

**APPENDIX E**

Benzene Unit Risk Estimates Based on 21 Models

**Table E-1. Benzene Unit Risk Estimates  
Results From Relative Risk Model Using Cumulative Dose**

Data set	Unit risk estimate (ppm) <sup>-1</sup>		
	95% lower bound	MLE	95% upper bound
I Rinsky et al. (follow-up from 1950, Table 6) <sup>a</sup>	1.65×10 <sup>-2</sup>	5.10×10 <sup>-2</sup>	1.08×10 <sup>-1</sup>
II Rinsky et al. (follow-up from 1940, Table 2)	1.53×10 <sup>-2</sup>	5.10×10 <sup>-2</sup>	1.13×10 <sup>-1</sup>
III Rinsky et al. (revised exposures, Table 7)	1.78×10 <sup>-2</sup>	6.43×10 <sup>-2</sup>	1.44×10 <sup>-1</sup>
IV Rinsky et al. (Table 6) and Ott et al. (Table 1)	7.78×10 <sup>-3</sup>	2.89×10 <sup>-2</sup>	6.87×10 <sup>-2</sup>
V Same as IV except two questionable cases added	4.45×10 <sup>-3</sup>	2.04×10 <sup>-2</sup>	5.10×10 <sup>-2</sup>
VI Wong et al. (Table 3, SMR=50 assumed for unexposed)	8.76×10 <sup>-4</sup>	1.04×10 <sup>-1</sup>	2.42×10 <sup>-1</sup>
VII Rinsky et al. (Table 6) Ott et al. (Table 1) and Wong et al. (Table 3)	2.67×10 <sup>-2</sup>	7.32×10 <sup>-2</sup>	1.60×10 <sup>-1</sup>
VIII Same as VII except SMR=100 assumed for unexposed	1.56×10 <sup>-2</sup>	3.55×10 <sup>-2</sup>	6.43×10 <sup>-2</sup>

<sup>a</sup>The tables referred to are those given in EPA (1985).

**Table E-2. Benzene Unit Risk Estimates (Continued)  
Results From Absolute Risk Model Using Cumulative Dose**

Data set	Unit risk estimate (ppm <sup>-1</sup> )		
	95% lower bound	MLE	95% upper bound
I Rinsky et al. (follow-up from 1950, Table 6) <sup>a</sup>	1.02×10 <sup>-2</sup>	2.45×10 <sup>-2</sup>	4.77×10 <sup>-1</sup>
II Rinsky et al. (follow-up from 1940, Table 2)	9.31×10 <sup>-3</sup>	2.20×10 <sup>-2</sup>	4.40×10 <sup>-2</sup>
III Rinsky et al. (revised exposures, Table 7)	1.22×10 <sup>-2</sup>	3.06×10 <sup>-2</sup>	5.99×10 <sup>-2</sup>
IV Rinsky et al. (Table 6) and Ott et al. (Table 1)	7.23×10 <sup>-3</sup>	1.96×10 <sup>-2</sup>	3.79×10 <sup>-2</sup>
V Same as IV except two questionable cases added	7.11×10 <sup>-3</sup>	2.08×10 <sup>-2</sup>	4.04×10 <sup>-2</sup>

<sup>a</sup>The tables referred to are those given in EPA (1985).

**Table E-3. Benzene Unit Risk Estimates (Continued)  
Results From Relative Risk Model Using Cumulative Dose**

Data set	Unit risk estimate (ppm <sup>-1</sup> )		
	95% lower bound	MLE	95% upper bound
I Rinsky et al. (Table 8) <sup>a</sup>	1.30×10 <sup>-2</sup>	4.10×10 <sup>-2</sup>	8.79×10 <sup>-2</sup>
II Rinsky et al. (Table 8) and Ott et al. (Table 10)	7.29×10 <sup>-3</sup>	2.49×10 <sup>-2</sup>	5.59×10 <sup>-2</sup>

<sup>a</sup>The tables referred to are those given in EPA (1985).

**Table E-4. Benzene Unit Risk Estimates (Continued)  
Results From Relative Risk Model Using Cumulative Dose**

Data set	Unit risk estimate (ppm <sup>-1</sup> )		
	95% lower bound	MLE	95% upper bound
I Rinsky et al. 1940-1970 follow-up (Table 8) <sup>a</sup>	7.47×10 <sup>-3</sup>	1.76×10 <sup>-2</sup>	3.36×10 <sup>-2</sup>
II Rinsky et al. (Table 8) and Ott et al. (Table 10)	5.43×10 <sup>-3</sup>	1.40×10 <sup>-2</sup>	2.71×10 <sup>-2</sup>

<sup>a</sup>The tables referred to are those given in EPA (1985).

**Table E-5. Benzene Unit Risk Estimates (Continued)  
Results From Relative Risk Model Using Cumulative Dose**

Data set	Unit risk estimate (ppm <sup>-1</sup> )		
	95% lower bound	MLE	95% upper bound
I Rinsky et al. (Table 9) <sup>a</sup>	5.56×10 <sup>-3</sup>	1.67×10 <sup>-2</sup>	2.48×10 <sup>-2</sup>
II Rinsky et al. (Table 9) and Ott et al. (Table 11)	3.60×10 <sup>-3</sup>	1.15×10 <sup>-2</sup>	2.48×10 <sup>-2</sup>

<sup>a</sup>The tables referred to are those given in EPA (1985).

**Table E-6. Benzene Unit Risk Estimates (Continued)  
Results From Relative Risk Model Using Cumulative Dose**

Data set	Unit risk estimate (ppm <sup>-1</sup> )		
	95% lower bound	MLE	95% upper bound
I Rinsky et al. (Table 9) <sup>a</sup>	4.34×10 <sup>-3</sup>	1.10×10 <sup>-2</sup>	2.17×10 <sup>-2</sup>
II Rinsky et al. (Table 9) and Ott et al. (Table 11)	3.48×10 <sup>-3</sup>	8.98×10 <sup>-3</sup>	2.52×10 <sup>-2</sup>

<sup>a</sup>The tables referred to are those given in EPA (1985).

**Table E-7. Effect of Modifications of EPA's Assumptions on Unit Risk Estimate for Benzene<sup>a</sup>**

Modification	Excess risk per 1 ppm lifetime exposure <sup>b</sup>
None (Combined EPA Estimate)	$2.7 \times 10^{-2}$ ( $8.3 \times 10^{-6}$ )
Model restricted to absolute risk and weighted cumulative dose form; data restricted to Rinsky cohort	$1.8 \times 10^{-2}$ ( $5.5 \times 10^{-6}$ )
Three years of follow-up added	$1.7 \times 10^{-2}$ ( $5.2 \times 10^{-6}$ )
Job code errors corrected	$1.8 \times 10^{-2}$ ( $5.5 \times 10^{-6}$ )
New weighted cumulative dose form from epidemiological latency data; new statistical method for estimating transition rate parameter	$3.2 \times 10^{-3}$ ( $9.8 \times 10^{-7}$ )
New definition of diseases induced by benzene; new estimate of background rates in U.S. population	$3.5 \times 10^{-3}$ ( $1.1 \times 10^{-6}$ )
Quadratic model: Two molecules of benzene metabolite required to induce initial event producing malignant cell	$1.4 \times 10^{-4}$ ( $4.3 \times 10^{-8}$ )
Linear-quadratic model: Upper bound on quadratic model	$1.0 \times 10^{-3}$ ( $3.1 \times 10^{-7}$ )

<sup>a</sup>Source: Clement Associates, Inc. 1988

<sup>b</sup>Numbers in parentheses are excess risk per  $\mu\text{g}/\text{m}^3$