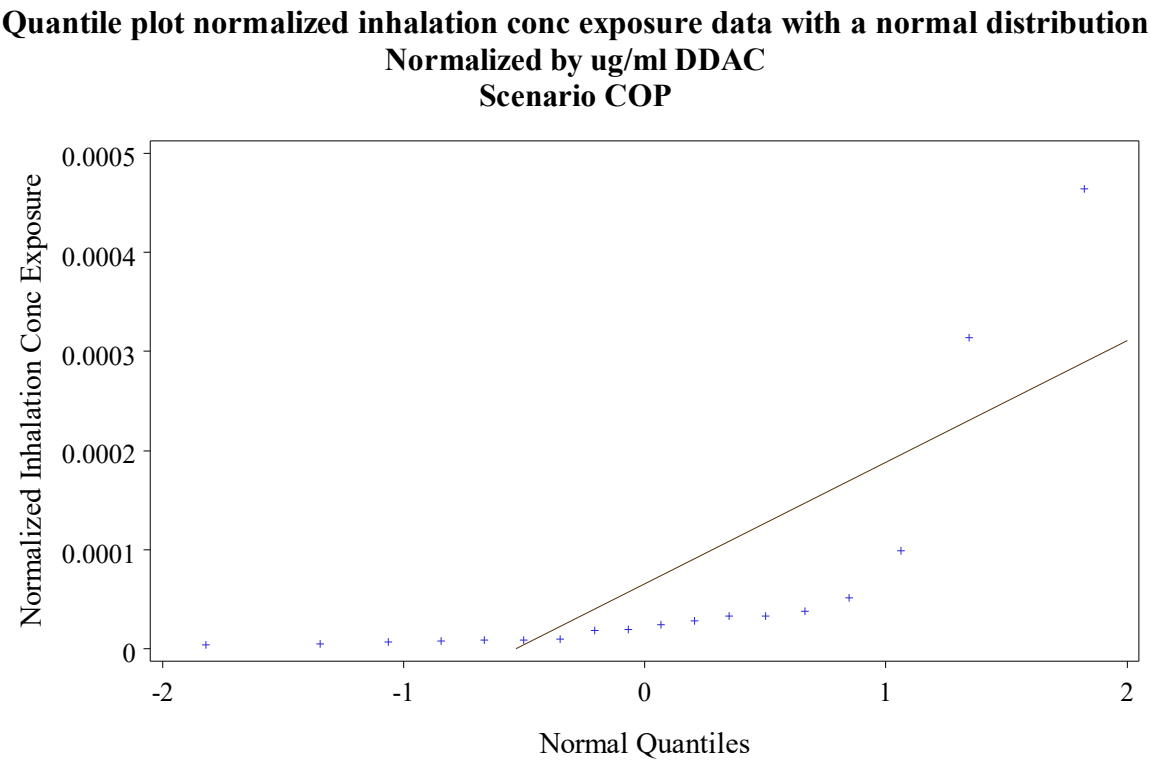


Figure BC9. Empirical quantile plot for Inhalation Concentration, with a normal distribution

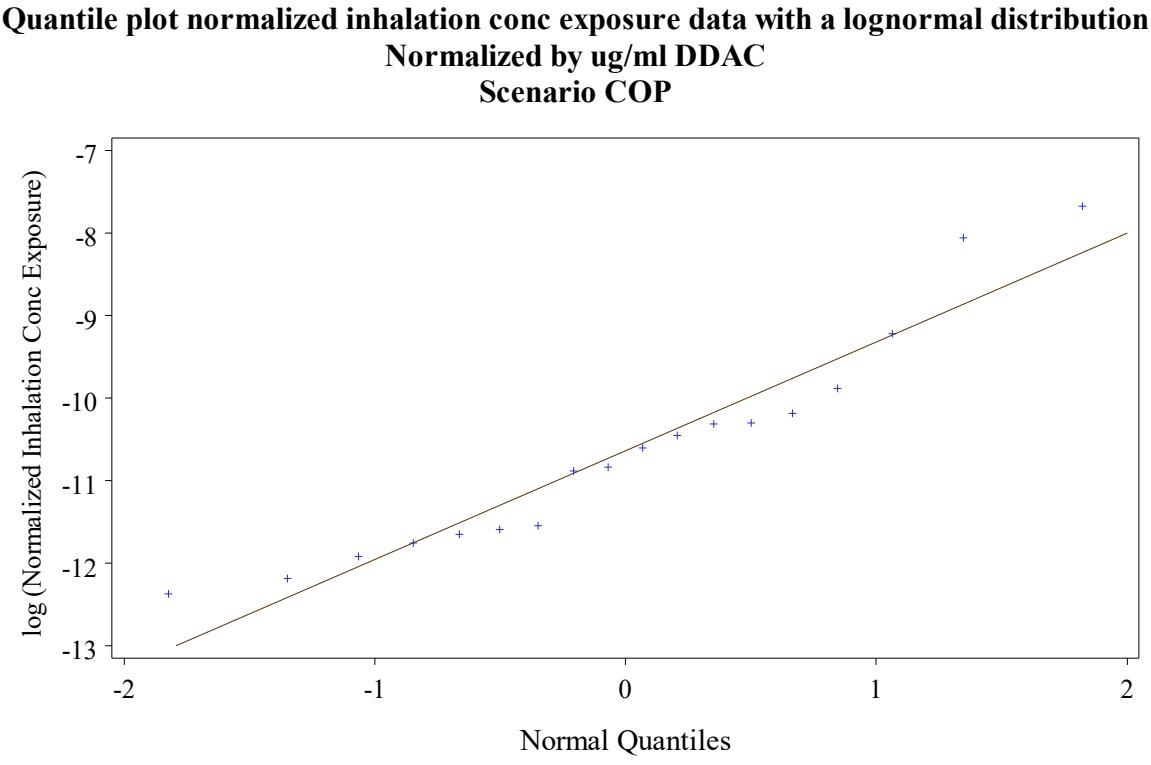


Figure BC10. Empirical quantile plot for Inhalation Concentration, with a lognormal distribution

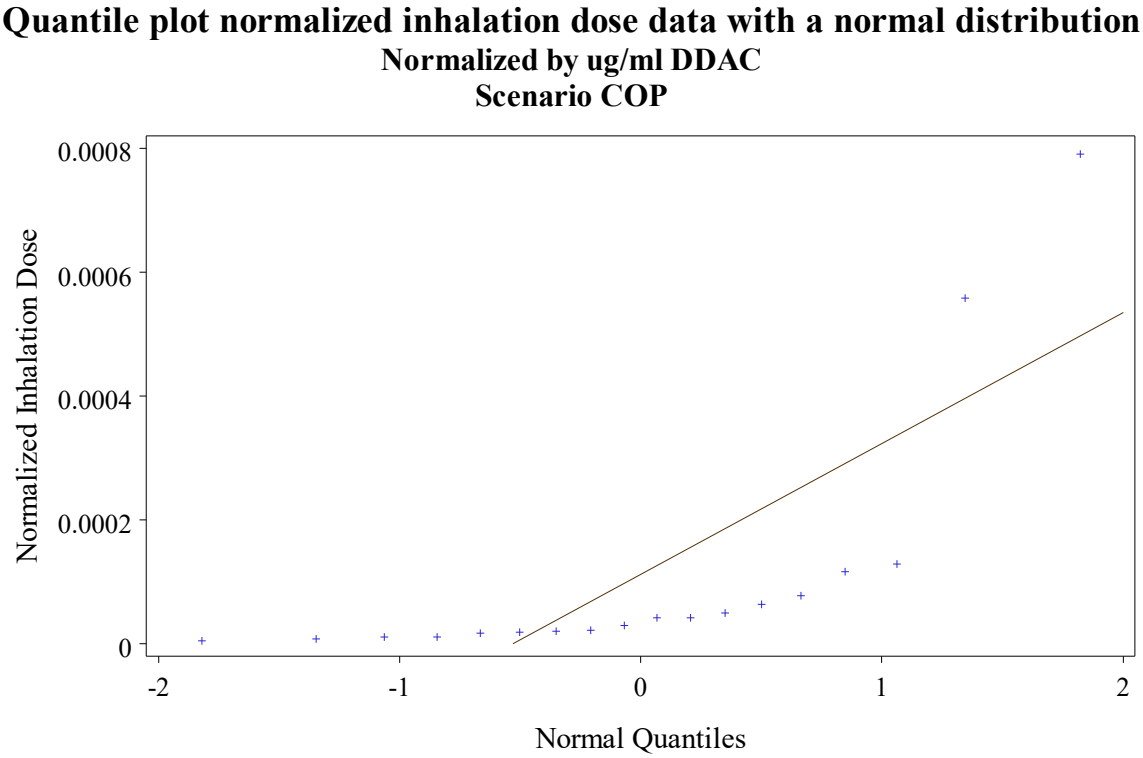


Figure BC11. Empirical quantile plot for Inhalation Dose, with a normal distribution

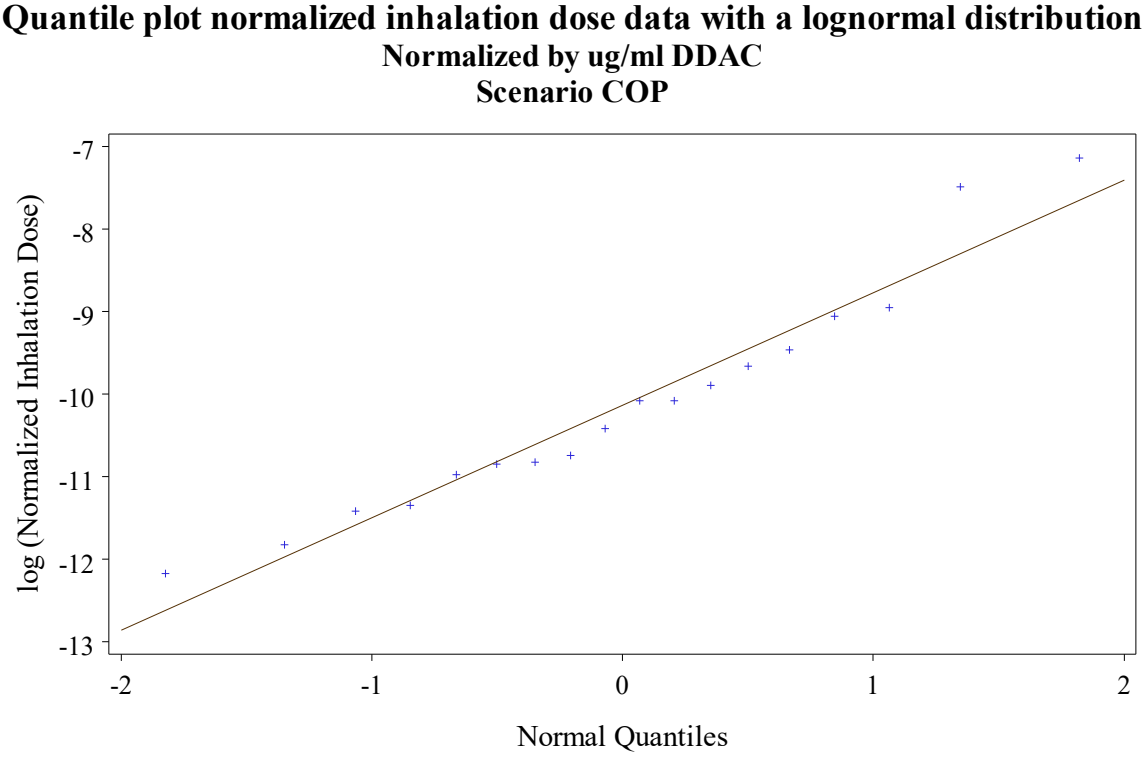


Figure BC12. Empirical quantile plot for Inhalation Dose, with a lognormal distribution

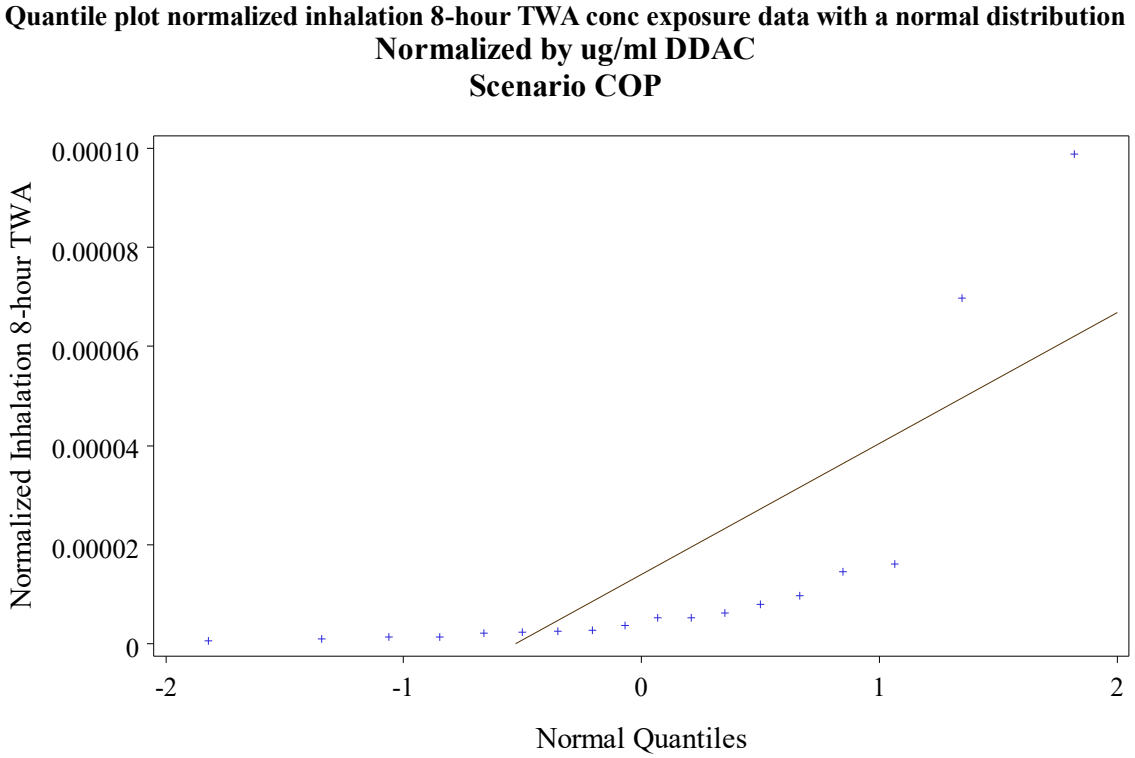


Figure BC13. Empirical quantile plot for Inhalation Time-weighted Average Conc, with a normal distribution

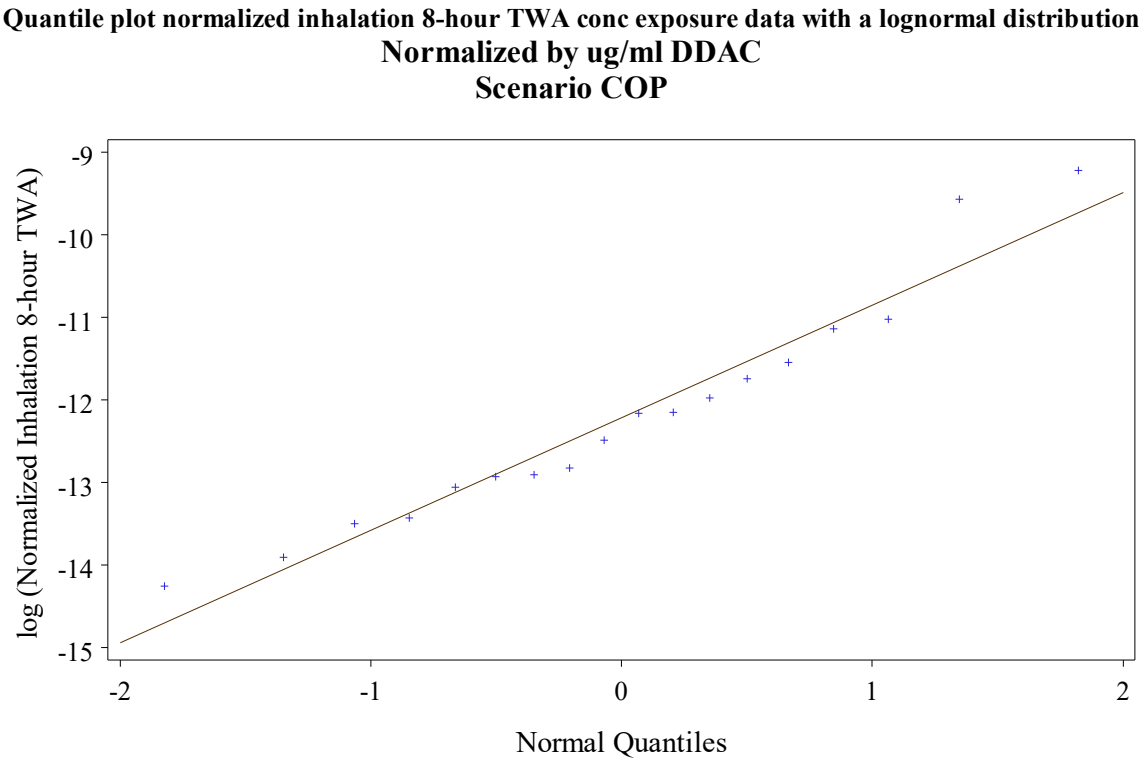


Figure BC14. Empirical quantile plot for Inhalation Time-weighted Average Conc, with a lognormal distribution

Test for log-log-linearity with slope 1

Table BC18 shows the 95% confidence intervals for the slope calculated from the above linear model. A confidence interval that includes one but not zero supports the use of unit exposures. A confidence interval that includes zero but not one suggests that the exposure does not depend on the normalizing factor. A confidence interval that includes both zero and one suggests that either the basic statistical model is incorrect or there are not enough data to statistically infer whether the slope is zero or one. This table also shows the widths of the confidence intervals used to evaluate the second benchmark for post-hoc power discussed in the next sub-section. The table also shows the values of the threshold concentration × duration (case A) or threshold concentration (case B) and the corresponding estimated exposure, to be described and discussed In the Supplement. Threshold values were not computed for the censored data models.

Table BC18. 95 percent confidence intervals for the slope of log exposure versus the log of the normalizing factor.

Exposure Route	Treatment of Non-detects	Estimate	Lower	Upper	Width	Threshold	Exposure
Long Dermal (mg)	Substitute mid value	–0.019	–0.333	0.295	0.628	46	0.06
	Censored data MLE	–0.018	–0.293	0.257	0.551		
Short Dermal (mg)	Substitute mid value	0.457	–0.007	0.920	0.927	61	0.26
	Censored data MLE	0.461	0.058	0.864	0.806		
Long Short Dermal (mg)	Substitute mid value	0.432	–0.081	0.946	1.027	60	0.22
	Censored data MLE	0.434	–0.017	0.884	0.901		
Hands Only (mg)	Substitute mid value	–0.187	–0.624	0.250	0.834	42	0.04
	Censored data MLE	–0.187	–0.568	0.194	0.762		
Inhalation Concentration (mg/m^3)	Substitute mid value	–0.019	–0.518	0.479	0.997	62	0.0035
	Censored data MLE	–0.019	–0.454	0.415	0.869		
Inhalation Dose (mg)	Substitute mid value	–0.018	–0.552	0.515	1.067	62	0.0062
	Censored data MLE	–0.018	–0.483	0.447	0.930		
Inhalation Time-Weighted Average Concentration (mg/m^3)	Substitute mid value	–0.018	–0.552	0.515	1.067	62	0.00078
	Censored data MLE	–0.018	–0.483	0.447	0.930		

Table BC18 gives the slopes for all the exposure routes.

The slopes range from –0.2 to 0.5. Except for Short Dermal using the censored data MLE, the confidence intervals include 0 but not 1, suggesting that the exposure does not depend on the normalizing factor. For Short Dermal using the censored data MLE, the slope is 0.46, and the confidence interval excludes both 0 and 1 showing that the exposure increases with the normalizing factor, but the model does not support the use of unit exposures. The negative slopes are counterintuitive.

Suppose that the study had a (post-hoc) power of at least 80% for detecting "proportionality" (i.e., log-log-linearity with a slope of 1) under the null hypothesis of independence (slope = 0). It follows that the confidence intervals have an approximate width of 1.4 or less. The results in **Error! Reference source not found.**AC18 show that observed widths are all below 1.4. The maximum width was about 1.1. Therefore, based on the confidence intervals, the secondary objective of meeting the 80% power for detecting proportionality was met.

Quantile plots for residuals

The quantile-quantile plots of the studentized residuals for all exposure routes are shown below in Figures BC15 to BC21.

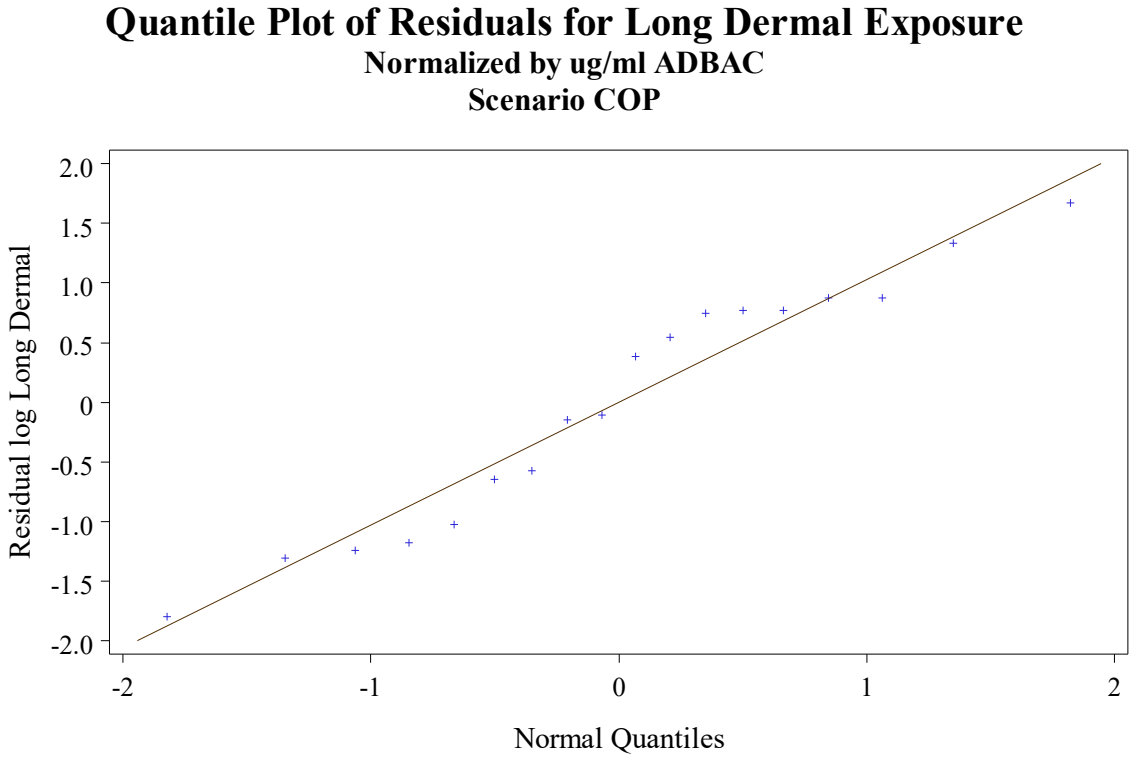


Figure BC15. Quantile plot of residuals from linear model for Long Dermal

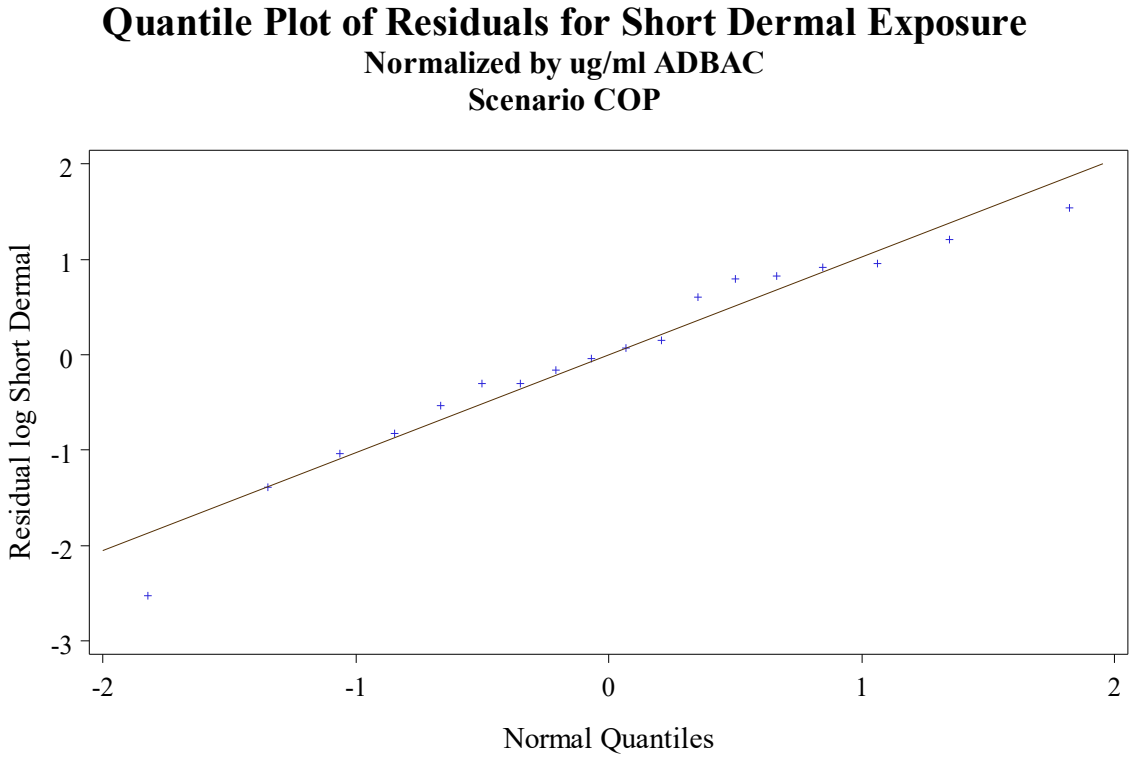


Figure BC16. Quantile plot of residuals from linear model for Short Dermal

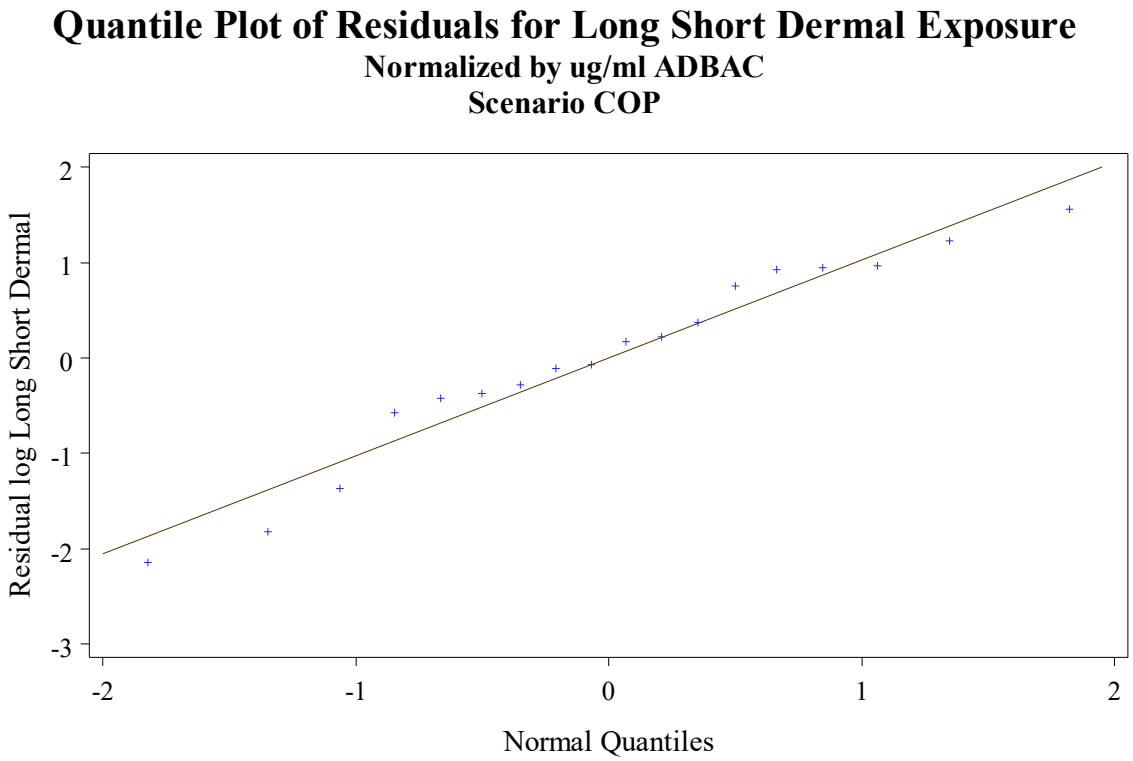


Figure BC17. Quantile plot of residuals from linear model for Long Short Dermal

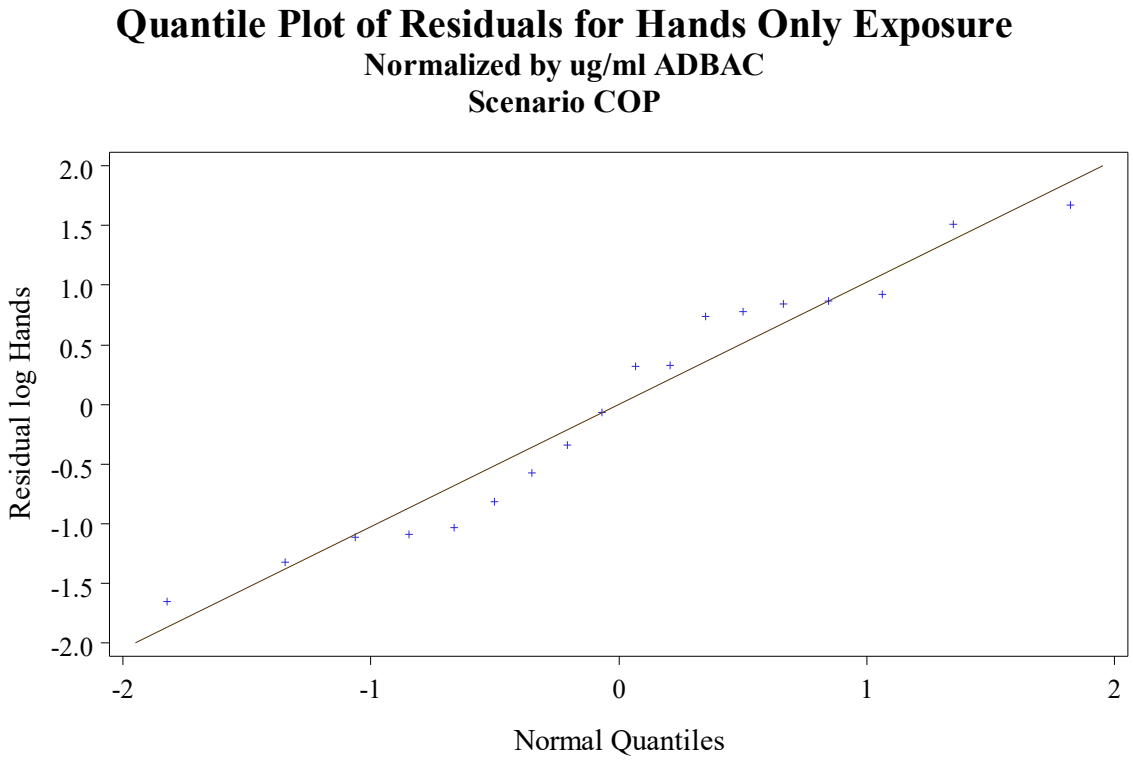


Figure BC18. Quantile plot of residuals from linear model for Hands Only

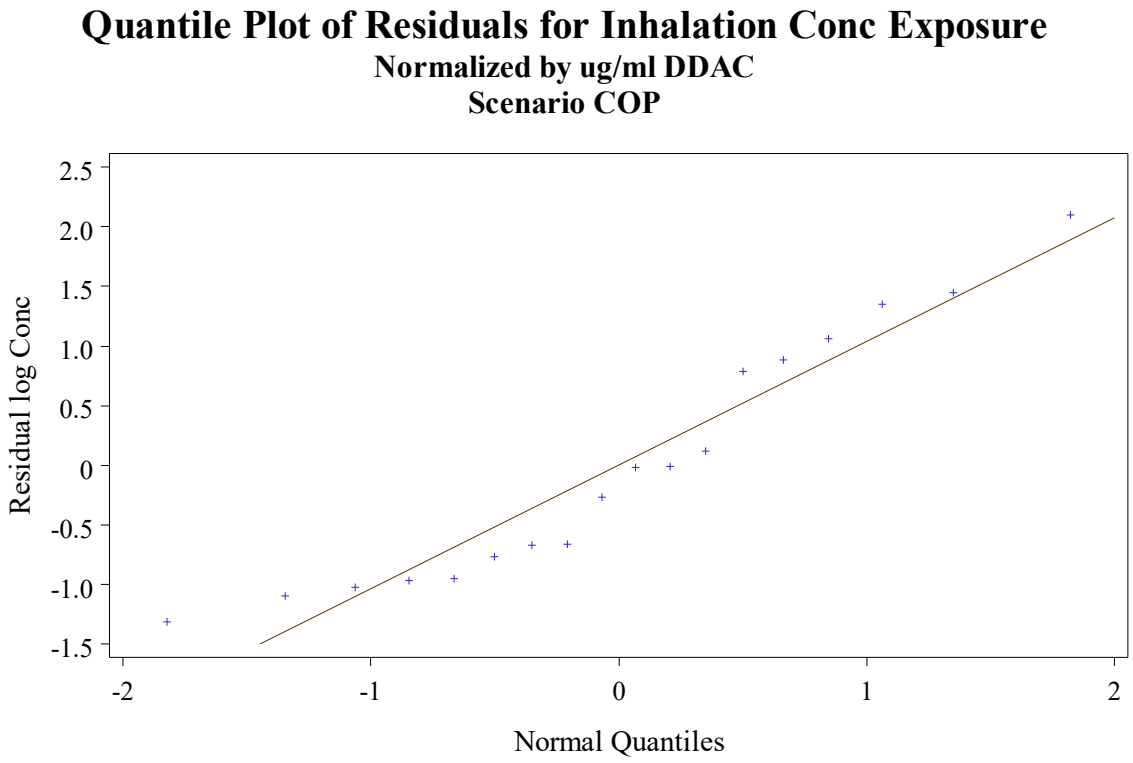


Figure BC19. Quantile plot of residuals from linear model for Inhalation Concentration

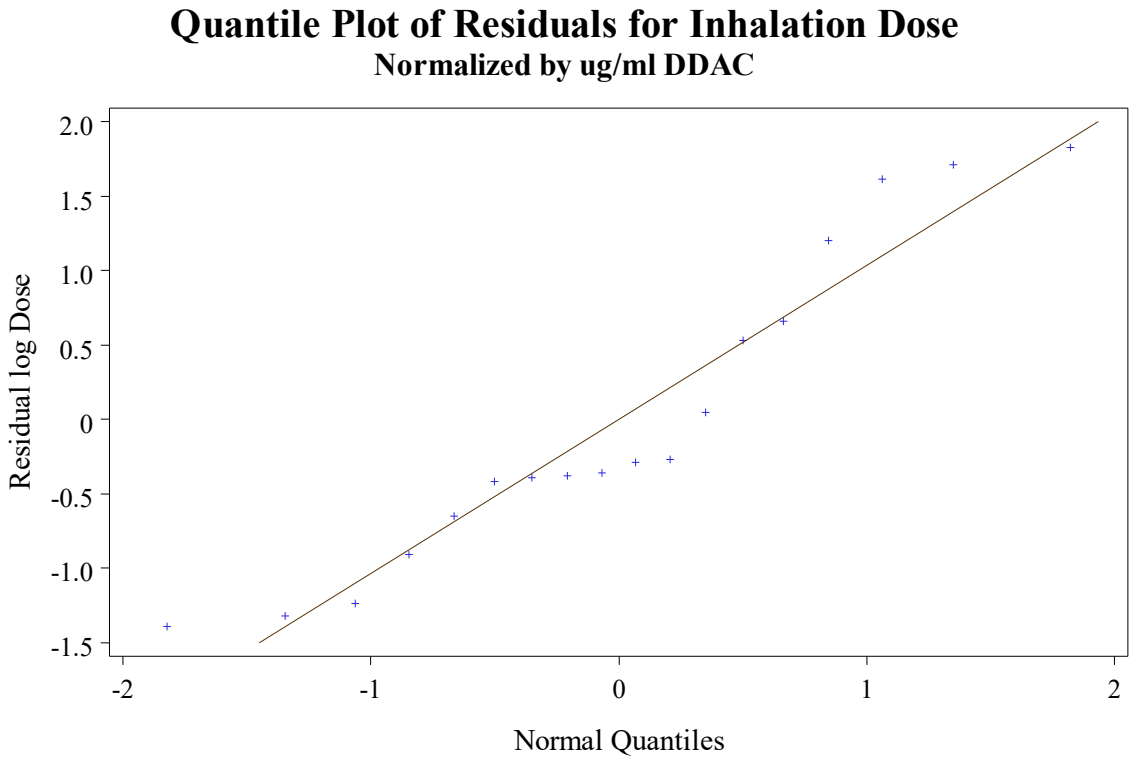


Figure BC20. Quantile plot of residuals from linear model for Inhalation Dose

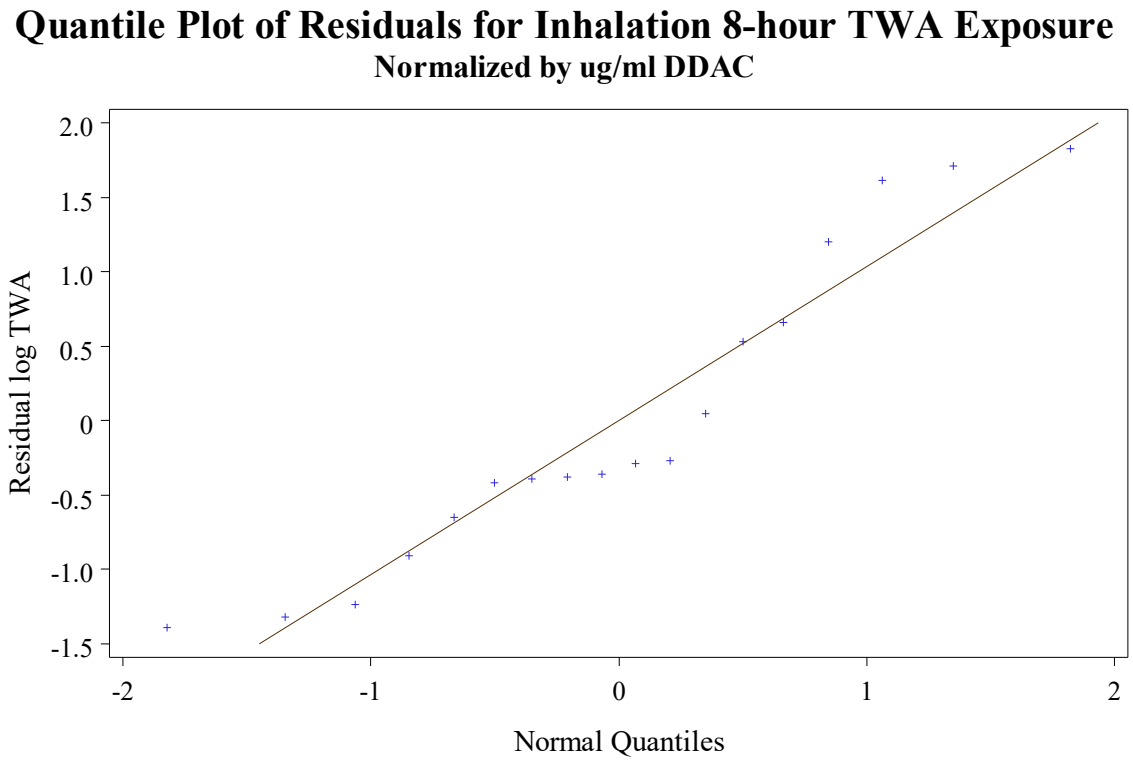


Figure BC21. Quantile plot of residuals from linear model for Inhalation Tine-Weighted Average Concentration

The quantile-quantile plots of the studentized residuals are reasonably close to the straight line except for the inhalation dose and the inhalation time-weighted average concentration. None of the studentized residuals exceeded the standard outlier cutoff of ±3.

Regression plots

The lognormal linear regression results for all the exposure routes are shown below using the mid value substitution method for non-detect values. The data points are labeled to show the targeted durations.

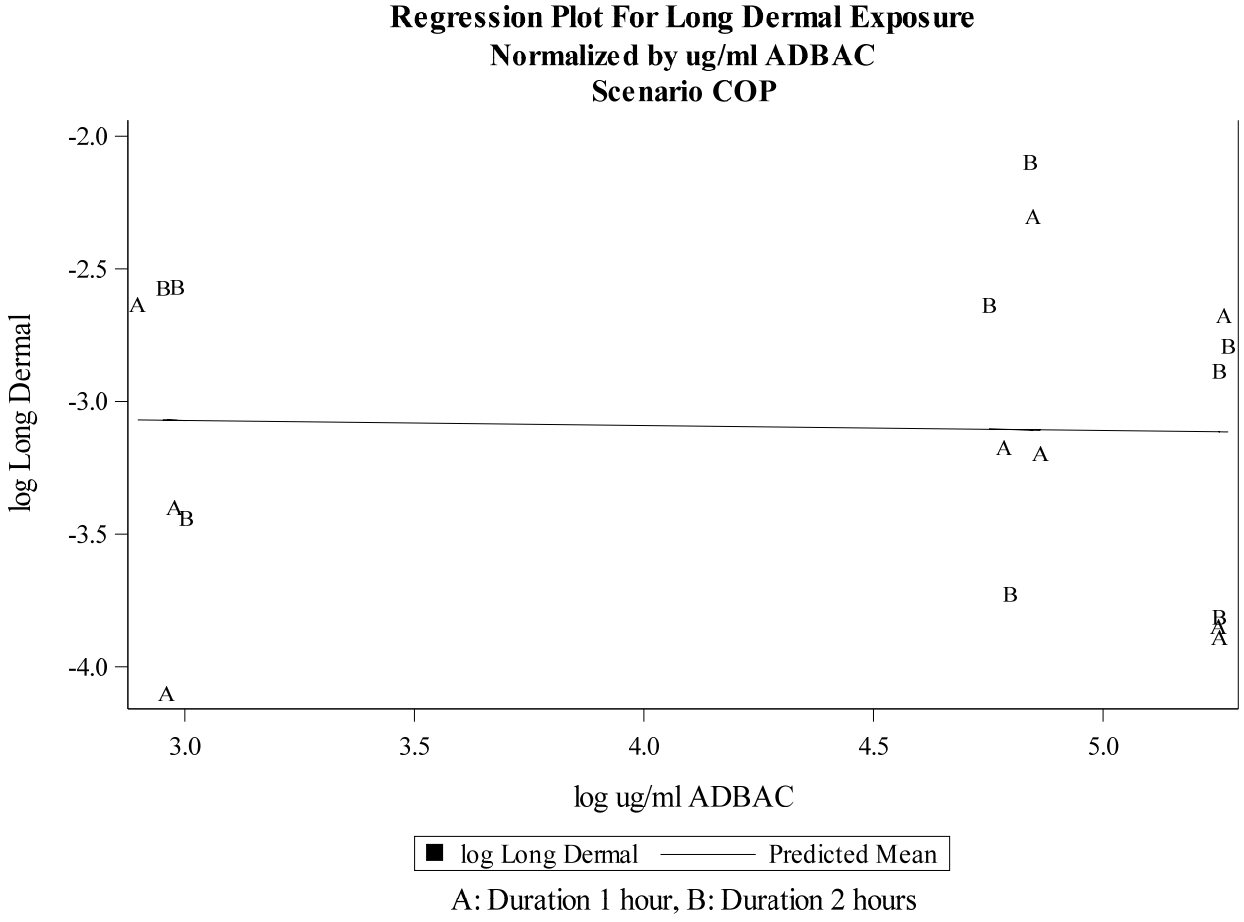


Figure BC22. Regression plot for Long Dermal Exposure (mg)

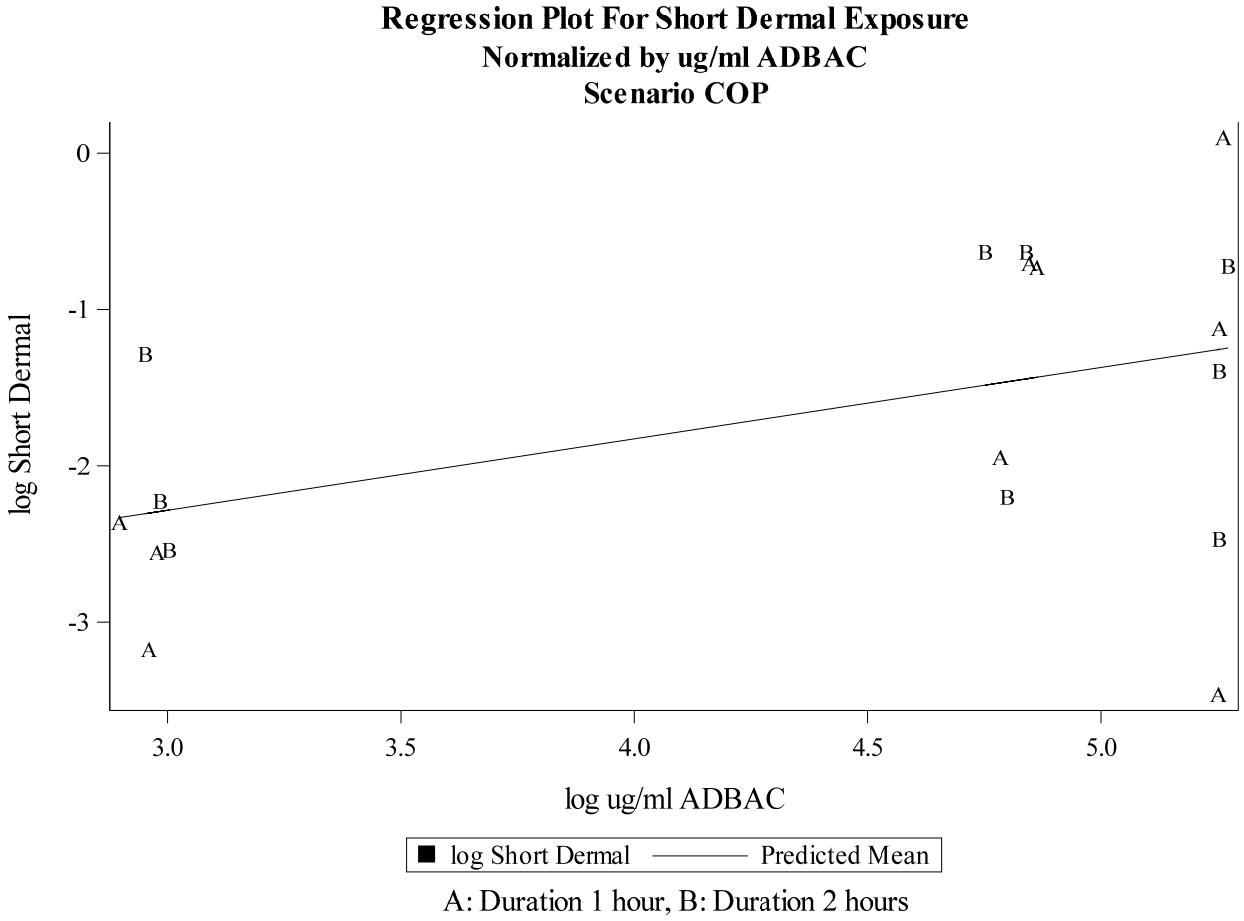


Figure BC23. Regression plot for Short Dermal Exposure (mg)

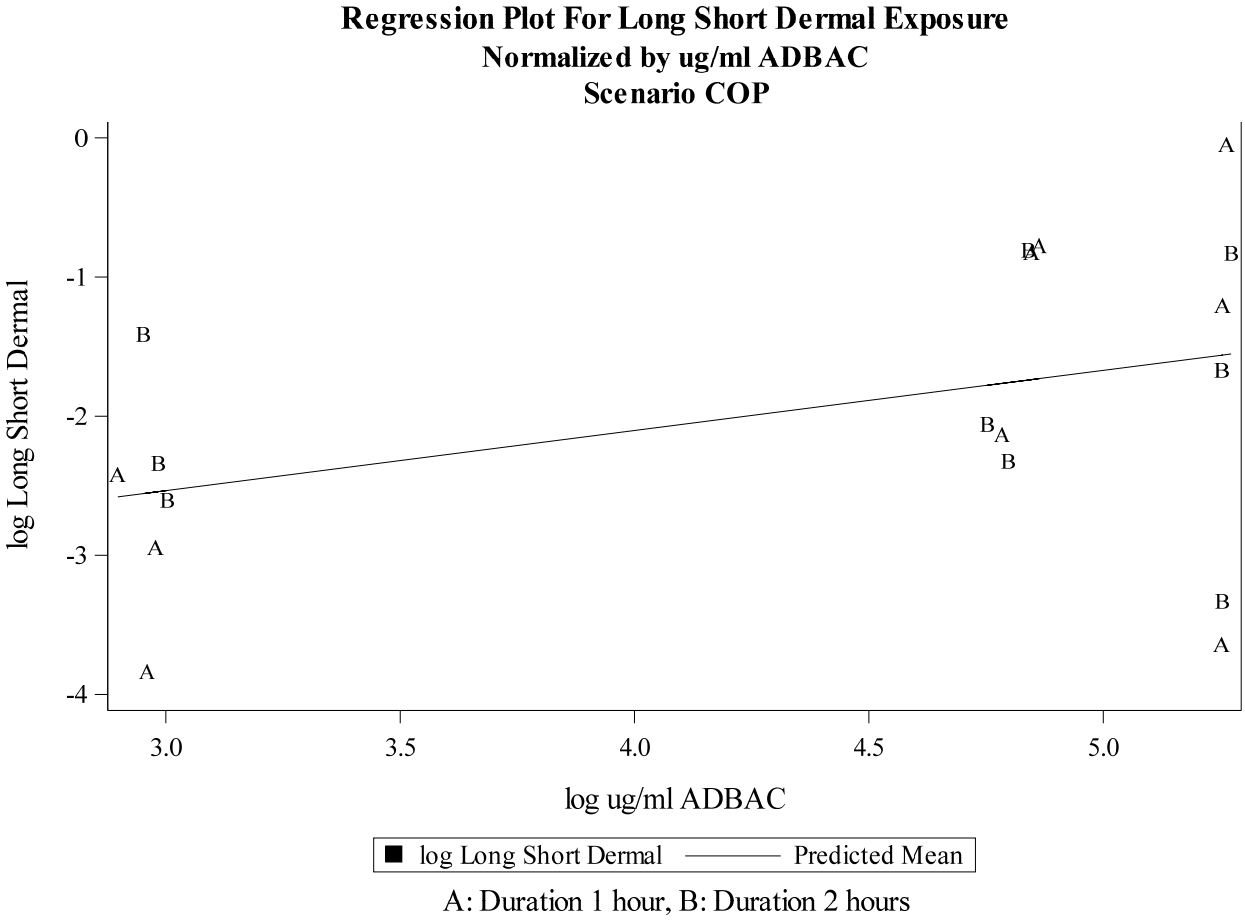
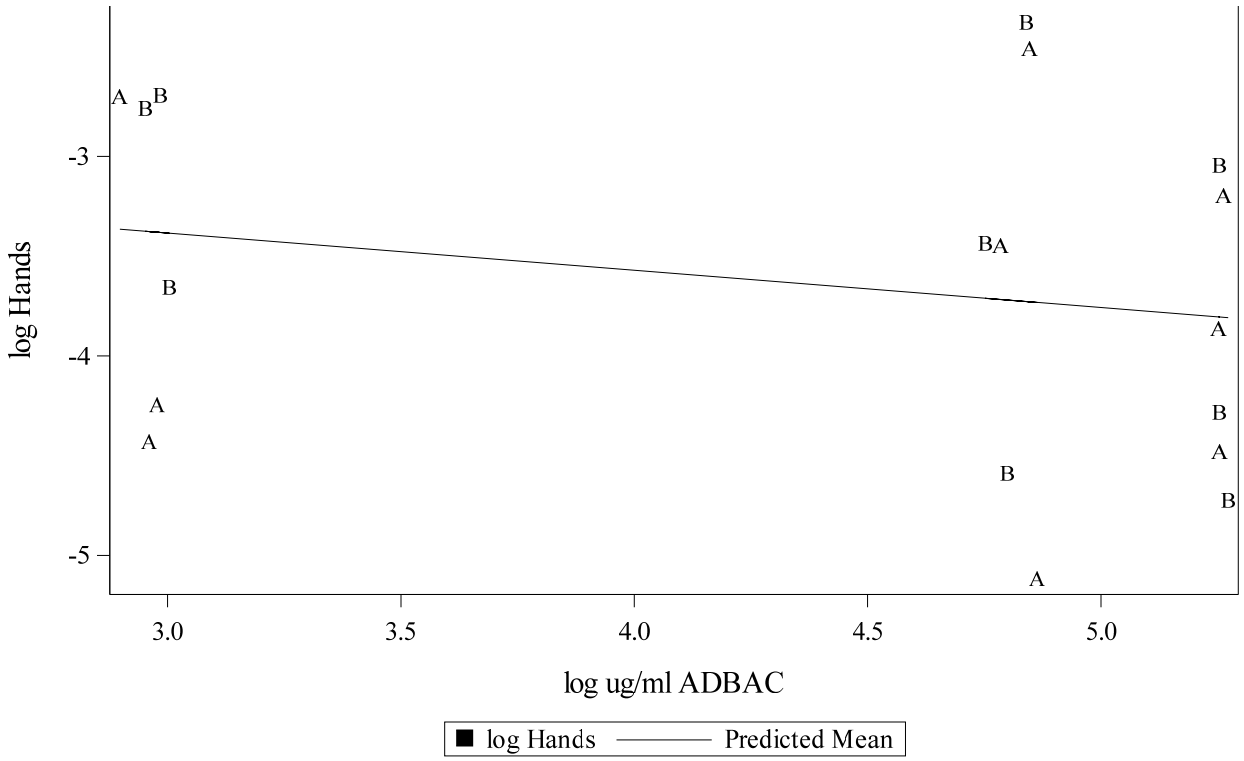


Figure BC24. Regression plot for Long Short Dermal Exposure (mg)

Regression Plot For Hands Only Exposure
Normalized by ug/ml ADBAC
Scenario COP



A: Duration 1 hour, B: Duration 2 hours

Figure BC25. Regression plot for Hands Only Exposure (mg)

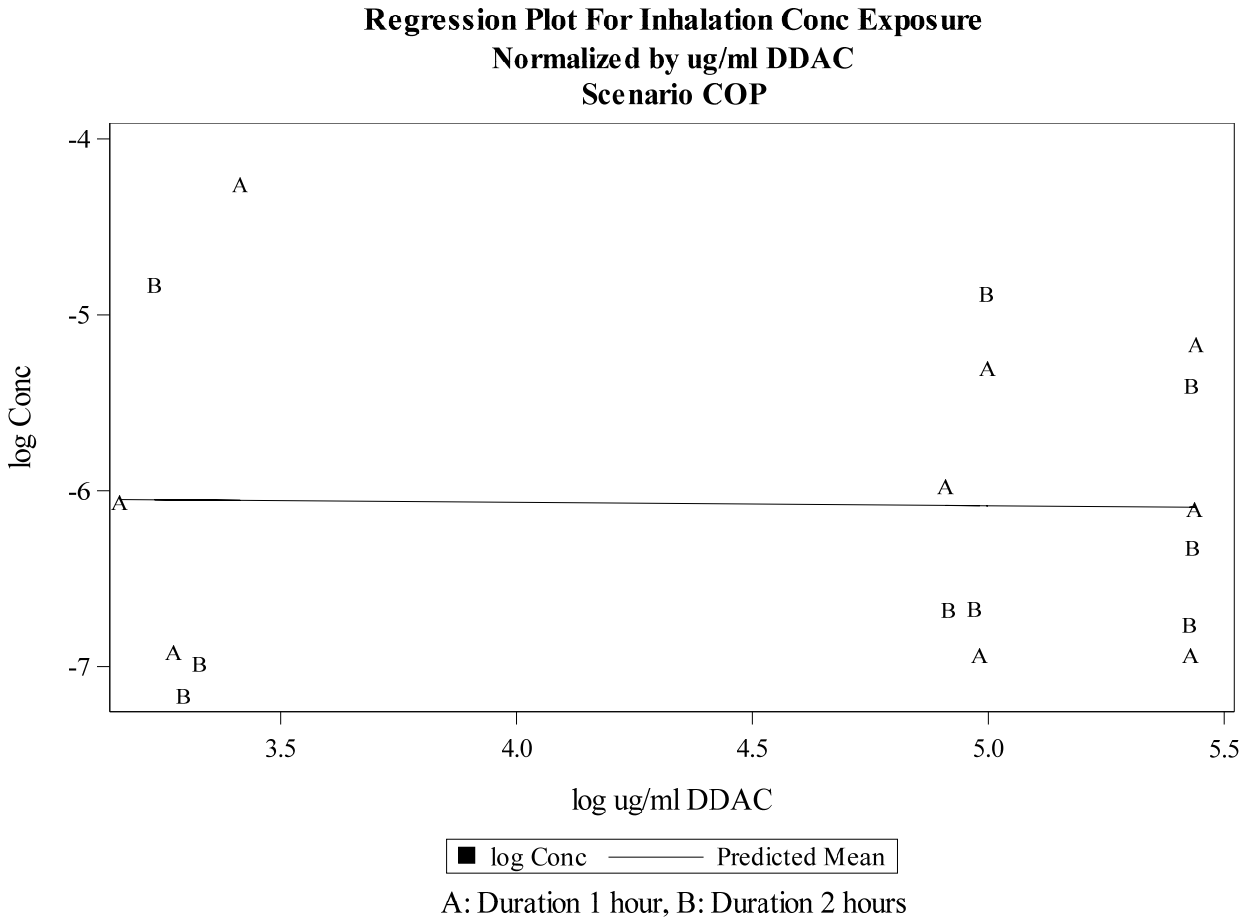


Figure BC26. Regression plot for Inhalation Concentration Exposure (mg/m^3)

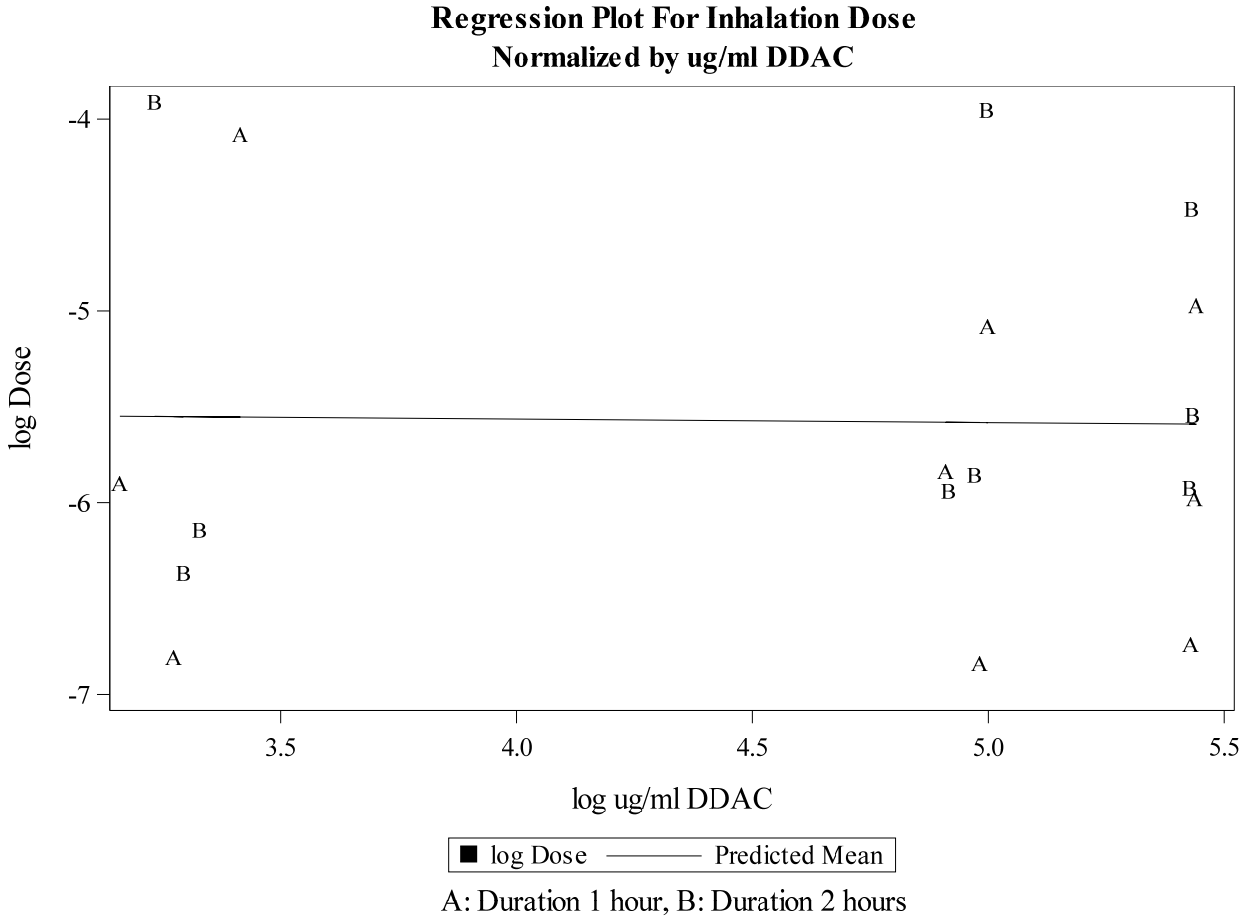


Figure BC27. Regression plot for Inhalation Dose (mg)

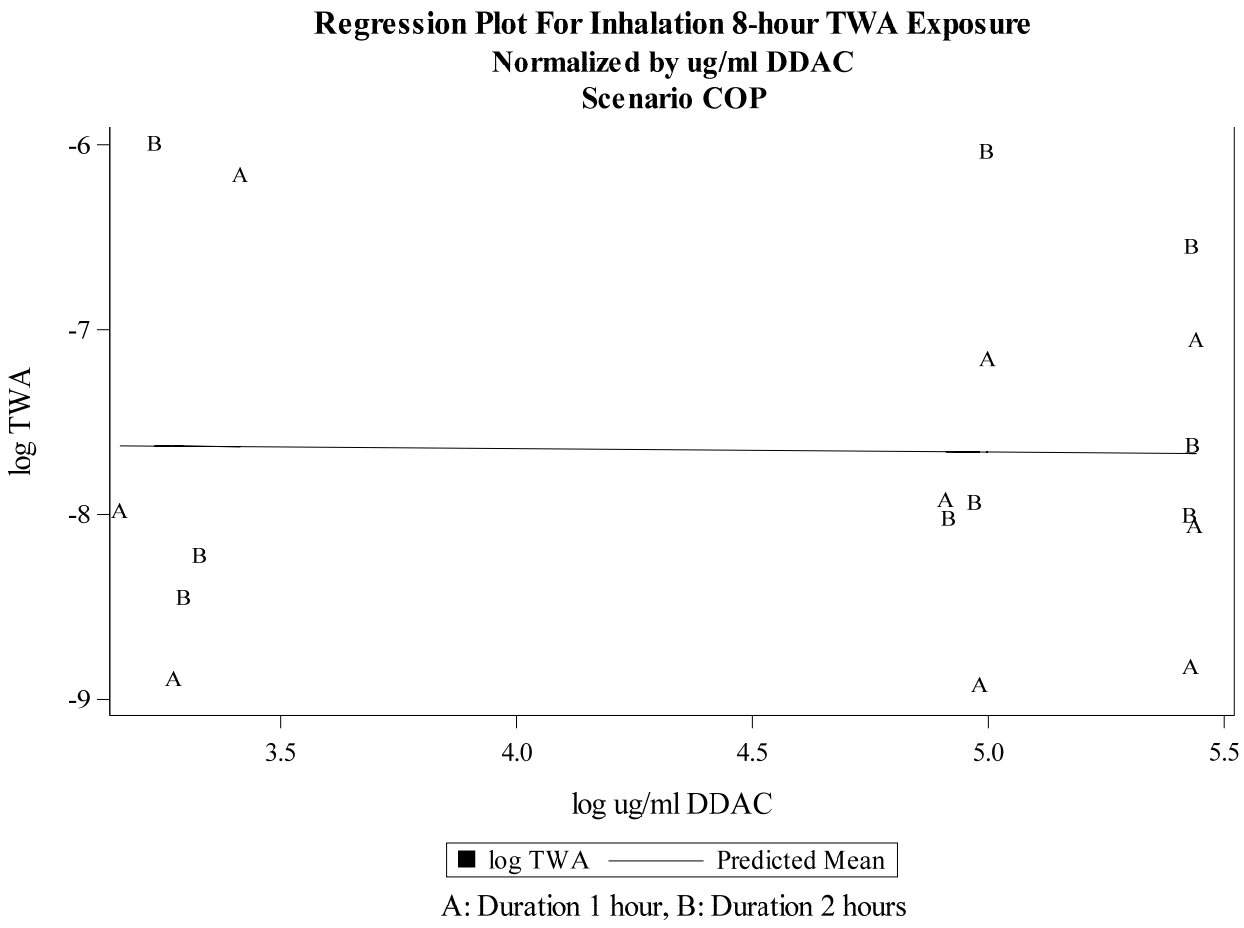


Figure BC28. Regression plot for Inhalation Time-Weighted Average Exposure (mg/m^3)

Quadratic models

Table BC19 presents the quadratic coefficient Quad from the fitted quadratic regression models for all the exposure routes using All data. Coefficients for the Intercept and Slope are shown under model 2 in Tables BC20 to BC26 below.

Table BC19. Quadratic coefficients with 95% confidence intervals for quadratic regression models for the log exposure versus log (Normalizing Factor)

Exposure Route	Estimate	Lower Bound	Upper Bound
Long Dermal	–0.43	–1.28	0.42
Short Dermal	–0.55	–1.81	0.71
Long Short Dermal	–0.39	–1.82	1.03
Hands Only	–0.28	–1.49	0.94

Exposure Route	Estimate	Lower Bound	Upper Bound
Inhalation Concentration	−0.07	−1.38	1.23
Inhalation Dose	−0.06	−1.45	1.34
Inhalation Time-weighted Average	−0.06	−1.45	1.34

Since all the 95% confidence intervals for Quad include zero, the quadratic coefficient is not statistically significant, and the quadratic models are not supported.

Alternative Statistical Approaches

In this section we present and compare some alternative statistical approaches to the linear and quadratic models.

Model Parameters

Table BC20. Alternative fitted statistical models for Long Dermal Exposure (mg)

Model	Parameter	Estimate	Lower Bound	Upper Bound
1. Linear regression of Ln(exposure) on Ln(NF)	μ	-3.015	-4.413	-1.616
	β	-0.019	-0.333	0.295
2. Quadratic regression of Ln(exposure) on Ln(NF)	μ	-9.589	-22.604	3.427
	β	3.461	-3.396	10.318
	γ	-0.430	-1.277	0.416
3. Log-log logistic regression of exposure on NF	**α**	5.407E-02	2.087E-02	8.727E-02
	γ	7.891E-07	-2.306E-03	2.307E-03
	β	1.710E+00	-5.479E+02	5.513E+02
4. 3-parameter logistic regression of exposure on NF	**α**	1.382E+00	-1.972E+03	1.975E+03
	c	2.829E-01	-4.461E+02	4.467E+02
	β	7.884E-04	-2.878E-01	2.893E-01

Model	Parameter	Estimate	Lower Bound	Upper Bound
5. Gamma model for exposure	**μ**	-2.900	-4.090	-1.709
	β	-0.008	-0.275	0.260
	ϕ	3.213	1.724	5.988

Table BC21. Alternative fitted statistical models for Short Dermal Exposure (mg)

Model	Parameter	Estimate	Lower Bound	Upper Bound
1. Linear regression of Ln(exposure) on Ln(NF)	μ	-3.655	-5.720	-1.589
	β	0.457	-0.007	0.920
2. Quadratic regression of Ln(exposure) on Ln(NF)	μ	-12.06	-31.46	7.35
	β	4.90	-5.32	15.13
	γ	-0.55	-1.81	0.71
3. Log-log logistic regression of exposure on NF	**α**	0.408	-0.238	1.054
	γ	502.620	-14939.511	15944.750
	β	-1.774	-12.633	9.085
4. 3-parameter logistic regression of exposure on NF	**α**	1.631	-2.734	5.996
	c	0.392	0.134	0.650
	β	-0.037	-0.217	0.142
5. Gamma model for exposure	**μ**	-3.846	-5.414	-2.277
	β	0.571	0.219	0.923
	ϕ	1.795	0.983	3.278

Table BC22. Alternative fitted statistical models for Long Short Dermal Exposure (mg)

Model	Parameter	Estimate	Lower Bound	Upper Bound
1. Linear regression of Ln(exposure) on Ln(NF)	μ	-3.833	-6.122	-1.543

Model	Parameter	Estimate	Lower Bound	Upper Bound
	β	0.432	-0.081	0.946
2. Quadratic regression of Ln(exposure) on Ln(NF)	μ	-9.838	-31.704	12.028
	β	3.611	-7.908	15.130
	γ	-0.393	-1.815	1.029
3. Log-log logistic regression of exposure on NF	**α**			
	γ			
	β			
4. 3-parameter logistic regression of exposure on NF	**α**	1.475	-1.841	4.791
	c	0.365	-0.093	0.823
	β	-0.021	-0.082	0.041
5. Gamma model for exposure	**μ**	-3.963	-5.658	-2.267
	β	0.548	0.168	0.928
	ϕ	1.485	0.820	2.691

Table BC23. Alternative fitted statistical models for Hands Only Exposure (mg)

Model	Parameter	Estimate	Lower Bound	Upper Bound
1. Linear regression of Ln(exposure) on Ln(NF)	μ	-2.824	-4.771	-0.876
	β	-0.187	-0.624	0.250
2. Quadratic regression of Ln(exposure) on Ln(NF)	μ	-7.073	-25.742	11.595
	β	2.063	-7.772	11.897
	γ	-0.278	-1.492	0.936
3. Log-log logistic regression of exposure on NF	**α**	0.046	-0.012	0.103
	γ	0.001	-0.073	0.075

Model	Parameter	Estimate	Lower Bound	Upper Bound
	β	1.131	-15.259	17.522
4. 3-parameter logistic regression of exposure on NF	**α**	-38.650	-355.503	278.204
	c	0.043	0.025	0.061
	β	0.200	-1.449	1.848
5. Gamma model for exposure	**μ**	-2.690	-4.320	-1.060
	β	-0.145	-0.511	0.222
	ϕ	1.730	0.949	3.156

Table BC24. Alternative fitted statistical models for Inhalation Concentration (mg/m^3)

Model	Parameter	Estimate	Lower Bound	Upper Bound
1. Linear regression of Ln(exposure) on Ln(NF)	μ	-5.988	-8.307	-3.670
	β	-0.019	-0.518	0.479
2. Quadratic regression of Ln(exposure) on Ln(NF)	μ	-7.284	-30.193	15.625
	β	0.616	-10.573	11.805
	γ	-0.074	-1.376	1.228
3. Log-log logistic regression of exposure on NF	**α**	0.005	-0.004	0.013
	γ	0.001	-0.071	0.073
	β	1.214	-11.538	13.967
4. 3-parameter logistic regression of exposure on NF	**α**	4.225	-6502.272	6510.722
	c	0.301	-1928.369	1928.971
	β	0.002	-0.136	0.139
5. Gamma model for exposure	**μ**	-4.726	-6.694	-2.759

Model	Parameter	Estimate	Lower Bound	Upper Bound
	β	-0.211	-0.635	0.212
	ϕ	1.438	0.795	2.601

Table BC25. Alternative fitted statistical models for Inhalation Dose (mg)

Model	Parameter	Estimate	Lower Bound	Upper Bound
1. Linear regression of Ln(exposure) on Ln(NF)	μ	-5.491	-7.972	-3.010
	β	-0.018	-0.552	0.515
2. Quadratic regression of Ln(exposure) on Ln(NF)	μ	-6.509	-31.030	18.012
	β	0.481	-11.495	12.457
	γ	-0.058	-1.452	1.335
3. Log-log logistic regression of exposure on NF	**α**	0.008	-0.004	0.019
	γ	0.000	-0.036	0.036
	β	1.325	-14.244	16.893
4. 3-parameter logistic regression of exposure on NF	**α**	0.867	-219.789	221.522
	c	0.026	-4.048	4.100
	β	0.003	-0.125	0.130
5. Gamma model for exposure	**μ**	-4.332	-6.432	-2.232
	β	-0.174	-0.626	0.277
	ϕ	1.258	0.699	2.261

Table BC26. Alternative fitted statistical models for Inhalation Time Weighted Average Concentration (mg/m^3)

Model	Parameter	Estimate	Lower Bound	Upper Bound
1. Linear regression of Ln(exposure) on Ln(NF)	μ	-7.571	-10.052	-5.090
	β	-0.018	-0.552	0.515

Model	Parameter	Estimate	Lower Bound	Upper Bound
2. Quadratic regression of Ln(exposure) on Ln(NF)	μ	-8.589	-33.110	15.932
	β	0.481	-11.495	12.457
	γ	-0.058	-1.452	1.335
3. Log-log logistic regression of exposure on NF	**α**	0.001	-0.001	0.002
	γ	0.000	-0.036	0.036
	β	1.325	-14.244	16.893
4. 3-parameter logistic regression of exposure on NF	**α**	3.334	-18448.838	18455.506
	c	0.327	-5981.792	5982.447
	β	0.099	-4.702	4.901
5. Gamma model for exposure	**μ**	-6.412	-8.512	-4.312
	β	-0.174	-0.626	0.277
	ϕ	1.258	0.699	2.261

Model Comparisons

One way to compare the fit of the 7 models presented above is to use the Akaike Information Criterion (AIC), which takes minus twice the log-likelihood and then makes an adjustment or penalty for the number of parameters in the model. The following two tables compare the AIC values for the various Dermal and Inhalation exposure measures. The smaller values of the AIC suggest a better-fitting model. AIC values for models that failed to converge are not shown.

Table BC27. Akaike Information Criteria values for alternative models for Dermal Exposure

Model	Long Dermal	Short Dermal	Long Short Dermal	Hands Only
1. Linear regression of Ln(exposure) on Ln(NF)	38.0	52.1	55.8	49.9
2. Quadratic regression of Ln(exposure) on Ln(NF)	38.7	53.0	57.3	51.7

Model	Long Dermal	Short Dermal	Long Short Dermal	Hands Only
3. Log-log logistic regression of exposure on NF	43.5	67.1		60.4
4. 3-parameter logistic regression of exposure on NF	43.4	67.1	73.1	59.0
5. Gamma model for exposure	37.9	49.8	53.9	50.6

Table BC28. Akaike Information Criteria values for alternative models for Inhalation Exposure

Model	Inhalation Concentration	Inhalation Dose	Inhalation Time-Weighted Average Concentration
1. Linear regression of Ln(exposure) on Ln(NF)	52.0	54.5	54.5
2. Quadratic regression of Ln(exposure) on Ln(NF)	54.0	56.4	56.4
3. Log-log logistic regression of exposure on NF	72.8	76.3	76.3
4. 3-parameter logistic regression of exposure on NF	72.9	76.3	84.4
5. Gamma model for exposure	54.6	57.6	57.6

Based on the AIC, the best-fitting models are the linear model for the Hands Only and the three inhalation exposure routes, and the gamma model for Long Dermal, Short Dermal, and Long Short Dermal.

9. Normalizing Factor One, Bucket Scenario

Summary Statistics of Exposure

Tables CB1 to CB7 summarize the (unnormalized) exposure data with the summary statistics from the 18 (all concentrations), or 6 (specific concentrations) measurements for each concentration group, and each dermal and inhalation exposure route. The unnormalized exposure is the same as the exposure normalized by one. These analyses assume that the exposure measurements within each subset come from some unspecified distribution for that subset.

Table CB1. Summary statistics for long dermal exposure (mg) using empirical sampling model

Statistic	All	Target Quat: 440 ppm	Target Quat: 880 ppm	Target Quat: 1760 ppm
Arithmetic Mean	10.624	5.941	11.343	14.587
Arithmetic Standard Deviation	8.001	3.469	9.724	8.079
Geometric Mean	8.129	5.011	8.839	12.130
Geometric Standard Deviation	2.169	1.954	2.097	2.114
Min	2.002	2.002	3.928	3.145
5%	2.002	2.002	3.928	3.145
10%	2.668	2.002	3.928	3.145
25%	4.647	2.668	5.254	9.104
50%	9.312	5.569	8.233	14.991
75%	14.583	9.520	12.385	18.474
90%	26.818	10.317	30.025	26.818
95%	30.025	10.317	30.025	26.818
Max	30.025	10.317	30.025	26.818

Table CB2. Summary statistics for short dermal exposure (mg) using empirical sampling model

Statistic	All	Target Quat: 440 ppm	Target Quat: 880 ppm	Target Quat: 1760 ppm
Arithmetic Mean	10.728	5.977	11.436	14.771
Arithmetic Standard Deviation	8.132	3.475	9.838	8.287
Geometric Mean	8.205	5.053	8.905	12.277
Geometric Standard Deviation	2.166	1.944	2.098	2.108
Min	2.037	2.037	3.947	3.225
5%	2.037	2.037	3.947	3.225
10%	2.711	2.037	3.947	3.225

Statistic	All	Target Quat: 440 ppm	Target Quat: 880 ppm	Target Quat: 1760 ppm
25%	4.654	2.711	5.267	9.167
50%	9.381	5.588	8.311	15.049
75%	14.632	9.595	12.412	18.569
90%	27.567	10.342	30.368	27.567
95%	30.368	10.342	30.368	27.567
Max	30.368	10.342	30.368	27.567

Table CB3. Summary statistics for long short dermal exposure (mg) using empirical sampling model

Statistic	All	Target Quat: 440 ppm	Target Quat: 880 ppm	Target Quat: 1760 ppm
Arithmetic Mean	10.678	5.961	11.373	14.699
Arithmetic Standard Deviation	8.047	3.465	9.720	8.184
Geometric Mean	8.180	5.039	8.877	12.237
Geometric Standard Deviation	2.163	1.944	2.091	2.103
Min	2.032	2.032	3.942	3.220
5%	2.032	2.032	3.942	3.220
10%	2.699	2.032	3.942	3.220
25%	4.649	2.699	5.262	9.162
50%	9.355	5.580	8.294	15.016
75%	14.608	9.547	12.392	18.544
90%	27.236	10.328	30.053	27.236
95%	30.053	10.328	30.053	27.236
Max	30.053	10.328	30.053	27.236

Table CB4. Summary statistics for hands only dermal exposure (mg) using empirical sampling model

Statistic	All	Target Quat: 440 ppm	Target Quat: 880 ppm	Target Quat: 1760 ppm
Arithmetic Mean	10.608	5.927	11.329	14.567
Arithmetic Standard Deviation	7.987	3.468	9.706	8.059
Geometric Mean	8.114	4.995	8.829	12.115
Geometric Standard Deviation	2.171	1.959	2.096	2.113
Min	1.983	1.983	3.924	3.142

Statistic	All	Target Quat: 440 ppm	Target Quat: 880 ppm	Target Quat: 1760 ppm
5%	1.983	1.983	3.924	3.142
10%	2.661	1.983	3.924	3.142
25%	4.645	2.661	5.251	9.087
50%	9.294	5.555	8.222	14.983
75%	14.578	9.500	12.381	18.456
90%	26.750	10.310	29.972	26.750
95%	29.972	10.310	29.972	26.750
Max	29.972	10.310	29.972	26.750

Table CB5. Summary statistics for inhalation concentration exposure (mg/m^3) using empirical sampling model

Statistic	All	Target Quat: 440 ppm	Target Quat: 880 ppm	Target Quat: 1760 ppm
Arithmetic Mean	4.517E-04	1.719E-04	6.493E-04	5.338E-04
Arithmetic Standard Deviation	6.728E-04	9.615E-05	1.107E-03	3.947E-04
Geometric Mean	2.638E-04	1.487E-04	2.983E-04	4.137E-04
Geometric Standard Deviation	2.568E+00	1.862E+00	3.170E+00	2.240E+00
Min	5.168E-05	5.168E-05	1.475E-04	1.493E-04
5%	5.168E-05	5.168E-05	1.475E-04	1.493E-04
10%	1.376E-04	5.168E-05	1.475E-04	1.493E-04
25%	1.478E-04	1.376E-04	1.491E-04	1.933E-04
50%	2.045E-04	1.448E-04	1.918E-04	4.088E-04
75%	4.016E-04	2.157E-04	3.110E-04	9.577E-04
90%	1.085E-03	3.368E-04	2.905E-03	1.085E-03
95%	2.905E-03	3.368E-04	2.905E-03	1.085E-03
Max	2.905E-03	3.368E-04	2.905E-03	1.085E-03

Table CB6. Summary statistics for inhalation dose exposure (mg) using empirical sampling model

Statistic	All	Target Quat: 440 ppm	Target Quat: 880 ppm	Target Quat: 1760 ppm
Arithmetic Mean	2.625E-04	1.050E-04	3.115E-04	3.709E-04
Arithmetic Standard Deviation	3.184E-04	6.819E-05	3.833E-04	3.825E-04
Geometric Mean	1.556E-04	8.821E-05	1.774E-04	2.408E-04

Statistic	All	Target Quat: 440 ppm	Target Quat: 880 ppm	Target Quat: 1760 ppm
Geometric Standard Deviation	2.766E+00	1.903E+00	3.201E+00	2.877E+00
Min	4.963E-05	4.963E-05	4.970E-05	4.978E-05
5%	4.963E-05	4.963E-05	4.970E-05	4.978E-05
10%	4.970E-05	4.963E-05	4.970E-05	4.978E-05
25%	5.163E-05	5.045E-05	5.163E-05	1.339E-04
50%	1.540E-04	8.197E-05	1.931E-04	2.579E-04
75%	3.161E-04	1.503E-04	3.161E-04	4.228E-04
90%	1.065E-03	2.157E-04	1.065E-03	1.103E-03
95%	1.103E-03	2.157E-04	1.065E-03	1.103E-03
Max	1.103E-03	2.157E-04	1.065E-03	1.103E-03

Table CB7. Summary statistics for inhalation time-weighted average concentration exposure (mg/m^3) using empirical sampling model

Statistic	All	Target Quat: 440 ppm	Target Quat: 880 ppm	Target Quat: 1760 ppm
Arithmetic Mean	3.281E-05	1.313E-05	3.893E-05	4.636E-05
Arithmetic Standard Deviation	3.979E-05	8.524E-06	4.791E-05	4.781E-05
Geometric Mean	1.945E-05	1.103E-05	2.217E-05	3.010E-05
Geometric Standard Deviation	2.766E+00	1.903E+00	3.201E+00	2.877E+00
Min	6.203E-06	6.203E-06	6.213E-06	6.222E-06
5%	6.203E-06	6.203E-06	6.213E-06	6.222E-06
10%	6.213E-06	6.203E-06	6.213E-06	6.222E-06
25%	6.453E-06	6.307E-06	6.453E-06	1.674E-05
50%	1.925E-05	1.025E-05	2.414E-05	3.223E-05
75%	3.952E-05	1.879E-05	3.952E-05	5.285E-05
90%	1.331E-04	2.697E-05	1.331E-04	1.379E-04
95%	1.379E-04	2.697E-05	1.331E-04	1.379E-04
Max	1.379E-04	2.697E-05	1.331E-04	1.379E-04

The results show the high proportions of the dermal exposure from hands only. For All and for each concentration group, based on the arithmetic means, the overall percentages of the exposure from hands only are 100% of the Long Dermal, 99% of the Short Dermal, and between 99 and 100% of the Long Short Dermal.

Compare Concentration Groups

The results in Tables CB1 to CB7 show some differences between the normalized exposure statistics for the three concentration groups "Target Quat: 440 ppm," "Target Quat: 880 ppm," and "Target Quat: 1760 ppm." To compare these groups, an analysis of variance was performed to test whether the geometric means were statistically significantly different at the 5% significance level.

The p-values for these ANOVA tests are shown in Table CB8. These analyses show that there were no statistically significant differences (at the 5% significance level) between the three concentration groups for any of the exposure modes.

Table CB8. P-values for testing differences in geometric means for different concentration groups

Exposure Route	ANOVA	Welch's ANOVA
Long Dermal	0.133	0.152
Short Dermal	0.129	0.148
Long Short Dermal	0.128	0.148
Hands Only	0.132	0.152
Inhalation Conc	0.160	0.098
Inhalation Dose	0.224	0.171
Inhalation 8-hr TWA	0.224	0.171

Statistical Models

Table CB9 presents the arithmetic mean and 95th percentile estimates from the lognormal simple random sampling model, together with 95% confidence intervals, for each of the exposure routes, for all concentration groups combined. These are the values of AMu and P95u. The other summary statistics are presented in more detail below.

Table CB9. Arithmetic mean and 95th percentile estimates from lognormal simple random sampling model for exposure for All

Exposure Route	Clothing	Arithmetic Mean (95% Confidence Interval)	95th Percentile (95% Confidence Interval)
Dermal (mg)	Long Dermal	10.97 (7.36, 16.85)	29.06 (16.58, 50.57)
	Short Dermal	11.06 (7.43, 16.97)	29.26 (16.72, 50.88)
	Long Short Dermal	11.02 (7.40, 16.88)	29.10 (16.64, 50.53)
	Hands Only	10.96 (7.35, 16.84)	29.05 (16.57, 50.58)
Inhalation Concentration (mg/m^3)		4.11×10^{-4} (2.47×10^{-4}, 7.13×10^{-4})	1.24×10^{-3} (6.28×10^{-4}, 2.44×10^{-3})
Inhalation Dose (mg)		2.61×10^{-4} (1.49×10^{-4}, 4.80×10^{-4})	8.30×10^{-4} (3.97×10^{-4}, 1.72×10^{-3})

Exposure Route	Clothing	Arithmetic Mean (95% Confidence Interval)	95th Percentile (95% Confidence Interval)
Inhalation 8-hr TWA (mg/m^3)		3.26×10^{-5} (1.86×10^{-5}, 5.99×10^{-5})	1.04×10^{-4} (4.96×10^{-5}, 2.15×10^{-4})

Non-detects

For all the analyses presented in this memorandum except for Table CB10, measurements below the LOQ or LOD were replaced by the mid-value, the midpoint of the lowest and highest possible value for that measurement. In Table CB10 we investigated the impact on the summary statistics of the censored values.

Table CB10. Exposure summary statistics calculated using alternative estimated exposures for values below the LOQ

Exposure Route	Method for Substituting Values Below the LOQ	Arithmetic Mean	95th Percentile
Long Dermal (mg)	Substitute mid value	10.97 (7.36, 16.85)	29.06 (16.58, 50.57)
	Substitute max value	10.97 (7.36, 16.85)	29.06 (16.58, 50.57)
	Substitute min value	10.97 (7.36, 16.85)	29.06 (16.58, 50.57)
	Censored data MLE	10.79 (7.33, 16.35)	28.03 (16.25, 48.03)
Short Dermal (mg)	Substitute mid value	11.06 (7.43, 16.97)	29.26 (16.72, 50.88)
	Substitute max value	11.07 (7.43, 16.97)	29.25 (16.72, 50.83)
	Substitute min value	11.06 (7.42, 16.98)	29.27 (16.72, 50.92)
	Censored data MLE	10.88 (7.40, 16.47)	28.23 (16.39, 48.33)
Long Short Dermal (mg)	Substitute mid value	11.02 (7.40, 16.88)	29.10 (16.65, 50.52)
	Substitute max value	11.02 (7.40, 16.88)	29.10 (16.65, 50.52)
	Substitute min value	11.01 (7.40, 16.88)	29.10 (16.64, 50.54)
	Censored data MLE	10.83 (7.37, 16.38)	28.08 (16.31, 48.00)
Hands Only (mg)	Substitute mid value	10.96 (7.35, 16.84)	29.05 (16.57, 50.58)
	Substitute max value	10.96 (7.35, 16.84)	29.05 (16.57, 50.58)
	Substitute min value	10.96 (7.35, 16.84)	29.05 (16.57, 50.58)
	Censored data MLE	10.78 (7.32, 16.34)	28.02 (16.24, 48.04)
Inhalation Concentration (mg/m^3)	Substitute mid value	4.11×10^{-4} (2.47×10^{-4}, 7.13×10^{-4})	1.24×10^{-3} (6.28×10^{-4}, 2.44×10^{-3})
	Substitute max value	4.54×10^{-4} (3.02×10^{-4}, 7.06×10^{-4})	1.24×10^{-3} (6.28×10^{-4}, 2.44×10^{-3})
	Substitute min value	5.81×10^{-4} (3.59×10^{-4}, 9.73×10^{-4})	1.70×10^{-3} (8.87×10^{-4}, 3.23×10^{-3})
	Censored data MLE	4.18×10^{-4} (2.43×10^{-4}, 7.53×10^{-4})	1.31×10^{-3} (6.37×10^{-4}, 2.66×10^{-3})
Inhalation Dose (mg)	Substitute mid value	2.61×10^{-4} (1.49×10^{-4}, 4.80×10^{-4})	8.30×10^{-4} (3.97×10^{-4}, 1.72×10^{-3})
	Substitute max value	2.64×10^{-4} (1.77×10^{-4}, 4.06×10^{-4})	6.99×10^{-4} (3.99×10^{-4}, 1.22×10^{-3})
	Substitute min value	3.62×10^{-4} (2.46×10^{-4}, 5.47×10^{-4})	9.38×10^{-4} (5.45×10^{-4}, 1.61×10^{-3})

Exposure Route	Method for Substituting Values Below the LOQ	Arithmetic Mean	95th Percentile
	Censored data MLE	2.67×10^{-4} (1.50×10^{-4}, 4.98×10^{-4})	8.58×10^{-4} (4.05×10^{-4}, 1.80×10^{-3})
Inhalation 8-hr TWA (mg/m^3)	Substitute mid value	3.26×10^{-5} (1.86×10^{-5}, 5.99×10^{-5})	1.04×10^{-4} (4.96×10^{-5}, 2.15×10^{-4})
	Substitute max value	3.30×10^{-5} (2.22×10^{-5}, 5.07×10^{-5})	8.74×10^{-5} (4.99×10^{-5}, 1.52×10^{-4})
	Substitute min value	4.53×10^{-5} (3.08×10^{-5}, 6.84×10^{-5})	1.17×10^{-4} (6.81×10^{-5}, 2.01×10^{-4})
	Censored data MLE	3.34×10^{-5} (1.88×10^{-5}, 6.22×10^{-5})	1.07×10^{-4} (5.06×10^{-5}, 2.25×10^{-4})

The results in Table CB10 for dermal exposure show very small impacts of the alternative substitution approaches for treating values below the LOQ on the unit exposure arithmetic mean and 95th percentile. This is mainly because the dermal exposure is dominated by the hand exposures which were all above the LOQ. For inhalation exposure, the results show some larger impacts of the max and min value substitution methods compared to substituting the mid value, but the results for the censored data MLE are very similar to the results for substituting the mid value.

Detailed Summary Statistics with Confidence Intervals and Fold Relative Accuracy

Tables CB11 to CB17 present the estimates, parametric and non-parametric confidence intervals and fold relative accuracy values for all the summary statistics for the All group. All these analyses use non-detects substituted by the mid-value.

Table CB11. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the long dermal exposure (mg) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.17	1.68	2.82	1.30	1.72	2.55	1.23
GMs	8.13	5.72	11.75	1.43	5.76	11.44	1.41
AMs	10.62	7.20	16.60	1.51	7.27	14.33	1.41
AMu	10.97	7.36	16.85	1.51	7.33	15.22	1.45
P95s	30.02	16.48	82.07	2.36	15.40	30.02	1.63
P95u	29.06	16.58	50.57	1.75	16.98	42.53	1.61

Table CB12. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the short dermal exposure (mg) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.17	1.68	2.82	1.30	1.72	2.54	1.23
GMs	8.20	5.77	11.85	1.43	5.82	11.54	1.41
AMs	10.73	7.27	16.72	1.51	7.33	14.50	1.41
AMu	11.06	7.43	16.97	1.51	7.40	15.38	1.45
P95s	30.37	16.61	82.51	2.36	15.47	30.37	1.64
P95u	29.26	16.72	50.88	1.74	17.03	43.05	1.62

Table CB13. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the long short dermal exposure (mg) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.16	1.67	2.81	1.30	1.72	2.54	1.23
GMs	8.18	5.76	11.80	1.43	5.81	11.50	1.41
AMs	10.68	7.25	16.63	1.51	7.31	14.40	1.41
AMu	11.02	7.40	16.88	1.51	7.37	15.29	1.45
P95s	30.05	16.54	81.86	2.36	15.42	30.05	1.62
P95u	29.10	16.64	50.53	1.74	16.99	42.67	1.61

Table CB14. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the hands only exposure (mg) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.17	1.68	2.82	1.30	1.72	2.55	1.23
GMs	8.11	5.70	11.73	1.43	5.75	11.42	1.41
AMs	10.61	7.19	16.59	1.51	7.26	14.31	1.41
AMu	10.96	7.35	16.84	1.51	7.32	15.20	1.45
P95s	29.97	16.46	82.14	2.37	15.39	29.97	1.62
P95u	29.05	16.57	50.58	1.75	16.97	42.53	1.61

Table CB15. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the inhalation concentration exposure (mg/m^3) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.57E+00	1.88E+00	3.54E+00	1.37	1.67E+00	3.49E+00	1.48
GMs	2.64E-04	1.72E-04	4.13E-04	1.55	1.78E-04	4.11E-04	1.52
AMs	4.52E-04	2.39E-04	6.98E-04	1.78	2.16E-04	7.90E-04	1.95
AMu	4.11E-04	2.47E-04	7.13E-04	1.70	2.16E-04	7.98E-04	1.92
P95s	2.90E-03	6.24E-04	4.40E-03	4.22	4.16E-04	2.90E-03	3.03
P95u	1.24E-03	6.28E-04	2.44E-03	1.97	4.54E-04	2.79E-03	2.53

Table CB16. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the normalized inhalation dose exposure (mg) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.77E+00	1.97E+00	3.91E+00	1.41	2.00E+00	3.47E+00	1.33
GMs	1.56E-04	9.80E-05	2.52E-04	1.60	1.00E-04	2.49E-04	1.58
AMs	2.62E-04	1.43E-04	4.69E-04	1.81	1.38E-04	4.20E-04	1.76
AMu	2.61E-04	1.49E-04	4.80E-04	1.80	1.38E-04	4.65E-04	1.84
P95s	1.10E-03	3.94E-04	3.25E-03	2.86	3.19E-04	1.10E-03	2.61
P95u	8.30E-04	3.97E-04	1.72E-03	2.08	3.55E-04	1.61E-03	2.16

Table CB17. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the normalized inhalation time-weighted average concentration exposure (mg/m^3) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.77E+00	1.97E+00	3.91E+00	1.41	2.00E+00	3.47E+00	1.33
GMs	1.95E-05	1.22E-05	3.15E-05	1.60	1.25E-05	3.12E-05	1.58
AMs	3.28E-05	1.79E-05	5.87E-05	1.81	1.73E-05	5.25E-05	1.76
AMu	3.26E-05	1.86E-05	5.99E-05	1.80	1.72E-05	5.82E-05	1.84
P95s	1.38E-04	4.92E-05	4.06E-04	2.86	3.99E-05	1.38E-04	2.61
P95u	1.04E-04	4.96E-05	2.15E-04	2.08	4.44E-05	2.01E-04	2.16

Tables CB11 to CB17 show that the study benchmark design value of 3 for the fold relative accuracy was met in every case, with the exception of the empirical 95th percentile for the inhalation concentration.

Empirical Quantile Plots

Quantile-quantile plots of the exposure values were used to evaluate whether the data were lognormally distributed, as implied by the assumed statistical lognormal models. These plots were intended to help determine whether the data supported using untransformed normalized exposure values or log-transformed values or neither.

In each case the quantile-quantile plot compared the observed quantiles of the measured values with the corresponding quantiles of a normal or lognormal distribution. A perfect fit would imply that the plotted values lie in a straight line. The quantile-quantile plots for all exposure routes are presented in Figures CB1 to CB14. In all cases the plots seem to show a better fit for the lognormal distributions, supporting the use of the log-transformed exposure values over the untransformed values.

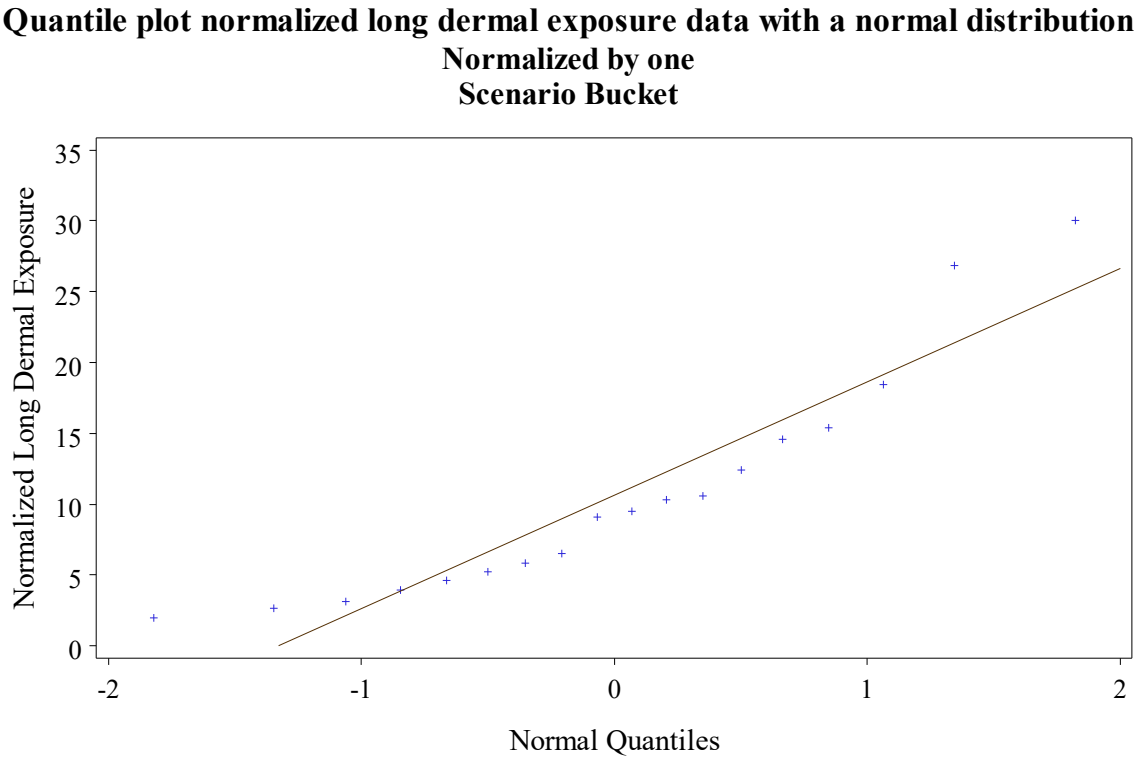


Figure CB1. Empirical quantile plot for Long Dermal, with a normal distribution

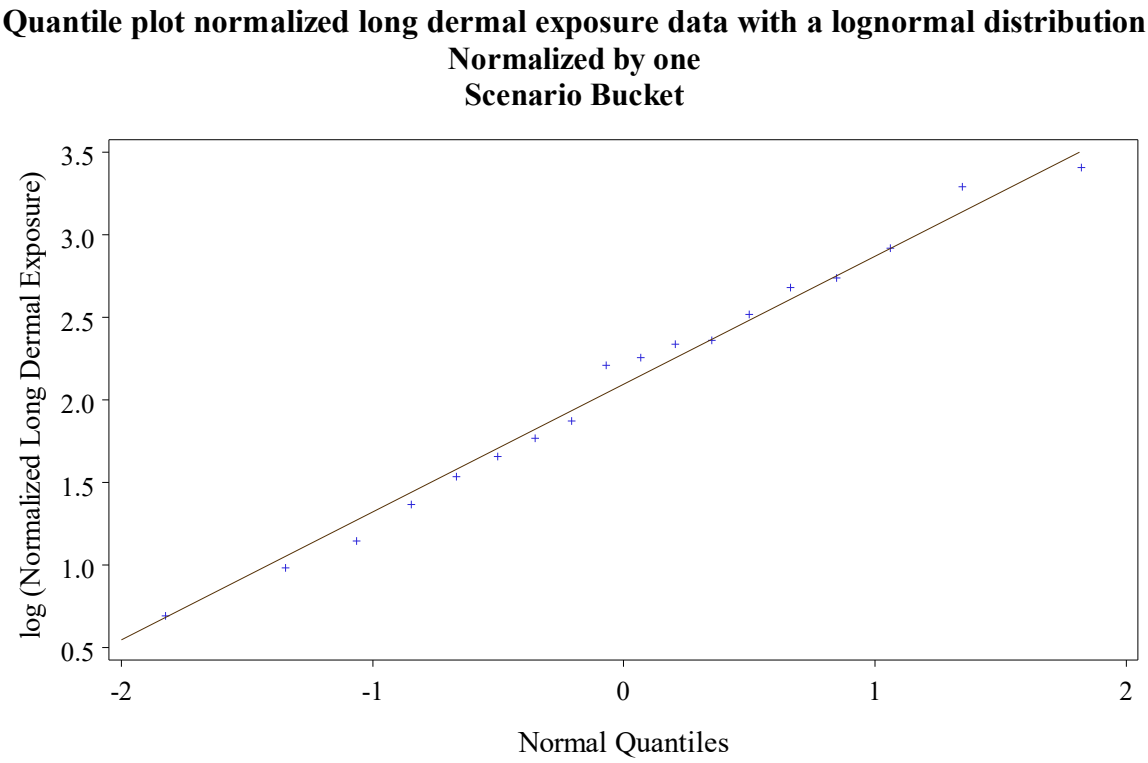


Figure CB2. Empirical quantile plot for Long Dermal, with a lognormal distribution

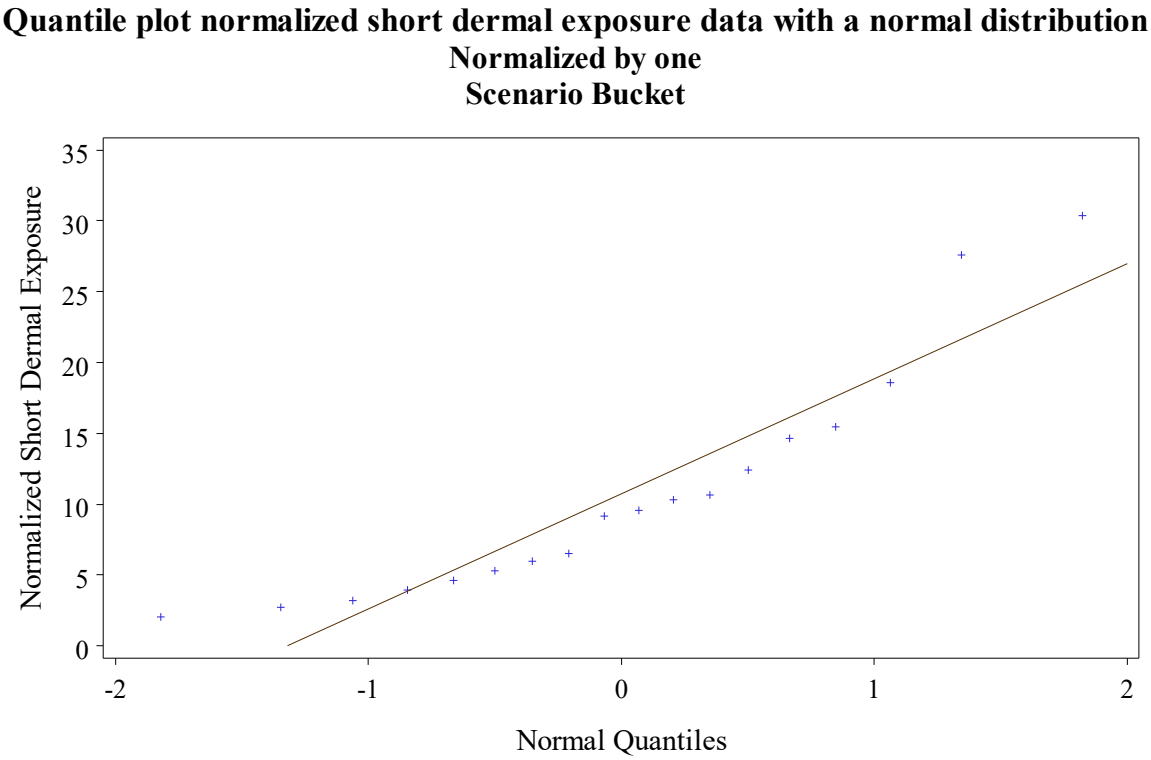


Figure CB3. Empirical quantile plot for Short Dermal, with a normal distribution

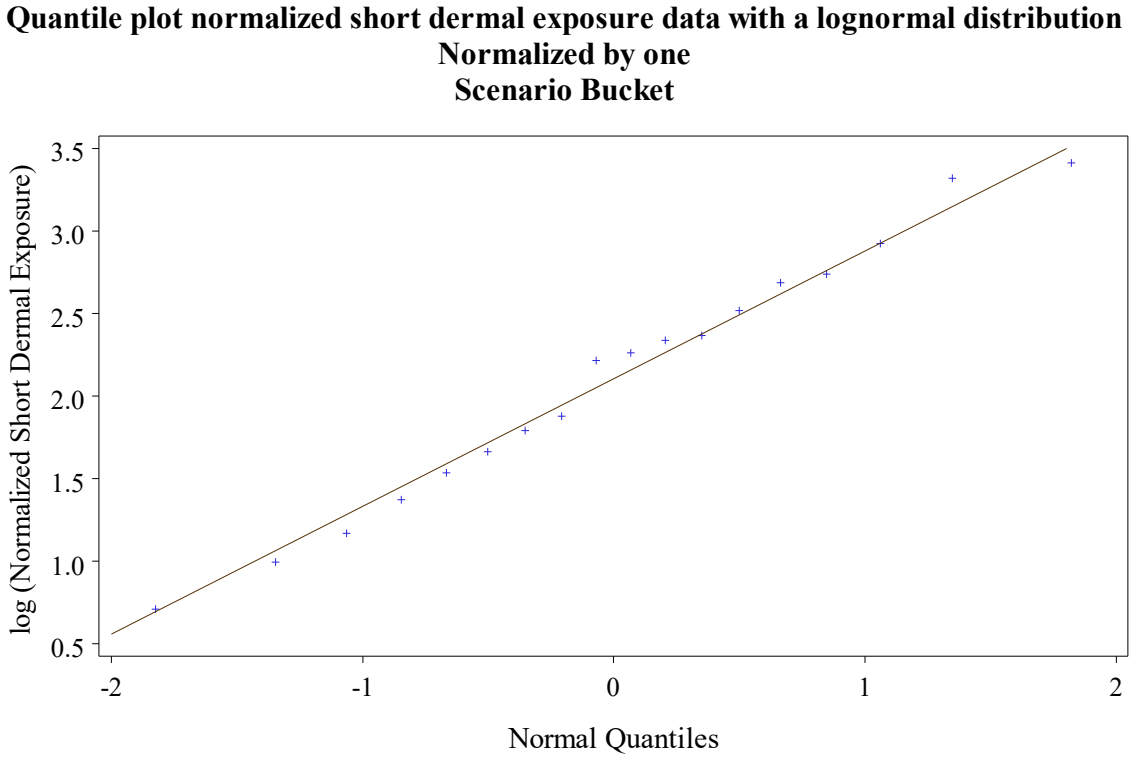


Figure CB4. Empirical quantile plot for Short Dermal, with a lognormal distribution

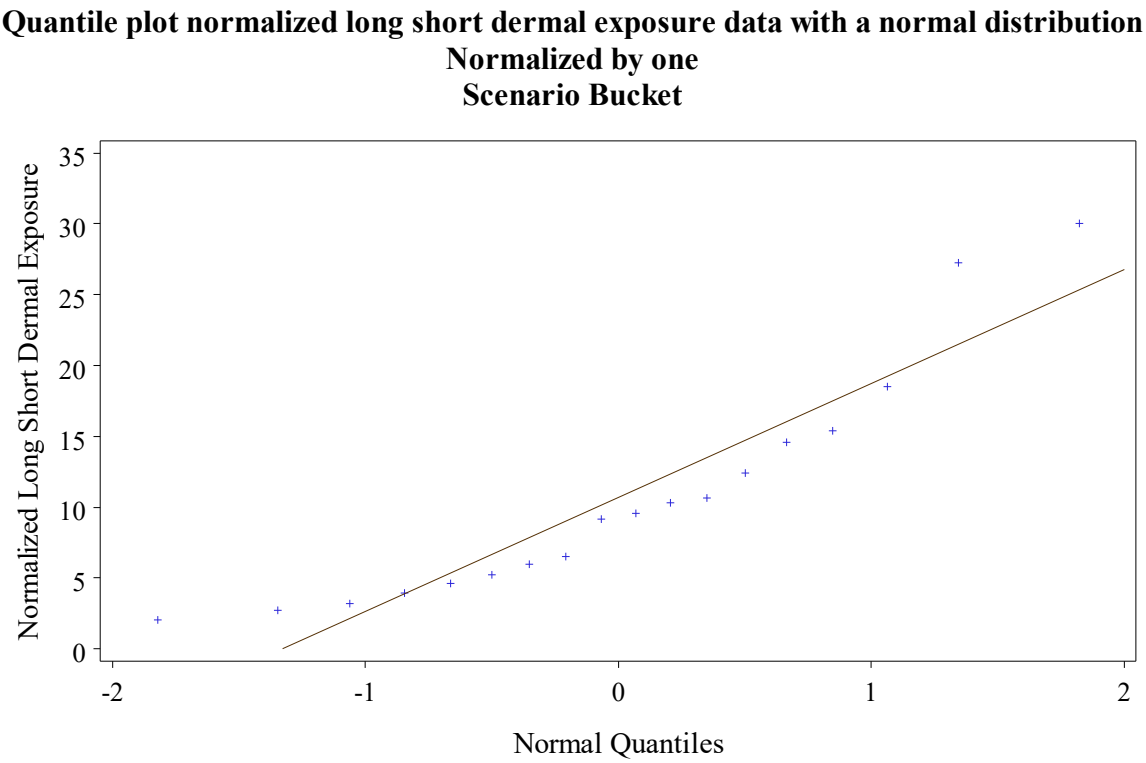


Figure CB5. Empirical quantile plot for Long Short Dermal, with a normal distribution

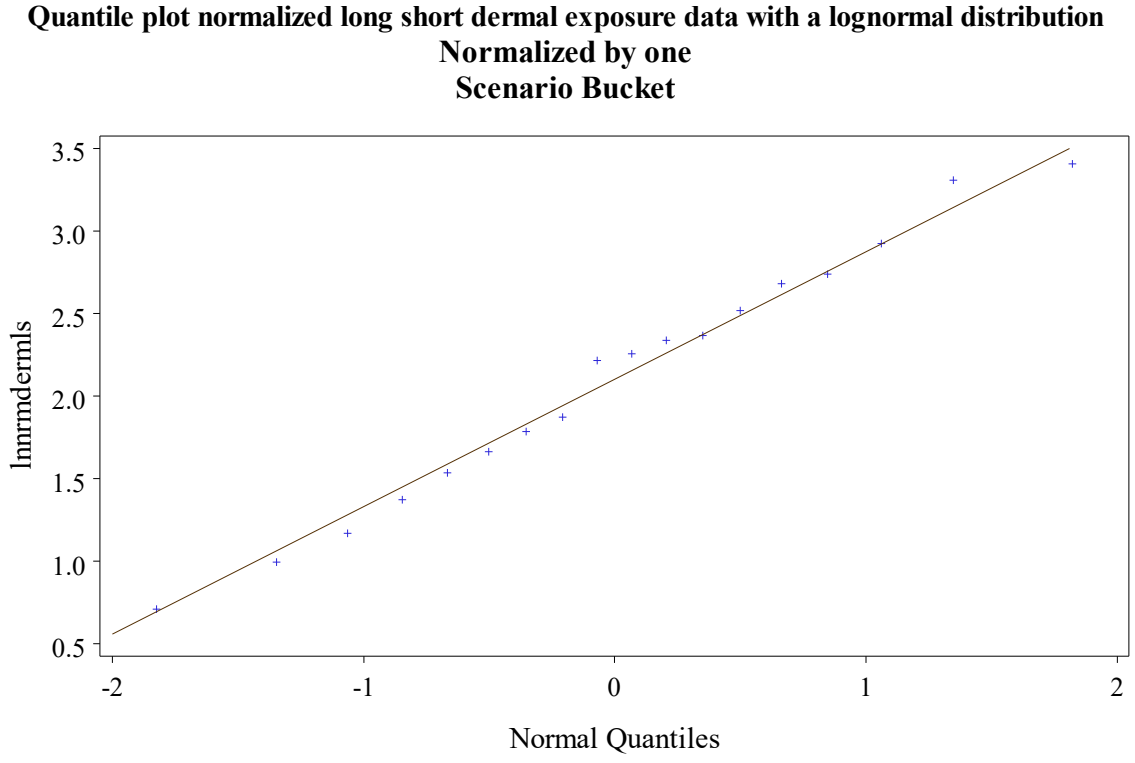


Figure CB6. Empirical quantile plot for Long Short Dermal, with a lognormal distribution

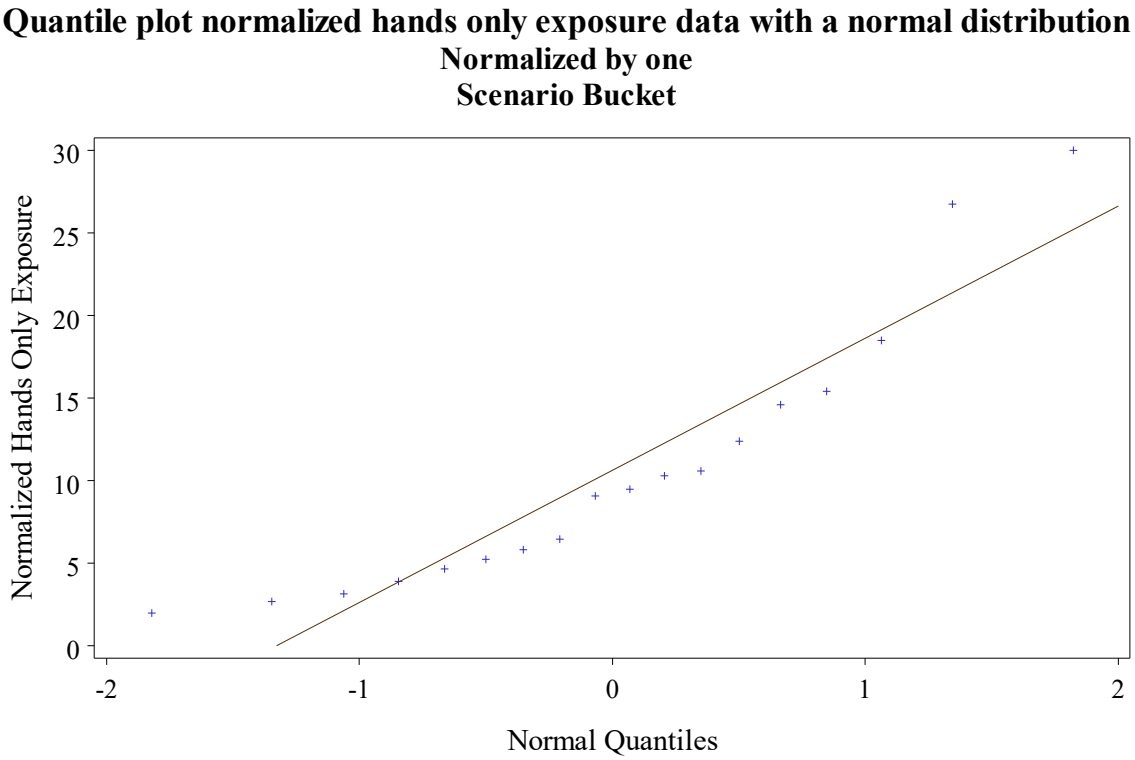


Figure CB7. Empirical quantile plot for Hands Only, with a normal distribution

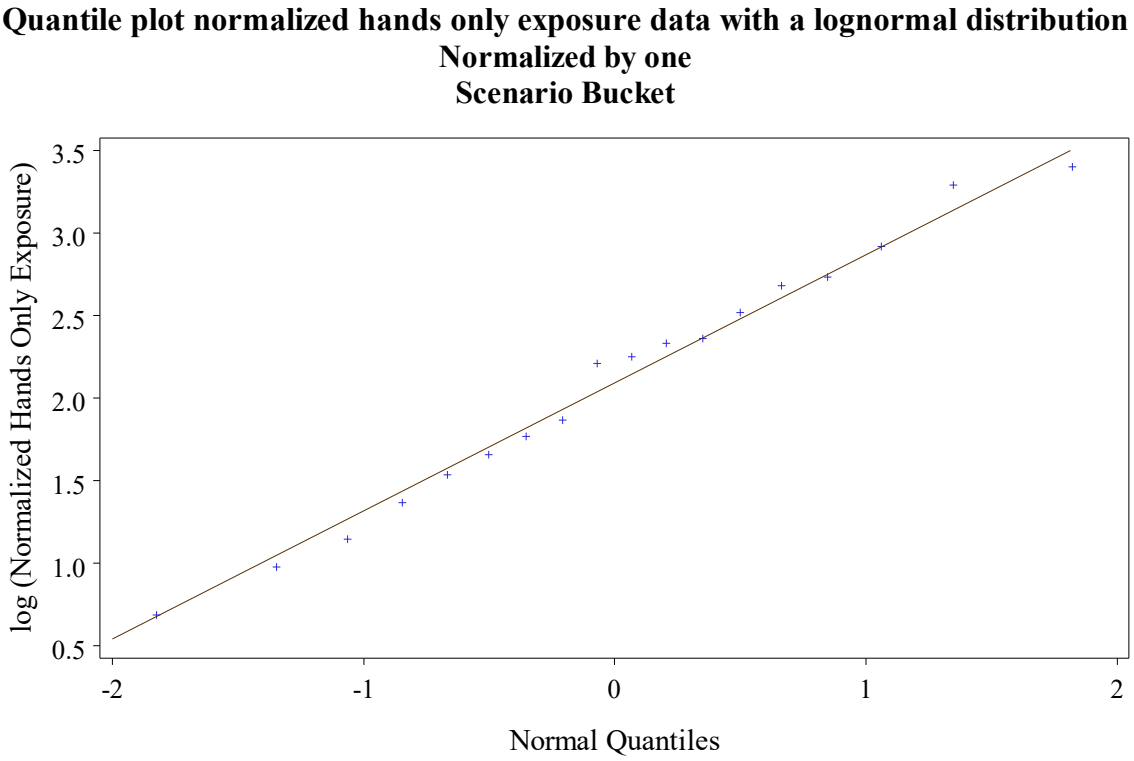


Figure CB8. Empirical quantile plot for Hands Only, with a lognormal distribution

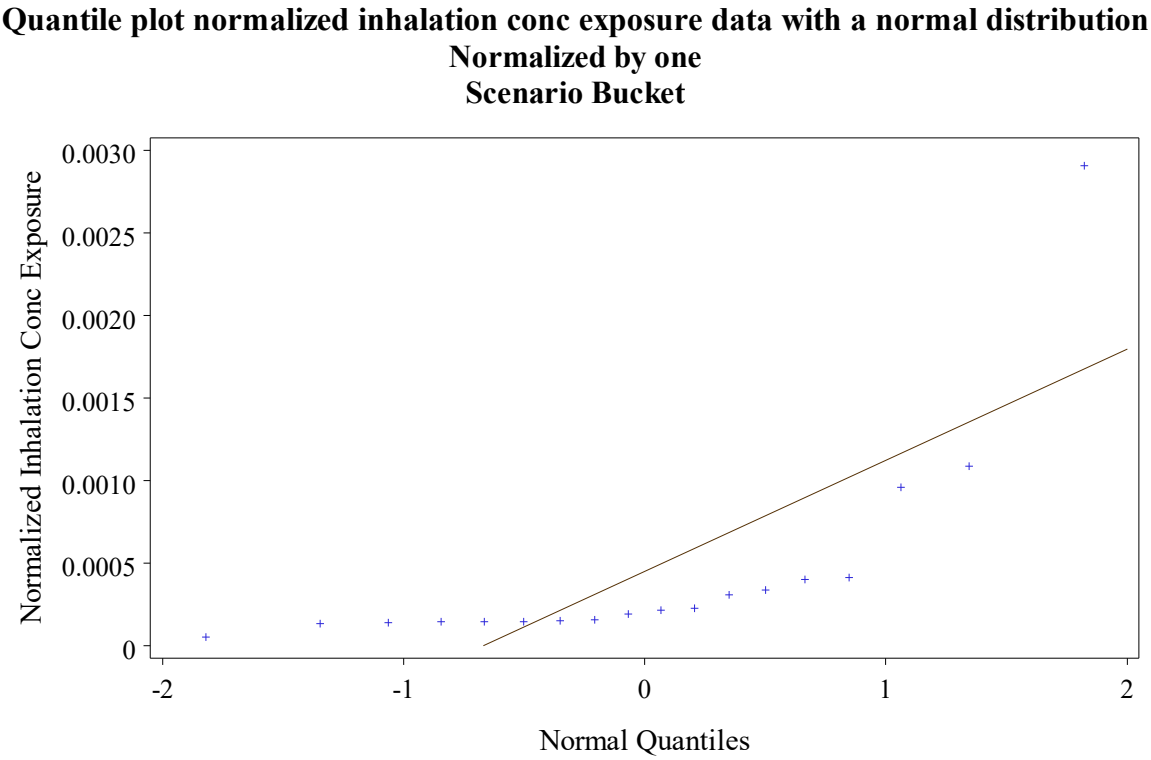


Figure CB9. Empirical quantile plot for Inhalation Concentration, with a normal distribution

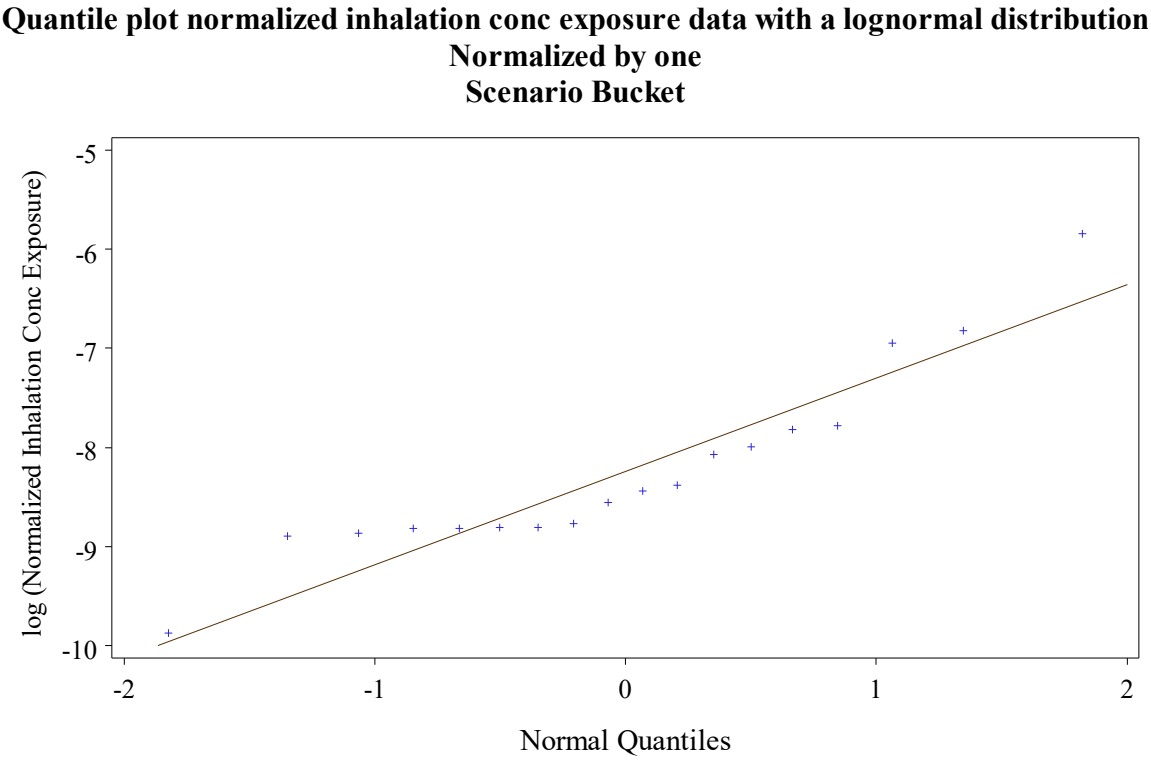


Figure CB10. Empirical quantile plot for Inhalation Concentration, with a lognormal distribution

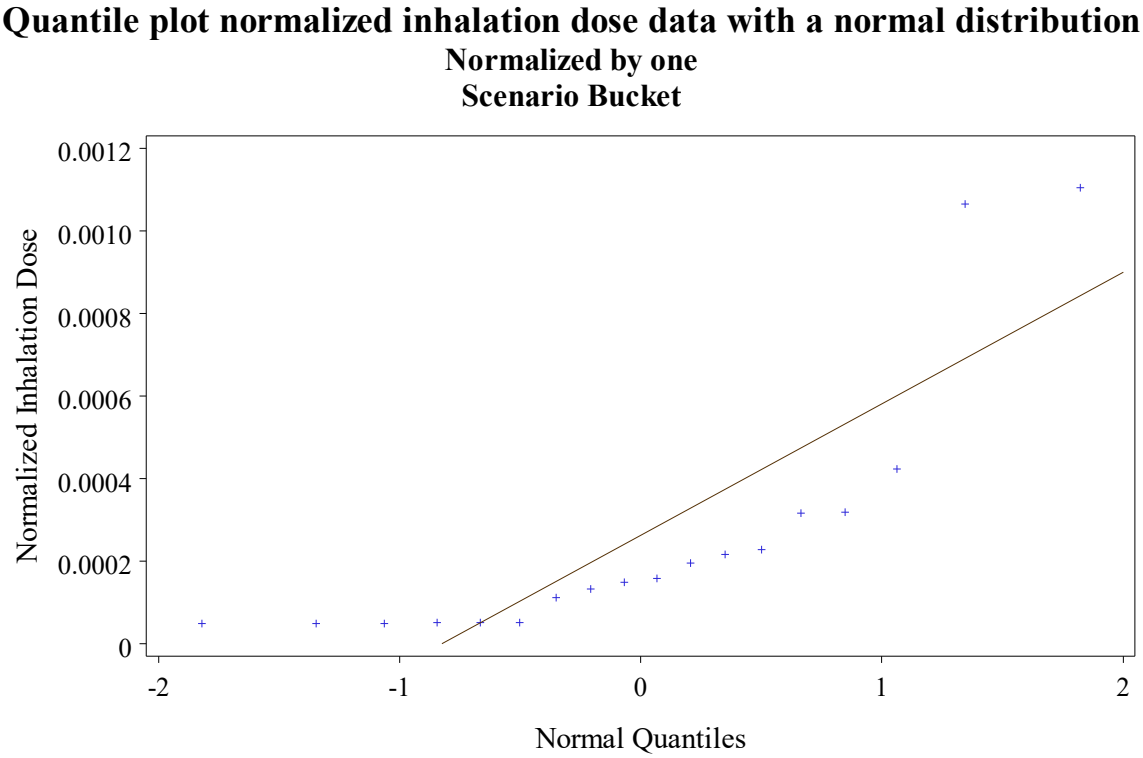


Figure CB11. Empirical quantile plot for Inhalation Dose, with a normal distribution

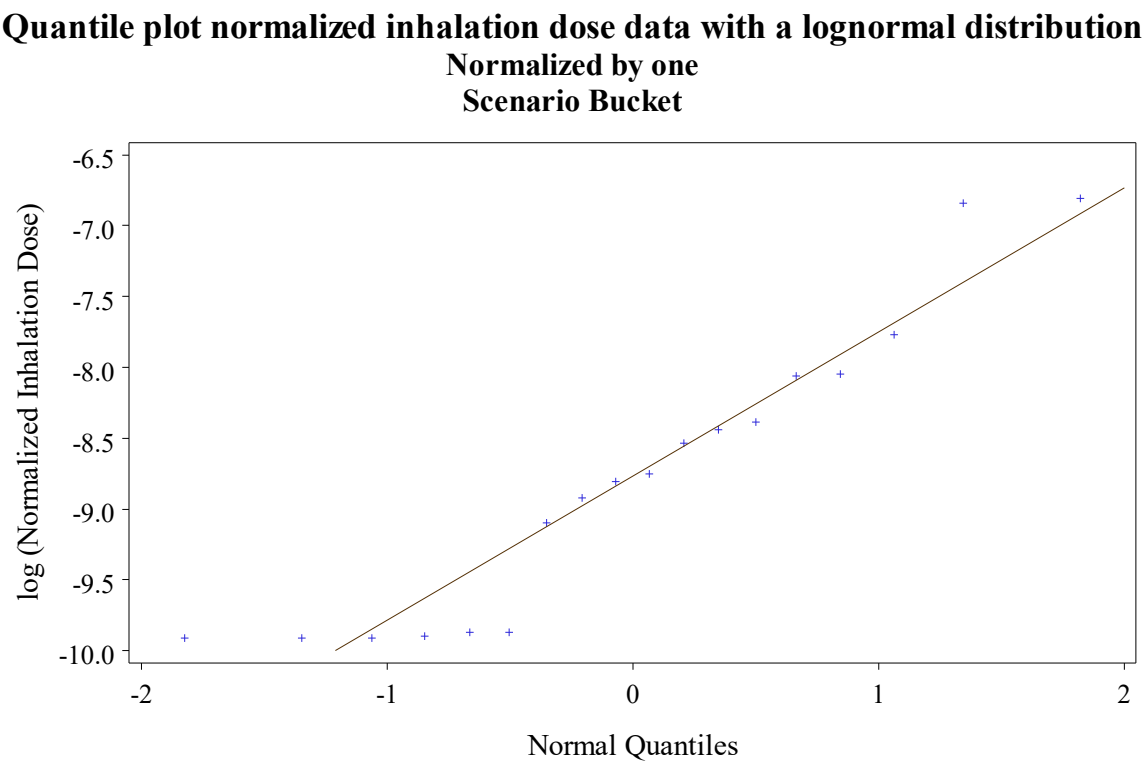


Figure CB12. Empirical quantile plot for Inhalation Dose, with a lognormal distribution

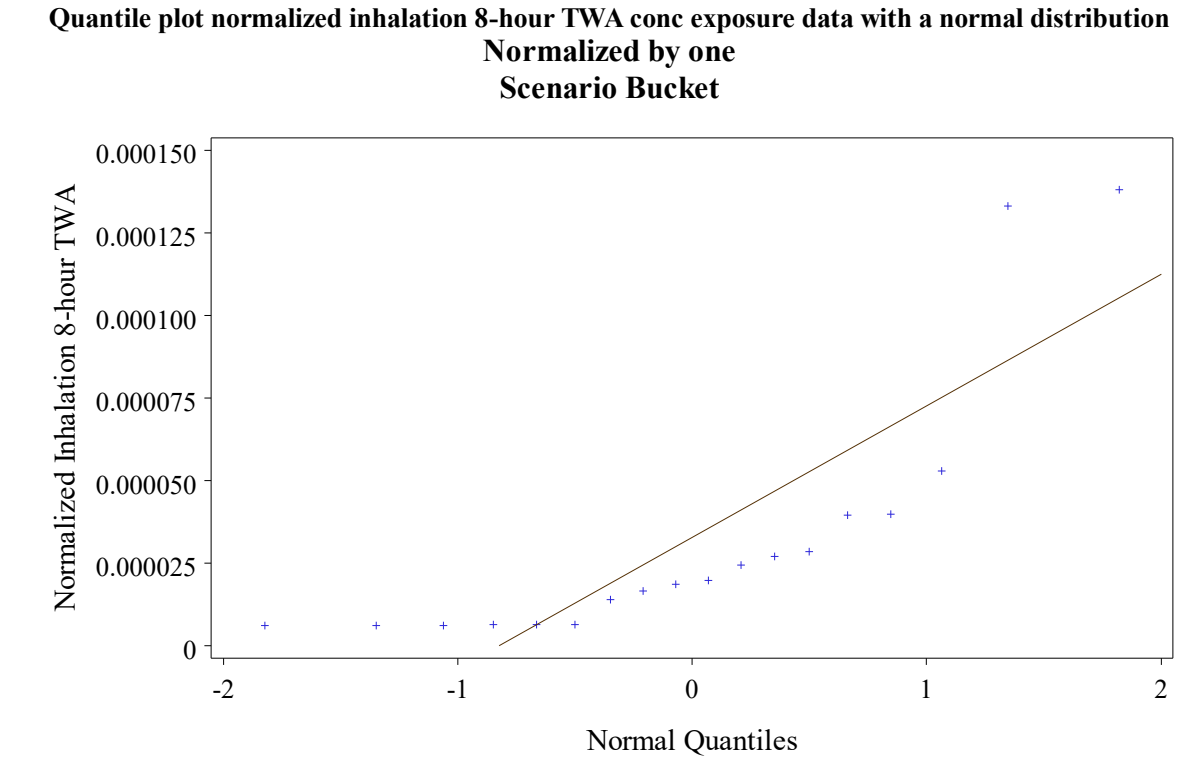


Figure CB13. Empirical quantile plot for Inhalation Time-weighted Average Conc, with a normal distribution

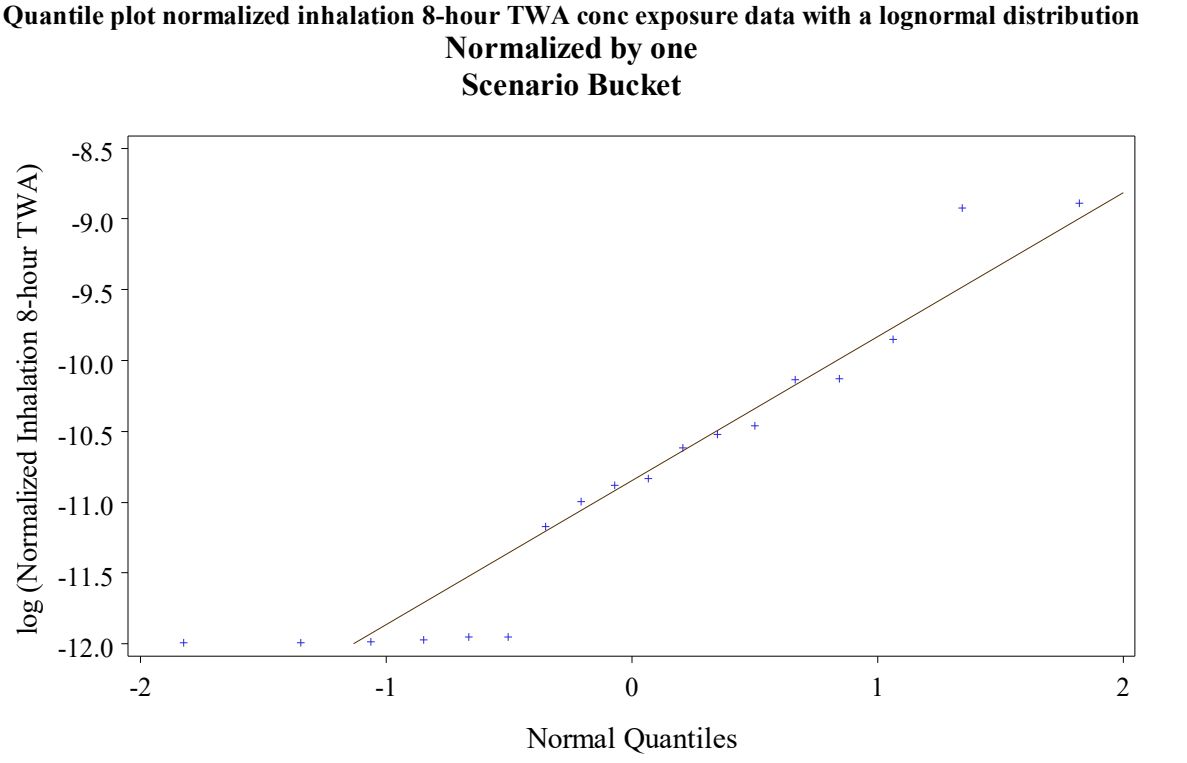


Figure CB14. Empirical quantile plot for Inhalation Time-weighted Average Conc, with a lognormal distribution

10. Normalizing Factor One, Sink Scenario

Summary Statistics of Exposure

Tables CS1 to CS7 summarize the (unnormalized) exposure data with the summary statistics from the 18 (all concentrations), or 6 (specific concentrations) measurements for each concentration group, and each dermal and inhalation exposure route. The unnormalized exposure is the same as the exposure normalized by one. These analyses assume that the exposure measurements within each subset come from some unspecified distribution for that subset.

Table CS1. Summary statistics for long dermal exposure (mg) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	5.489	1.001	6.226	9.239
Arithmetic Standard Deviation	4.337	0.598	2.515	3.945
Geometric Mean	3.554	0.903	5.806	8.564
Geometric Standard Deviation	2.971	1.573	1.514	1.534
Min	0.685	0.685	3.207	5.077
5%	0.685	0.685	3.207	5.077
10%	0.700	0.685	3.207	5.077
25%	0.935	0.700	4.099	5.593
50%	5.335	0.741	6.425	8.723
75%	8.329	0.935	6.781	11.748
90%	11.748	2.206	10.415	15.570
95%	15.570	2.206	10.415	15.570
Max	15.570	2.206	10.415	15.570

Table CS2. Summary statistics for short dermal exposure (mg) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	5.861	1.085	6.624	9.874
Arithmetic Standard Deviation	4.613	0.627	2.677	4.170
Geometric Mean	3.822	0.984	6.189	9.165
Geometric Standard Deviation	2.937	1.554	1.501	1.528
Min	0.727	0.727	3.619	5.634
5%	0.727	0.727	3.619	5.634
10%	0.765	0.727	3.619	5.634

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
25%	1.000	0.765	4.202	5.869
50%	5.752	0.833	6.828	9.173
75%	8.771	1.000	7.107	13.096
90%	13.096	2.350	11.162	16.297
95%	16.297	2.350	11.162	16.297
Max	16.297	2.350	11.162	16.297

Table CS3. Summary statistics for long short dermal exposure (mg) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	5.813	1.053	6.579	9.809
Arithmetic Standard Deviation	4.603	0.635	2.679	4.173
Geometric Mean	3.753	0.947	6.143	9.092
Geometric Standard Deviation	2.985	1.581	1.503	1.534
Min	0.711	0.711	3.583	5.589
5%	0.711	0.711	3.583	5.589
10%	0.731	0.711	3.583	5.589
25%	0.995	0.731	4.183	5.741
50%	5.665	0.773	6.785	9.129
75%	8.755	0.995	6.990	13.058
90%	13.058	2.332	11.148	16.208
95%	16.208	2.332	11.148	16.208
Max	16.208	2.332	11.148	16.208

Table CS4. Summary statistics for hands only dermal exposure (mg) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	5.371	0.937	5.971	9.204
Arithmetic Standard Deviation	4.378	0.633	2.723	3.962
Geometric Mean	3.351	0.815	5.419	8.520
Geometric Standard Deviation	3.137	1.705	1.654	1.540
Min	0.481	0.481	2.383	5.061

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
5%	0.481	0.481	2.383	5.061
10%	0.617	0.481	2.383	5.061
25%	0.933	0.617	4.089	5.494
50%	5.278	0.700	6.094	8.694
75%	8.278	0.933	6.778	11.722
90%	11.722	2.189	10.389	15.556
95%	15.556	2.189	10.389	15.556
Max	15.556	2.189	10.389	15.556

Table CS5. Summary statistics for inhalation concentration exposure (mg/m^3) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	1.54E-04	1.92E-04	1.53E-04	1.16E-04
Arithmetic Standard Deviation	1.26E-04	8.30E-05	2.03E-04	4.88E-05
Geometric Mean	1.19E-04	1.80E-04	8.75E-05	1.06E-04
Geometric Standard Deviation	2.11E+00	1.46E+00	2.97E+00	1.61E+00
Min	2.54E-05	1.26E-04	2.54E-05	4.85E-05
5%	2.54E-05	1.26E-04	2.54E-05	4.85E-05
10%	4.85E-05	1.26E-04	2.54E-05	4.85E-05
25%	8.09E-05	1.43E-04	4.99E-05	8.38E-05
50%	1.34E-04	1.53E-04	6.57E-05	1.10E-04
75%	1.65E-04	2.38E-04	1.55E-04	1.65E-04
90%	3.42E-04	3.42E-04	5.58E-04	1.78E-04
95%	5.58E-04	3.42E-04	5.58E-04	1.78E-04
Max	5.58E-04	3.42E-04	5.58E-04	1.78E-04

Table CS6. Summary statistics for inhalation dose exposure (mg) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	2.18E-04	2.85E-04	2.00E-04	1.69E-04
Arithmetic Standard Deviation	1.47E-04	1.29E-04	2.11E-04	6.38E-05
Geometric Mean	1.70E-04	2.59E-04	1.24E-04	1.53E-04

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Geometric Standard Deviation	2.17E+00	1.64E+00	2.91E+00	1.75E+00
Min	4.99E-05	1.35E-04	4.99E-05	5.01E-05
5%	4.99E-05	1.35E-04	4.99E-05	5.01E-05
10%	5.01E-05	1.35E-04	4.99E-05	5.01E-05
25%	1.35E-04	1.51E-04	5.05E-05	1.65E-04
50%	1.76E-04	3.00E-04	1.06E-04	1.76E-04
75%	3.10E-04	3.42E-04	3.10E-04	2.20E-04
90%	4.80E-04	4.80E-04	5.76E-04	2.27E-04
95%	5.76E-04	4.80E-04	5.76E-04	2.27E-04
Max	5.76E-04	4.80E-04	5.76E-04	2.27E-04

Table CS7. Summary statistics for inhalation time-weighted average concentration exposure (mg/m^3) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	2.72E-05	3.56E-05	2.50E-05	2.11E-05
Arithmetic Standard Deviation	1.84E-05	1.61E-05	2.64E-05	7.97E-06
Geometric Mean	2.13E-05	3.24E-05	1.55E-05	1.91E-05
Geometric Standard Deviation	2.17E+00	1.64E+00	2.91E+00	1.75E+00
Min	6.24E-06	1.68E-05	6.24E-06	6.26E-06
5%	6.24E-06	1.68E-05	6.24E-06	6.26E-06
10%	6.26E-06	1.68E-05	6.24E-06	6.26E-06
25%	1.68E-05	1.89E-05	6.31E-06	2.06E-05
50%	2.19E-05	3.76E-05	1.33E-05	2.19E-05
75%	3.88E-05	4.27E-05	3.88E-05	2.74E-05
90%	6.00E-05	6.00E-05	7.20E-05	2.84E-05
95%	7.20E-05	6.00E-05	7.20E-05	2.84E-05
Max	7.20E-05	6.00E-05	7.20E-05	2.84E-05

The results show the high proportions of the dermal exposure from hands only. For All and for each concentration group, based on the arithmetic means, the overall percentages of the normalized exposure from hands only are between 94 and 100% of the Long Dermal, between 86 and 93% of the Short Dermal, and between 89 and 94% of the Long Short Dermal.

Compare Concentration Groups

The results in Tables CS1 to CS7 show some differences between the normalized exposure statistics for the three concentration groups "Target Quat: 100 pm," "Target Quat: 600 ppm," and "Target Quat: 1000 ppm." To compare these groups, an analysis of variance was performed to test whether the geometric means were statistically significantly different at the 5% significance level.

The p-values for these ANOVA tests are shown in Table CS8. These analyses show that there were very statistically significant differences (at the 5% significance level) between the three concentration groups for the dermal exposure modes, but no significant differences for the inhalation modes.

Table CS8. P-values for testing differences in geometric means for different concentration groups

Exposure Route	ANOVA	Welch's ANOVA
Long Dermal	0.000	0.000
Short Dermal	0.000	0.000
Long Short Dermal	0.000	0.000
Hands Only	0.000	0.000
Inhalation Conc	0.231	0.121
Inhalation Dose	0.252	0.197
Inhalation 8-hr TWA	0.252	0.197

Statistical Models

Table CS9 presents the arithmetic mean and 95th percentile estimates from the lognormal simple random sampling model, together with 95% confidence intervals, for each of the exposure routes, for all concentration groups combined. These are the values of AMu and P95u. The other summary statistics are presented in more detail below.

Table CS9. Arithmetic mean and 95th percentile estimates from lognormal simple random sampling model for normalized exposure for All

Exposure Route	Clothing	Arithmetic Mean (95% Confidence Interval)	95th Percentile (95% Confidence Interval)
Dermal (mg)	Long Dermal	6.43 (3.48, 12.59)	21.31 (9.68, 46.44)
	Short Dermal	6.83 (3.73, 13.23)	22.48 (10.30, 48.58)
	Long Short Dermal	6.83 (3.68, 13.43)	22.68 (10.27, 49.60)
	Hands Only	6.44 (3.35, 13.31)	21.98 (9.60, 49.79)
Inhalation Concentration (mg/m^3)		1.57×10^{-4} (1.07×10^{-4}, 2.36×10^{-4})	4.05×10^{-4} (2.36×10^{-4}, 6.89×10^{-4})
Inhalation Dose (mg)		2.30×10^{-4} (1.54×10^{-4}, 3.53×10^{-4})	6.09×10^{-4} (3.47×10^{-4}, 1.06×10^{-3})

Exposure Route	Clothing	Arithmetic Mean (95% Confidence Interval)	95th Percentile (95% Confidence Interval)
Inhalation 8-hr TWA (mg/m^3)		2.87×10^{-5} (1.92×10^{-5}, 4.41×10^{-5})	7.61×10^{-5} (4.34×10^{-5}, 1.33×10^{-4})

Non-detects

For all the analyses presented in this memorandum except for Table CS10, measurements below the LOQ or LOD were replaced by the mid-value, the midpoint of the lowest and highest possible value for that measurement. In Tables CS10 we investigated the impact on the summary statistics of the censored values.

Table CS10. Exposure summary statistics calculated using alternative estimated exposures for values below the LOQ

Exposure Route	Method for Substituting Values Below the LOQ	Arithmetic Mean	95th Percentile
Long Dermal (mg)	Substitute mid value	6.43 (3.45, 12.59)	21.31 (9.64, 46.47)
	Substitute max value	6.43 (3.45, 12.58)	21.29 (9.64, 46.40)
	Substitute min value	6.43 (3.44, 12.61)	21.32 (9.64, 46.54)
	Censored data MLE	6.22 (3.41, 11.85)	20.26 (9.38, 43.22)
Short Dermal (mg)	Substitute mid value	6.83 (3.69, 13.22)	22.48 (10.26, 48.61)
	Substitute max value	6.83 (3.70, 13.21)	22.45 (10.26, 48.51)
	Substitute min value	6.83 (3.69, 13.24)	22.50 (10.26, 48.71)
	Censored data MLE	6.61 (3.65, 12.46)	21.38 (9.98, 45.25)
Long Short Dermal (mg)	Substitute mid value	6.83 (3.64, 13.43)	22.68 (10.23, 49.63)
	Substitute max value	6.82 (3.65, 13.41)	22.66 (10.23, 49.55)
	Substitute min value	6.83 (3.64, 13.44)	22.70 (10.23, 49.71)
	Censored data MLE	6.60 (3.61, 12.63)	21.56 (9.95, 46.15)
Hands Only (mg)	Substitute mid value	6.44 (3.31, 13.30)	21.98 (9.56, 49.83)
	Substitute max value	6.44 (3.31, 13.30)	21.98 (9.56, 49.83)
	Substitute min value	6.44 (3.31, 13.30)	21.98 (9.56, 49.83)
	Censored data MLE	6.21 (3.28, 12.43)	20.84 (9.28, 46.18)
Inhalation Concentration (mg/m^3)	Substitute mid value	1.57×10^{-4} (1.06×10^{-4}, 2.36×10^{-4})	4.05×10^{-4} (2.35×10^{-4}, 6.90×10^{-4})
	Substitute max value	1.61×10^{-4} (1.23×10^{-4}, 2.14×10^{-4})	3.43×10^{-4} (2.30×10^{-4}, 5.09×10^{-4})
	Substitute min value	1.83×10^{-4} (1.41×10^{-4}, 2.39×10^{-4})	3.77×10^{-4} (2.58×10^{-4}, 5.48×10^{-4})
	Censored data MLE	1.56×10^{-4} (1.12×10^{-4}, 2.21×10^{-4})	3.69×10^{-4} (2.30×10^{-4}, 5.87×10^{-4})
Inhalation Dose (mg)	Substitute mid value	2.30×10^{-4} (1.53×10^{-4}, 3.52×10^{-4})	6.09×10^{-4} (3.46×10^{-4}, 1.06×10^{-3})
	Substitute max value	2.30×10^{-4} (1.76×10^{-4}, 3.02×10^{-4})	4.83×10^{-4} (3.26×10^{-4}, 7.10×10^{-4})
	Substitute min value	2.66×10^{-4} (2.14×10^{-4}, 3.32×10^{-4})	5.02×10^{-4} (3.63×10^{-4}, 6.92×10^{-4})

Exposure Route	Method for Substituting Values Below the LOQ	Arithmetic Mean	95th Percentile
	Censored data MLE	2.27×10^{-4} (1.63×10^{-4}, 3.20×10^{-4})	5.35×10^{-4} (3.33×10^{-4}, 8.52×10^{-4})
Inhalation 8-hr TWA (mg/m^3)	Substitute mid value	2.87×10^{-5} (1.91×10^{-5}, 4.40×10^{-5})	7.61×10^{-5} (4.33×10^{-5}, 1.33×10^{-4})
	Substitute max value	2.87×10^{-5} (2.19×10^{-5}, 3.78×10^{-5})	6.03×10^{-5} (4.07×10^{-5}, 8.88×10^{-5})
	Substitute min value	3.33×10^{-5} (2.67×10^{-5}, 4.15×10^{-5})	6.28×10^{-5} (4.53×10^{-5}, 8.65×10^{-5})
	Censored data MLE	2.87×10^{-5} (2.03×10^{-5}, 4.00×10^{-5})	6.68×10^{-5} (4.16×10^{-5}, 1.06×10^{-4})

The results in Table CS10 for dermal exposure show very small impacts of the alternative substitution approaches for treating values below the LOQ on the unit exposure arithmetic mean and 95th percentile. This is mainly because the dermal exposure is dominated by the hand exposures which were all above the LOQ. For inhalation concentration exposure, the results show some large impacts of the max and min value substitution methods compared to substituting the mid value, but the results for the censored data MLE are very similar to the results for substituting the mid value. For inhalation does and time-weighted average concentration exposure, the results show small impacts of the alternative substitution methods for the arithmetic mean but larger impacts of the alternative substitution methods for the 95th percentile.

Detailed Summary Statistics with Confidence Intervals and Fold Relative Accuracy

Tables CS11 to CS17 present the estimates, parametric and non-parametric confidence intervals and fold relative accuracy values for all the summary statistics for the All group. All these analyses use non-detects substituted by the mid-value.

Table CS11. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the long dermal exposure (mg) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.97	2.07	4.30	1.44	2.17	3.51	1.29
GMs	3.55	2.17	5.96	1.66	2.14	5.68	1.63
AMs	5.49	3.32	12.24	1.98	3.63	7.47	1.44
AMu	6.43	3.48	12.59	1.91	3.89	8.94	1.52
P95s	15.57	9.60	91.75	4.72	9.12	15.57	1.49
P95u	21.31	9.68	46.44	2.19	12.53	29.70	1.57

Table CS12. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the short dermal exposure (mg) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.94	2.05	4.23	1.17	2.16	3.46	1.29
GMs	3.82	2.34	6.38	1.24	2.31	6.06	1.62
AMs	5.86	3.56	12.87	1.25	3.89	7.97	1.44
AMu	6.83	3.73	13.23	1.25	4.17	9.48	1.52
P95s	16.30	10.21	95.28	1.65	9.58	16.30	1.46
P95u	22.48	10.30	48.58	1.39	13.27	31.38	1.57

Table CS13. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the long short dermal exposure (mg) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.99	2.07	4.33	1.44	2.18	3.53	1.29
GMs	3.75	2.28	6.31	1.66	2.25	6.00	1.63
AMs	5.81	3.51	13.05	1.99	3.85	7.92	1.44
AMu	6.83	3.68	13.43	1.91	4.15	9.51	1.53
P95s	16.21	10.18	98.28	4.86	9.50	16.21	1.45
P95u	22.68	10.27	49.60	2.20	13.33	31.71	1.57

Table CS14. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the hands only exposure (mg) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	3.14	2.14	4.62	1.47	2.24	3.76	1.32
GMs	3.35	1.99	5.77	1.70	1.97	5.50	1.66
AMs	5.37	3.17	12.81	2.09	3.50	7.36	1.45
AMu	6.44	3.35	13.31	2.00	3.78	9.11	1.56
P95s	15.56	9.51	101.78	5.19	9.11	15.56	1.50
P95u	21.98	9.60	49.79	2.28	12.51	31.16	1.61

Table CS15. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the inhalation concentration exposure (mg/m^3) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.11E+00	1.64E+00	2.71E+00	1.28	1.60E+00	2.59E+00	1.29
GMs	1.19E-04	8.46E-05	1.69E-04	1.41	8.48E-05	1.65E-04	1.39
AMs	1.54E-04	1.05E-04	2.32E-04	1.48	1.04E-04	2.15E-04	1.44
AMu	1.57E-04	1.07E-04	2.36E-04	1.48	1.07E-04	2.23E-04	1.45
P95s	5.58E-04	2.34E-04	1.10E-03	2.28	1.78E-04	5.58E-04	2.34
P95u	4.05E-04	2.36E-04	6.89E-04	1.71	2.32E-04	6.31E-04	1.67

Table CS16. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the inhalation dose exposure (mg) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.17E+00	1.68E+00	2.83E+00	1.30	1.68E+00	2.54E+00	1.24
GMs	1.70E-04	1.20E-04	2.46E-04	1.43	1.19E-04	2.39E-04	1.42
AMs	2.18E-04	1.51E-04	3.48E-04	1.52	1.55E-04	2.88E-04	1.36
AMu	2.30E-04	1.54E-04	3.53E-04	1.51	1.60E-04	3.05E-04	1.39
P95s	5.76E-04	3.45E-04	1.72E-03	2.56	3.15E-04	5.76E-04	1.69
P95u	6.09E-04	3.47E-04	1.06E-03	1.75	3.94E-04	8.33E-04	1.48

Table CS17. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the inhalation time-weighted average concentration exposure (mg/m^3) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.17E+00	1.68E+00	2.83E+00	1.30	1.68E+00	2.54E+00	1.24
GMs	2.13E-05	1.49E-05	3.07E-05	1.43	1.49E-05	2.98E-05	1.42
AMs	2.72E-05	1.88E-05	4.35E-05	1.52	1.94E-05	3.59E-05	1.36
AMu	2.87E-05	1.92E-05	4.41E-05	1.51	2.00E-05	3.81E-05	1.39
P95s	7.20E-05	4.31E-05	2.15E-04	2.56	3.94E-05	7.20E-05	1.69
P95u	7.61E-05	4.34E-05	1.33E-04	1.75	4.92E-05	1.04E-04	1.48

Tables CS11 to CS17 show that the study benchmark design value of 3 for the fold relative accuracy was met in every case.

Empirical Quantile Plots

Quantile-quantile plots of the normalized exposure values were used to evaluate whether the data were lognormally distributed, as implied by the assumed statistical lognormal models. These plots were intended to help determine whether the data supported using untransformed normalized exposure values or log-transformed values or neither.

In each case the quantile-quantile plot compared the observed quantiles of the measured values with the corresponding quantiles of a normal or lognormal distribution. A perfect fit would imply that the plotted values lie in a straight line. The quantile-quantile plots for all exposure routes are presented in Figures CS1 to CS14. For the dermal exposures, the plots seem to show a better fit for the normal distributions, supporting the use of the untransformed exposure values over the log-transformed values, an unexpected finding. For the inhalation exposures, the plots seem to show a better fit for the lognormal distributions, supporting the use of the untransformed exposure values over the log-transformed values, the expected finding.

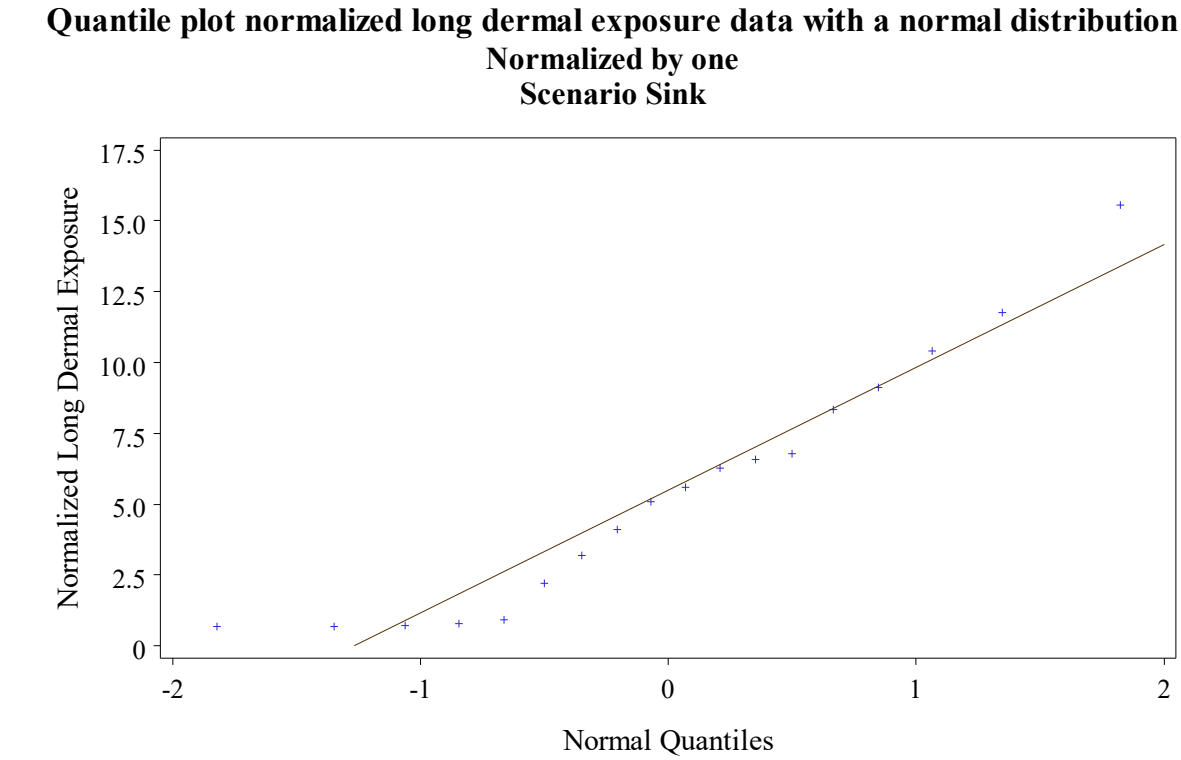


Figure CS1. Empirical quantile plot for Long Dermal, with a normal distribution

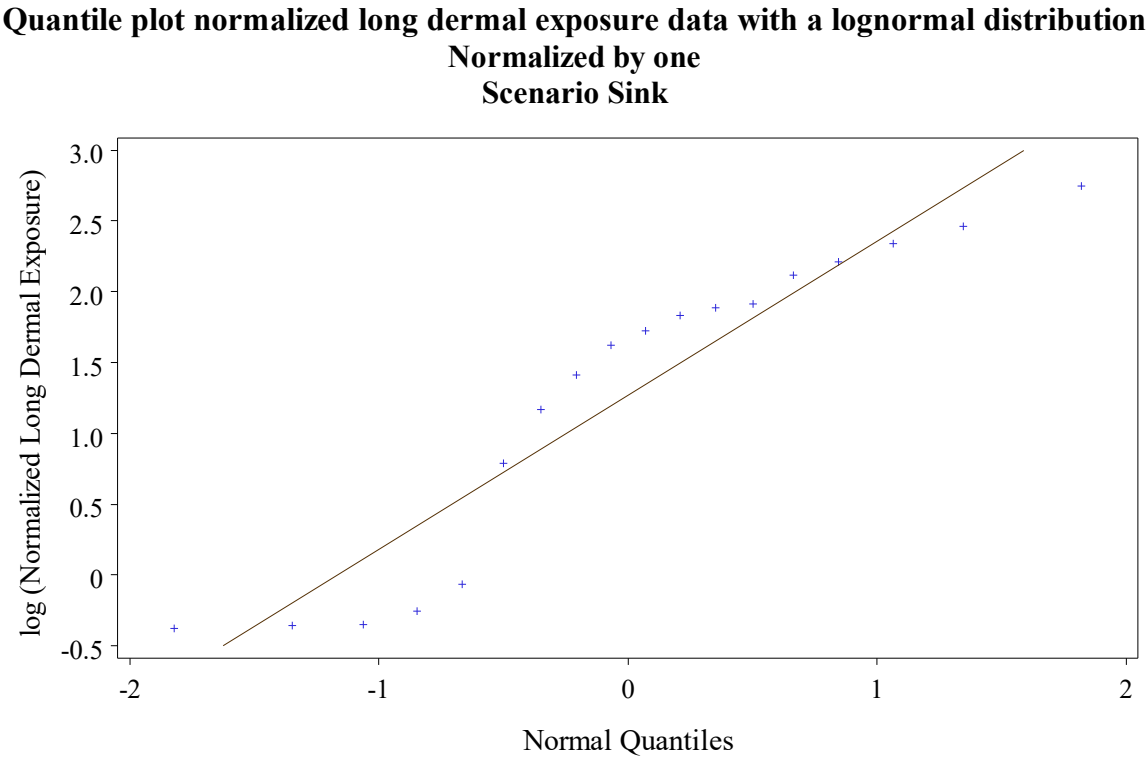


Figure CS2. Empirical quantile plot for Long Dermal, with a lognormal distribution

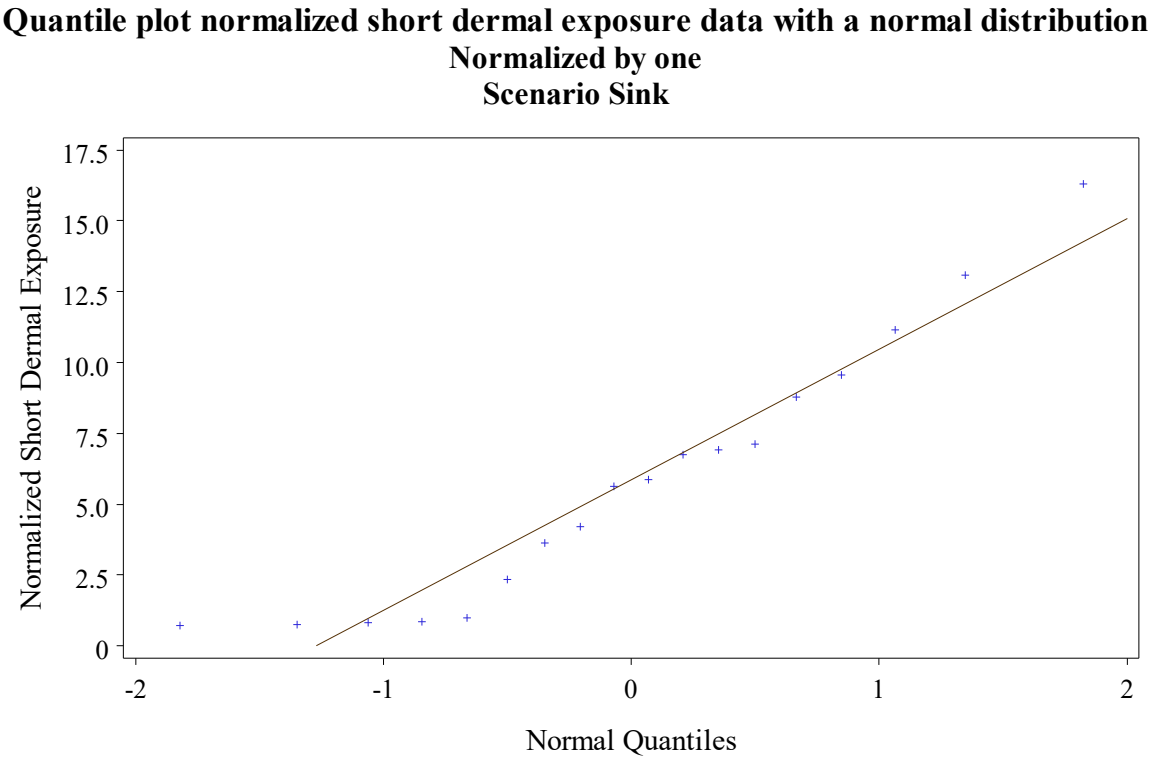


Figure CS3. Empirical quantile plot for Short Dermal, with a normal distribution

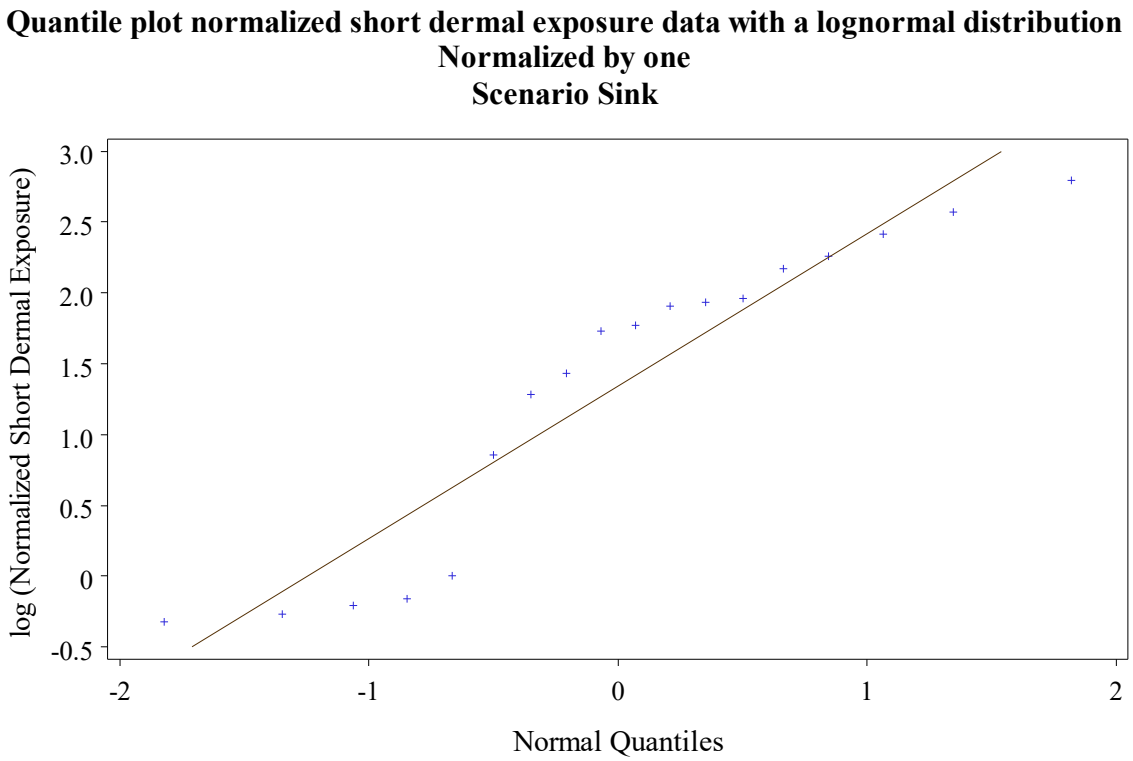


Figure CS4. Empirical quantile plot for Short Dermal, with a lognormal distribution

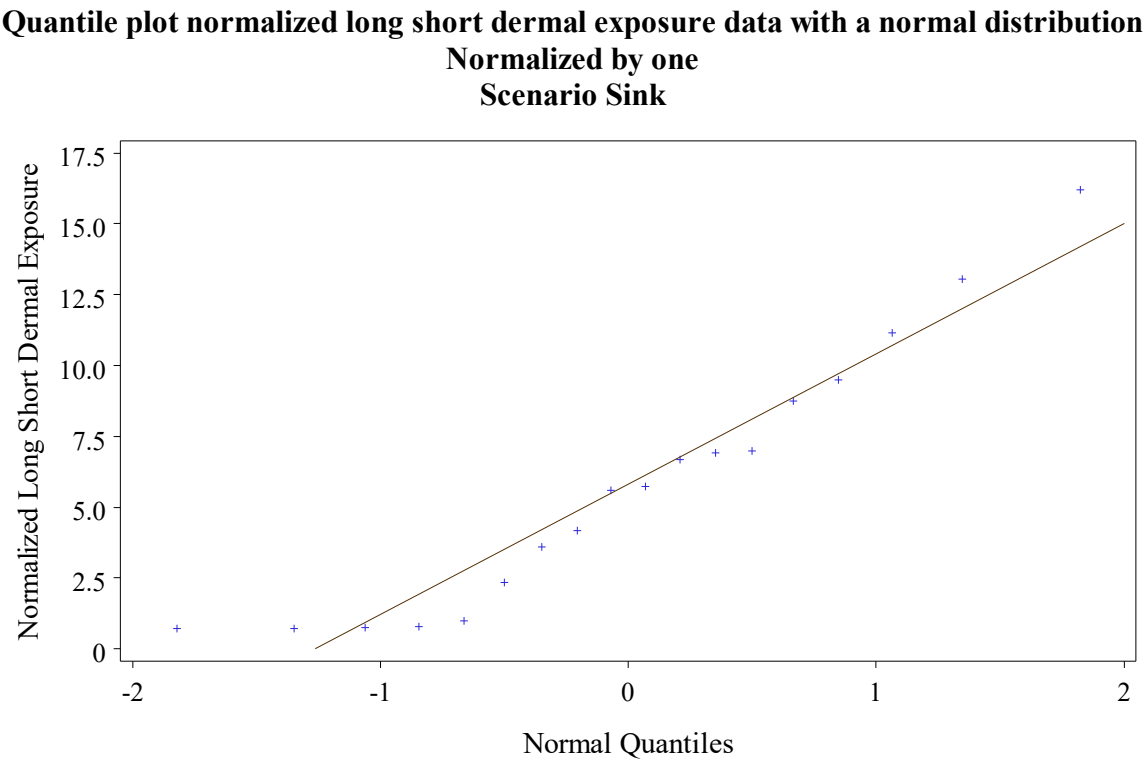


Figure CS5. Empirical quantile plot for Long Short Dermal, with a normal distribution

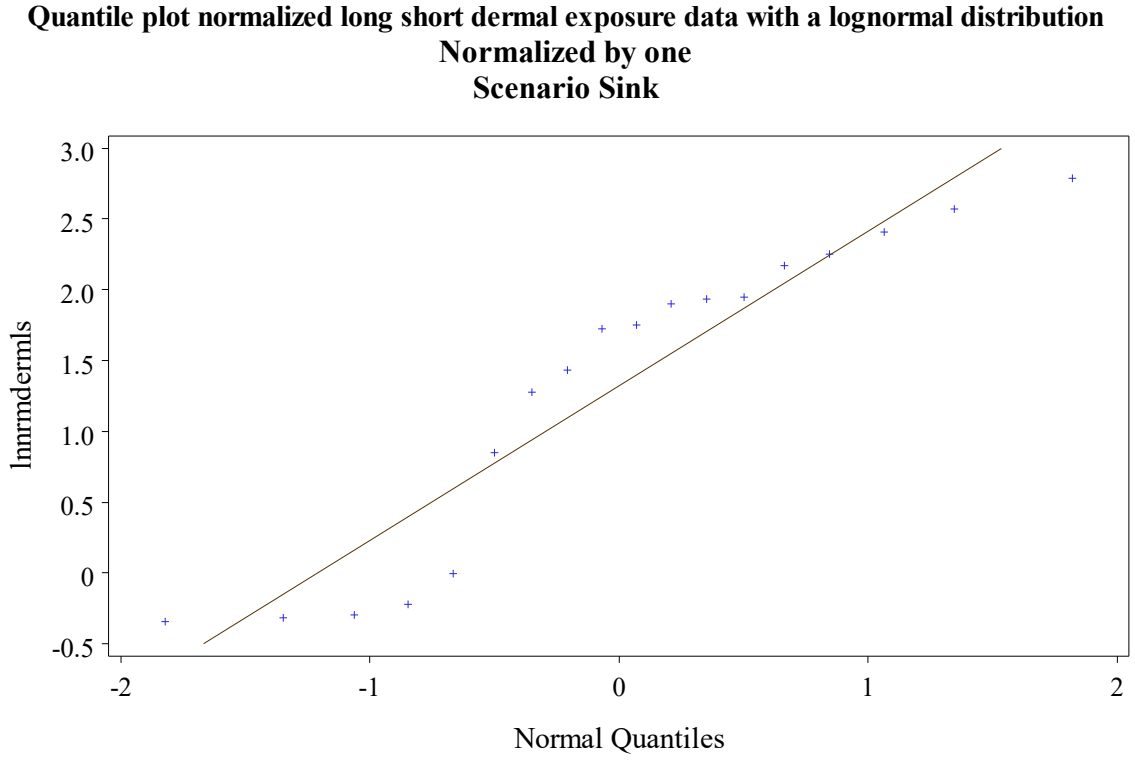


Figure CS6. Empirical quantile plot for Long Short Dermal, with a lognormal distribution

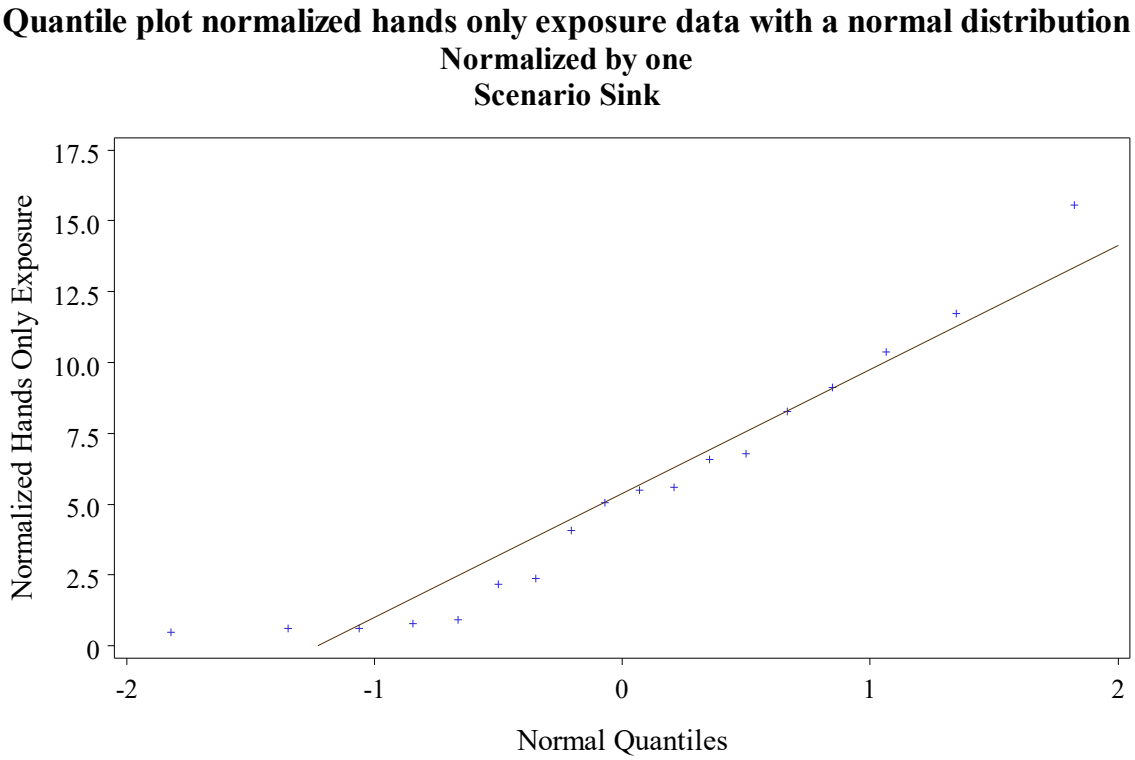


Figure CS7. Empirical quantile plot for Hands Only, with a normal distribution

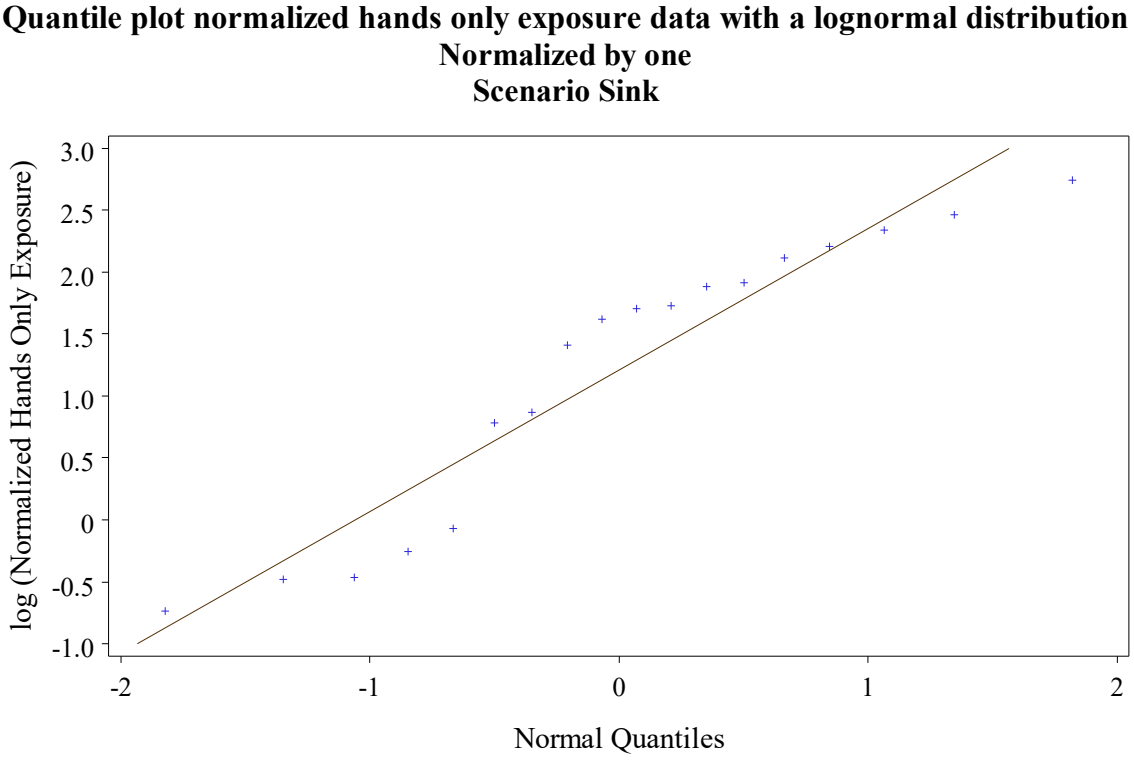


Figure CS8. Empirical quantile plot for Hands Only, with a lognormal distribution

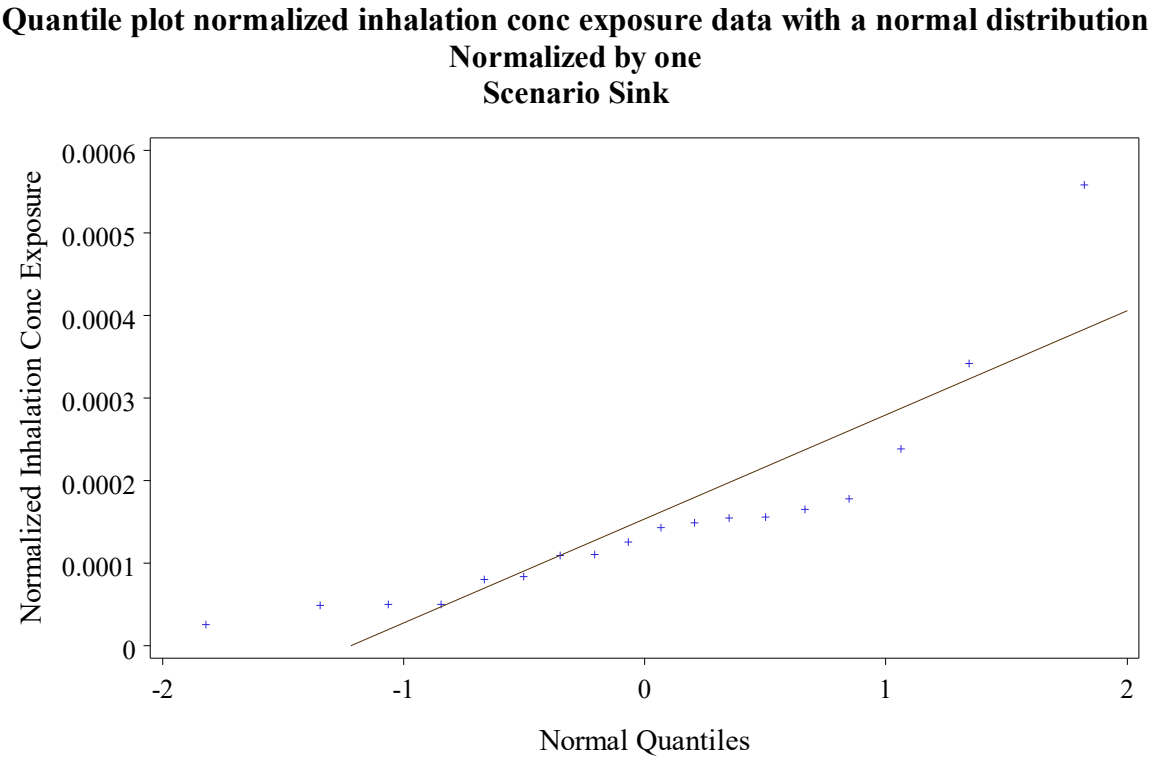


Figure CS9. Empirical quantile plot for Inhalation Concentration, with a normal distribution

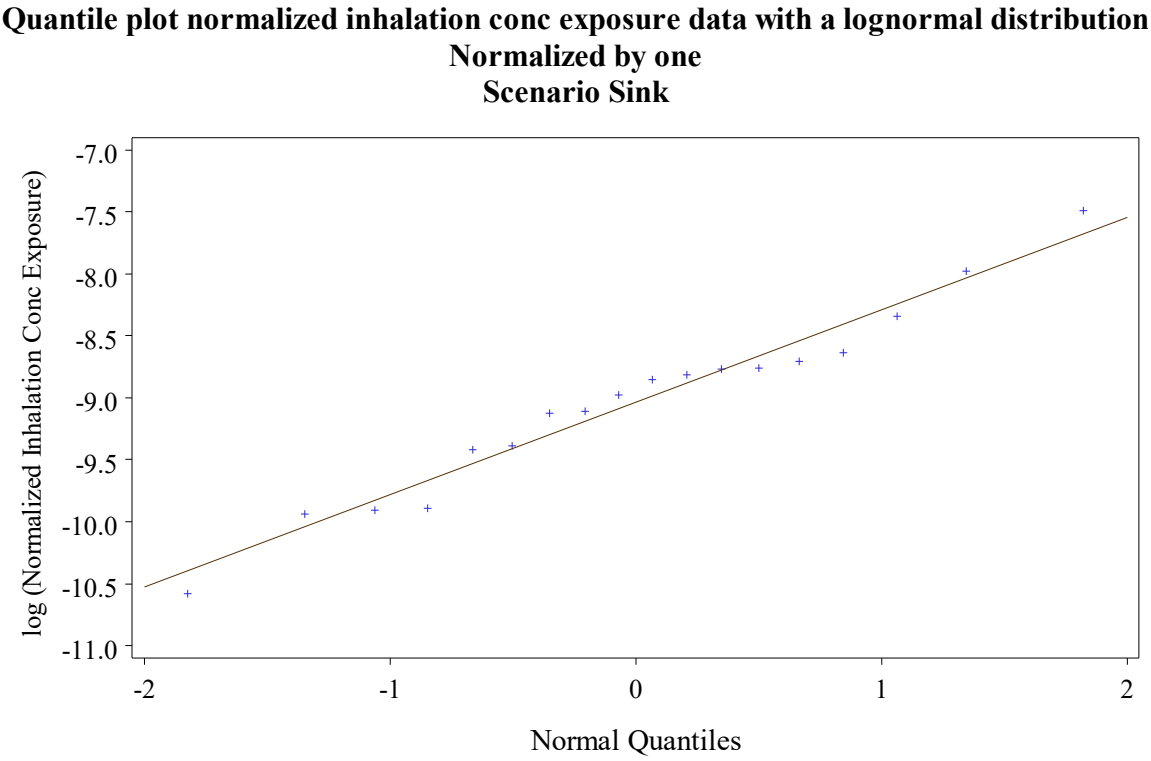


Figure CS10. Empirical quantile plot for Inhalation Concentration, with a lognormal distribution

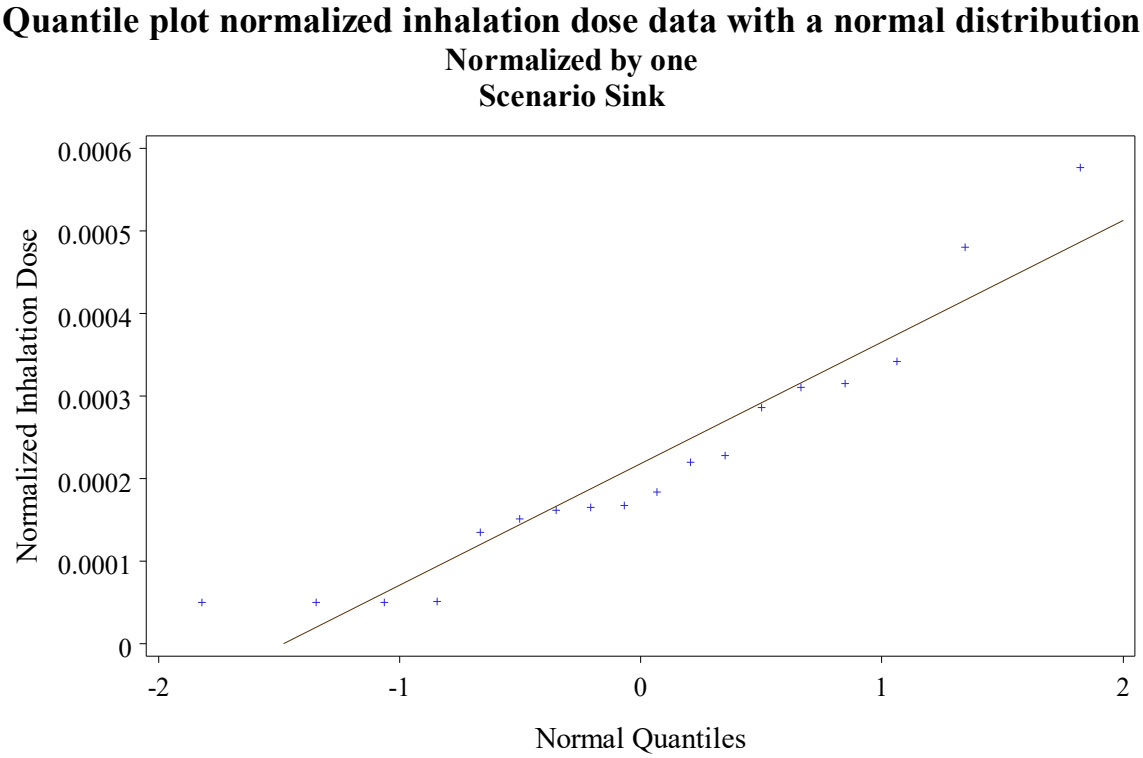


Figure CS11. Empirical quantile plot for Inhalation Dose, with a normal distribution

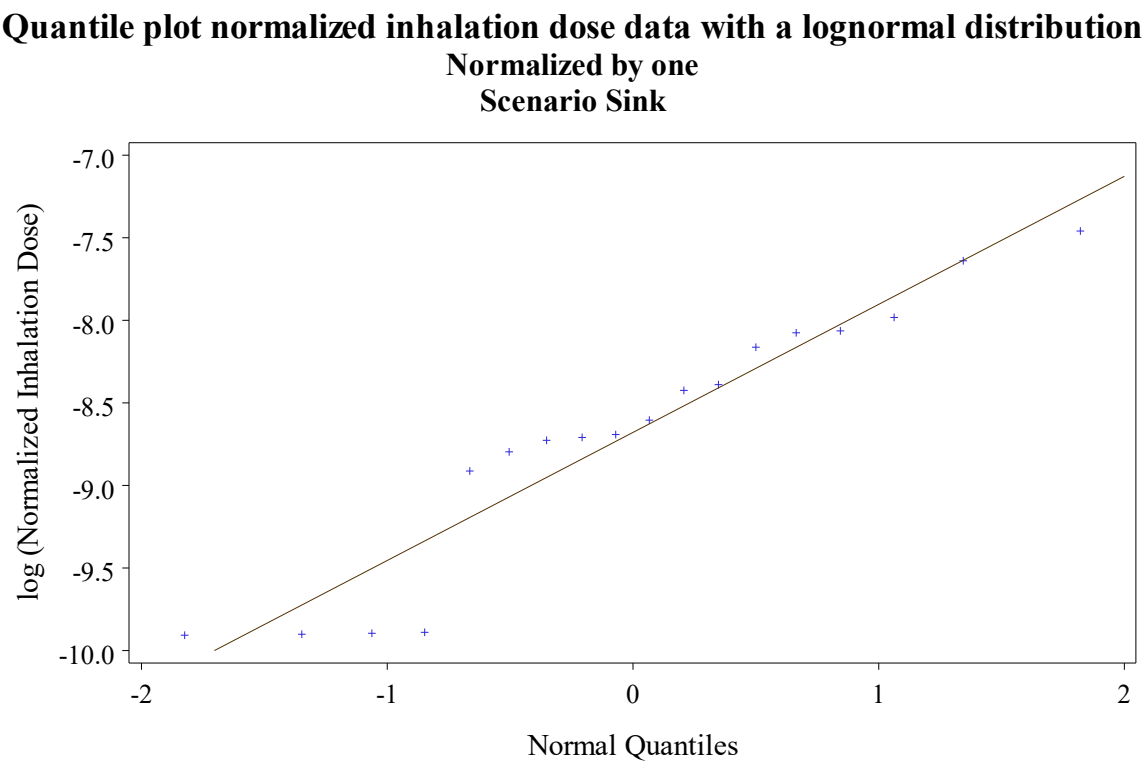


Figure CS12. Empirical quantile plot for Inhalation Dose, with a lognormal distribution

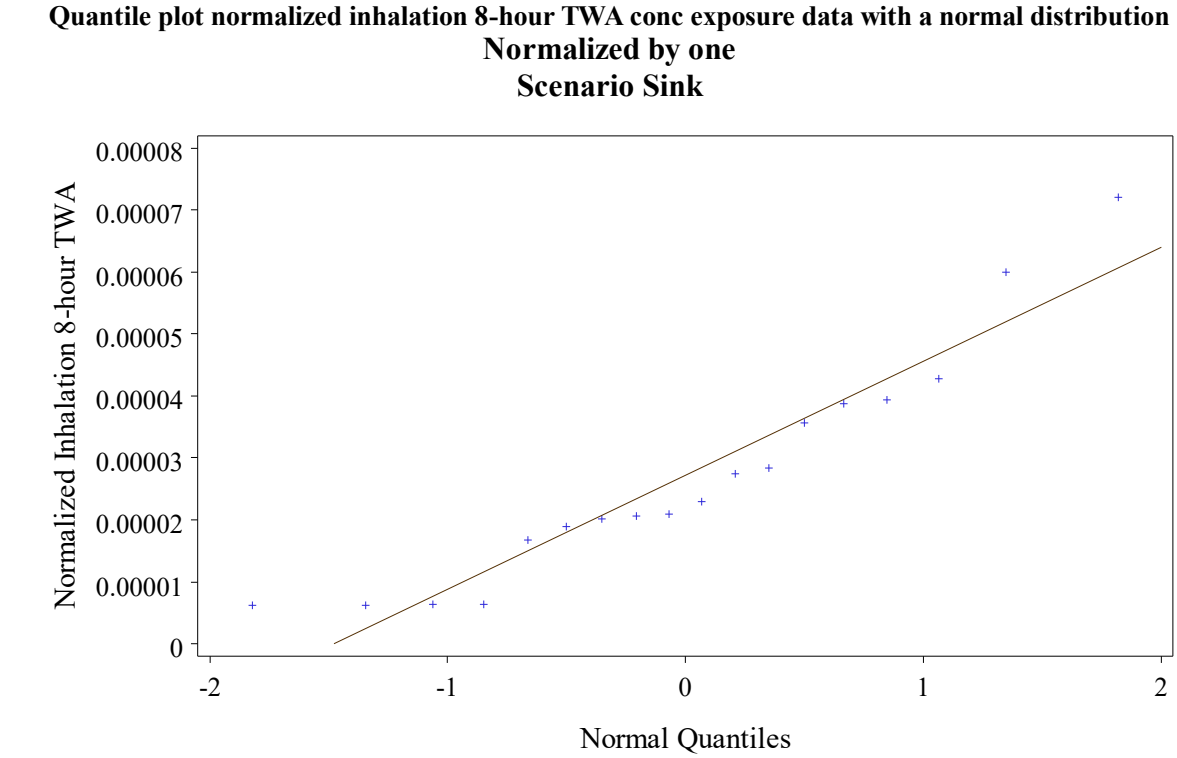


Figure CS13. Empirical quantile plot for Inhalation Time-weighted Average Conc, with a normal distribution

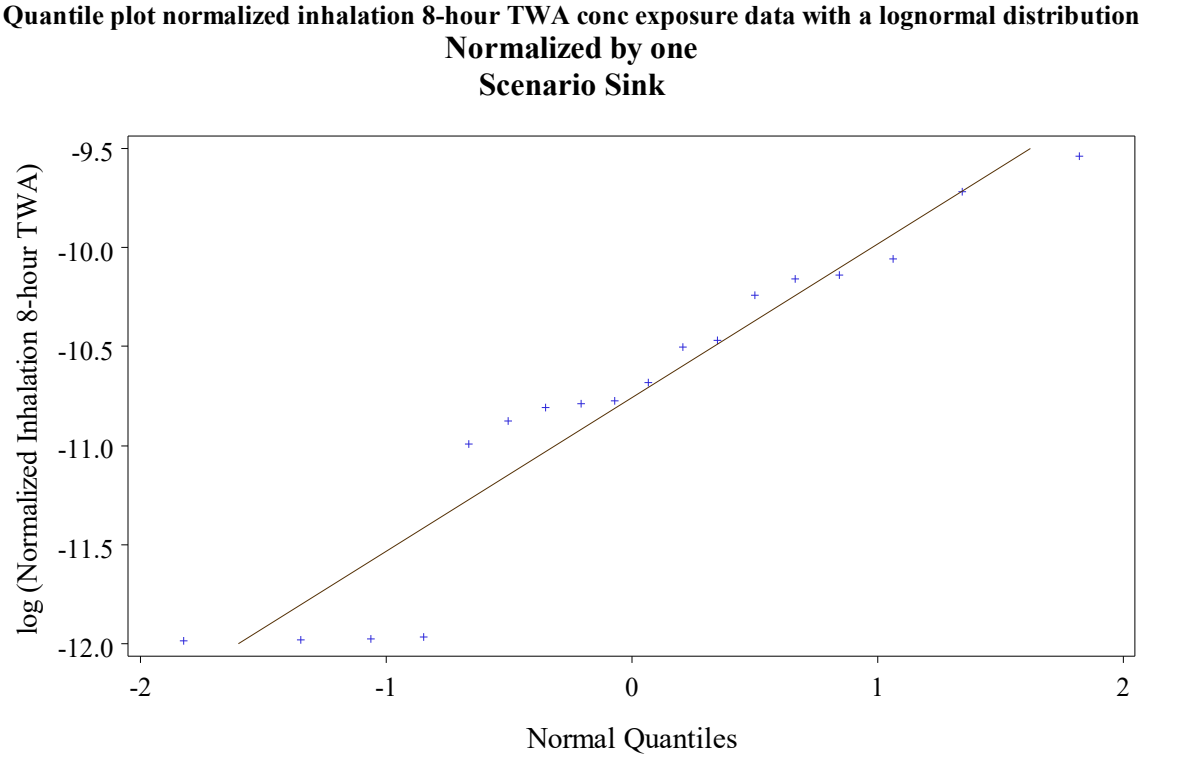


Figure CS14. Empirical quantile plot for Inhalation Time-weighted Average Conc, with a lognormal distribution

11. Normalizing Factor One, COP Scenario

Summary Statistics of Exposure

Tables CC1 to CC7 summarize the (unnormalized) exposure data with the summary statistics from the 18 (all concentrations), or 6 (specific concentrations) measurements for each concentration group, and each dermal and inhalation exposure route. The unnormalized exposure is the same as the exposure normalized by one. These analyses assume that the exposure measurements within each subset come from some unspecified distribution for that subset.

Table CC1. Summary statistics for long dermal exposure (mg) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	0.053	0.051	0.067	0.042
Arithmetic Standard Deviation	0.030	0.027	0.038	0.023
Geometric Mean	0.045	0.044	0.058	0.036
Geometric Standard Deviation	1.834	1.877	1.852	1.800
Min	0.017	0.017	0.024	0.020
5%	0.017	0.017	0.024	0.020
10%	0.020	0.017	0.024	0.020
25%	0.024	0.032	0.041	0.021
50%	0.049	0.053	0.057	0.039
75%	0.072	0.076	0.100	0.061
90%	0.100	0.077	0.123	0.069
95%	0.123	0.077	0.123	0.069
Max	0.123	0.077	0.123	0.069

Table CC2. Summary statistics for short dermal exposure (mg) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	0.292	0.113	0.382	0.380
Arithmetic Standard Deviation	0.275	0.083	0.199	0.391
Geometric Mean	0.188	0.095	0.320	0.221
Geometric Standard Deviation	2.744	1.853	2.070	3.575
Min	0.031	0.042	0.111	0.031
5%	0.031	0.042	0.111	0.031
10%	0.042	0.042	0.111	0.031

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
25%	0.085	0.078	0.143	0.085
50%	0.196	0.087	0.488	0.287
75%	0.487	0.108	0.531	0.487
90%	0.532	0.276	0.532	1.104
95%	1.104	0.276	0.532	1.104
Max	1.104	0.276	0.532	1.104

Table CC3. Summary statistics for long short dermal exposure (mg) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	0.234	0.096	0.282	0.324
Arithmetic Standard Deviation	0.240	0.077	0.183	0.347
Geometric Mean	0.142	0.075	0.226	0.168
Geometric Standard Deviation	2.962	2.212	2.127	4.147
Min	0.022	0.022	0.098	0.026
5%	0.022	0.022	0.098	0.026
10%	0.026	0.022	0.098	0.026
25%	0.074	0.053	0.119	0.036
50%	0.123	0.082	0.284	0.244
75%	0.438	0.096	0.446	0.438
90%	0.461	0.243	0.461	0.956
95%	0.956	0.243	0.461	0.956
Max	0.956	0.243	0.461	0.956

Table CC4. Summary statistics for hands only dermal exposure (mg) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	0.037	0.042	0.044	0.024
Arithmetic Standard Deviation	0.029	0.027	0.039	0.016
Geometric Mean	0.026	0.033	0.028	0.020
Geometric Standard Deviation	2.375	2.236	3.058	1.995
Min	0.006	0.012	0.006	0.009

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
5%	0.006	0.012	0.006	0.009
10%	0.009	0.012	0.006	0.009
25%	0.012	0.014	0.010	0.011
50%	0.029	0.045	0.032	0.017
75%	0.063	0.067	0.086	0.041
90%	0.086	0.068	0.098	0.048
95%	0.098	0.068	0.098	0.048
Max	0.098	0.068	0.098	0.048

Table CC5. Summary statistics for inhalation concentration exposure (mg/m^3) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	3.44E-03	4.51E-03	5.44E-03	2.72E-03
Arithmetic Standard Deviation	3.54E-03	5.44E-03	2.39E-03	1.93E-03
Geometric Mean	2.30E-03	2.39E-03	3.42E+00	2.20E-03
Geometric Standard Deviation	2.45E+00	3.42E+00	7.73E-04	2.04E+00
Min	7.73E-04	7.73E-04	7.73E-04	9.72E-04
5%	7.73E-04	7.73E-04	7.73E-04	9.72E-04
10%	9.28E-04	7.73E-04	9.28E-04	9.72E-04
25%	9.92E-04	9.28E-04	1.66E-03	1.16E-03
50%	2.01E-03	1.66E-03	7.96E-03	2.01E-03
75%	4.98E-03	7.96E-03	1.41E-02	4.50E-03
90%	7.96E-03	1.41E-02	1.41E-02	5.69E-03
95%	1.41E-02	1.41E-02	1.41E-02	5.69E-03
Max	1.41E-02	1.41E-02	7.56E-03	5.69E-03

Table CC6. Summary statistics for inhalation dose exposure (mg) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	6.01E-03	7.45E-03	5.81E-03	4.78E-03
Arithmetic Standard Deviation	6.39E-03	8.62E-03	6.75E-03	3.81E-03
Geometric Mean	3.79E-03	3.95E-03	3.76E-03	3.68E-03

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Geometric Standard Deviation	2.60E+00	3.42E+00	2.65E+00	2.23E+00
Min	1.07E-03	1.11E-03	1.07E-03	1.18E-03
5%	1.07E-03	1.11E-03	1.07E-03	1.18E-03
10%	1.11E-03	1.11E-03	1.07E-03	1.18E-03
25%	2.15E-03	1.71E-03	2.63E-03	2.53E-03
50%	2.81E-03	2.45E-03	2.89E-03	3.29E-03
75%	6.92E-03	1.69E-02	6.23E-03	6.92E-03
90%	1.92E-02	2.00E-02	1.92E-02	1.15E-02
95%	2.00E-02	2.00E-02	1.92E-02	1.15E-02
Max	2.00E-02	2.00E-02	1.92E-02	1.15E-02

Table CC7. Summary statistics for inhalation time-weighted average concentration exposure (mg/m^3) using empirical sampling model

Statistic	All	Target Quat: 100 ppm	Target Quat: 600 ppm	Target Quat: 1000 ppm
Arithmetic Mean	7.52E-04	9.31E-04	7.26E-04	5.97E-04
Arithmetic Standard Deviation	7.99E-04	1.08E-03	8.44E-04	4.76E-04
Geometric Mean	4.74E-04	4.94E-04	4.70E-04	4.60E-04
Geometric Standard Deviation	2.60E+00	3.42E+00	2.65E+00	2.23E+00
Min	1.34E-04	1.38E-04	1.34E-04	1.48E-04
5%	1.34E-04	1.38E-04	1.34E-04	1.48E-04
10%	1.38E-04	1.38E-04	1.34E-04	1.48E-04
25%	2.69E-04	2.14E-04	3.29E-04	3.16E-04
50%	3.51E-04	3.06E-04	3.61E-04	4.12E-04
75%	8.65E-04	2.12E-03	7.78E-04	8.65E-04
90%	2.39E-03	2.50E-03	2.39E-03	1.43E-03
95%	2.50E-03	2.50E-03	2.39E-03	1.43E-03
Max	2.50E-03	2.50E-03	2.39E-03	1.43E-03

The results show fairly high proportions of the Long Dermal exposure from hands only, but not as high as for the Bucket and Sink scenarios. For All and for each concentration group, based on the arithmetic means, the overall percentages of the normalized exposure from hands only range from 57 to 82% of the Long Dermal and is 69% for All. Similarly, for the unnormalized dermal exposure, the arithmetic mean hands only exposure is 69% of the arithmetic mean total dermal exposure (defined in the study report as the sum of the residues from hand wash, face/neck wipe, and the inner

dosimeters, which is the definition of Long Dermal used in this memorandum). (The percentages are much lower if you include the outer dosimeters.)

Compare Concentration Groups

The results in Tables CC1 to CC7 show some differences between the normalized exposure statistics for the three concentration groups "Target Quat: 100 ppm," "Target Quat: 600 ppm," and "Target Quat: 1000 ppm." To compare these groups, an analysis of variance was performed to test whether the geometric means were statistically significantly different at the 5% significance level.

The p-values for these ANOVA tests are shown in Table CC8. These analyses show that there were no statistically significant differences (at the 5% significance level) between the three concentration groups for any of the exposure modes.

Table CC8. P-values for testing differences in geometric means for different concentration groups

Exposure Route	ANOVA	Welch's ANOVA
Long Dermal	0.633	0.671
Short Dermal	0.195	0.065
Long Short Dermal	0.341	0.186
Hands Only	0.775	0.713
Inhalation Conc	0.999	0.999
Inhalation Dose	0.999	1.000
Inhalation 8-hr TWA	0.999	1.000

Statistical Models

Table CC9 presents the arithmetic mean and 95th percentile estimates from the lognormal simple random sampling model, together with 95% confidence intervals, for each of the exposure routes, for all concentration groups combined. These are the values of AMu and P95u. The other summary statistics are presented in more detail below.

Table CC9. Arithmetic mean and 95th percentile estimates from lognormal simple random sampling model for normalized exposure for All

Exposure Route	Clothing	Arithmetic Mean (95% Confidence Interval)	95th Percentile (95% Confidence Interval)
Dermal (mg)	Long Dermal	0.054 (0.040, 0.075)	0.123 (0.079, 0.189)
	Short Dermal	0.313 (0.180, 0.572)	0.991 (0.477, 2.040)
	Long Short Dermal	0.255 (0.139, 0.499)	0.845 (0.385, 1.838)
	Hands Only	0.038 (0.024, 0.063)	0.109 (0.059, 0.203)

Exposure Route	Clothing	Arithmetic Mean (95% Confidence Interval)	95th Percentile (95% Confidence Interval)
Inhalation Concentration (mg/m^3)		3.42×10^{-3} (2.12×10^{-3}, 5.72×10^{-3})	9.99×10^{-3} (5.23×10^{-3}, 1.89×10^{-2})
Inhalation Dose (mg)		6.00×10^{-3} (3.57×10^{-3}, 1.05×10^{-2})	1.83×10^{-2} (9.15×10^{-3}, 3.63×10^{-2})
Inhalation 8-hr TWA (mg/m^3)		7.49×10^{-4} (4.46×10^{-4}, 1.31×10^{-3})	2.29×10^{-3} (1.14×10^{-3}, 4.54×10^{-3})

Non-detects

For all the analyses presented in this memorandum except for Table CC10, measurements below the LOQ or LOD were replaced by the mid-value, the midpoint of the lowest and highest possible value for that measurement. In Table CC10 we investigated the impact on the summary statistics of the censored values.

Table CC10. Exposure summary statistics calculated using alternative estimated exposures for values below the LOQ

Exposure Route	Method for Substituting Values Below the LOQ	Arithmetic Mean	95th Percentile
Long Dermal (mg)	Substitute mid value	0.054 (0.040, 0.075)	0.123 (0.079, 0.189)
	Substitute max value	0.059 (0.045, 0.078)	0.125 (0.084, 0.186)
	Substitute min value	0.050 (0.035, 0.074)	0.125 (0.075, 0.208)
	Censored data MLE	0.054 (0.040, 0.073)	0.119 (0.078, 0.181)
Short Dermal (mg)	Substitute mid value	0.313 (0.178, 0.573)	0.991 (0.477, 2.041)
	Substitute max value	0.313 (0.186, 0.547)	0.953 (0.477, 1.882)
	Substitute min value	0.318 (0.170, 0.623)	1.054 (0.477, 2.301)
	Censored data MLE	0.305 (0.177, 0.545)	0.947 (0.463, 1.913)
Long Short Dermal (mg)	Substitute mid value	0.255 (0.139, 0.499)	0.845 (0.383, 1.839)
	Substitute max value	0.255 (0.143, 0.470)	0.812 (0.385, 1.688)
	Substitute min value	0.263 (0.131, 0.564)	0.915 (0.387, 2.135)
	Censored data MLE	0.248 (0.136, 0.471)	0.805 (0.373, 1.716)
Hands Only (mg)	Substitute mid value	0.038 (0.024, 0.063)	0.109 (0.059, 0.203)
	Substitute max value	0.038 (0.024, 0.063)	0.109 (0.059, 0.203)
	Substitute min value	0.038 (0.024, 0.063)	0.109 (0.059, 0.203)
	Censored data MLE	0.038 (0.024, 0.060)	0.105 (0.057, 0.192)
Inhalation Concentration (mg/m^3)	Substitute mid value	3.42×10^{-3} (2.11×10^{-3}, 5.72×10^{-3})	9.99×10^{-3} (5.21×10^{-3}, 1.90×10^{-2})
	Substitute max value	3.42×10^{-3} (2.11×10^{-3}, 5.72×10^{-3})	9.99×10^{-3} (5.21×10^{-3}, 1.90×10^{-2})
	Substitute min value	3.42×10^{-3} (2.11×10^{-3}, 5.72×10^{-3})	9.99×10^{-3} (5.21×10^{-3}, 1.90×10^{-2})
	Censored data MLE	3.35×10^{-3} (2.10×10^{-3}, 5.50×10^{-3})	9.59×10^{-3} (5.21×10^{-3}, 1.90×10^{-2})

Exposure Route	Method for Substituting Values Below the LOQ	Arithmetic Mean	95th Percentile
Inhalation Dose (mg)	Substitute mid value	6.00×10^{-3} (3.54×10^{-3}, 1.05×10^{-2})	1.83×10^{-2} (9.12×10^{-3}, 3.63×10^{-2})
	Substitute max value	6.00×10^{-3} (3.54×10^{-3}, 1.05×10^{-2})	1.83×10^{-2} (9.12×10^{-3}, 3.63×10^{-2})
	Substitute min value	6.00×10^{-3} (3.54×10^{-3}, 1.05×10^{-2})	1.83×10^{-2} (9.12×10^{-3}, 3.63×10^{-2})
	Censored data MLE	5.85×10^{-3} (3.51×10^{-3}, 1.00×10^{-2})	1.75×10^{-2} (8.90×10^{-3}, 3.41×10^{-2})
Inhalation 8-hr TWA (mg/m^3)	Substitute mid value	7.49×10^{-4} (4.42×10^{-4}, 1.31×10^{-3})	2.29×10^{-3} (1.14×10^{-3}, 4.54×10^{-3})
	Substitute max value	7.49×10^{-4} (4.42×10^{-4}, 1.31×10^{-3})	2.29×10^{-3} (1.14×10^{-3}, 4.54×10^{-3})
	Substitute min value	7.49×10^{-4} (4.42×10^{-4}, 1.31×10^{-3})	2.29×10^{-3} (1.14×10^{-3}, 4.54×10^{-3})
	Censored data MLE	7.31×10^{-4} (4.39×10^{-4}, 1.25×10^{-3})	2.19×10^{-3} (1.11×10^{-3}, 4.26×10^{-3})

The results in Table CC10 for all the exposure routes show very small impacts of the alternative substitution approaches for treating values below the LOQ on the unit exposure arithmetic mean and 95th percentile.

Detailed Summary Statistics with Confidence Intervals and Fold Relative Accuracy

Tables CC11 to CC17 present the estimates, parametric and non-parametric confidence intervals and fold relative accuracy values for all the summary statistics for the All group. All these analyses use non-detects substituted by the mid-value.

Table CC11. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the long dermal exposure (mg) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	1.834	1.499	2.253	1.23	1.568	2.032	1.14
GMs	0.045	0.034	0.060	1.33	0.034	0.060	1.32
AMs	0.053	0.040	0.074	1.36	0.040	0.067	1.30
AMu	0.054	0.040	0.075	1.36	0.040	0.070	1.32
P95s	0.123	0.079	0.276	2.01	0.076	0.123	1.60
P95u	0.123	0.079	0.189	1.55	0.083	0.158	1.40

Table CC12. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the short dermal exposure (mg) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.744	1.961	3.866	1.40	2.095	3.354	1.28
GMs	0.188	0.119	0.304	1.60	0.120	0.295	1.57
AMs	0.292	0.173	0.560	1.79	0.180	0.426	1.55
AMu	0.313	0.180	0.572	1.79	0.180	0.482	1.65
P95s	1.104	0.473	3.836	2.95	0.494	1.104	2.08
P95u	0.991	0.477	2.040	2.07	0.498	1.591	1.81

Table CC13. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the long short dermal exposure (mg) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.962	2.064	4.282	1.44	2.166	3.682	1.32
GMs	0.142	0.086	0.237	1.66	0.087	0.230	1.63
AMs	0.234	0.132	0.485	1.91	0.137	0.351	1.61
AMu	0.255	0.139	0.499	1.90	0.139	0.411	1.73
P95s	0.956	0.382	3.625	3.18	0.440	0.956	2.14
P95u	0.845	0.385	1.838	2.18	0.402	1.419	1.92

Table CC14. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the hands only exposure (mg) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.375	1.781	3.186	1.34	1.909	2.743	1.21
GMs	0.026	0.018	0.040	1.50	0.018	0.039	1.47
AMs	0.037	0.024	0.062	1.61	0.024	0.050	1.44
AMu	0.038	0.024	0.063	1.61	0.024	0.055	1.51
P95s	0.098	0.058	0.349	3.00	0.067	0.098	1.44
P95u	0.109	0.059	0.203	1.86	0.061	0.160	1.65

Table CC15. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the inhalation concentration exposure (mg/m^3) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.45E+00	1.82E+00	3.31E+00	1.35	1.86E+00	2.89E+00	1.26
GMs	2.30E-03	1.53E-03	3.51E-03	1.52	1.56E-03	3.46E-03	1.49
AMs	3.44E-03	2.06E-03	5.61E-03	1.65	2.03E-03	5.16E-03	1.61
AMu	3.42E-03	2.12E-03	5.72E-03	1.64	1.96E-03	5.51E-03	1.69
P95s	1.41E-02	5.19E-03	3.31E-02	2.63	5.69E-03	1.41E-02	1.87
P95u	9.99E-03	5.23E-03	1.89E-02	1.90	4.60E-03	1.74E-02	1.96

Table CC16. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the inhalation dose exposure (mg) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.60E+00	1.89E+00	3.60E+00	1.38	1.91E+00	3.14E+00	1.30
GMs	3.79E-03	2.46E-03	5.98E-03	1.56	2.50E-03	5.85E-03	1.53
AMs	6.01E-03	3.45E-03	1.03E-02	1.73	3.41E-03	9.01E-03	1.64
AMu	6.00E-03	3.57E-03	1.05E-02	1.72	3.28E-03	1.00E-02	1.76
P95s	2.00E-02	9.08E-03	6.60E-02	2.80	1.15E-02	2.00E-02	1.18
P95u	1.83E-02	9.15E-03	3.63E-02	1.99	7.90E-03	3.30E-02	2.08

Table CC17. Arithmetic mean, geometric mean, geometric standard deviation, and 95th percentiles (with 95% confidence intervals and fold relative accuracy), for different statistical models of the inhalation time-weighted average concentration exposure (mg/m^3) using All data

		Parametric Bootstrap			Non-parametric Bootstrap		
Parameter	Estimate	Lower Bound	Upper Bound	Fold Relative Accuracy	Lower Bound	Upper Bound	Fold Relative Accuracy
GSDs	2.60E+00	1.89E+00	3.60E+00	1.38	1.91E+00	3.14E+00	1.30
GMs	4.74E-04	3.07E-04	7.47E-04	1.56	3.12E-04	7.31E-04	1.53
AMs	7.52E-04	4.31E-04	1.28E-03	1.73	4.26E-04	1.13E-03	1.64
AMu	7.49E-04	4.46E-04	1.31E-03	1.72	4.10E-04	1.25E-03	1.76
P95s	2.50E-03	1.14E-03	8.25E-03	2.80	1.43E-03	2.50E-03	1.18
P95u	2.29E-03	1.14E-03	4.54E-03	1.99	9.88E-04	4.12E-03	2.08

Tables CC11 to CC17 show that the study benchmark design value of 3 for the fold relative accuracy was met in every case, with the exception of the parametric bootstrap empirical 95th percentile for Long Short Dermal and Hand Only.

Empirical Quantile Plots

Quantile-quantile plots of the normalized exposure values were used to evaluate whether the data were lognormally distributed, as implied by the assumed statistical lognormal models. These plots were intended to help determine whether the data supported using untransformed normalized exposure values or log-transformed values or neither.

In each case the quantile-quantile plot compared the observed quantiles of the measured values with the corresponding quantiles of a normal or lognormal distribution. A perfect fit would imply that the plotted values lie in a straight line. The quantile-quantile plots for all exposure routes are presented in Figures CC1 to CC14. In all cases the plots seem to show a better fit for the lognormal distributions, supporting the use of the log-transformed exposure values over the untransformed values.

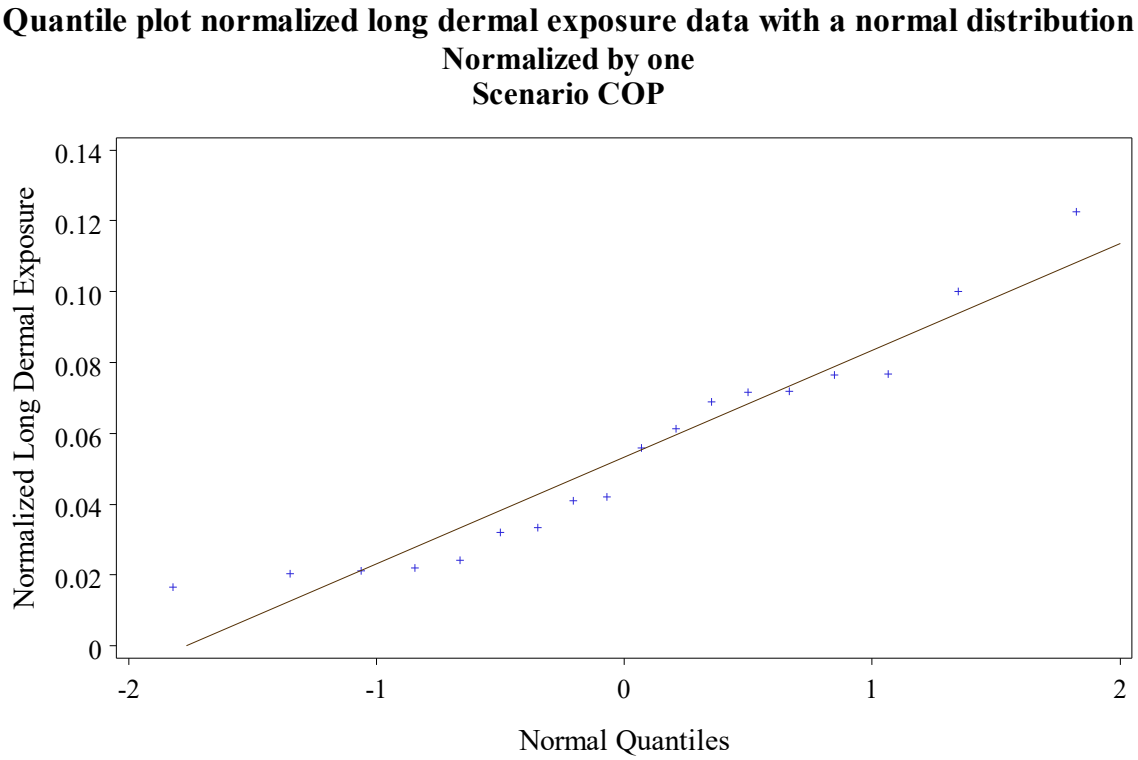


Figure CC1. Empirical quantile plot for Long Dermal, with a normal distribution

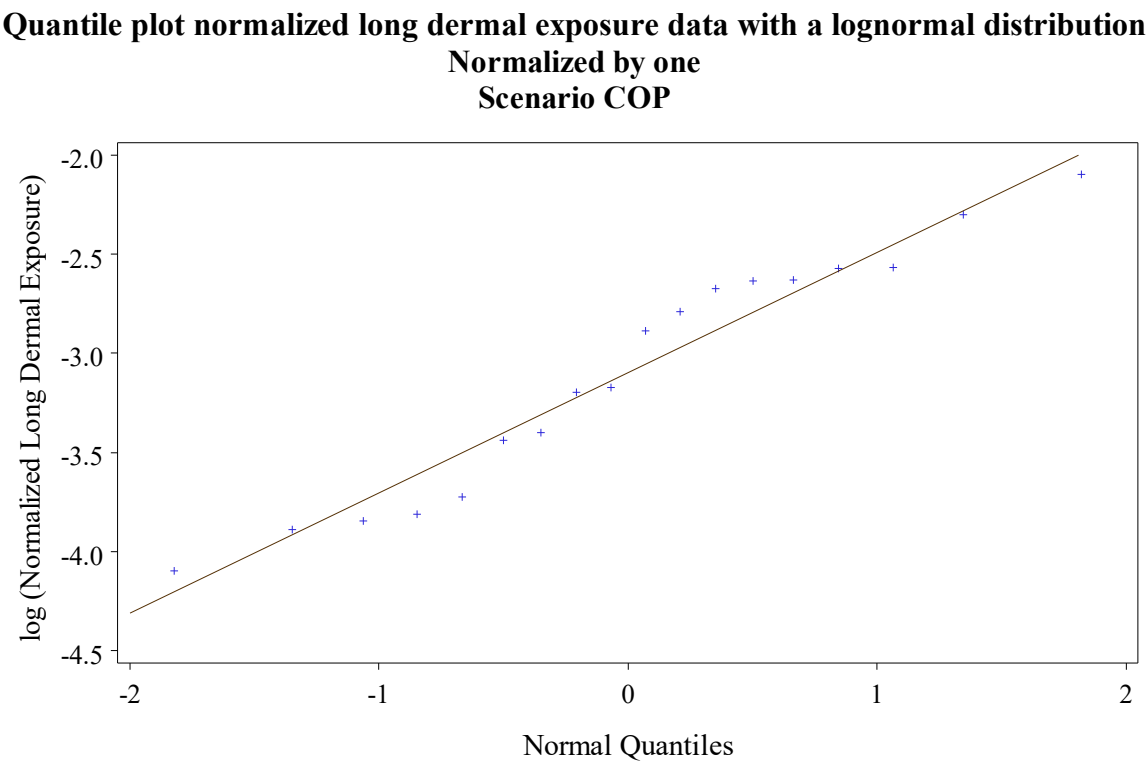


Figure CC2. Empirical quantile plot for Long Dermal, with a lognormal distribution

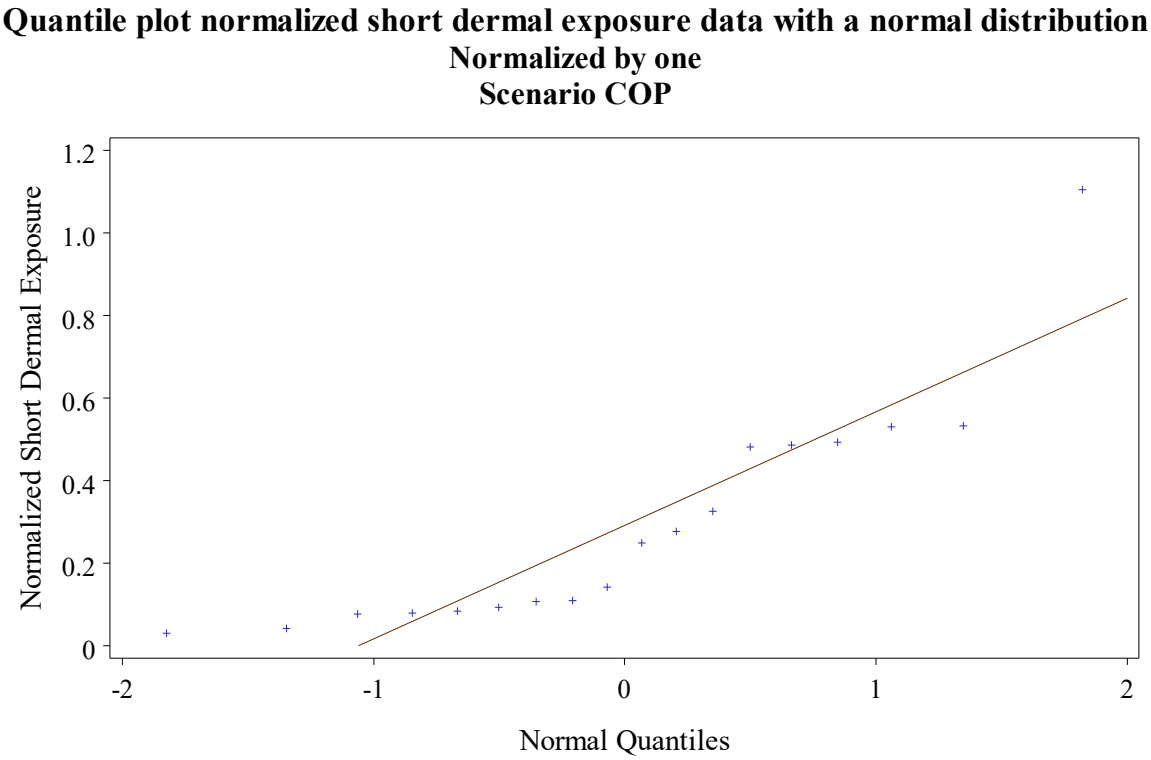


Figure CC3. Empirical quantile plot for Short Dermal, with a normal distribution

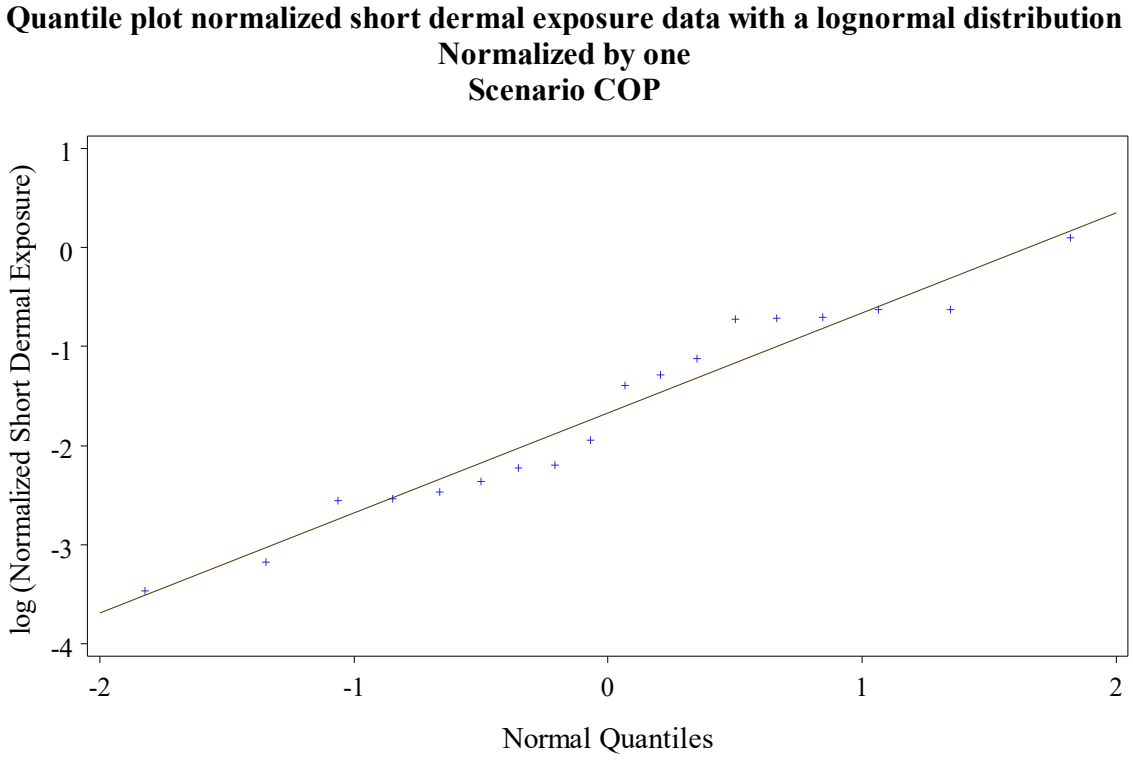


Figure CC4. Empirical quantile plot for Short Dermal, with a lognormal distribution

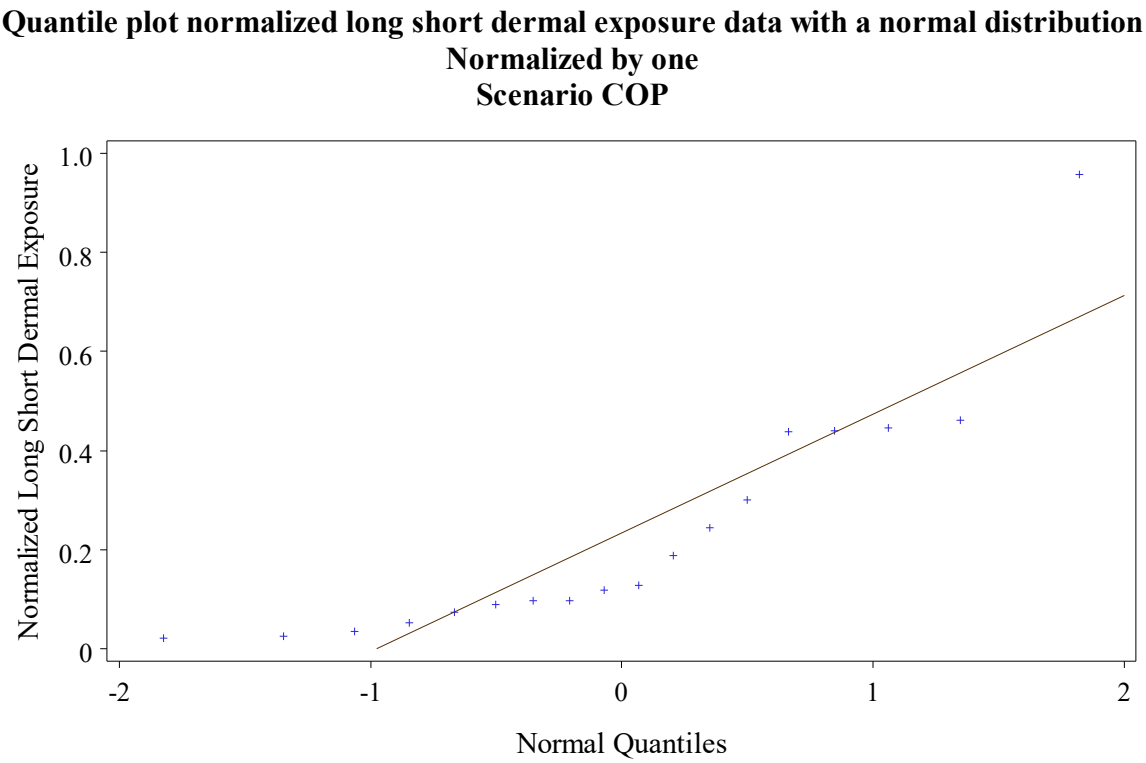


Figure CC5. Empirical quantile plot for Long Short Dermal, with a normal distribution

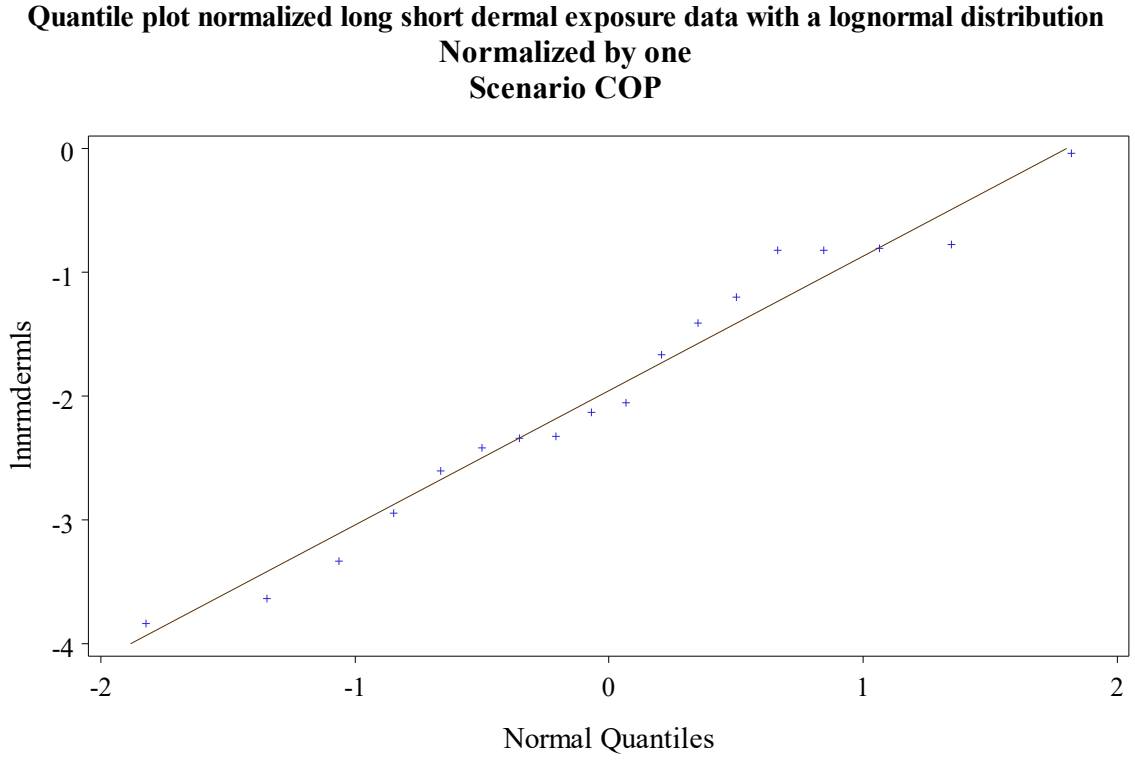


Figure CC6. Empirical quantile plot for Long Short Dermal, with a lognormal distribution

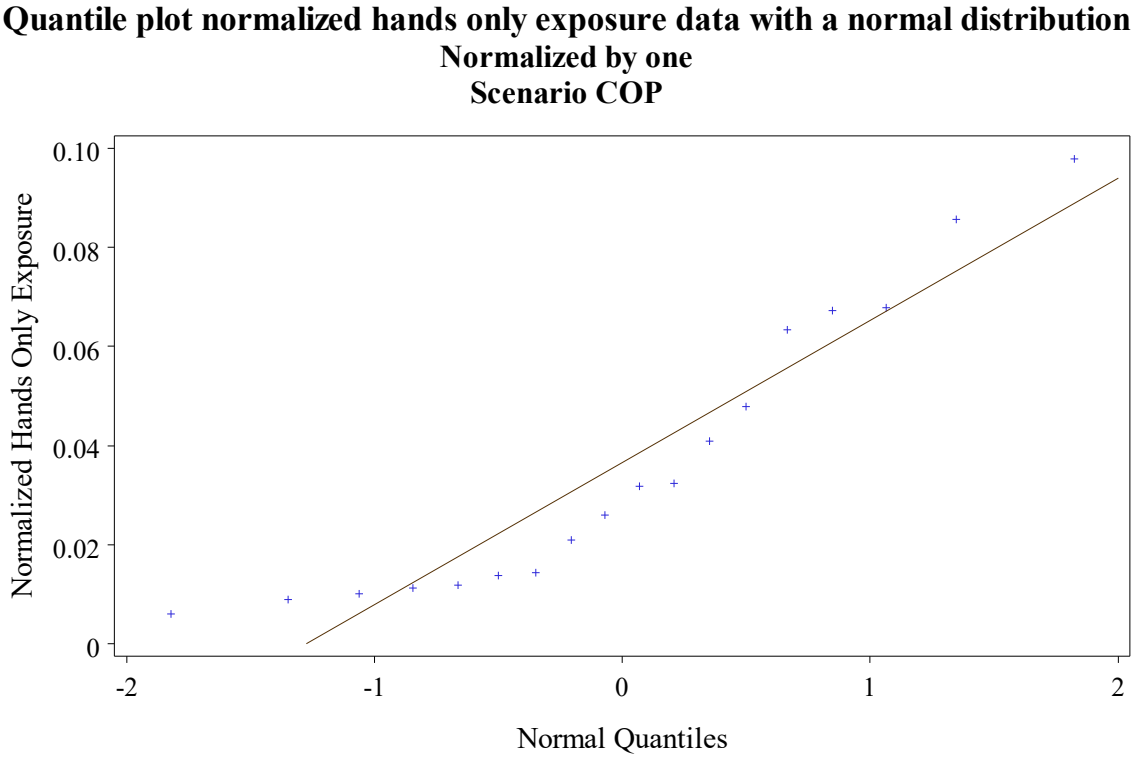


Figure CC7. Empirical quantile plot for Hands Only, with a normal distribution

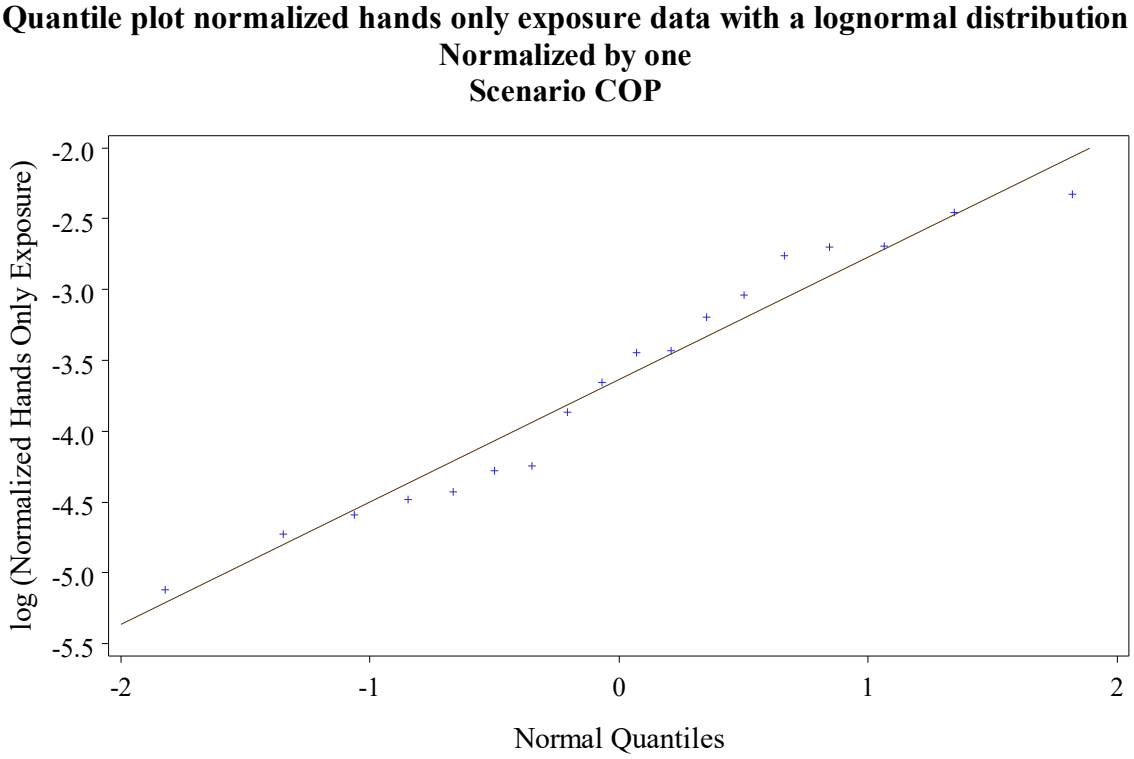


Figure CC8. Empirical quantile plot for Hands Only, with a lognormal distribution

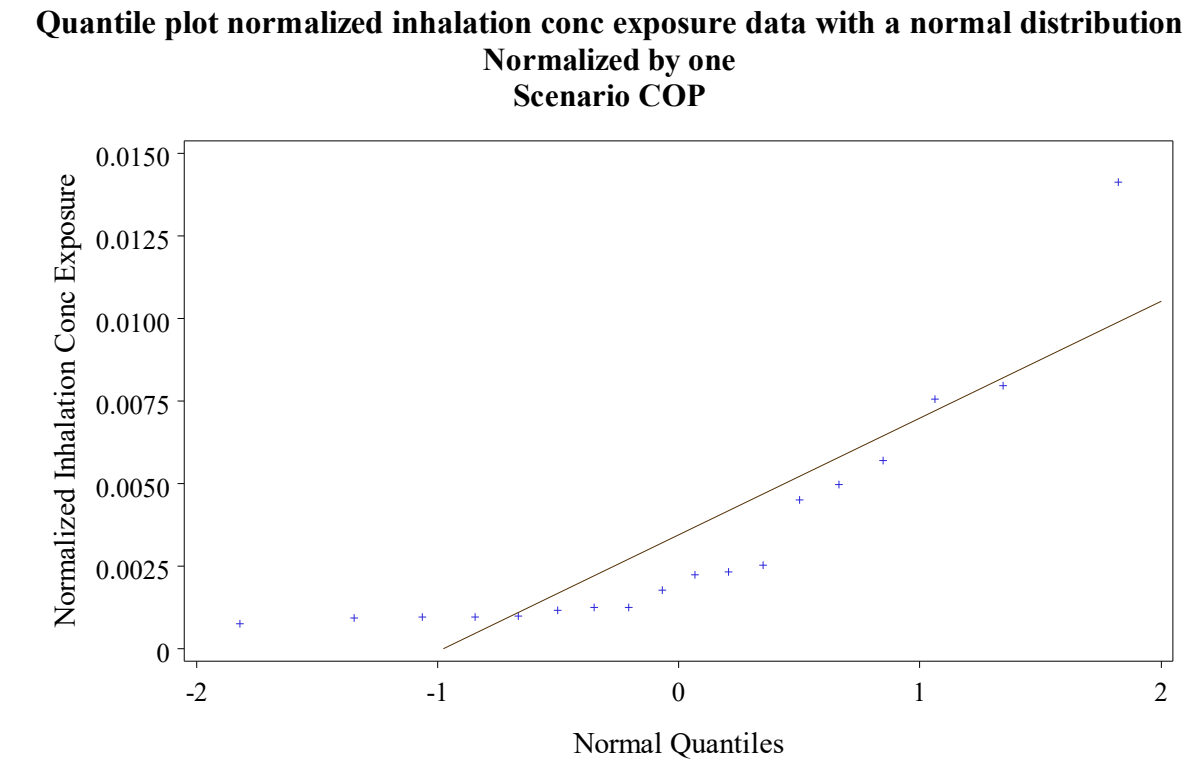


Figure CC9. Empirical quantile plot for Inhalation Concentration, with a normal distribution

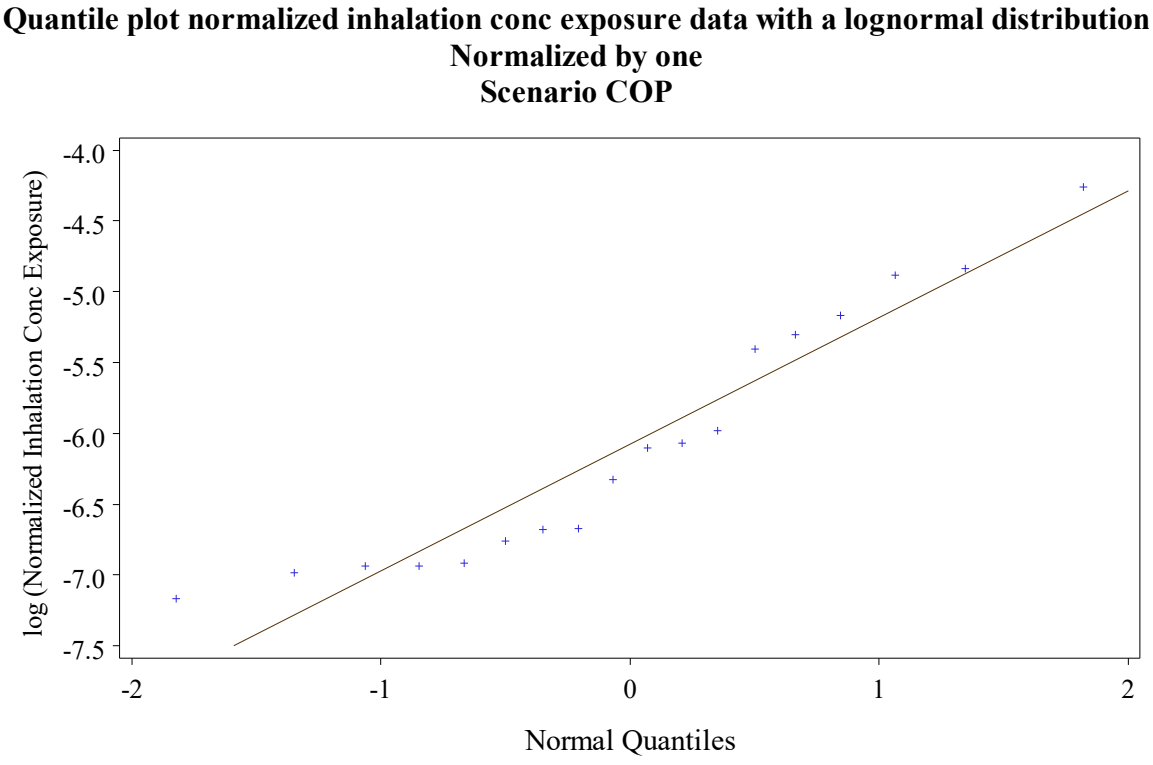


Figure CC10. Empirical quantile plot for Inhalation Concentration, with a lognormal distribution

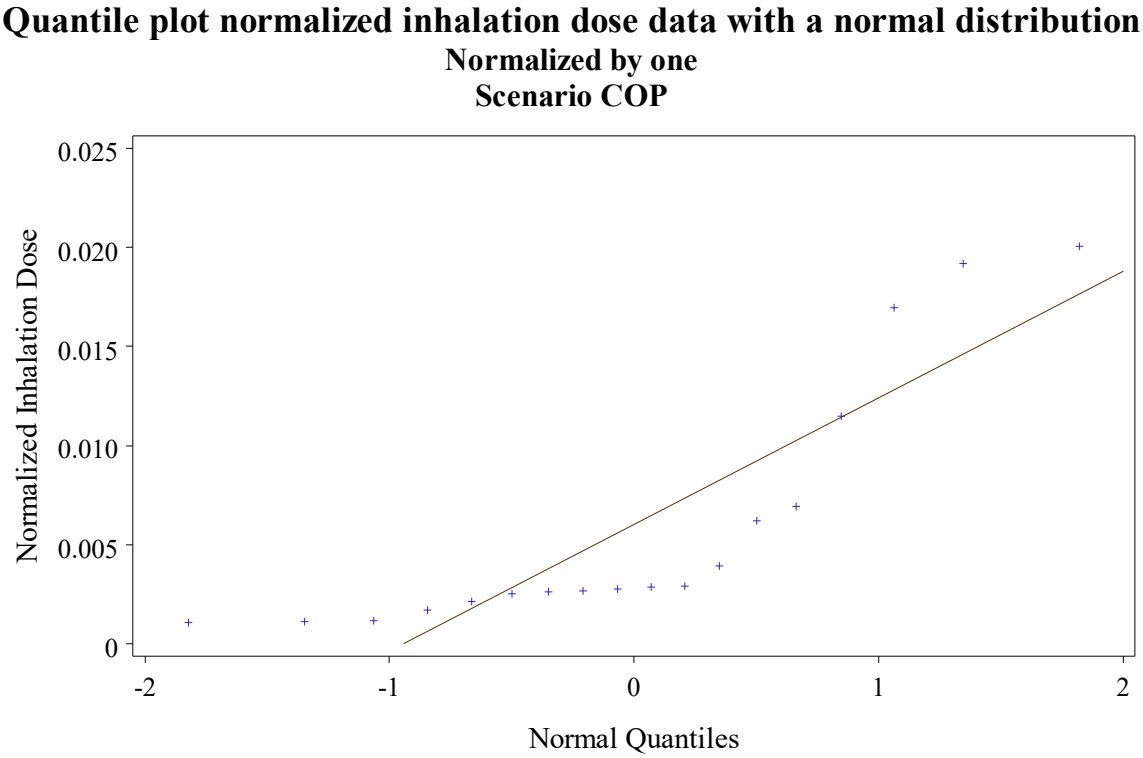


Figure CC11. Empirical quantile plot for Inhalation Dose, with a normal distribution

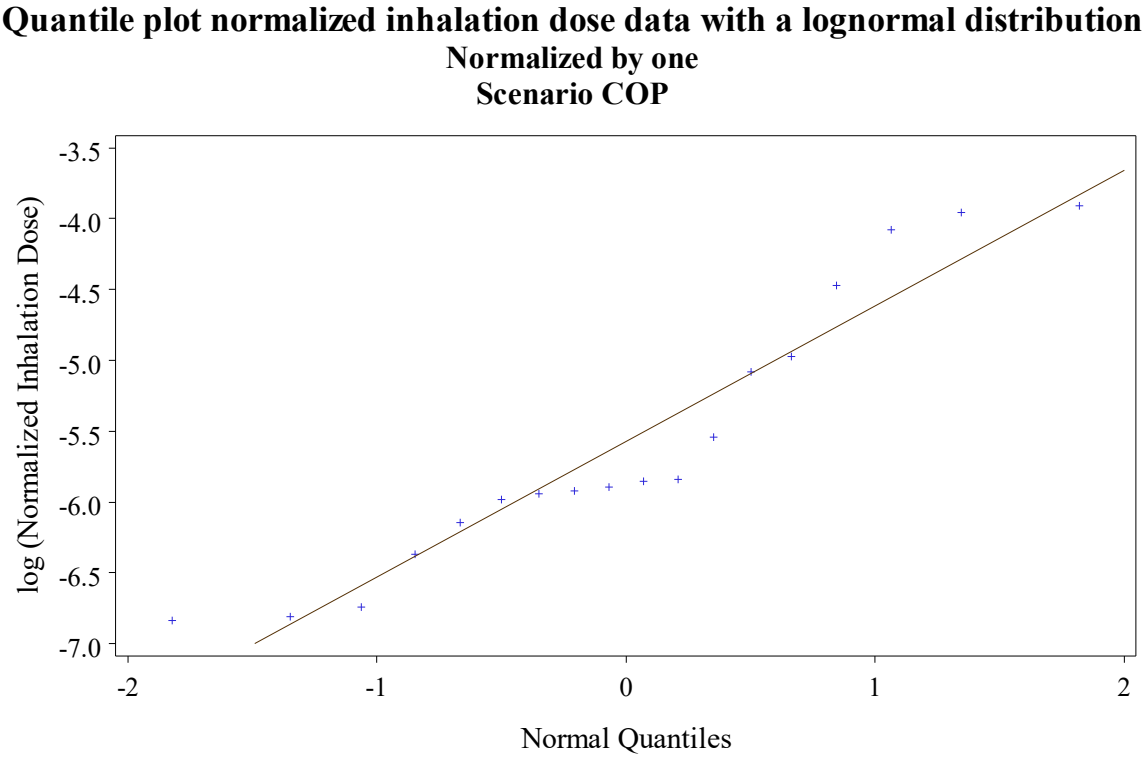


Figure CC12. Empirical quantile plot for Inhalation Dose, with a lognormal distribution

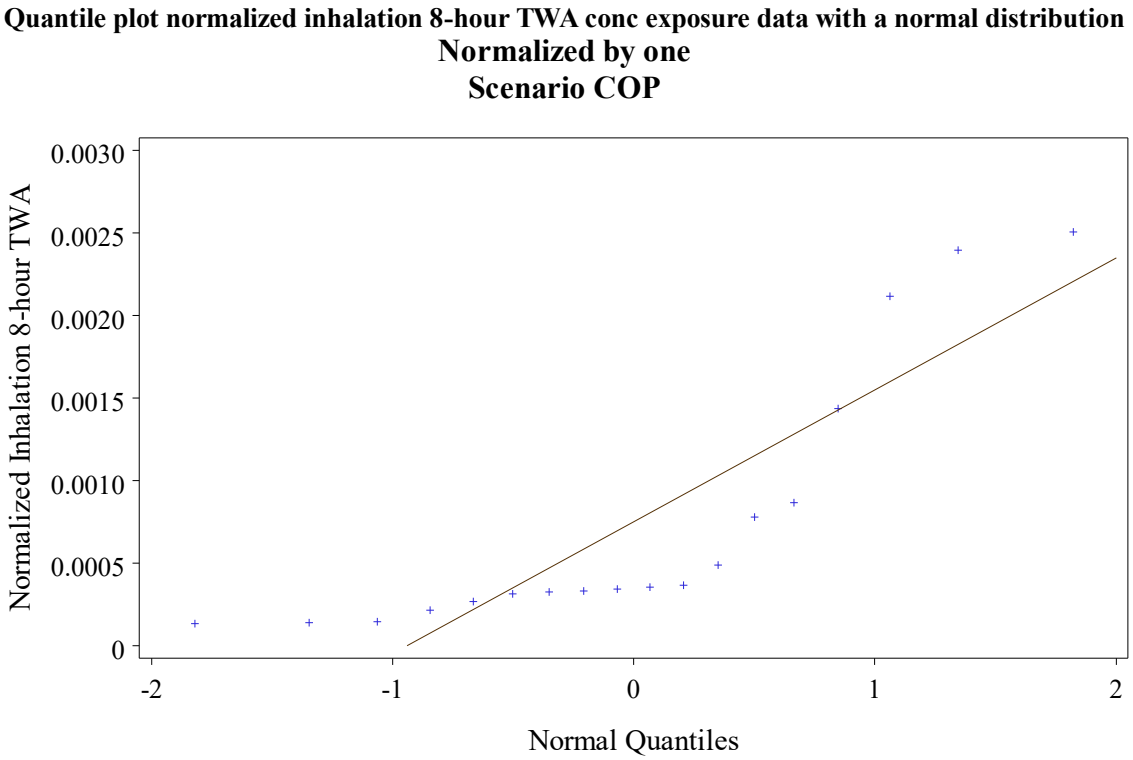


Figure CC13. Empirical quantile plot for Inhalation Time-weighted Average Conc, with a normal distribution

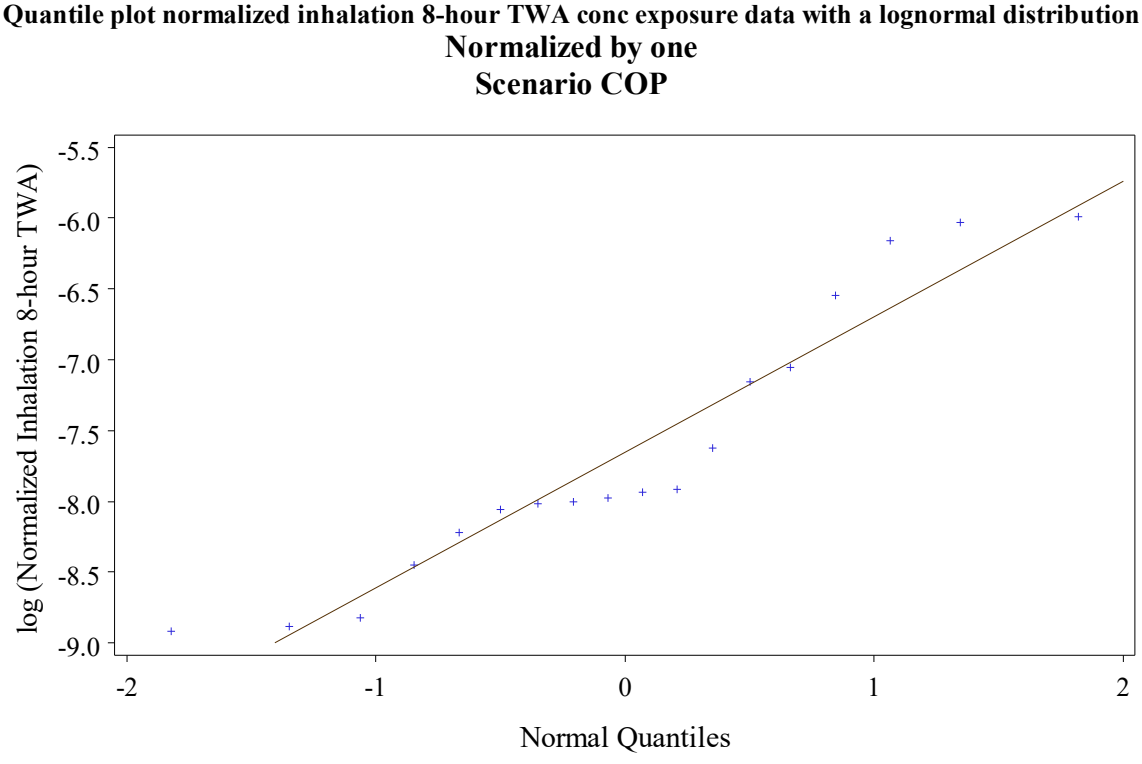


Figure CC14. Empirical quantile plot for Inhalation Time-weighted Average Conc, with a lognormal distribution

12. Threshold Analyses

The following analyses do not apply to the normalizing factor one since for that normalizing factor there were no regression models fitted.

As shown in the main memo, two statistical models were fitted to the exposure data and can be used to estimate the conditional mean exposure, i.e., the expected exposure conditional on the normalizing factor, NF, E{Exposure | NF}.

Linear Model

Log (Exposure) = Intercept + Slope × Log (NF) + Random Error,

which implies

Equation 1: E{Exposure | NF} = Expected Exposure Given NF = $C \times NF^{Slope}$,

where

$C = e^{Intercept} \times e^{Varerror/2}$.

Lognormal Model

If the value of Slope in the linear model is 1, then

Log (Normalized Exposure) = Log(Exposure / NF)

= Intercept* + Random Error,

which implies

Equation 2: E{Exposure | NF} = Expected Exposure Given the NF = $C^* \times NF$,

where

$C^* = e^{Intercept^*} \times e^{Varerror^*/2}$.

(The parameters for the lognormal model are asterisked). If Slope equals 1 then the two models are identical.

These two statistical models can be compared by calculating the threshold value of the normalizing factor at which both models predict the same conditional mean exposure.

Define Threshold = $\left(\frac{C}{C^*}\right)^{\frac{1}{1-Slope}}$.

Thus E(X | NF) for the lognormal model > E(X | NF) for the linear model if and only if

$C^* \times NF > C \times NF^{Slope}$, which is true if and only if

Either Slope < 1 and NF > Threshold

Or Slope > 1 and NF < Threshold.

These are the conditions under which the lognormal model overestimates exposure compared to the linear model.

The most useful case is when slope < 1. If so, the lognormal model is "more conservative" (i.e., predicts higher exposure) when the normalizing factor is high (more specifically, above the threshold). When the normalizing factor is below the threshold, then either the linear model equation $C \times NF^{Slope}$ can be used to estimate the conditional mean exposure, or instead one can use the upper bound C* × Threshold. If normalizing factor = Threshold, then the estimates of the conditional mean exposure are the same.

The Threshold normalizing factor values and corresponding exposure values C* × Threshold were tabulated together with the estimated slopes in the corresponding main memo and Supplement Tables coded as XY18 above.

We now have two estimates of the conditional mean exposure for a given normalizing factor, equations 1 and 2. The graphs below compare the conditional mean exposure estimates for each normalizing factor (concentration or concentration time duration), all three scenarios, and all seven exposure routes. The conditional mean exposure is plotted against the normalizing factor. The brown curve gives the estimates for the linear model in equation 1. The green line gives the estimates for the lognormal model in equation 2. The two estimates are equal if the normalizing factor equals the Threshold value. The data points are labeled to show the sample target durations.

As proven above, the conditional mean exposure from the lognormal model will be greater than the conditional mean exposure from the linear model for normalizing factor values above the threshold (right hand side of the graph). The conditional mean exposure from the lognormal model will be less than the conditional mean exposure from the linear model for normalizing factor values below the threshold (left hand side of the graph).

The threshold plots are shown below in Figures labeled XY29 to XY35 where X denotes the normalizing factor (A = concentration times duration, B = concentration), Y denotes the scenario (B = Bucket, S = Sink, C = COP), and the numbers 29-35 give the seven exposure routes.

Normalizing Factor concentration × duration. Bucket Scenario.

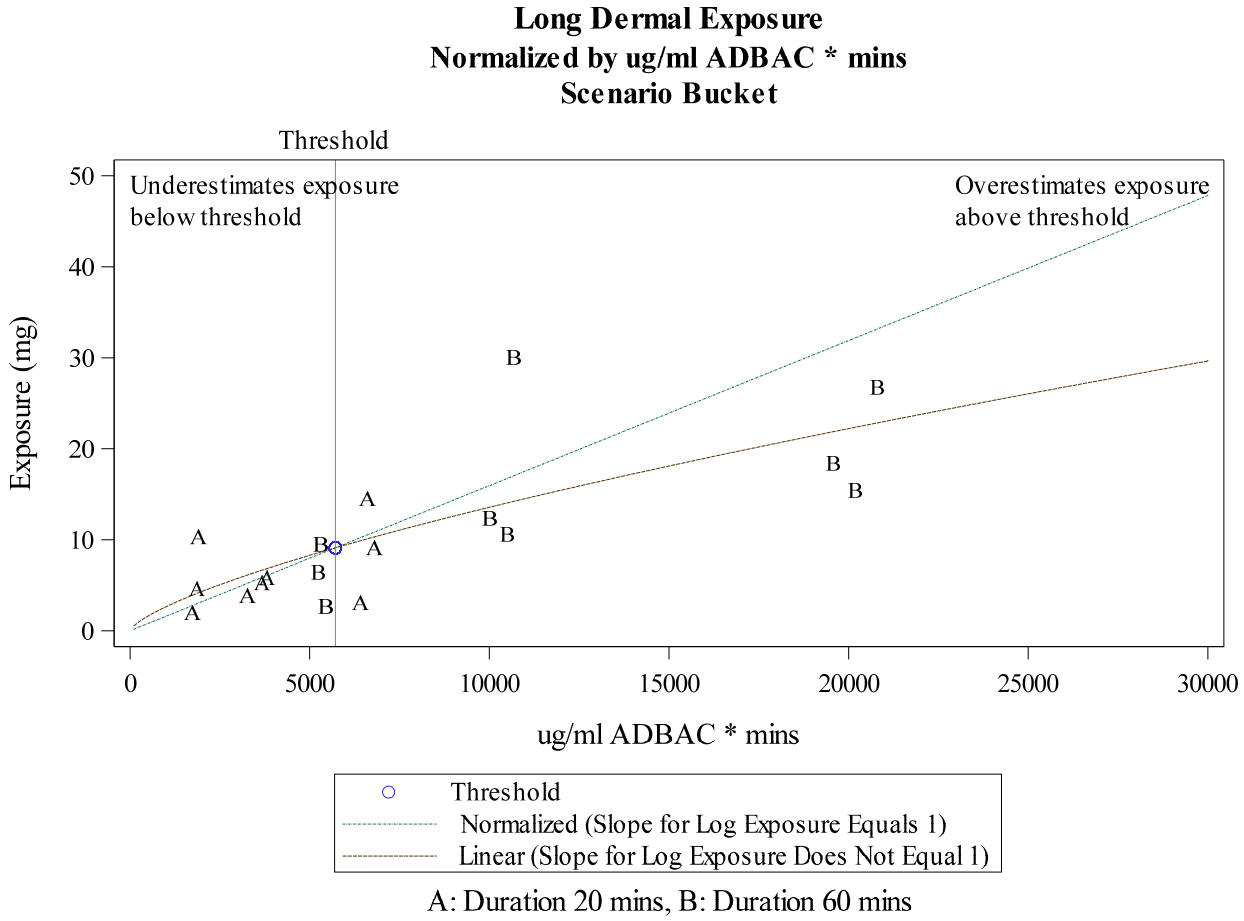


Figure AB29. Threshold plot for Long Dermal Exposure (mg)

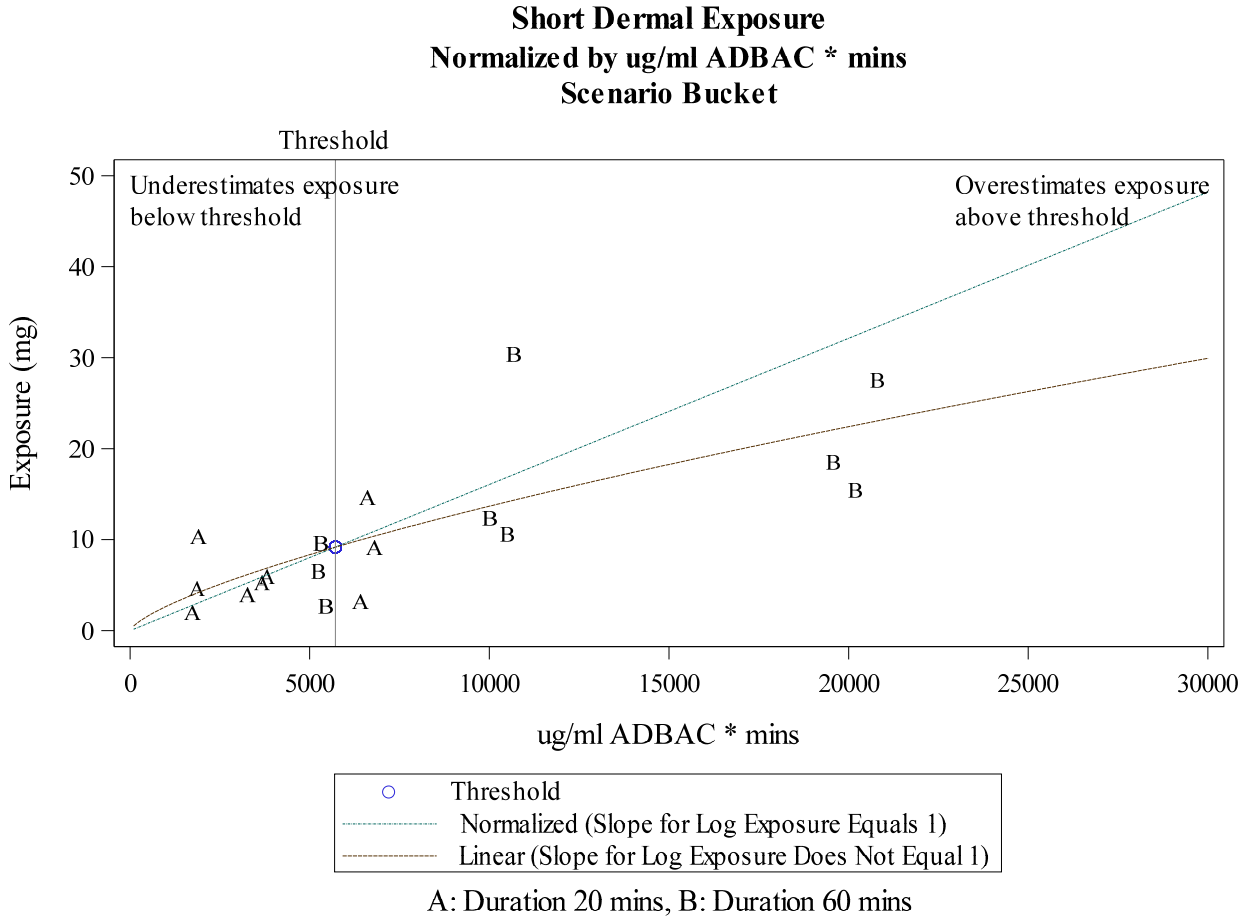


Figure AB30. Threshold plot for Short Dermal Exposure (mg)

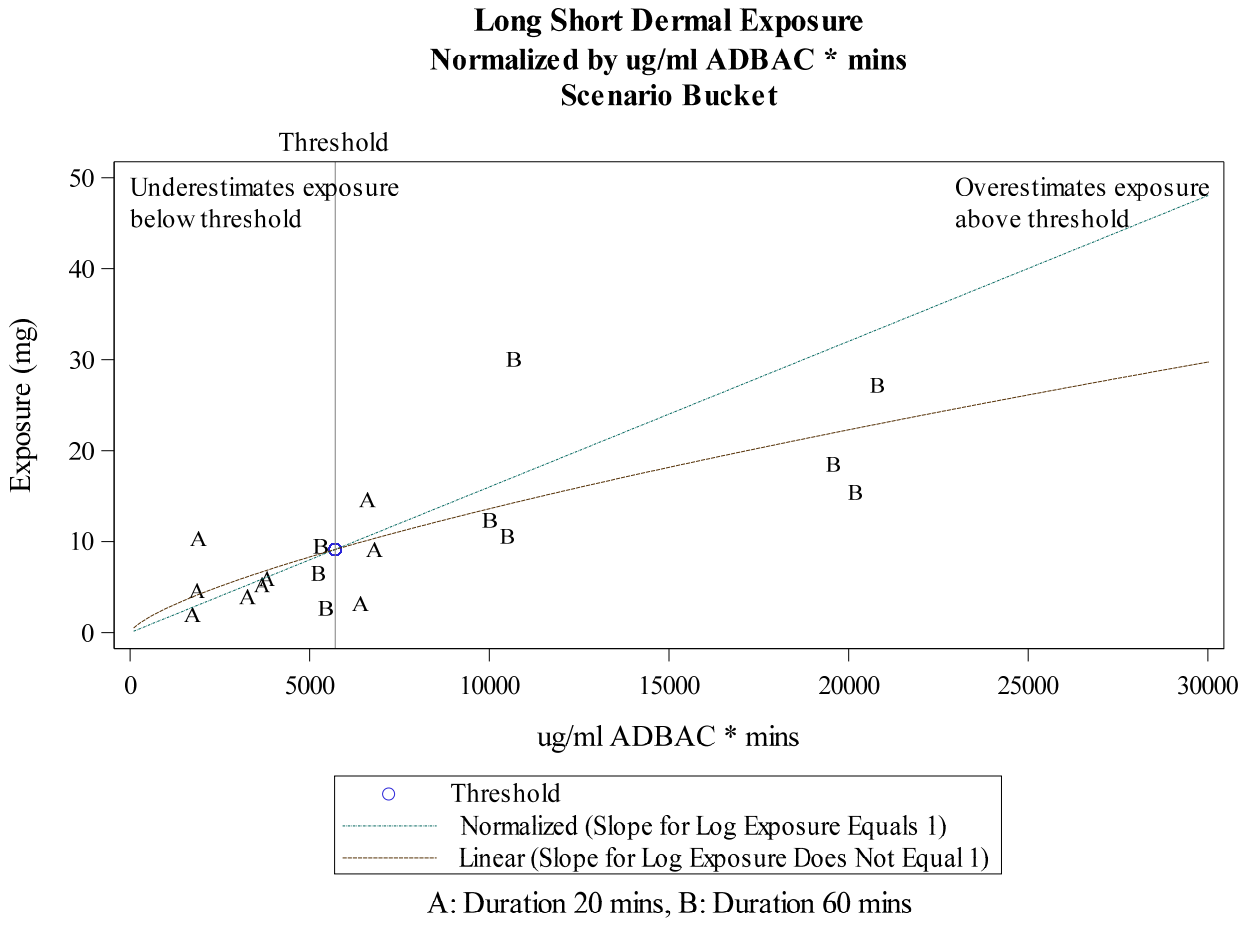


Figure AB31. Threshold plot for Long Short Dermal Exposure (mg)

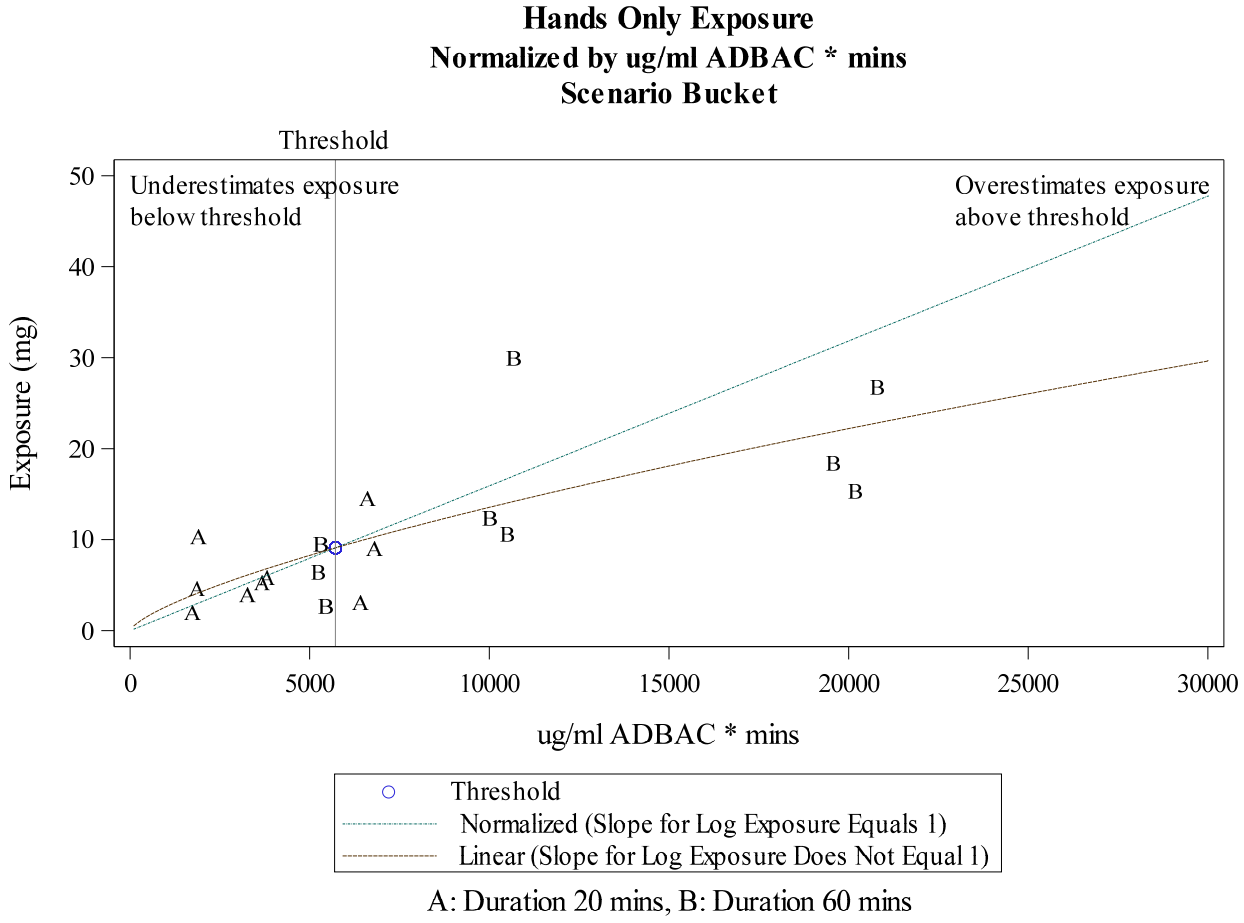


Figure AB32. Threshold plot for Hands Only Exposure (mg)

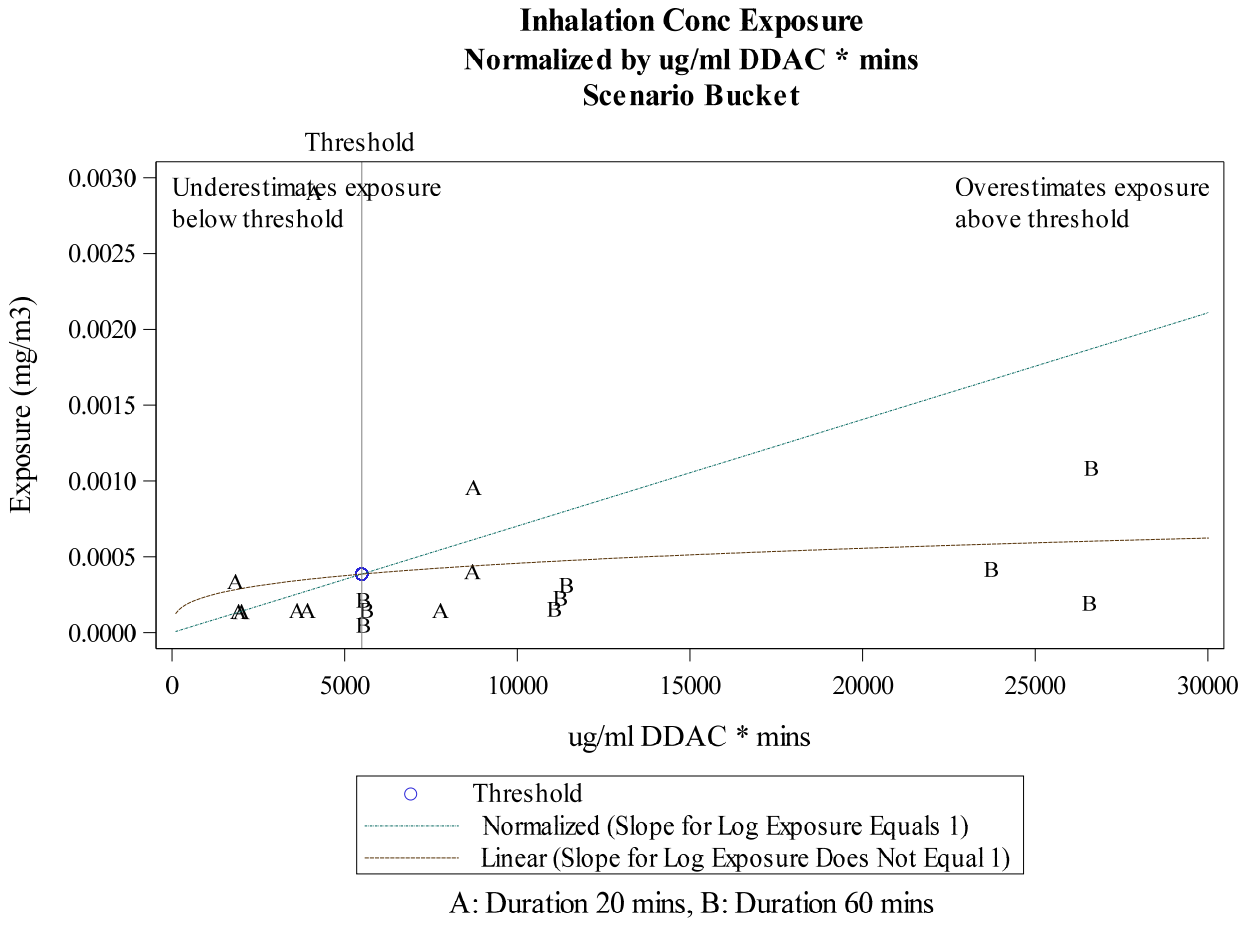


Figure AB33. Threshold plot for Inhalation Concentration Exposure (mg/m^3)

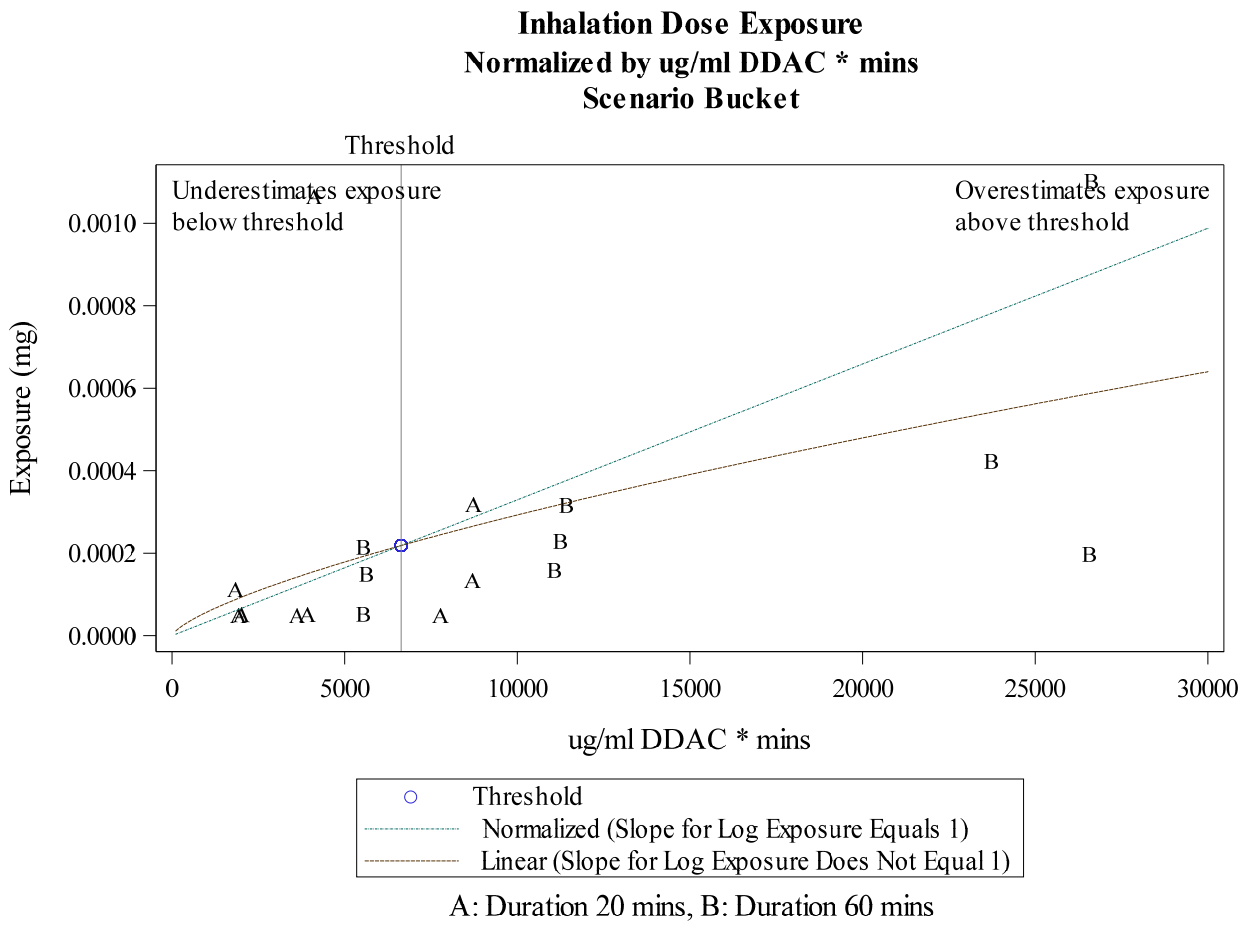


Figure AB34. Threshold plot for Inhalation Dose Exposure (mg)

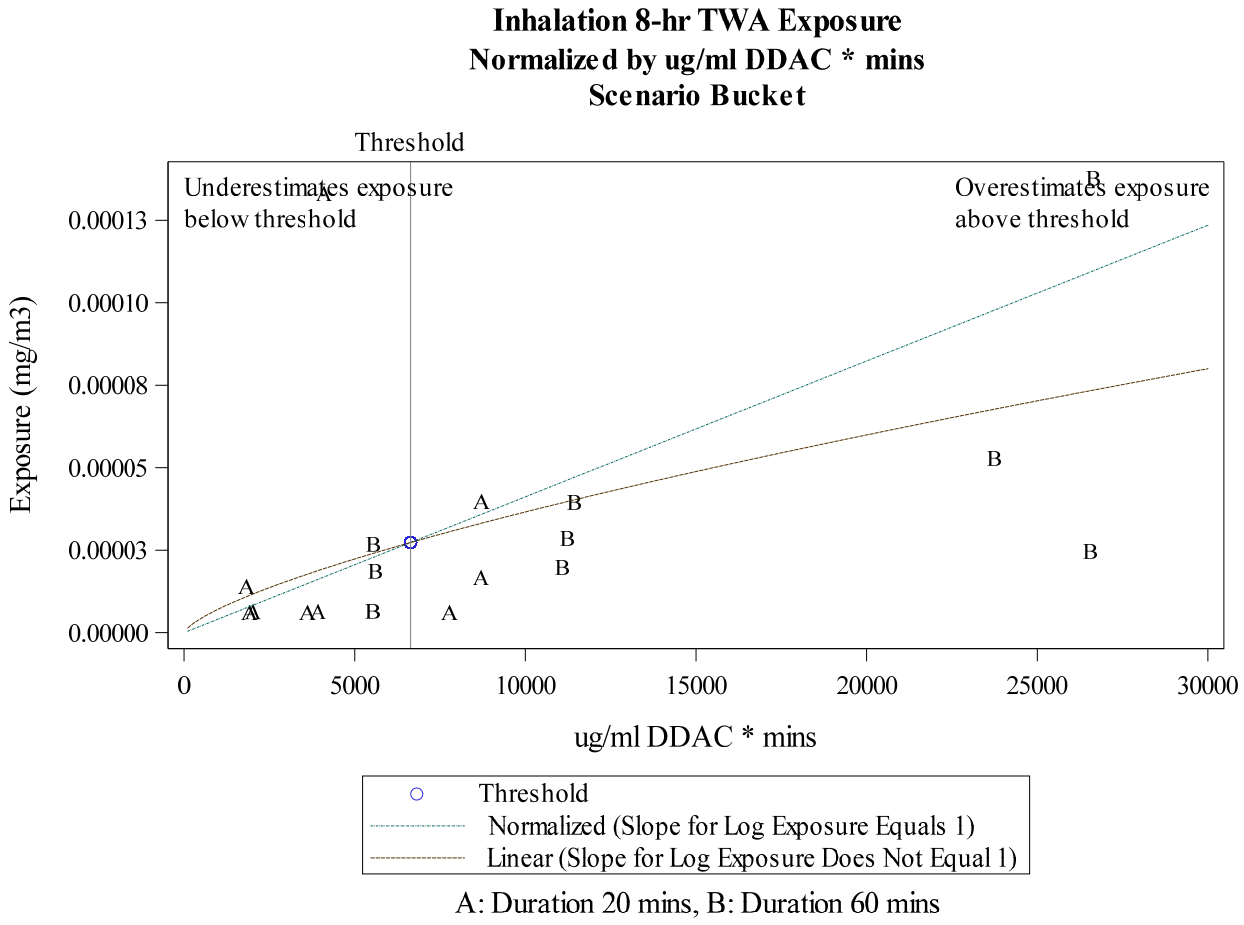


Figure AB35. Threshold plot for Inhalation Time Weighted Average Exposure (mg/m^3)

Normalizing Factor concentration × duration. Sink Scenario.

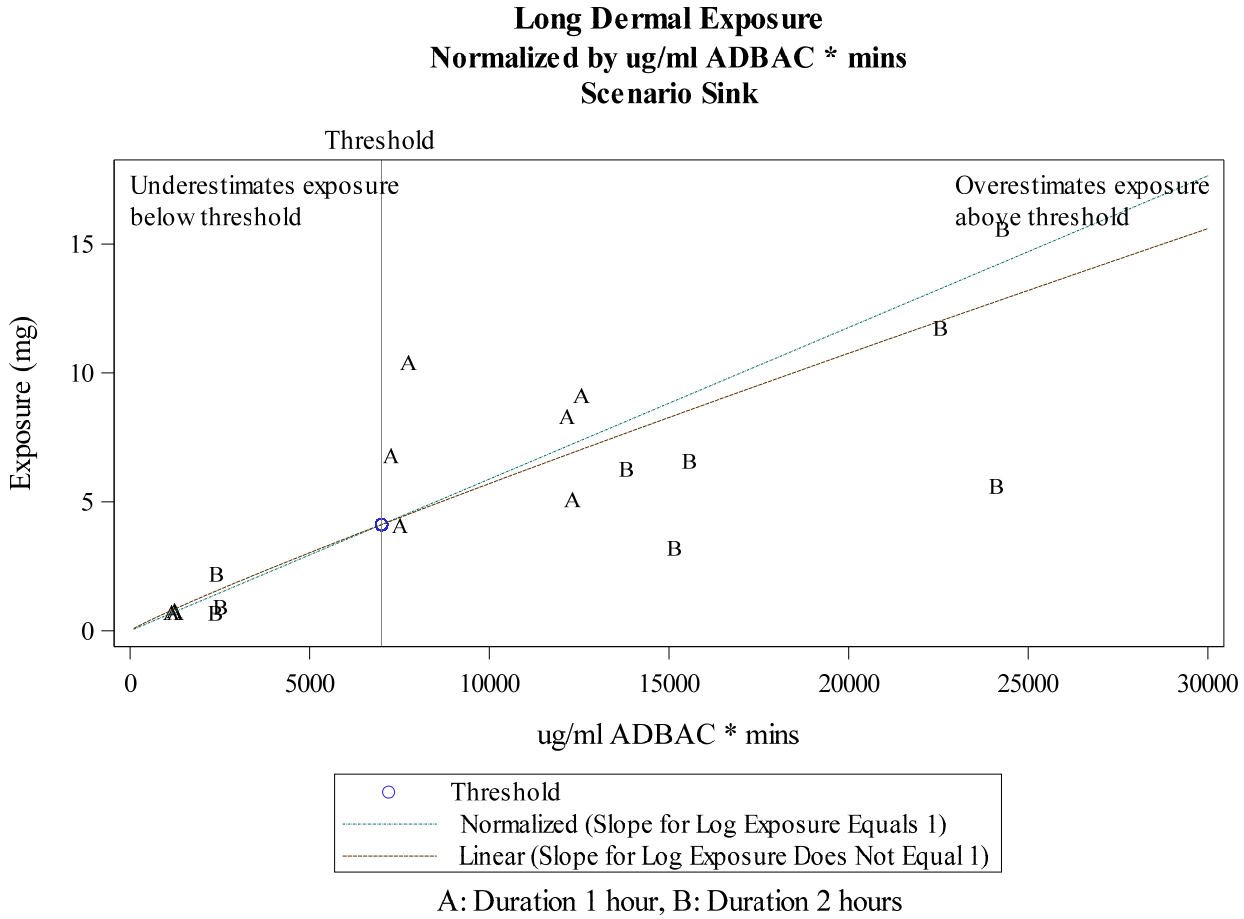


Figure AS29. Threshold plot for Long Dermal Exposure (mg)

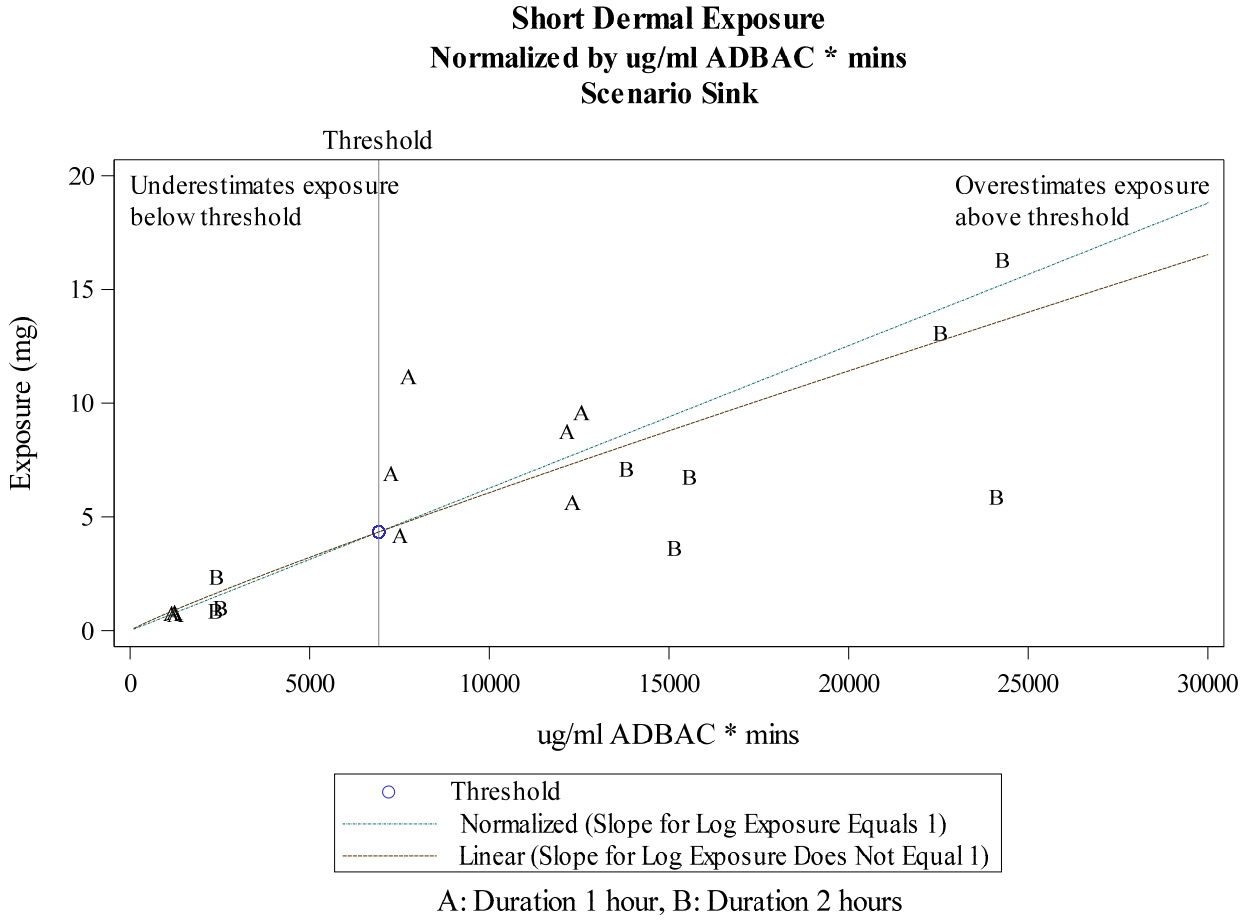


Figure AS30. Threshold plot for Short Dermal Exposure (mg)

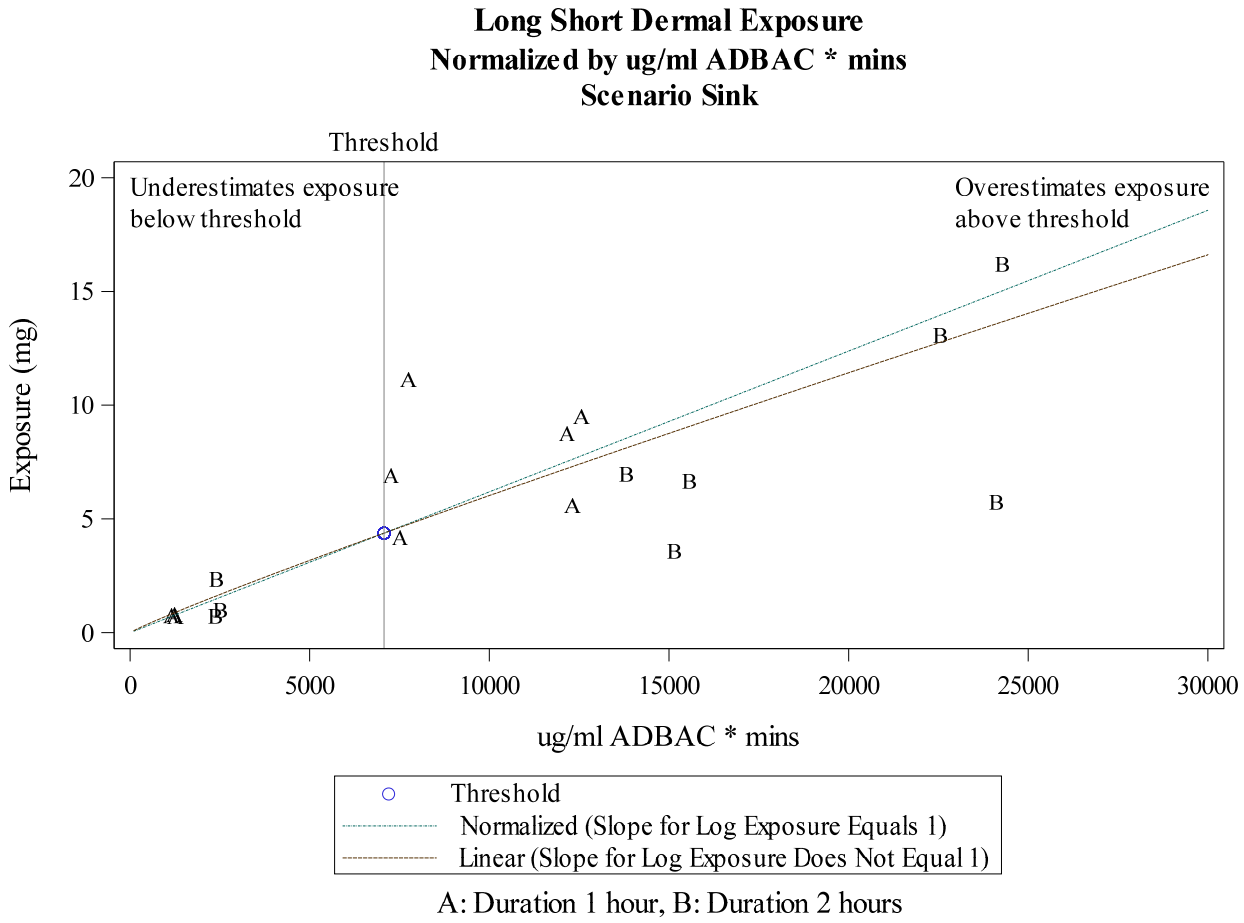


Figure AS31. Threshold plot for Long Short Dermal Exposure (mg)

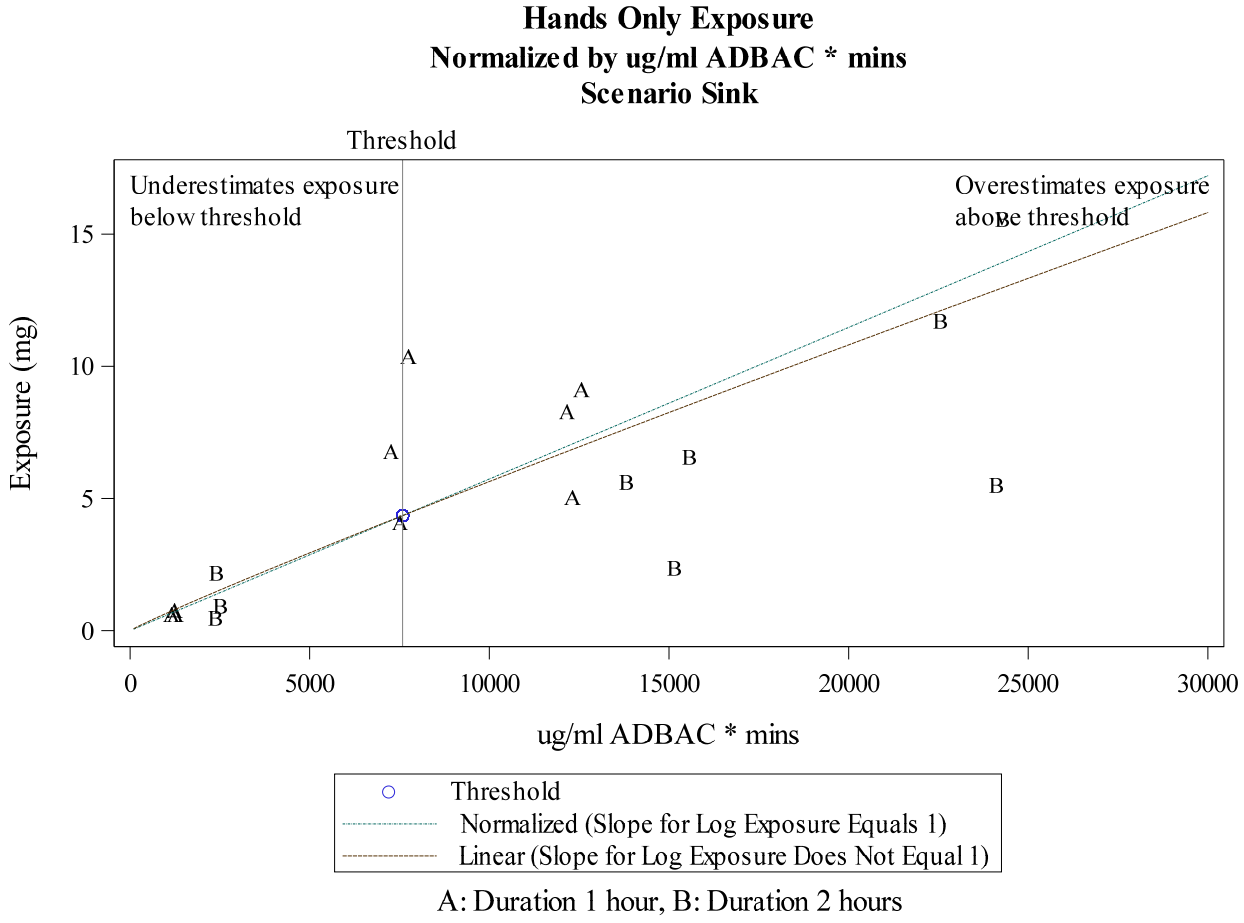


Figure AS32. Threshold plot for Hands Only Exposure (mg)

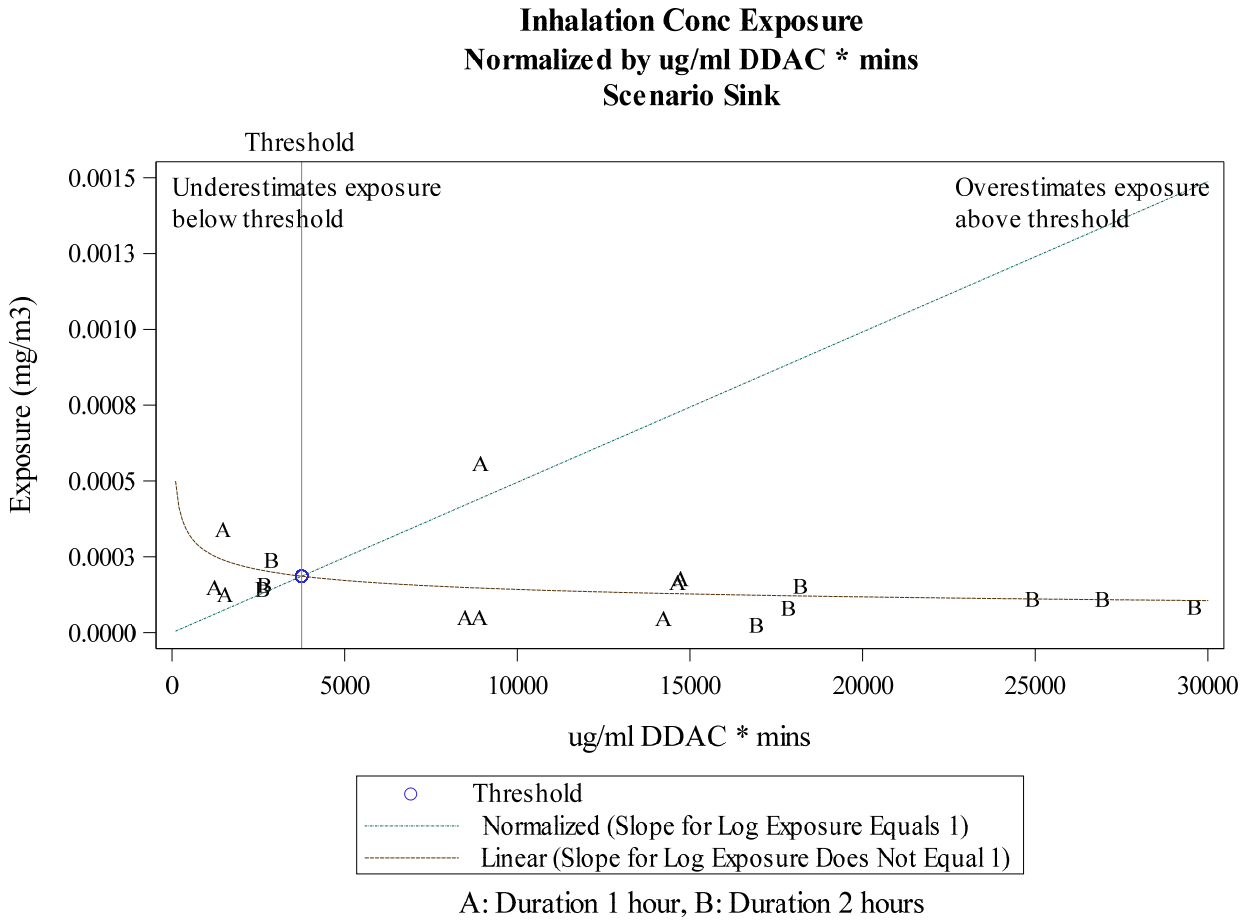


Figure AS33. Threshold plot for Inhalation Concentration Exposure (mg/m^3)

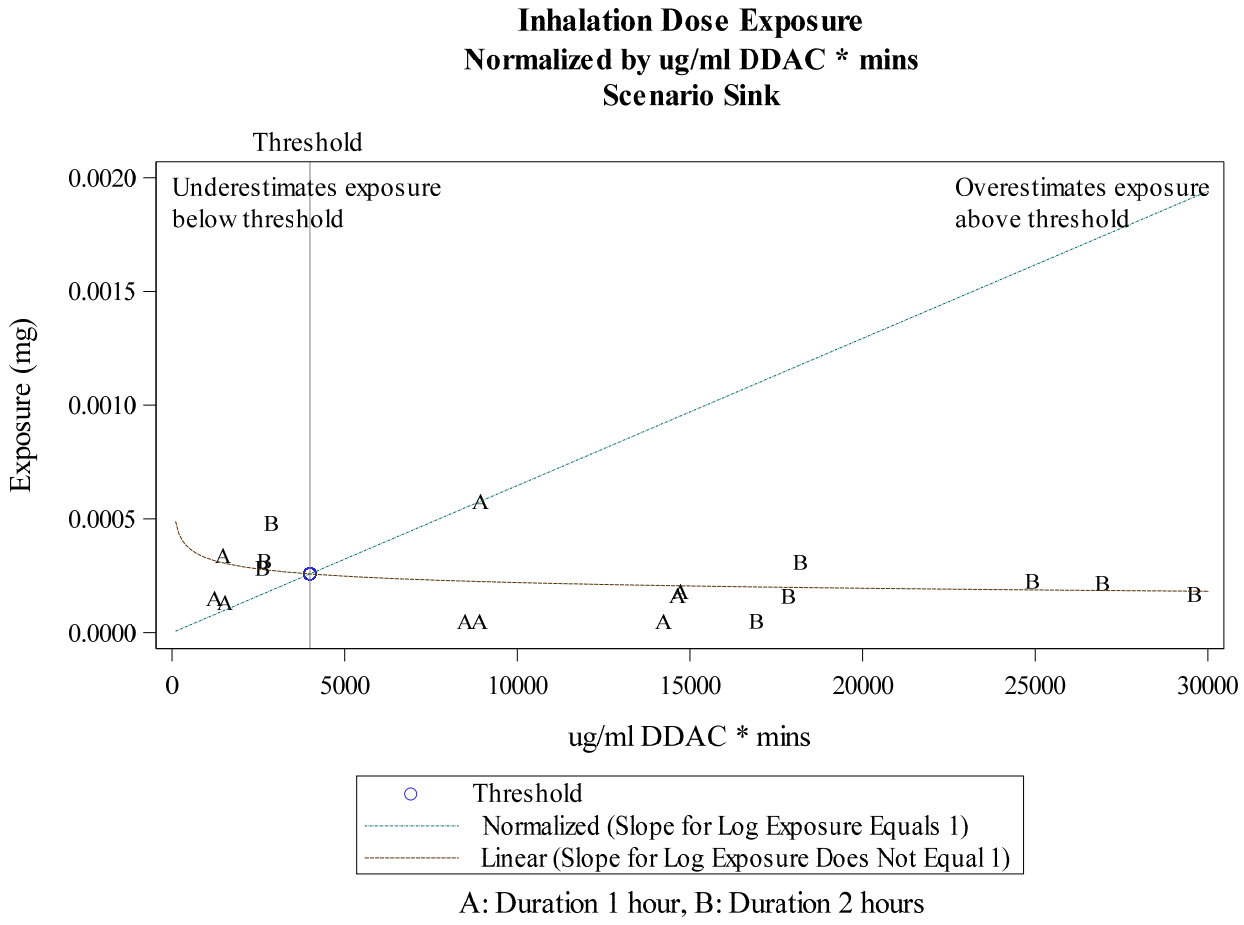


Figure AS34. Threshold plot for Inhalation Dose Exposure (mg)

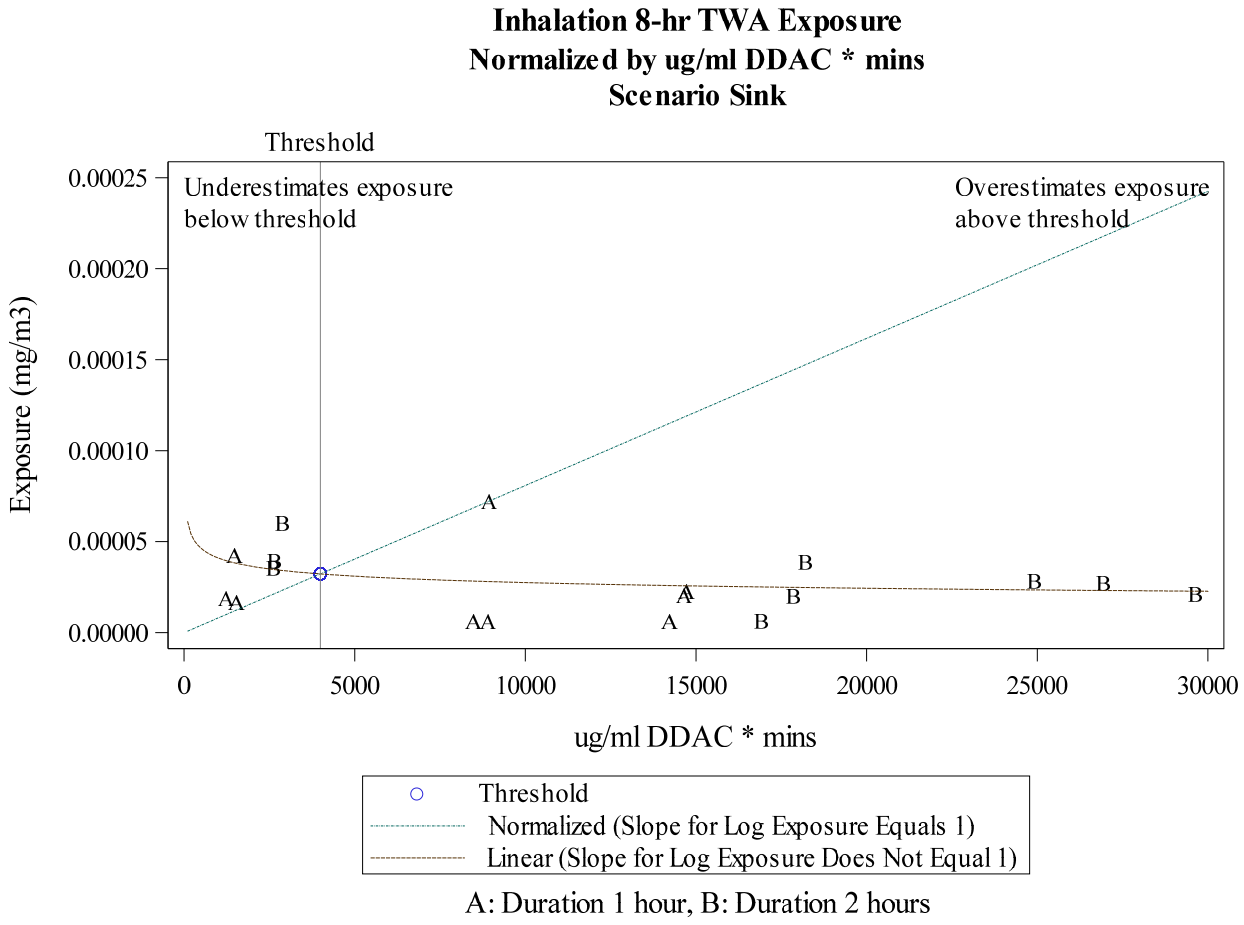


Figure AS35. Threshold plot for Inhalation Time Weighted Average Exposure (mg/m^3)

Normalizing Factor concentration × duration. COP Scenario.

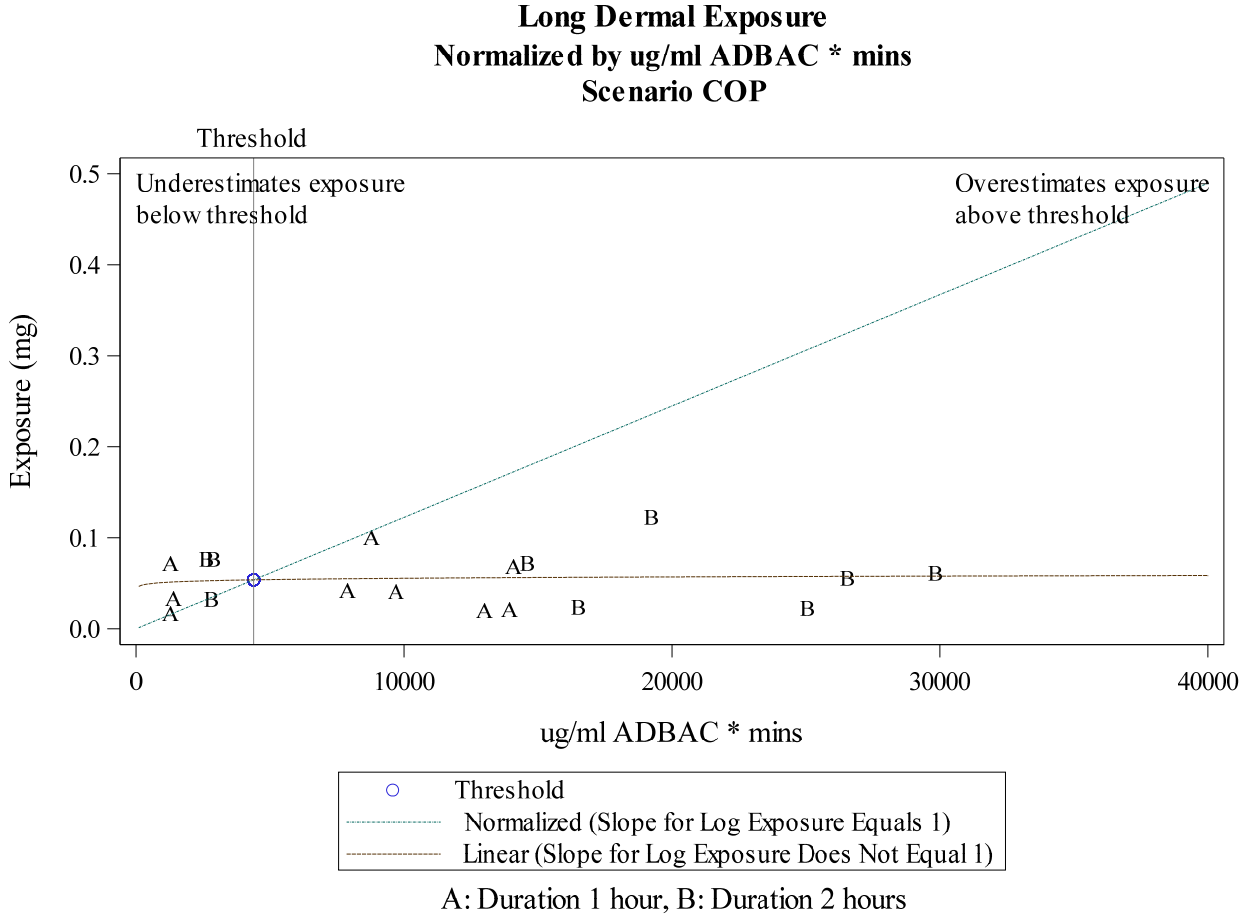


Figure AC29. Threshold plot for Long Dermal Exposure (mg)

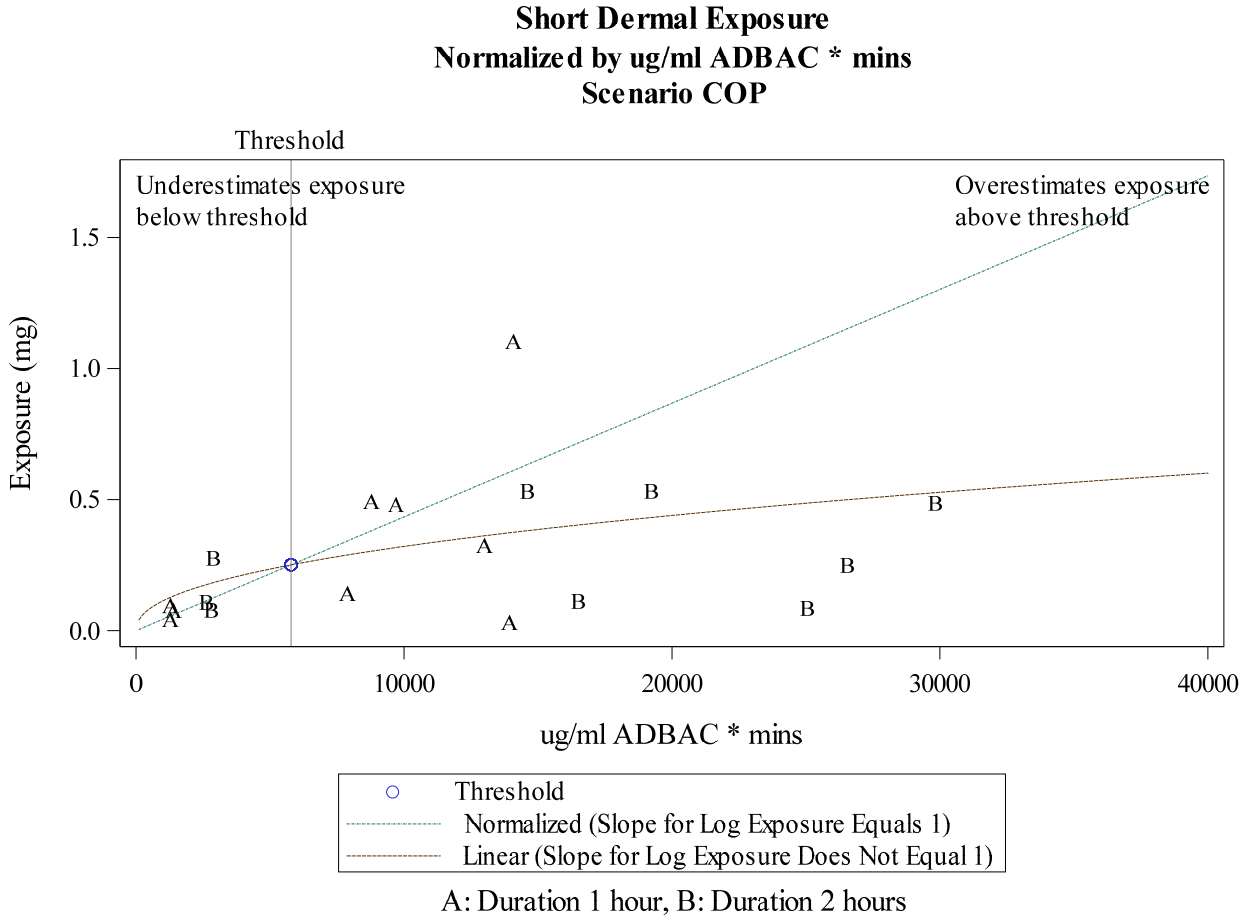


Figure AC30. Threshold plot for Short Dermal Exposure (mg)

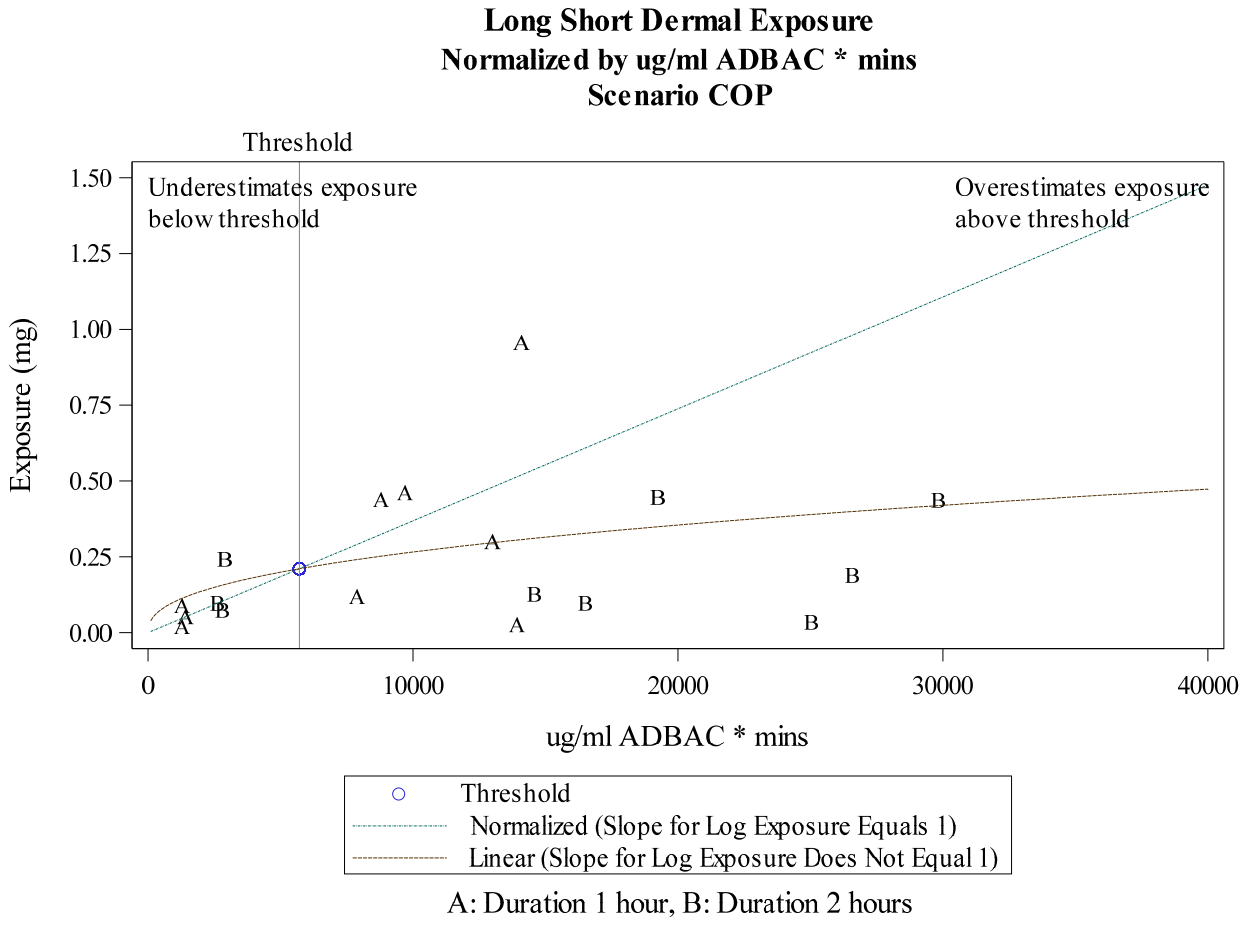


Figure AC31. Threshold plot for Long Short Dermal Exposure (mg)

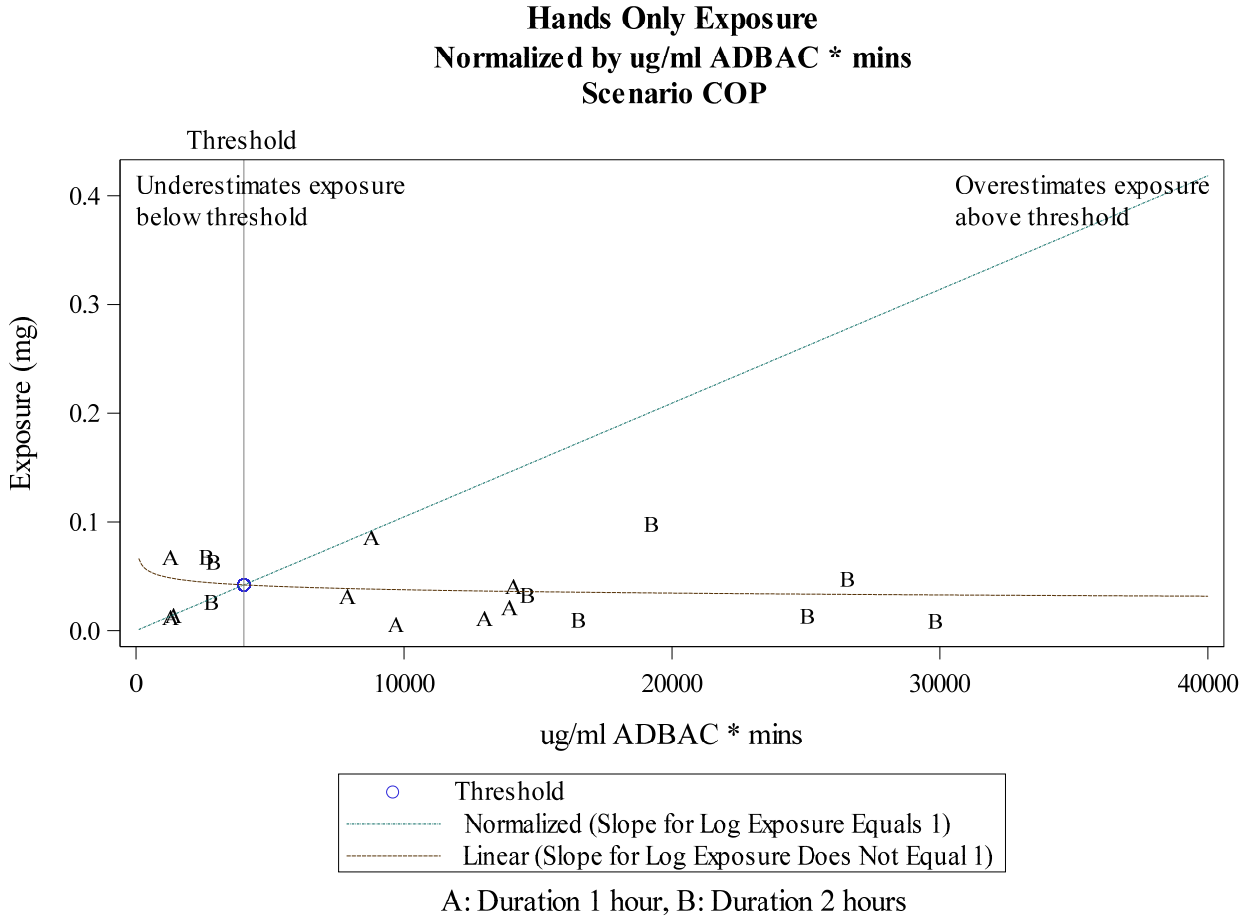


Figure AC32. Threshold plot for Hands Only Exposure (mg)

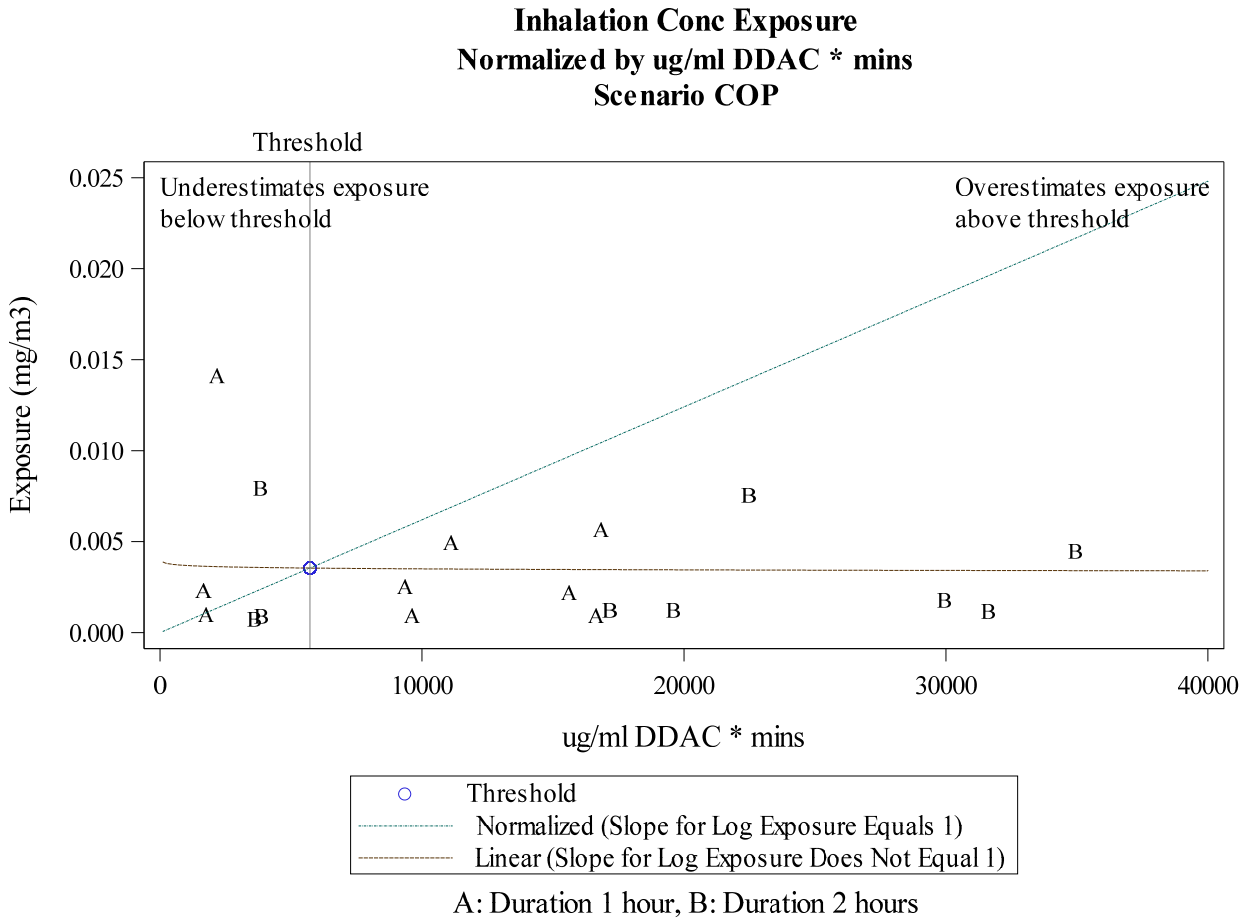


Figure AC33. Threshold plot for Inhalation Concentration Exposure (mg/m³)

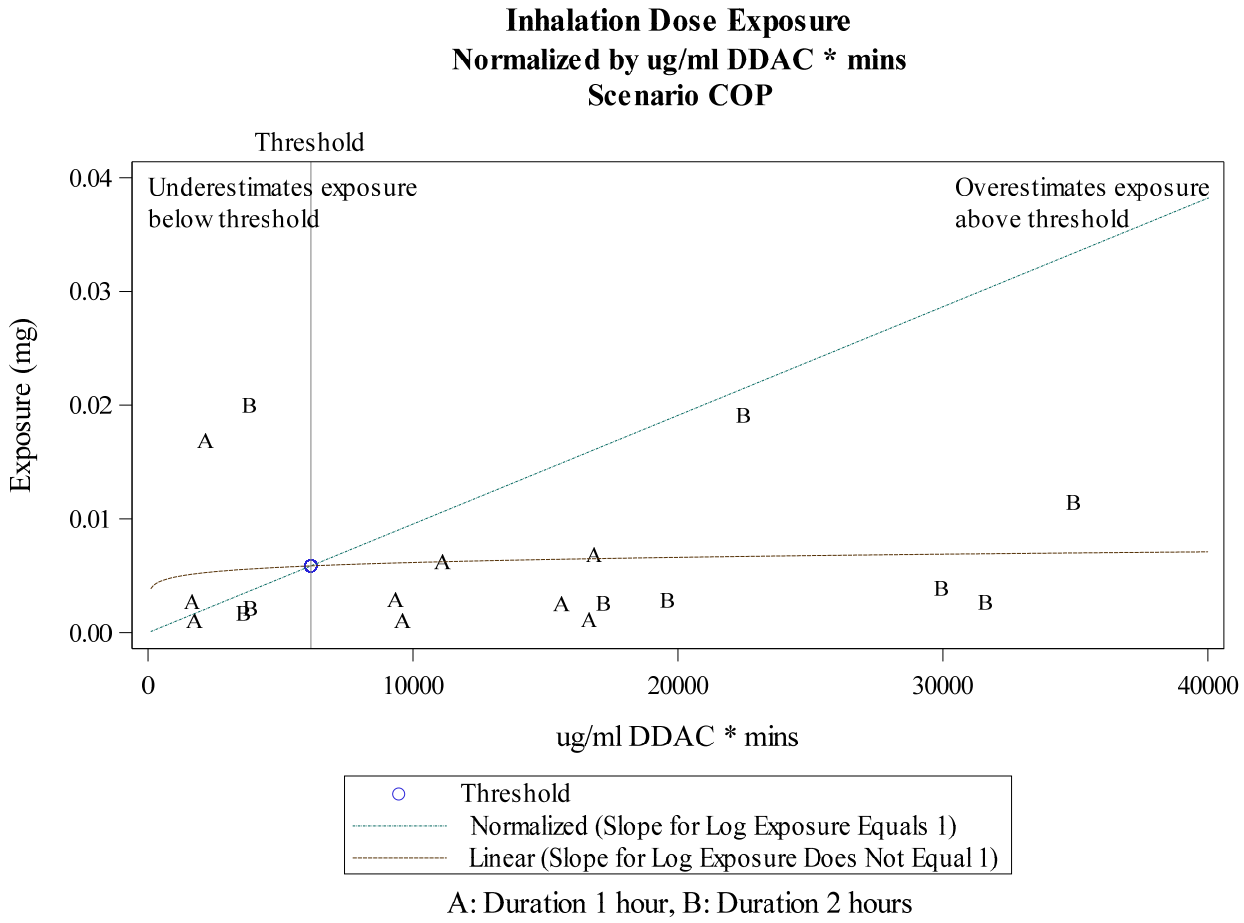


Figure AC33. Threshold plot for Inhalation Dose Exposure (mg)

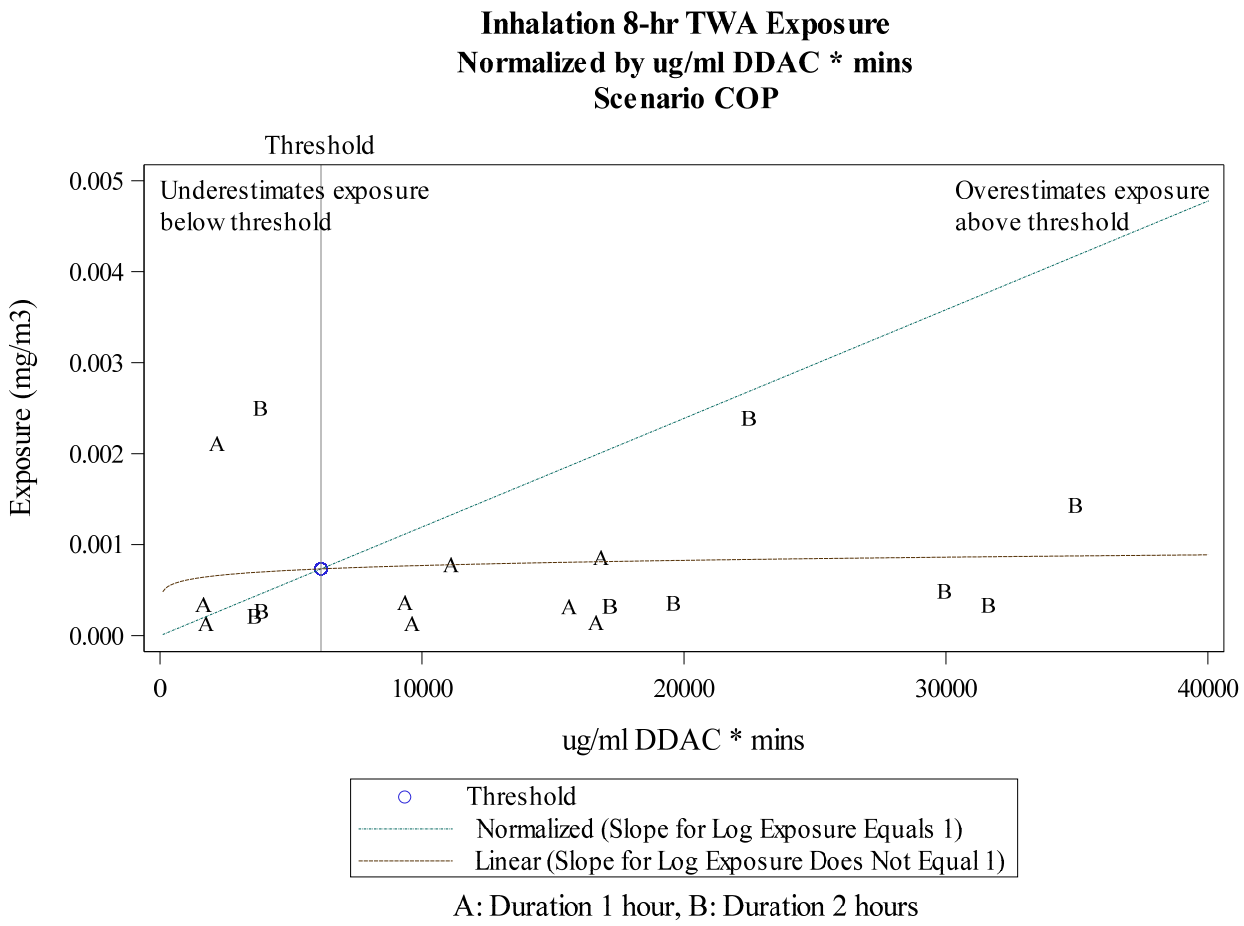


Figure AC34. Threshold plot for Inhalation Time Weighted Average Exposure (mg/m^3)

Normalizing Factor concentration. Bucket Scenario.

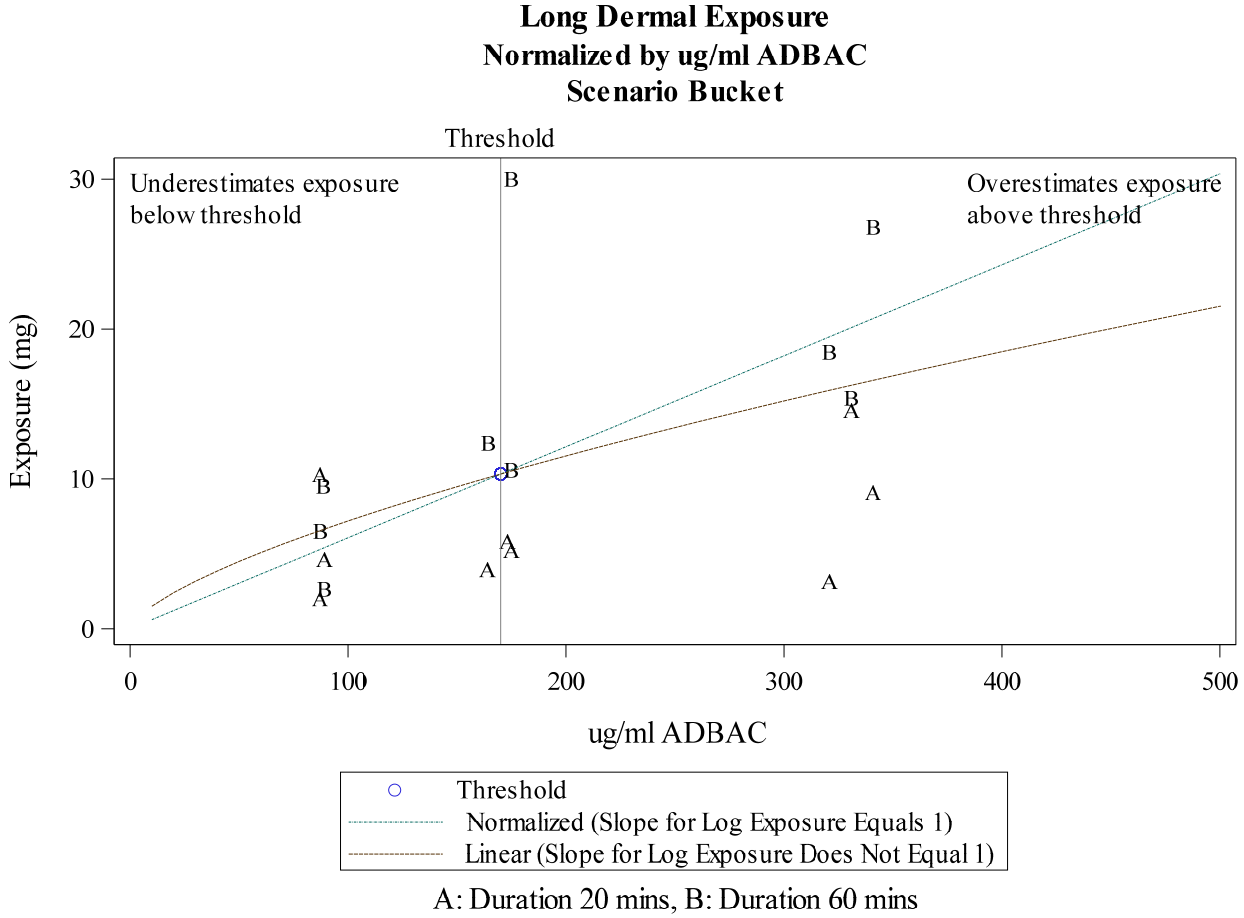


Figure BB29. Threshold plot for Long Dermal Exposure (mg)

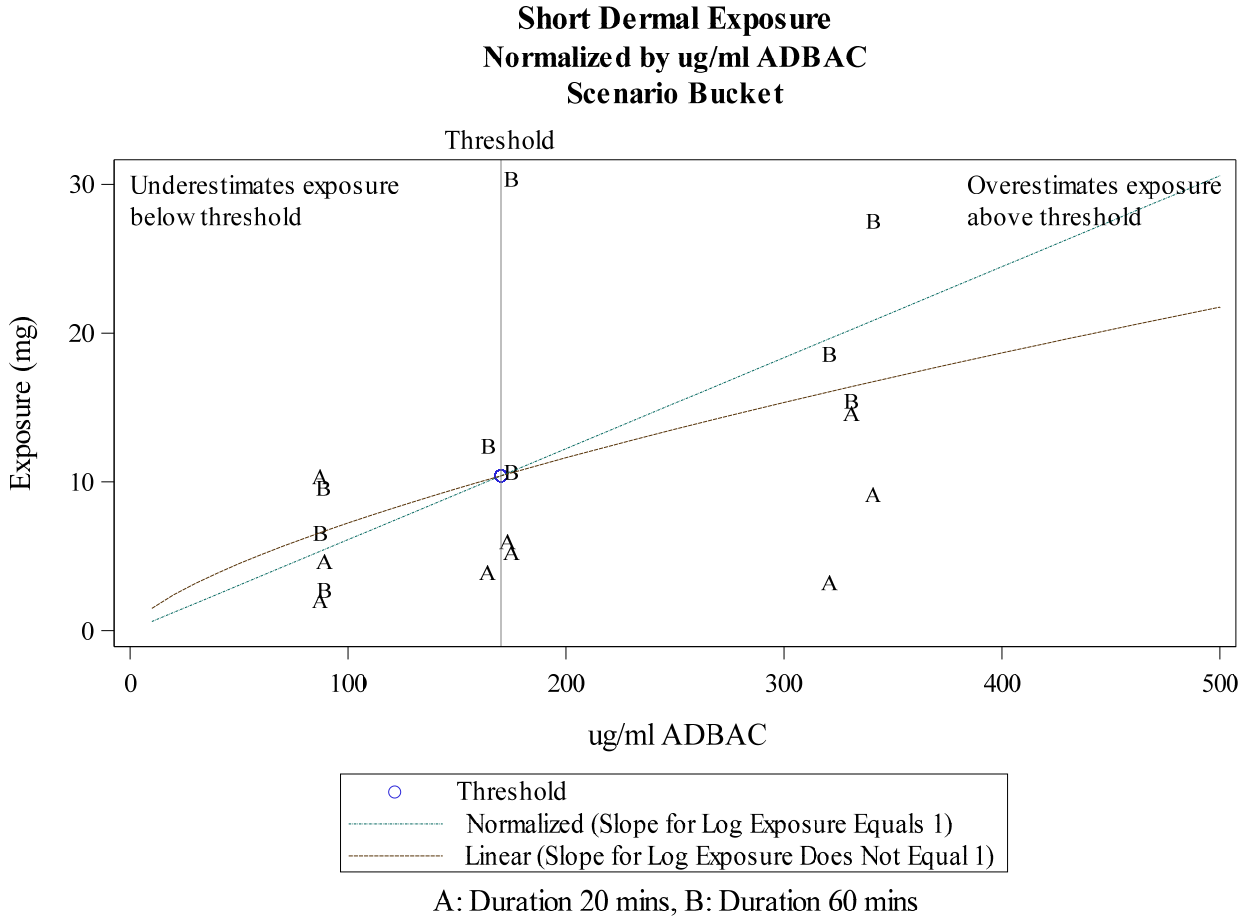


Figure BB30. Threshold plot for Short Dermal Exposure (mg)

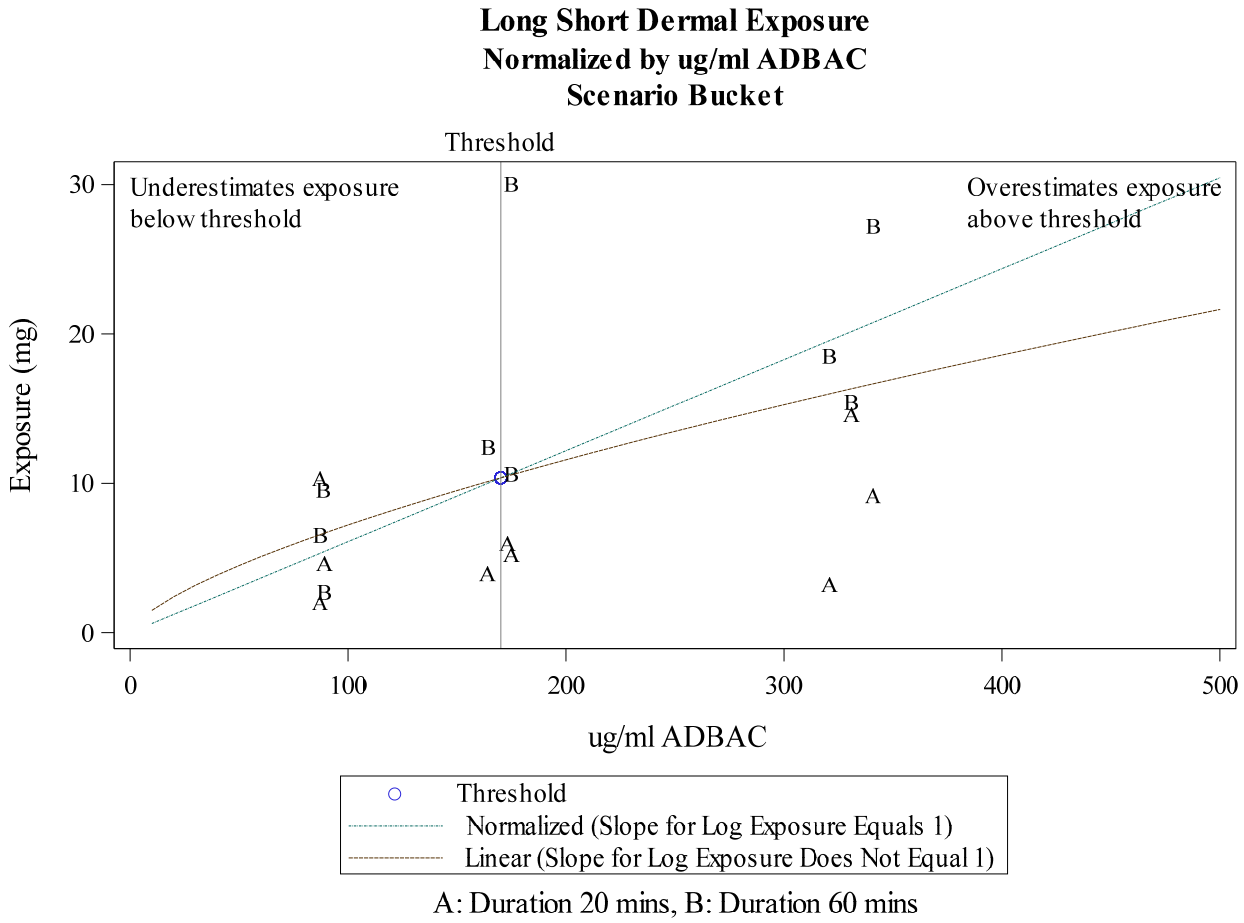


Figure BB31. Threshold plot for Long Short Dermal Exposure (mg)

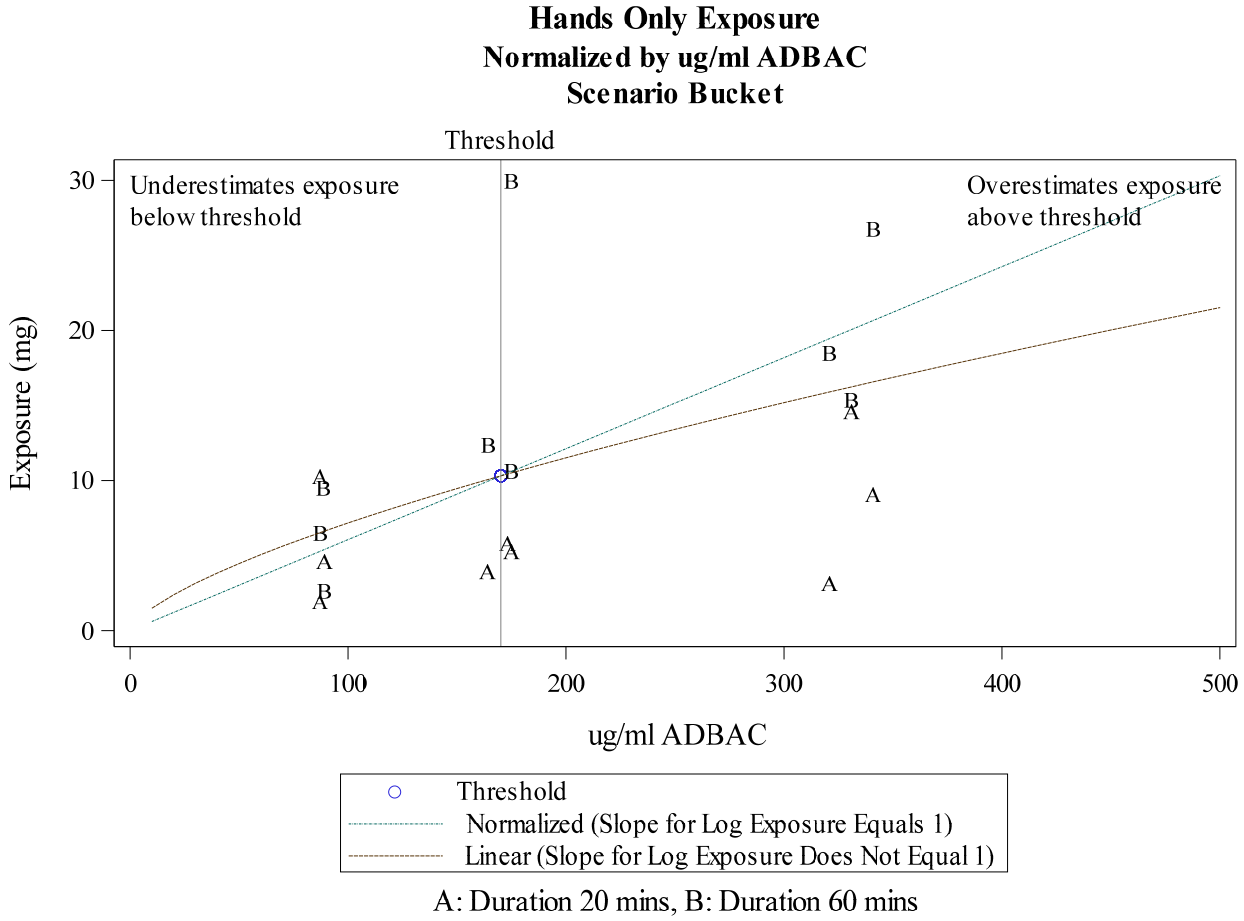


Figure BB32. Threshold plot for Hands Only Exposure (mg)

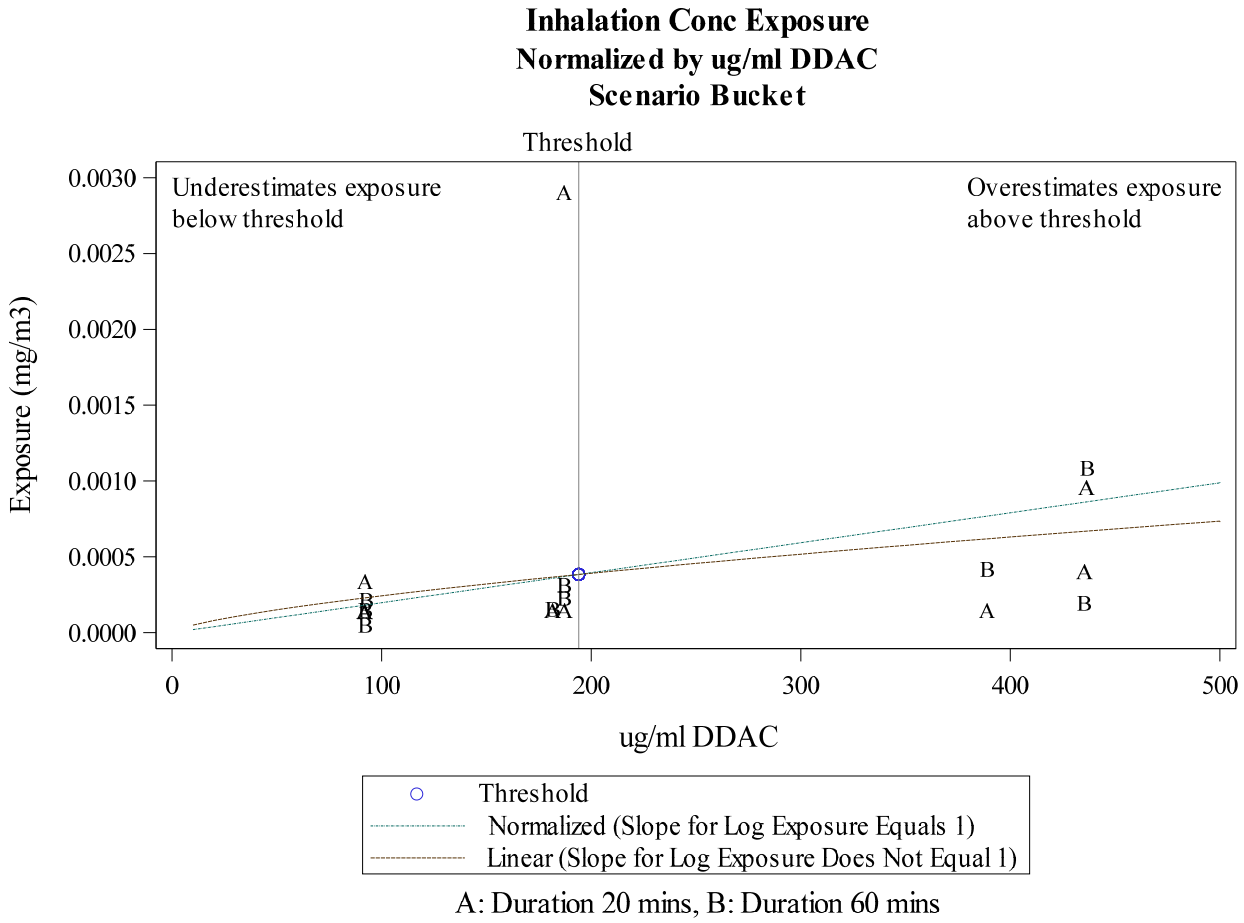


Figure BB33. Threshold plot for Inhalation Concentration Exposure (mg/m^3)

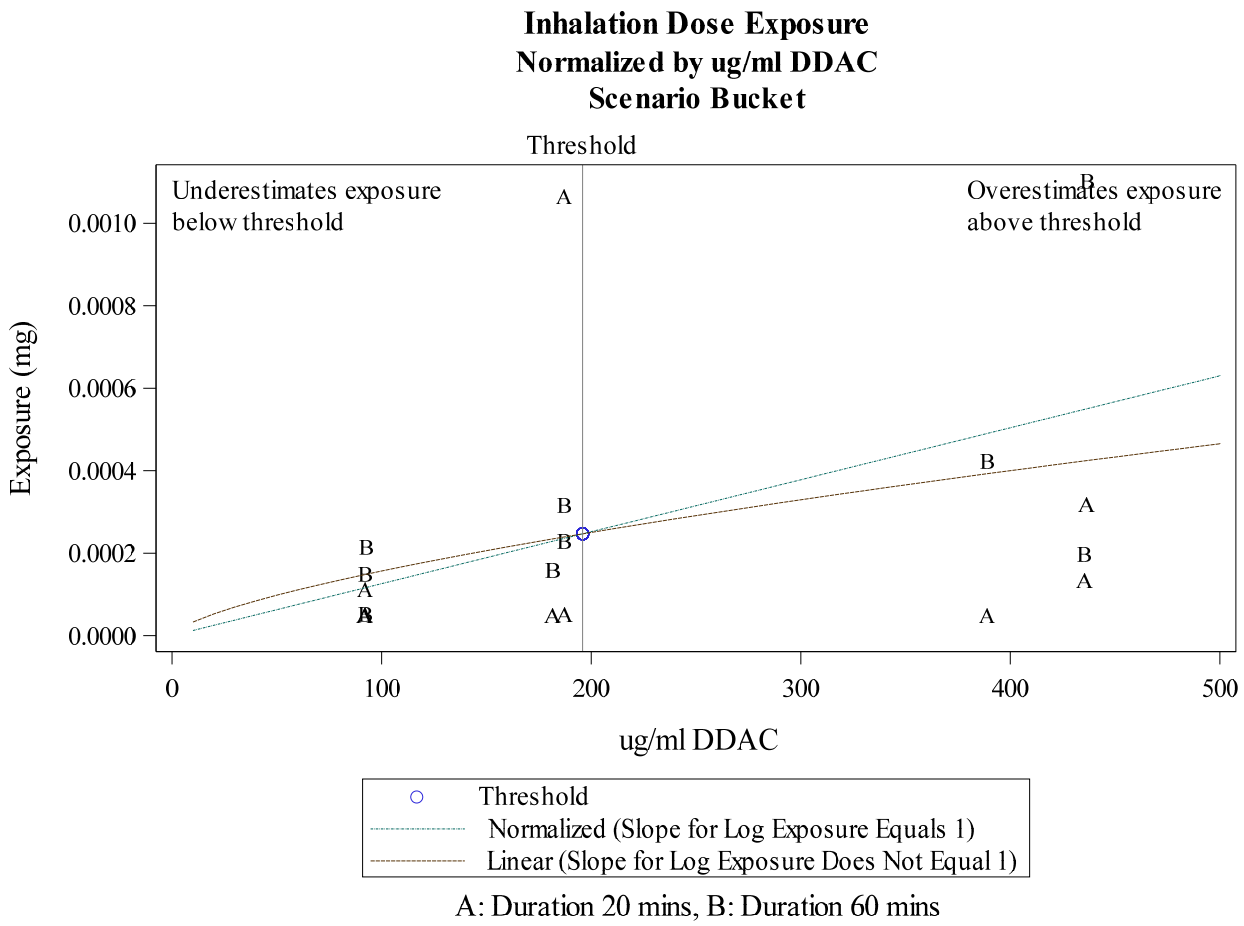


Figure BB34. Threshold plot for Inhalation Dose Exposure (mg)

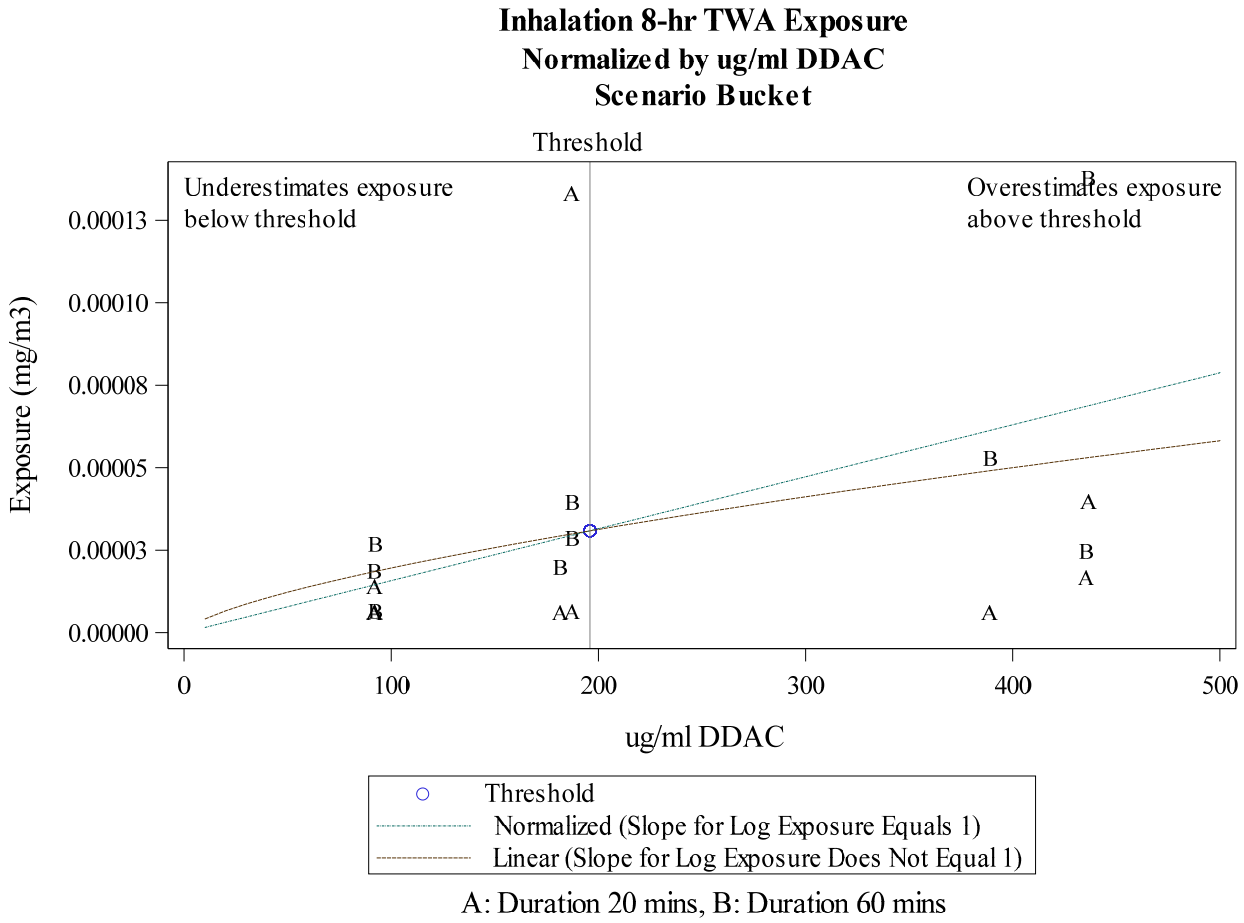


Figure BB35. Threshold plot for Inhalation Time Weighted Average Exposure (mg/m^3)

Normalizing Factor concentration. Sink Scenario.

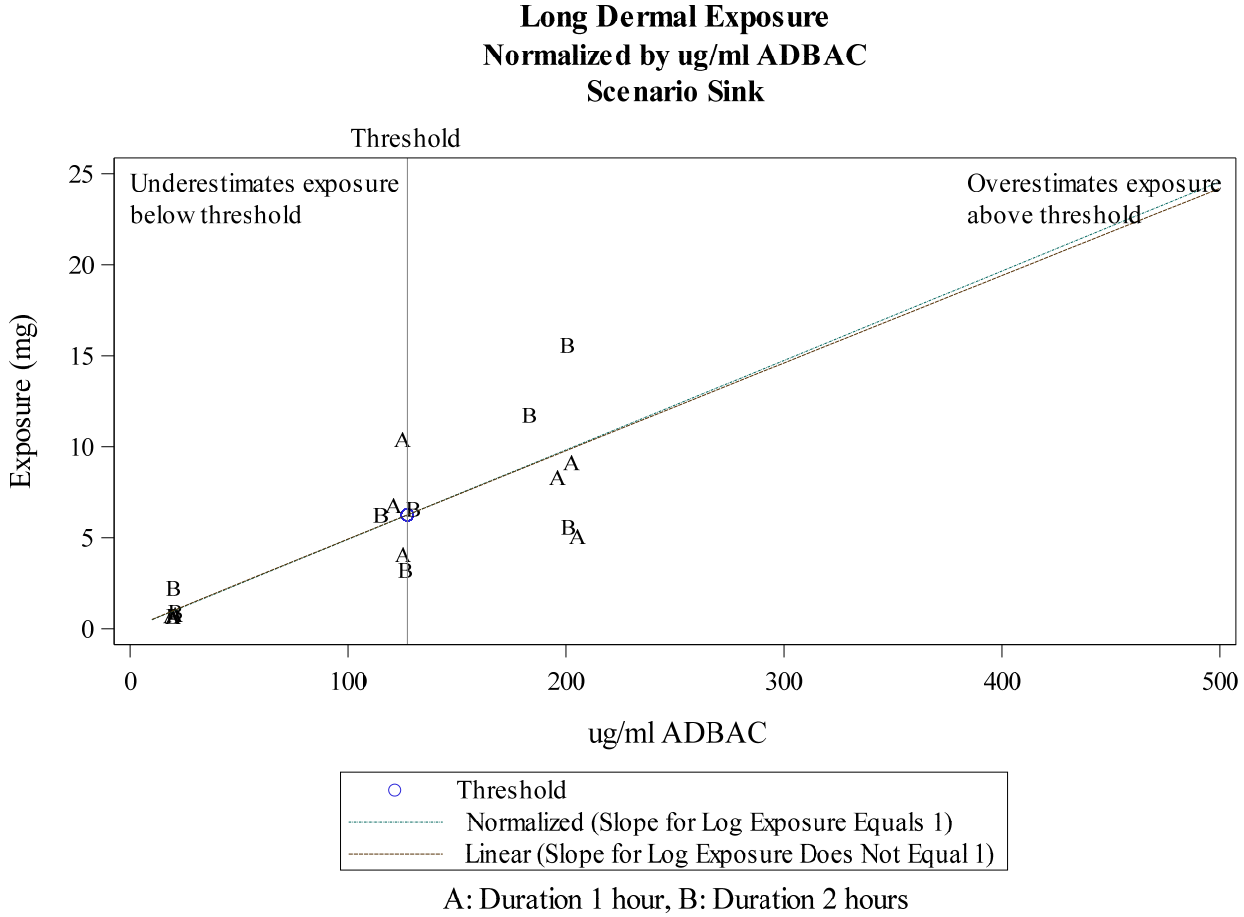
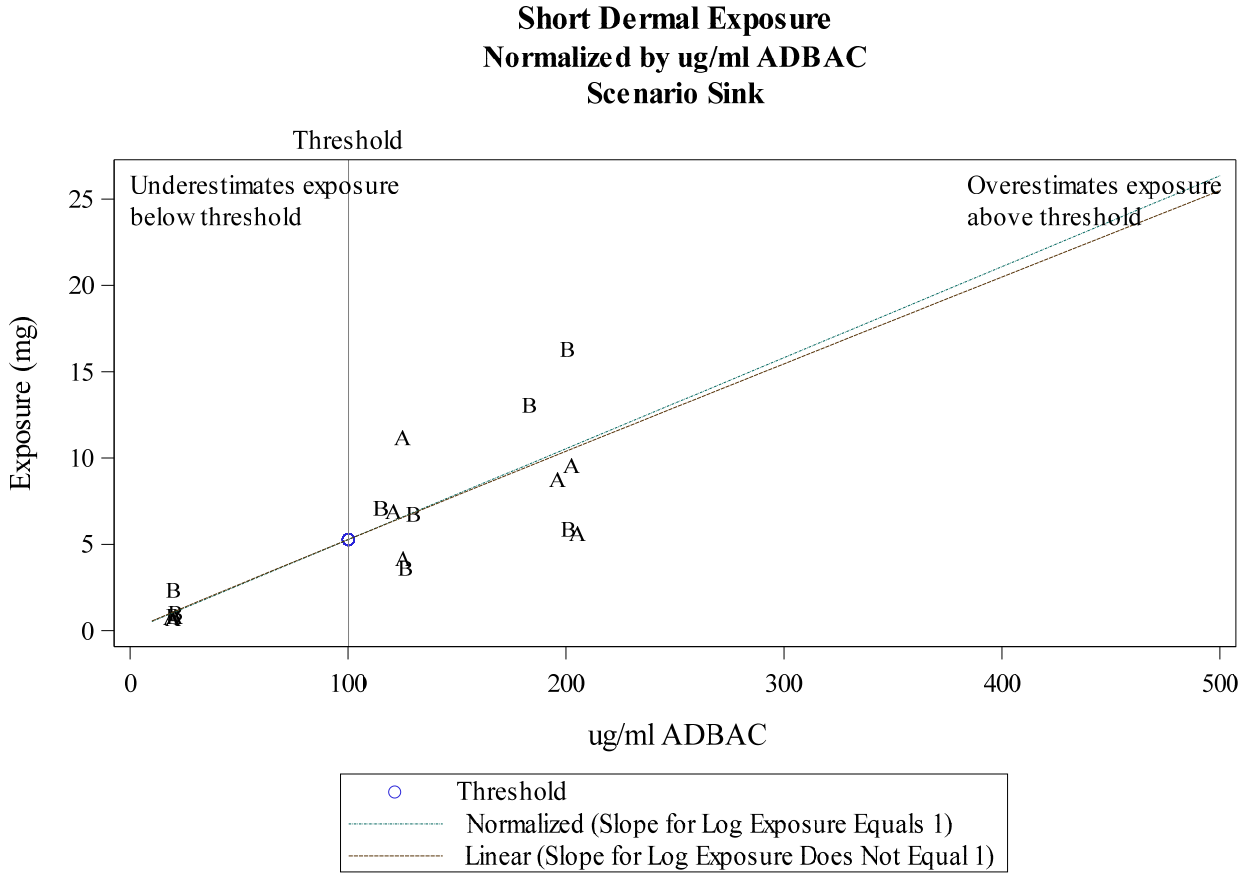


Figure BS29. Threshold plot for Long Dermal Exposure (mg)



A: Duration 1 hour, B: Duration 2 hours

Figure BS30. Threshold plot for Short Dermal Exposure (mg)

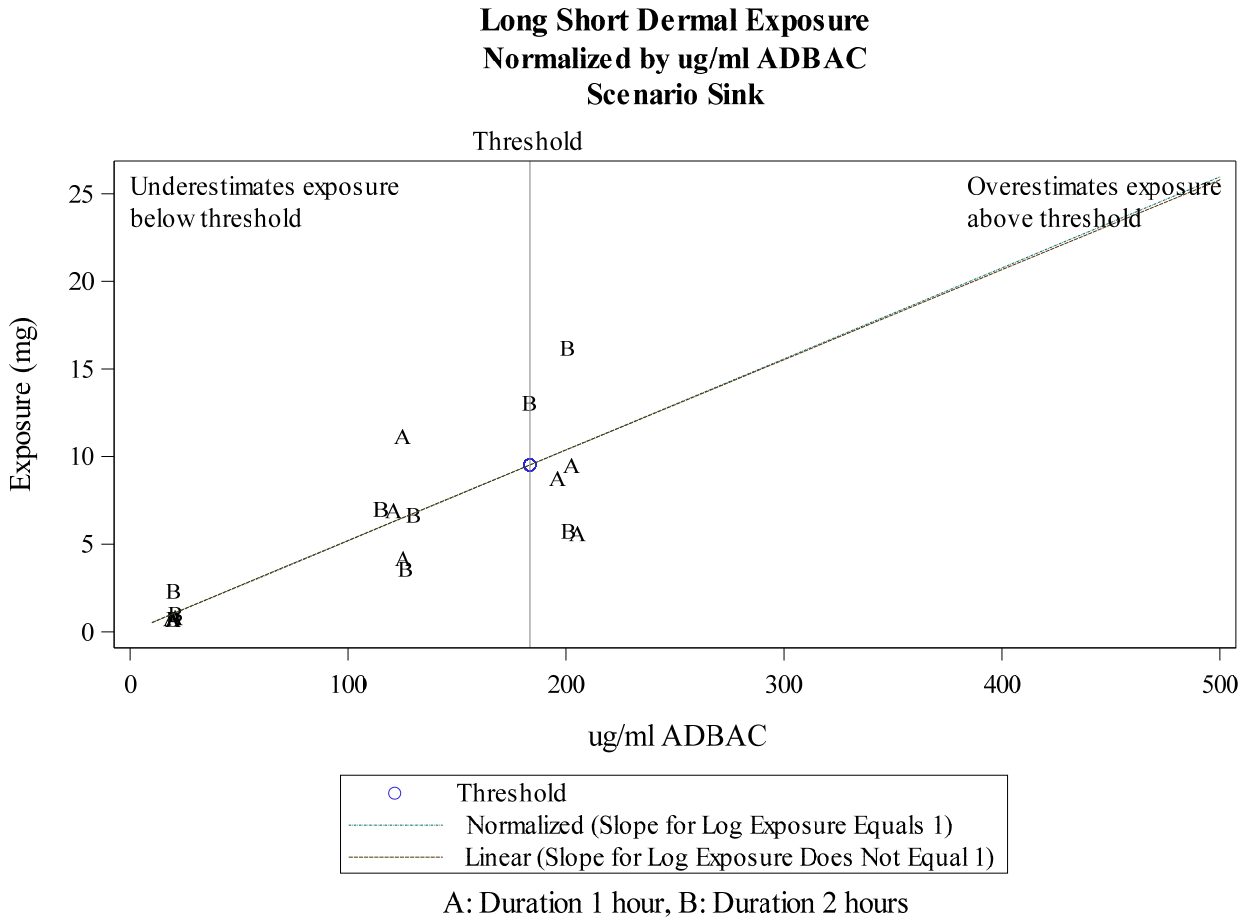


Figure BS31. Threshold plot for Long Short Dermal Exposure (mg)

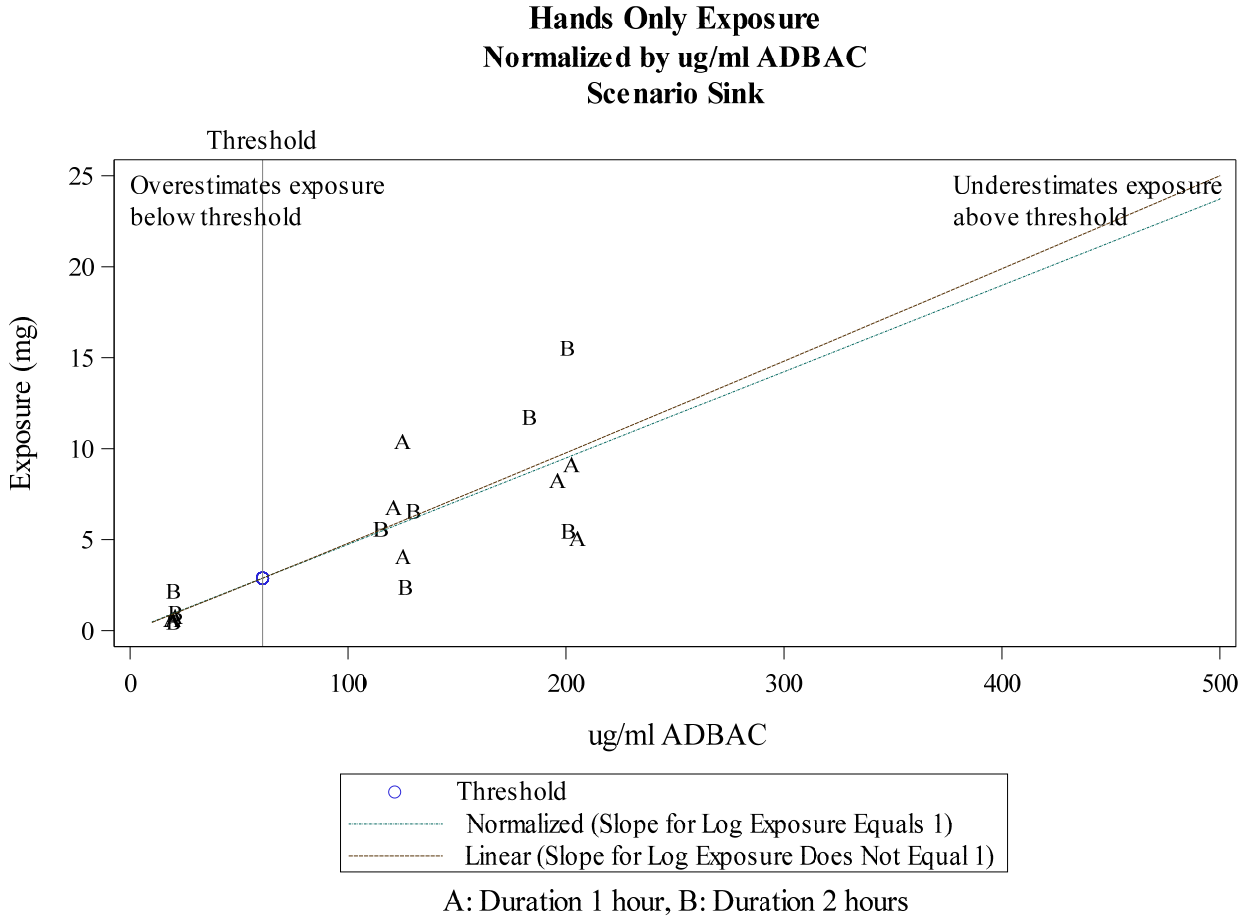


Figure BS32. Threshold plot for Hands Only Exposure (mg)

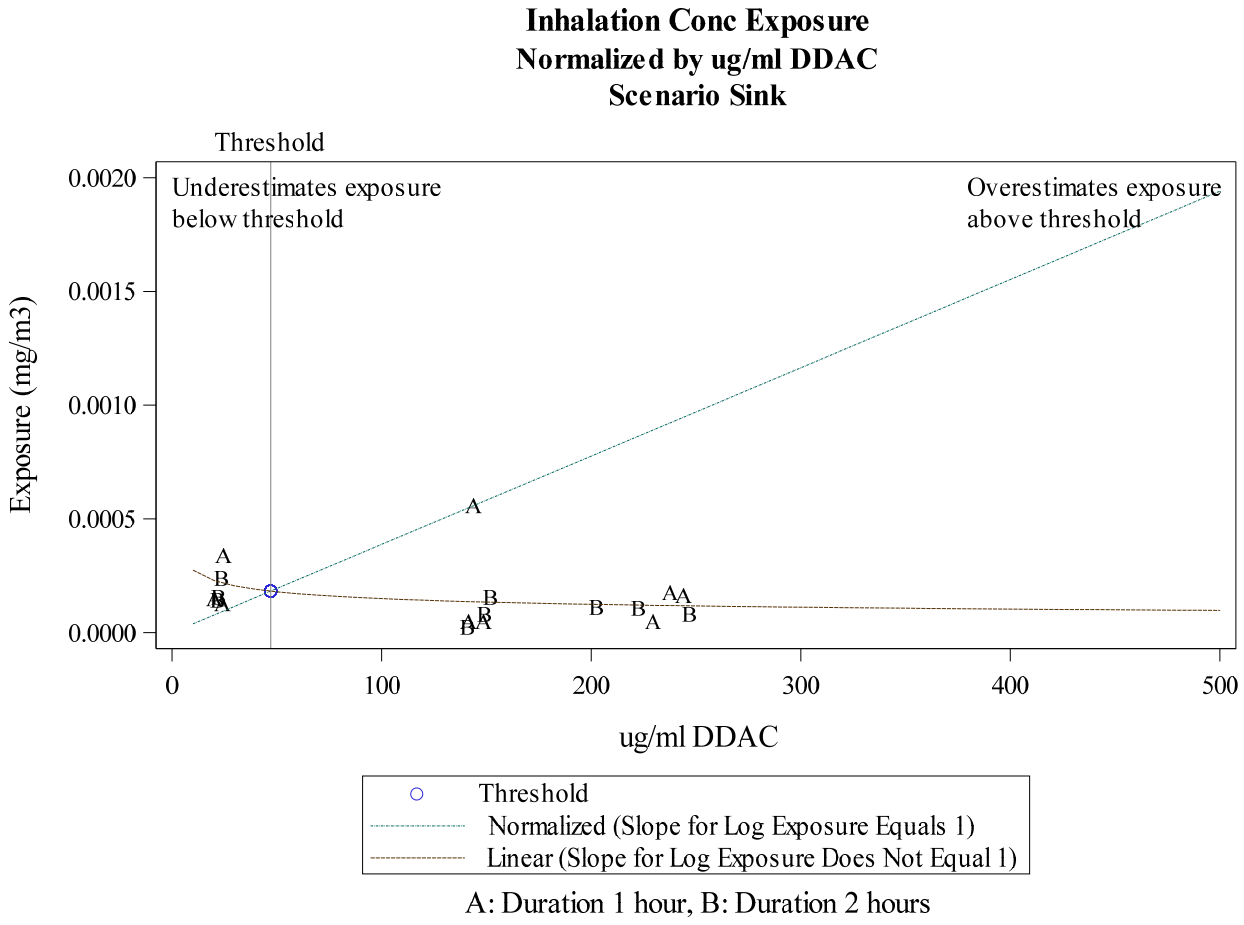


Figure BS33. Threshold plot for Inhalation Concentration Exposure (mg/m^3)

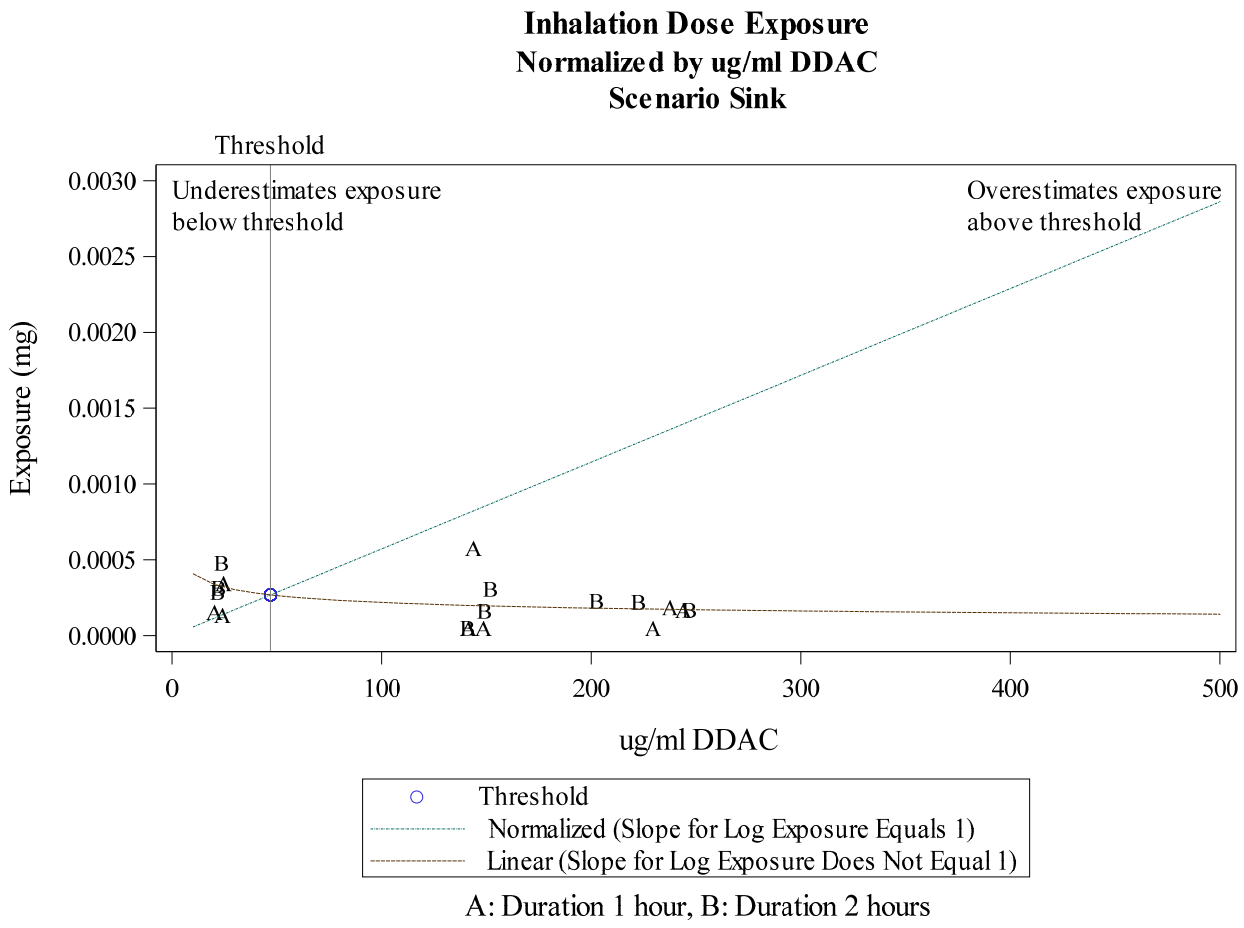


Figure BS34. Threshold plot for Inhalation Dose Exposure (mg)

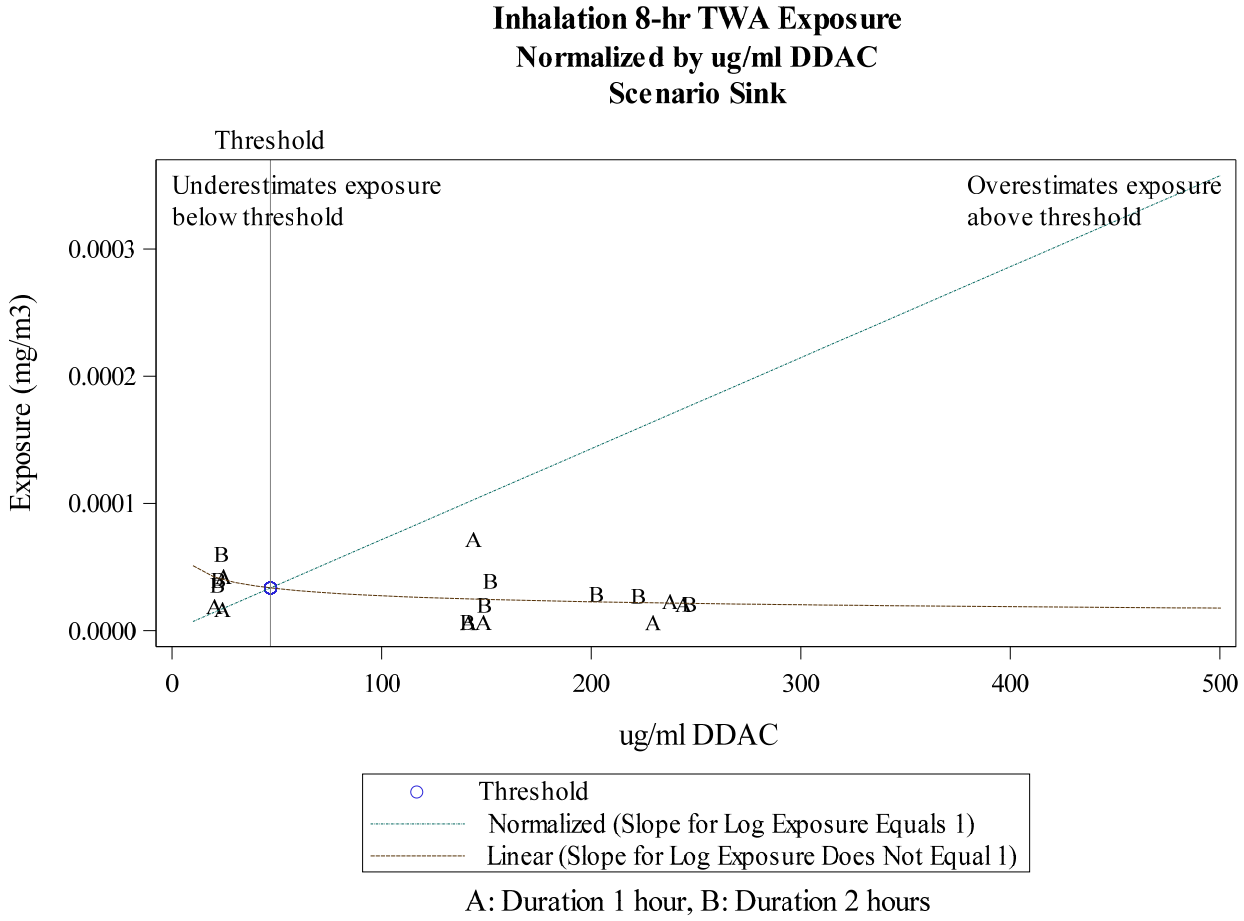


Figure BS35. Threshold plot for Inhalation Time Weighted Average Exposure (mg/m^3)

Normalizing Factor concentration. COP Scenario.

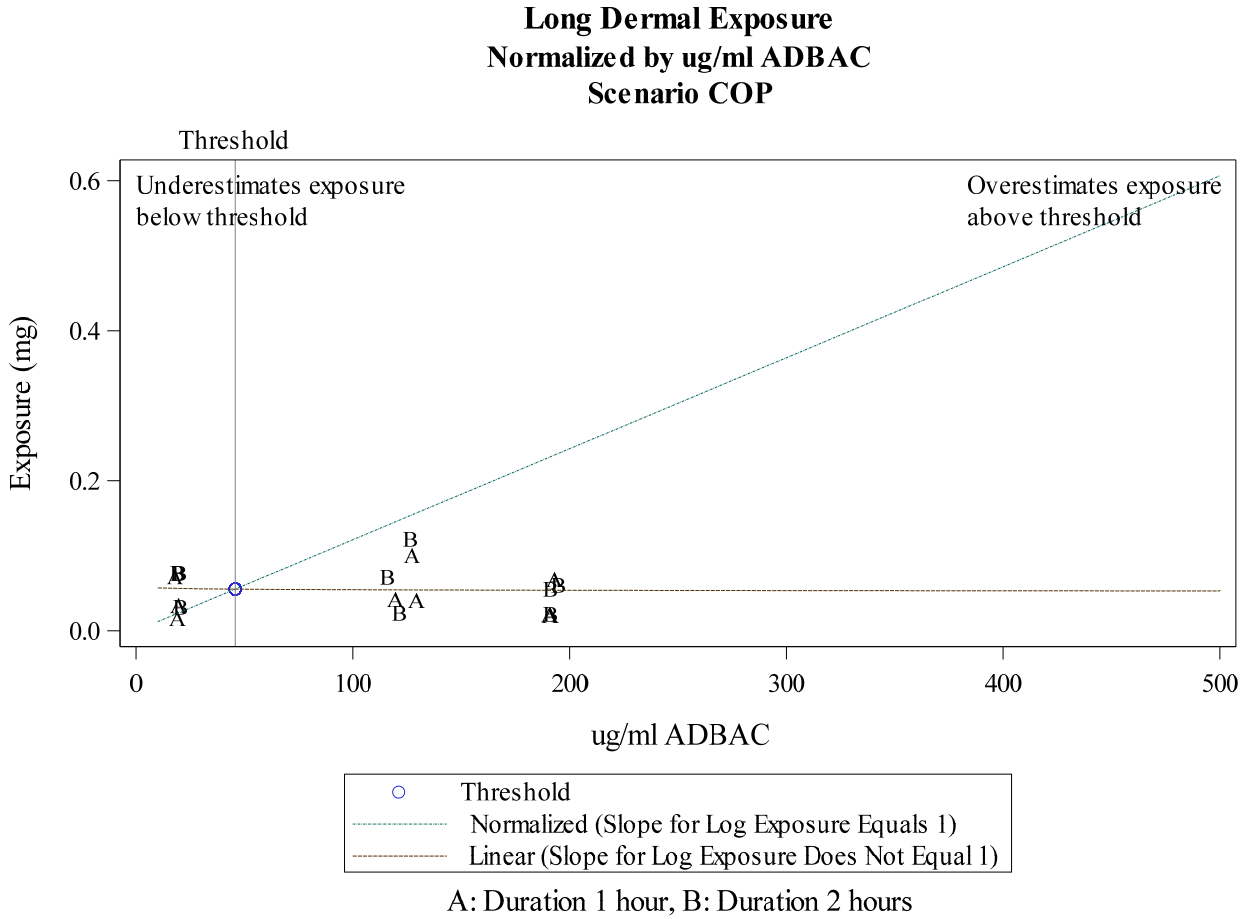


Figure CC29. Threshold plot for Long Dermal Exposure (mg)

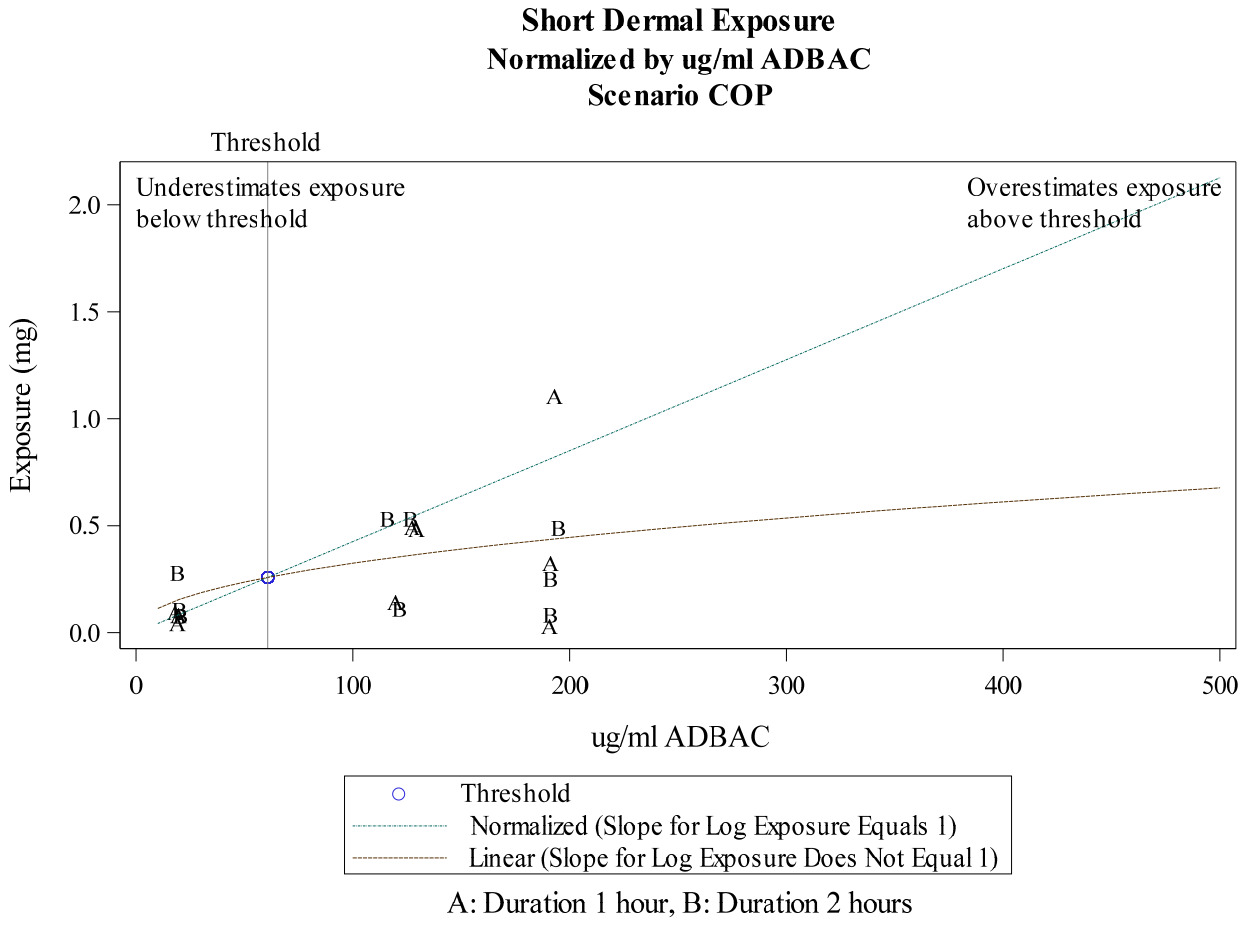


Figure CC30. Threshold plot for Short Dermal Exposure (mg)

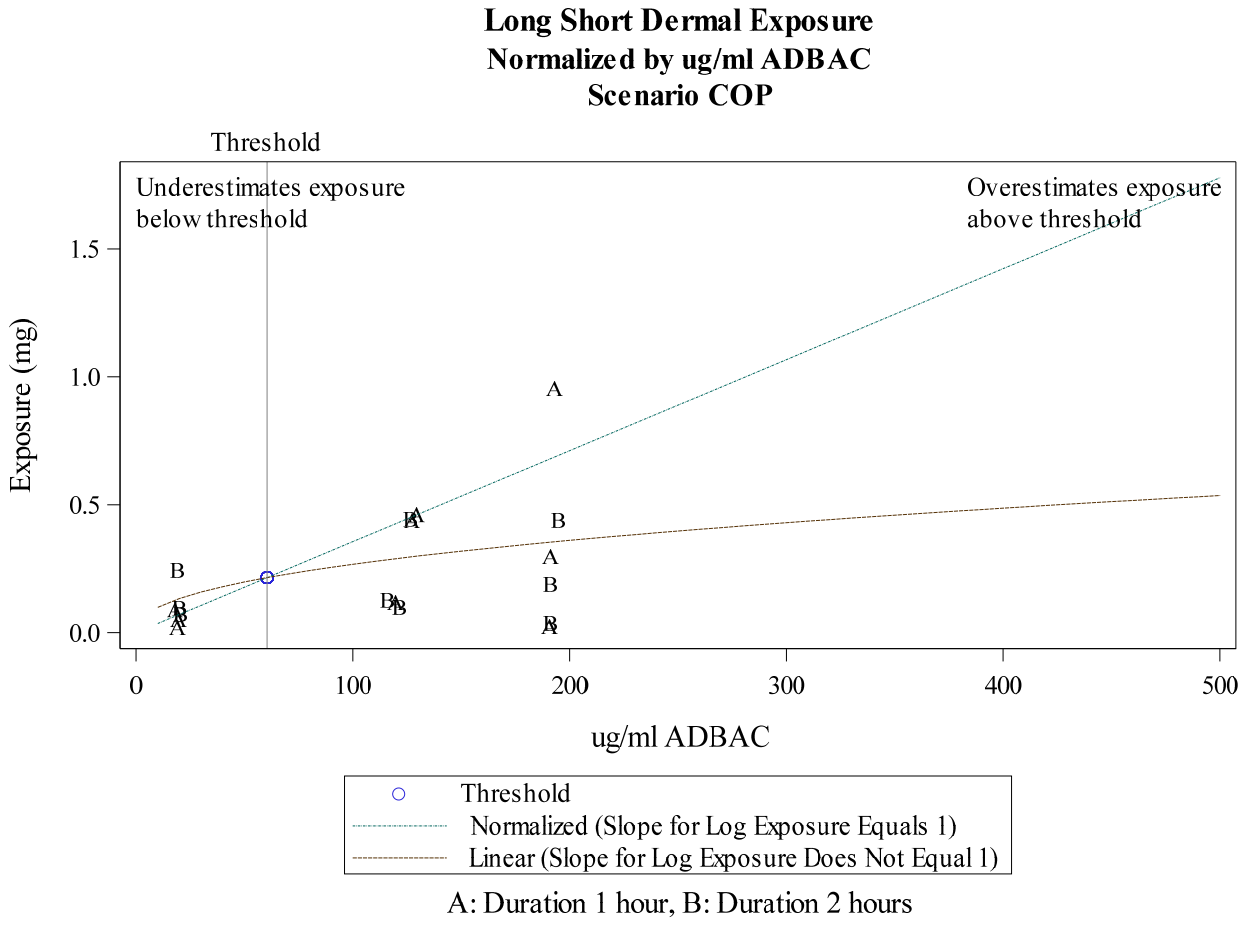
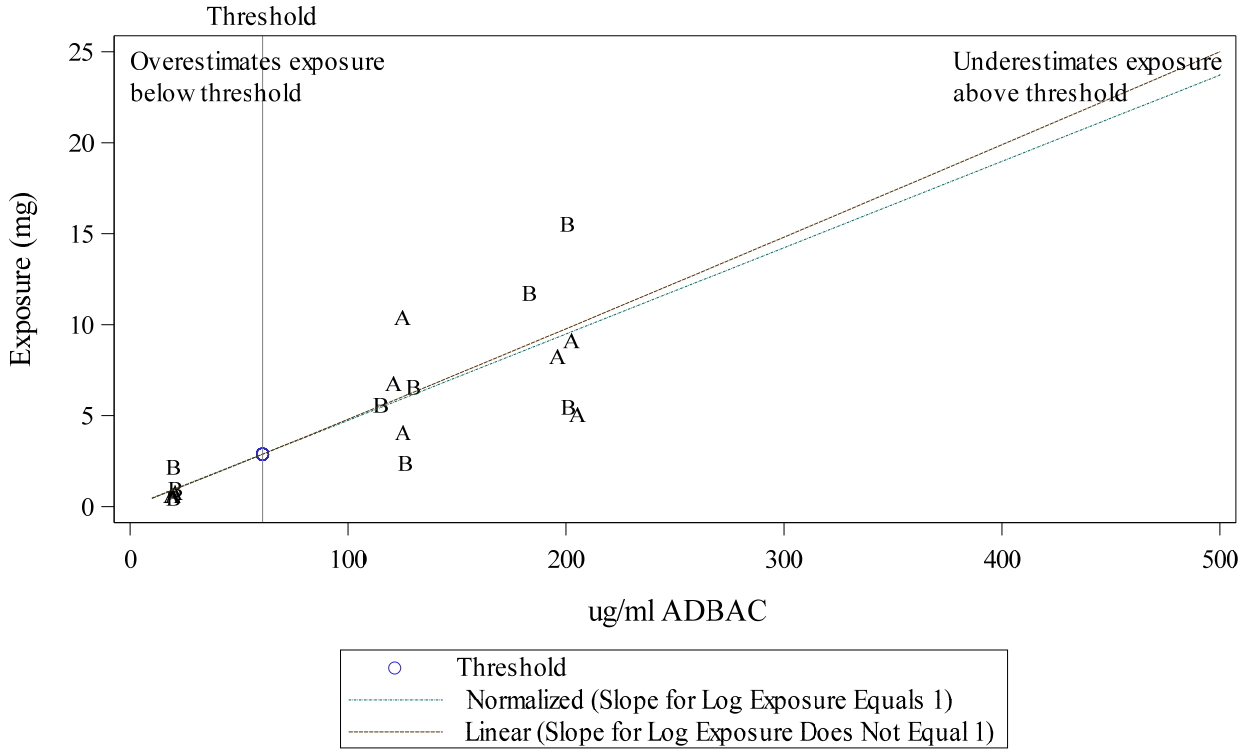


Figure CC31. Threshold plot for Long Short Dermal Exposure (mg)

Hands Only Exposure
Normalized by ug/ml ADBAC
Scenario Sink



A: Duration 1 hour, B: Duration 2 hours

Figure CC32. Threshold plot for Hands Only Exposure (mg)

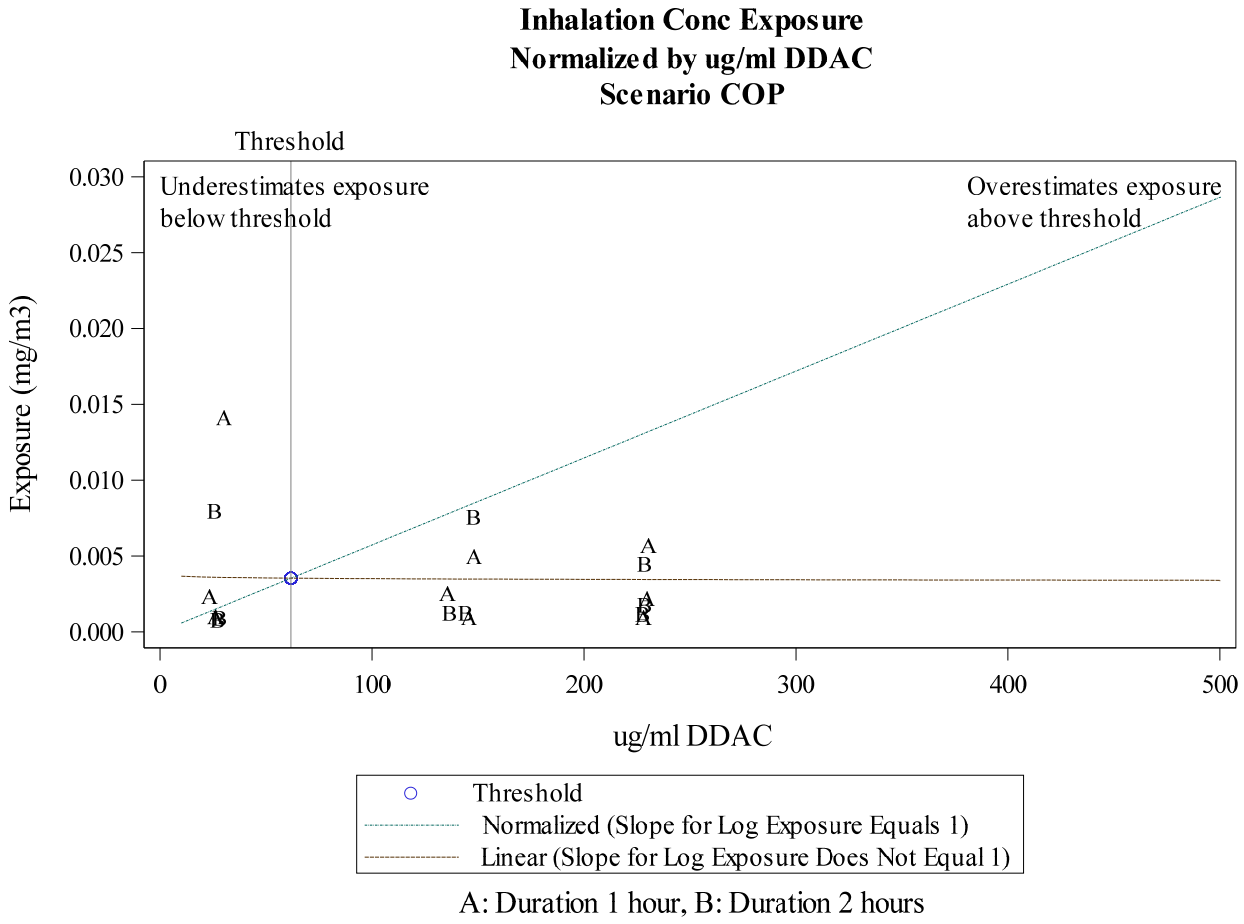


Figure CC33. Threshold plot for Inhalation Concentration Exposure (mg/m^3)

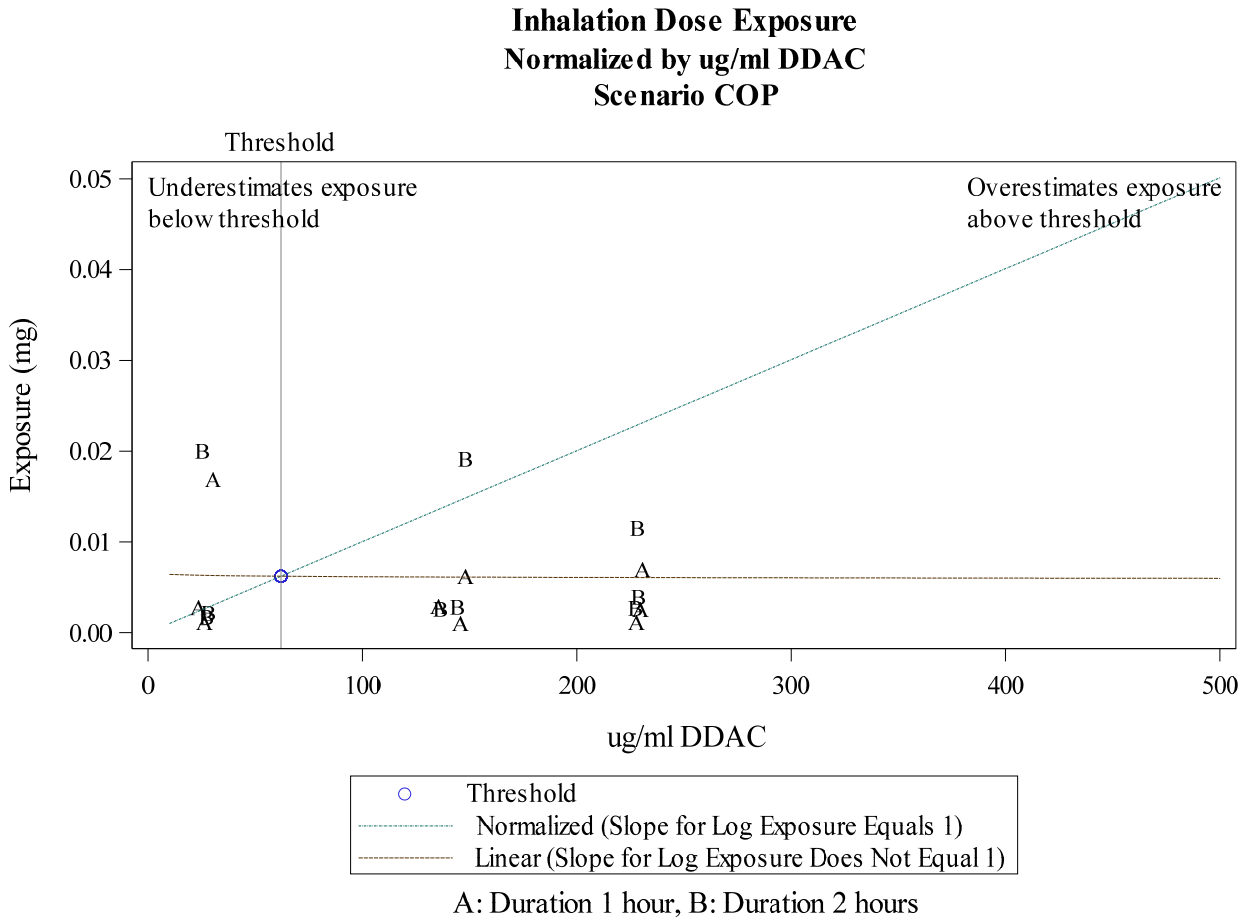


Figure CC33. Threshold plot for Inhalation Dose Exposure (mg)

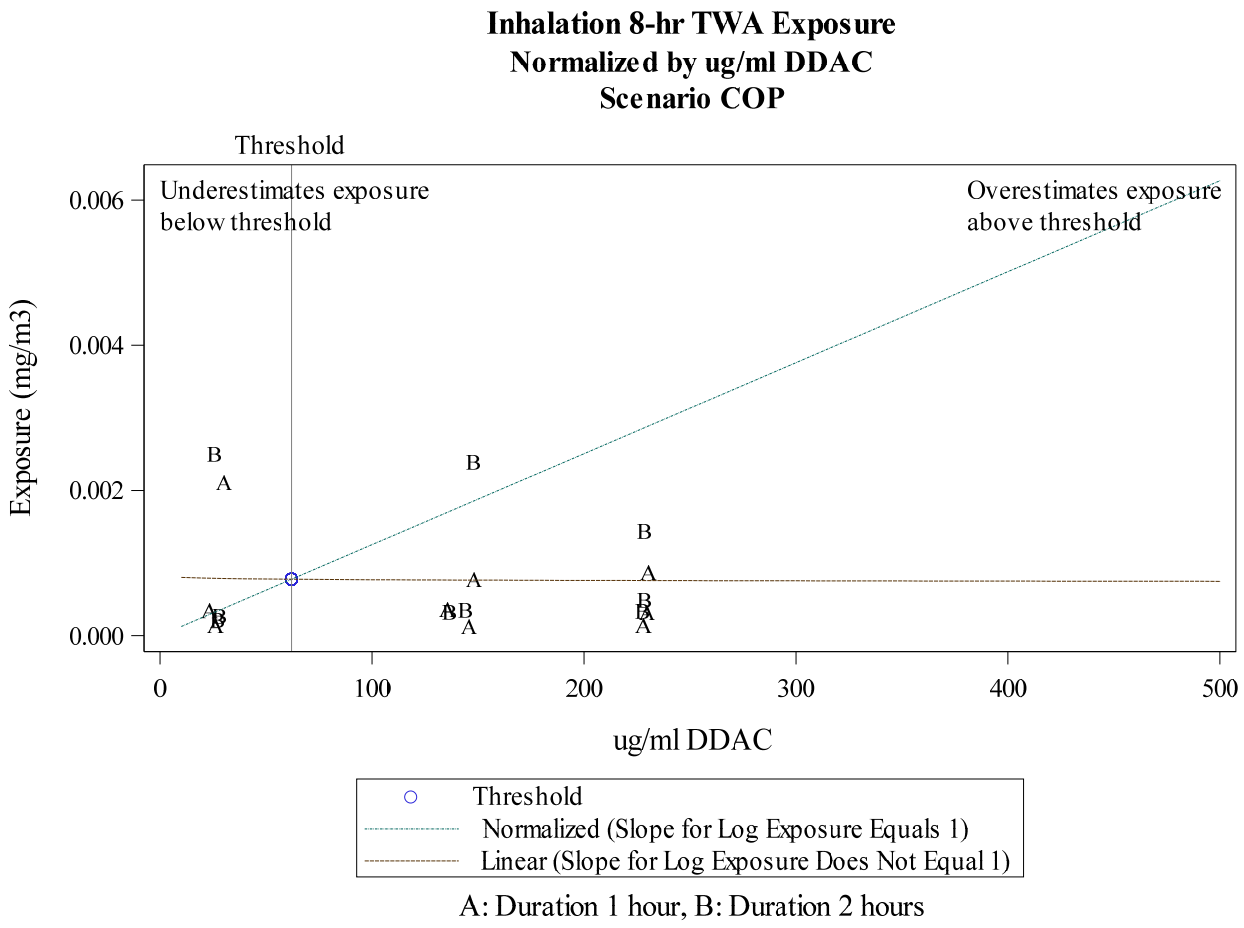


Figure CC34. Threshold plot for Inhalation Time Weighted Average Exposure (mg/m^3)