APPENDIX E

Statistical Analysis

General UCL Statistics for Full Data Sets

User Selected Options

From File	C:\Documents and Settings\vincent.yanagita\My Documents\Projects\pvt\Risk Assessment\2008 - 2009 Condition
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Sb (Antimony)

General Statistics

Number of Valid Observations 42

Number of Distinct Observations 38

Raw Statistics

Minimum	0.102
Maximum	3.235
Mean	0.541
Median	0.331
SD	0.669
Coefficient of Variation	1.236
Skewness	3.169

Log-transformed Statistics

Minimum of Log Data	-2.288
Maximum of Log Data	1.174
Mean of log Data	-1.013
SD of log Data	0.817

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.571
Shapiro Wilk Critical Value	0.942

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.898
Shapiro Wilk Critical Value	0.942

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	0.715

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL	0.765
95% Modified-t UCL	0.723

Assuming Lognormal Distribution

95% H-UCL	0.668
95% Chebyshev (MVUE) UCL	0.81
97.5% Chebyshev (MVUE) UCL	0.944
99% Chebyshev (MVUE) UCL	1.206

Gamma Distribution Test

k star (bias corrected)	1.312
Theta Star	0.412
nu star	110.2
Approximate Chi Square Value (.05)	87.01
Adjusted Level of Significance	0.0443
Adjusted Chi Square Value	86.28
Anderson-Darling Test Statistic	2.106
Anderson-Darling 5% Critical Value	0.769
Kolmogorov-Smirnov Test Statistic	0.205
Kolmogorov-Smirnov 5% Critical Value	0.139

Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	0.686
95% Adjusted Gamma UCL	0.692

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL	0.711
95% Jackknife UCL	0.715
95% Standard Bootstrap UCL	0.711
95% Bootstrap-t UCL	0.871
95% Hall's Bootstrap UCL	1.515
95% Percentile Bootstrap UCL	0.719
95% BCA Bootstrap UCL	0.778
95% Chebyshev(Mean, Sd) UCL	0.991
97.5% Chebyshev(Mean, Sd) UCL	1.186
99% Chebyshev(Mean, Sd) UCL	1.569

Potential UCL to Use

Use 95% Chebyshev (Mean, Sd) UCL 0.991

As (Arsenic)

General Statistics

Number of Valid Observations 42

Number of Distinct Observations 37

Raw Statistics

Minimum 2.54
Maximum 45
Mean 16.26
Median 14.9
SD 7.455
Coefficient of Variation 0.458
Skewness 1.535

Log-transformed Statistics

Minimum of Log Data 0.932
Maximum of Log Data 3.807
Mean of log Data 2.689
SD of log Data 0.474

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic 0.871
Shapiro Wilk Critical Value 0.942
Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic 0.911
Shapiro Wilk Critical Value 0.942
Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 18.2

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL 18.45
95% Modified-t UCL 18.24

Assuming Lognormal Distribution

95% H-UCL 18.92
95% Chebyshev (MVUE) UCL 21.89
97.5% Chebyshev (MVUE) UCL 24.25
99% Chebyshev (MVUE) UCL 28.9

Gamma Distribution Test

k star (bias corrected) 4.808
Theta Star 3.382
nu star 403.9
Approximate Chi Square Value (.05) 358.3
Adjusted Level of Significance 0.0443
Adjusted Chi Square Value 356.8

Anderson-Darling Test Statistic 0.483
Anderson-Darling 5% Critical Value 0.752
Kolmogorov-Smirnov Test Statistic 0.101
Kolmogorov-Smirnov 5% Critical Value 0.137
Data appear Gamma Distributed at 5% Significance Level

Data Distribution

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL 18.33
95% Adjusted Gamma UCL 18.41

Nonparametric Statistics

95% CLT UCL 18.15
95% Jackknife UCL 18.2
95% Standard Bootstrap UCL 18.14
95% Bootstrap-t UCL 18.58
95% Hall's Bootstrap UCL 18.93
95% Percentile Bootstrap UCL 18.17
95% BCA Bootstrap UCL 18.59
95% Chebyshev(Mean, Sd) UCL 21.28
97.5% Chebyshev(Mean, Sd) UCL 23.45
99% Chebyshev(Mean, Sd) UCL 27.71

Potential UCL to Use

Use 95% Approximate Gamma UCL 18.33

Ba (Barium)

General Statistics

Number of Valid Observations 42

Number of Distinct Observations 42

Raw Statistics

Minimum 193
Maximum 1450
Mean 570.6
Median 477
SD 290.7
Coefficient of Variation 0.51
Skewness 1.485

Log-transformed Statistics

Minimum of Log Data 5.263
Maximum of Log Data 7.279
Mean of log Data 6.241
SD of log Data 0.45

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic 0.809
Shapiro Wilk Critical Value 0.942
Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic 0.918
Shapiro Wilk Critical Value 0.942
Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 646.1

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL 655.3
95% Modified-t UCL 647.8

Assuming Lognormal Distribution

95% H-UCL 647.5
95% Chebyshev (MVUE) UCL 744.9
97.5% Chebyshev (MVUE) UCL 822
99% Chebyshev (MVUE) UCL 973.4

Gamma Distribution Test

k star (bias corrected) 4.573
Theta Star 124.8
nu star 384.1
Approximate Chi Square Value (.05) 339.7
Adjusted Level of Significance 0.0443
Adjusted Chi Square Value 338.2

Anderson-Darling Test Statistic 1.234
Anderson-Darling 5% Critical Value 0.752
Kolmogorov-Smirnov Test Statistic 0.17
Kolmogorov-Smirnov 5% Critical Value 0.137
Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL 644.4
95% Jackknife UCL 646.1
95% Standard Bootstrap UCL 645.2
95% Bootstrap-t UCL 668
95% Hall's Bootstrap UCL 658.7
95% Percentile Bootstrap UCL 644.4
95% BCA Bootstrap UCL 655.8
95% Chebyshev(Mean, Sd) UCL 766.1
97.5% Chebyshev(Mean, Sd) UCL 850.7
99% Chebyshev(Mean, Sd) UCL 1017

Assuming Gamma Distribution

95% Approximate Gamma UCL 645.2
95% Adjusted Gamma UCL 648

Potential UCL to Use

Use 95% Student's-t UCL 646.1
or 95% Modified-t UCL 647.8

Be (Berylium)

General Statistics

Number of Valid Observations 42

Number of Distinct Observations 39

Raw Statistics

Minimum	0.339
Maximum	7.86
Mean	2.704
Median	2.41
SD	1.642
Coefficient of Variation	0.607
Skewness	1.326

Log-transformed Statistics

Minimum of Log Data	-1.082
Maximum of Log Data	2.062
Mean of log Data	0.82
SD of log Data	0.619

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.853
Shapiro Wilk Critical Value	0.942

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.93
Shapiro Wilk Critical Value	0.942

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	3.13

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL	3.176
95% Modified-t UCL	3.139

Assuming Lognormal Distribution

95% H-UCL	3.331
95% Chebyshev (MVUE) UCL	3.956
97.5% Chebyshev (MVUE) UCL	4.484
99% Chebyshev (MVUE) UCL	5.522

Gamma Distribution Test

k star (bias corrected)	2.819
Theta Star	0.959
nu star	236.8
Approximate Chi Square Value (.05)	202.2
Adjusted Level of Significance	0.0443
Adjusted Chi Square Value	201
Anderson-Darling Test Statistic	0.356
Anderson-Darling 5% Critical Value	0.755
Kolmogorov-Smirnov Test Statistic	0.0865
Kolmogorov-Smirnov 5% Critical Value	0.137

Data appear Gamma Distributed at 5% Significance Level

Data Distribution

Data appear Gamma Distributed at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	3.12
95% Jackknife UCL	3.13
95% Standard Bootstrap UCL	3.121
95% Bootstrap-t UCL	3.236
95% Hall's Bootstrap UCL	3.222
95% Percentile Bootstrap UCL	3.12
95% BCA Bootstrap UCL	3.175
95% Chebyshev(Mean, Sd) UCL	3.808
97.5% Chebyshev(Mean, Sd) UCL	4.286
99% Chebyshev(Mean, Sd) UCL	5.225

Assuming Gamma Distribution

95% Approximate Gamma UCL	3.167
95% Adjusted Gamma UCL	3.184

Potential UCL to Use

Use 95% Approximate Gamma UCL 3.167

B (Boron)

General Statistics

Number of Valid Observations 42

Number of Distinct Observations 41

Raw Statistics

Minimum	151
Maximum	2190
Mean	680.5
Median	585
SD	353.4
Coefficient of Variation	0.519
Skewness	2.022

Log-transformed Statistics

Minimum of Log Data	5.017
Maximum of Log Data	7.692
Mean of log Data	6.408
SD of log Data	0.492

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.823
Shapiro Wilk Critical Value	0.942

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.935
Shapiro Wilk Critical Value	0.942

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	772.2

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL	788.3
95% Modified-t UCL	775.1

Assuming Lognormal Distribution

95% H-UCL	791.5
95% Chebyshev (MVUE) UCL	918.8
97.5% Chebyshev (MVUE) UCL	1021
99% Chebyshev (MVUE) UCL	1222

Gamma Distribution Test

k star (bias corrected)	4.198
Theta Star	162.1
nu star	352.7
Approximate Chi Square Value (.05)	310.2
Adjusted Level of Significance	0.0443
Adjusted Chi Square Value	308.7
Anderson-Darling Test Statistic	0.513
Anderson-Darling 5% Critical Value	0.752
Kolmogorov-Smirnov Test Statistic	0.106
Kolmogorov-Smirnov 5% Critical Value	0.137

Data appear Gamma Distributed at 5% Significance Level

Data Distribution

Data appear Gamma Distributed at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	770.2
95% Jackknife UCL	772.2
95% Standard Bootstrap UCL	766.9
95% Bootstrap-t UCL	799.9
95% Hall's Bootstrap UCL	831.3
95% Percentile Bootstrap UCL	769.7
95% BCA Bootstrap UCL	790.7
95% Chebyshev(Mean, Sd) UCL	918.2
97.5% Chebyshev(Mean, Sd) UCL	1021
99% Chebyshev(Mean, Sd) UCL	1223

Assuming Gamma Distribution

95% Approximate Gamma UCL	773.8
95% Adjusted Gamma UCL	777.3

Potential UCL to Use

Use 95% Approximate Gamma UCL 773.8

Cd (Cadmium)

General Statistics

Number of Valid Observations 42

Number of Distinct Observations 39

Raw Statistics

Minimum	0.0575
Maximum	3.235
Mean	0.421
Median	0.316
SD	0.643
Coefficient of Variation	1.526
Skewness	4.007

Log-transformed Statistics

Minimum of Log Data	-2.856
Maximum of Log Data	1.174
Mean of log Data	-1.32
SD of log Data	0.849

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.434
Shapiro Wilk Critical Value	0.942

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.875
Shapiro Wilk Critical Value	0.942

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	0.588

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL	0.65
95% Modified-t UCL	0.599

Assuming Lognormal Distribution

95% H-UCL	0.512
95% Chebyshev (MVUE) UCL	0.623
97.5% Chebyshev (MVUE) UCL	0.728
99% Chebyshev (MVUE) UCL	0.935

Gamma Distribution Test

k star (bias corrected)	1.166
Theta Star	0.361
nu star	97.92
Approximate Chi Square Value (.05)	76.09
Adjusted Level of Significance	0.0443
Adjusted Chi Square Value	75.4
Anderson-Darling Test Statistic	2.634
Anderson-Darling 5% Critical Value	0.773
Kolmogorov-Smirnov Test Statistic	0.204
Kolmogorov-Smirnov 5% Critical Value	0.14

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL	0.585
95% Jackknife UCL	0.588
95% Standard Bootstrap UCL	0.578
95% Bootstrap-t UCL	1.032
95% Hall's Bootstrap UCL	1.548
95% Percentile Bootstrap UCL	0.606
95% BCA Bootstrap UCL	0.649
95% Chebyshev(Mean, Sd) UCL	0.854
97.5% Chebyshev(Mean, Sd) UCL	1.041
99% Chebyshev(Mean, Sd) UCL	1.408

Assuming Gamma Distribution

95% Approximate Gamma UCL	0.542
95% Adjusted Gamma UCL	0.547

Potential UCL to Use

Use 95% Chebyshev (Mean, Sd) UCL 0.854

Cr (Chromium)

General Statistics

Number of Valid Observations 42

Number of Distinct Observations 39

Raw Statistics

Minimum 14.3
Maximum 240
Mean 39.88
Median 33.65
SD 34.39
Coefficient of Variation 0.862
Skewness 5.08

Log-transformed Statistics

Minimum of Log Data 2.66
Maximum of Log Data 5.481
Mean of log Data 3.538
SD of log Data 0.47

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic 0.464
Shapiro Wilk Critical Value 0.942
Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic 0.85
Shapiro Wilk Critical Value 0.942
Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 48.81

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL 53.05
95% Modified-t UCL 49.5

Assuming Lognormal Distribution

95% H-UCL 44.08
95% Chebyshev (MVUE) UCL 50.94
97.5% Chebyshev (MVUE) UCL 56.41
99% Chebyshev (MVUE) UCL 67.15

Gamma Distribution Test

k star (bias corrected) 3.303
Theta Star 12.07
nu star 277.4
Approximate Chi Square Value (.05) 239.9
Adjusted Level of Significance 0.0443
Adjusted Chi Square Value 238.6

Anderson-Darling Test Statistic 2.897
Anderson-Darling 5% Critical Value 0.754
Kolmogorov-Smirnov Test Statistic 0.23
Kolmogorov-Smirnov 5% Critical Value 0.137
Data not Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL 46.13
95% Adjusted Gamma UCL 46.37

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL 48.61
95% Jackknife UCL 48.81
95% Standard Bootstrap UCL 48.7
95% Bootstrap-t UCL 62.76
95% Hall's Bootstrap UCL 83.74
95% Percentile Bootstrap UCL 49.39
95% BCA Bootstrap UCL 55.22
95% Chebyshev(Mean, Sd) UCL 63.01
97.5% Chebyshev(Mean, Sd) UCL 73.02
99% Chebyshev(Mean, Sd) UCL 92.68

Potential UCL to Use

Use 95% Student's-t UCL 48.81
or 95% Modified-t UCL 49.5

Cu (Copper)

General Statistics

Number of Valid Observations 42

Number of Distinct Observations 39

Raw Statistics

Minimum	14.5
Maximum	59.8
Mean	32.7
Median	31.4
SD	10.98
Coefficient of Variation	0.336
Skewness	0.504

Log-transformed Statistics

Minimum of Log Data	2.674
Maximum of Log Data	4.091
Mean of log Data	3.43
SD of log Data	0.349

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.927
Shapiro Wilk Critical Value	0.942

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.934
Shapiro Wilk Critical Value	0.942

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	35.55

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL	35.62
95% Modified-t UCL	35.57

Assuming Lognormal Distribution

95% H-UCL	36.19
95% Chebyshev (MVUE) UCL	40.64
97.5% Chebyshev (MVUE) UCL	44.05
99% Chebyshev (MVUE) UCL	50.74

Gamma Distribution Test

k star (bias corrected)	8.305
Theta Star	3.937
nu star	697.6
Approximate Chi Square Value (.05)	637.4
Adjusted Level of Significance	0.0443
Adjusted Chi Square Value	635.3
Anderson-Darling Test Statistic	0.166
Anderson-Darling 5% Critical Value	0.749
Kolmogorov-Smirnov Test Statistic	0.0628
Kolmogorov-Smirnov 5% Critical Value	0.136

Data appear Gamma Distributed at 5% Significance Level

Data Distribution

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	35.79
95% Adjusted Gamma UCL	35.91

Nonparametric Statistics

95% CLT UCL	35.48
95% Jackknife UCL	35.55
95% Standard Bootstrap UCL	35.39
95% Bootstrap-t UCL	35.73
95% Hall's Bootstrap UCL	35.69
95% Percentile Bootstrap UCL	35.37
95% BCA Bootstrap UCL	35.51
95% Chebyshev(Mean, Sd) UCL	40.08
97.5% Chebyshev(Mean, Sd) UCL	43.28
99% Chebyshev(Mean, Sd) UCL	49.55

Potential UCL to Use

Use 95% Approximate Gamma UCL 35.79

Fe (Iron)

General Statistics

Number of Valid Observations 42

Number of Distinct Observations 41

Raw Statistics

Minimum 10600
Maximum 58600
Mean 22869
Median 21000
SD 9390
Coefficient of Variation 0.411
Skewness 1.317

Log-transformed Statistics

Minimum of Log Data 9.269
Maximum of Log Data 10.98
Mean of log Data 9.961
SD of log Data 0.396

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic 0.857
Shapiro Wilk Critical Value 0.942
Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic 0.912
Shapiro Wilk Critical Value 0.942
Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 25307

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL 25567
95% Modified-t UCL 25357

Assuming Lognormal Distribution

95% H-UCL 25642
95% Chebyshev (MVUE) UCL 29132
97.5% Chebyshev (MVUE) UCL 31845
99% Chebyshev (MVUE) UCL 37175

Gamma Distribution Test

k star (bias corrected) 6.232
Theta Star 3669
nu star 523.5
Approximate Chi Square Value (.05) 471.5
Adjusted Level of Significance 0.0443
Adjusted Chi Square Value 469.7

Anderson-Darling Test Statistic 0.472
Anderson-Darling 5% Critical Value 0.751
Kolmogorov-Smirnov Test Statistic 0.0846
Kolmogorov-Smirnov 5% Critical Value 0.137
Data appear Gamma Distributed at 5% Significance Level

Data Distribution

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL 25394
95% Adjusted Gamma UCL 25489

Nonparametric Statistics

95% CLT UCL 25252
95% Jackknife UCL 25307
95% Standard Bootstrap UCL 25169
95% Bootstrap-t UCL 25760
95% Hall's Bootstrap UCL 25888
95% Percentile Bootstrap UCL 25350
95% BCA Bootstrap UCL 25488
95% Chebyshev(Mean, Sd) UCL 29185
97.5% Chebyshev(Mean, Sd) UCL 31918
99% Chebyshev(Mean, Sd) UCL 37286

Potential UCL to Use

Use 95% Approximate Gamma UCL 25394

Pb (Lead)

General Statistics

Number of Valid Observations 42

Number of Distinct Observations 37

Raw Statistics

Minimum 7.09
Maximum 51.5
Mean 19.45
Median 17.35
SD 8.544
Coefficient of Variation 0.439
Skewness 1.732

Log-transformed Statistics

Minimum of Log Data 1.959
Maximum of Log Data 3.942
Mean of log Data 2.89
SD of log Data 0.39

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic 0.83
Shapiro Wilk Critical Value 0.942
Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic 0.943
Shapiro Wilk Critical Value 0.942
Data appear Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL 21.67

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL 22
95% Modified-t UCL 21.73

Assuming Lognormal Distribution

95% H-UCL 21.69
95% Chebyshev (MVUE) UCL 24.61
97.5% Chebyshev (MVUE) UCL 26.87
99% Chebyshev (MVUE) UCL 31.32

Gamma Distribution Test

k star (bias corrected) 6.099
Theta Star 3.19
nu star 512.3
Approximate Chi Square Value (.05) 460.8
Adjusted Level of Significance 0.0443
Adjusted Chi Square Value 459.1

Anderson-Darling Test Statistic 0.878
Anderson-Darling 5% Critical Value 0.751
Kolmogorov-Smirnov Test Statistic 0.141
Kolmogorov-Smirnov 5% Critical Value 0.137
Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data appear Lognormal at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL 21.63
95% Adjusted Gamma UCL 21.71

Nonparametric Statistics

95% CLT UCL 21.62
95% Jackknife UCL 21.67
95% Standard Bootstrap UCL 21.58
95% Bootstrap-t UCL 22.21
95% Hall's Bootstrap UCL 22.57
95% Percentile Bootstrap UCL 21.64
95% BCA Bootstrap UCL 22.1
95% Chebyshev(Mean, Sd) UCL 25.2
97.5% Chebyshev(Mean, Sd) UCL 27.69
99% Chebyshev(Mean, Sd) UCL 32.57

Potential UCL to Use

Use 95% Student's-t UCL 21.67
or 95% Modified-t UCL 21.73
or 95% H-UCL 21.69

Hg (Mercury)

General Statistics

Number of Valid Observations 42

Number of Distinct Observations 40

Raw Statistics

Minimum	0.0457
Maximum	0.939
Mean	0.361
Median	0.337
SD	0.168
Coefficient of Variation	0.464
Skewness	0.695

Log-transformed Statistics

Minimum of Log Data	-3.087
Maximum of Log Data	-0.0629
Mean of log Data	-1.169
SD of log Data	0.647

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.903
Shapiro Wilk Critical Value	0.942

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.777
Shapiro Wilk Critical Value	0.942

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	0.405

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL	0.407
95% Modified-t UCL	0.405

Assuming Lognormal Distribution

95% H-UCL	0.469
95% Chebyshev (MVUE) UCL	0.559
97.5% Chebyshev (MVUE) UCL	0.636
99% Chebyshev (MVUE) UCL	0.788

Gamma Distribution Test

k star (bias corrected)	3.25
Theta Star	0.111
nu star	273
Approximate Chi Square Value (.05)	235.7
Adjusted Level of Significance	0.0443
Adjusted Chi Square Value	234.5
Anderson-Darling Test Statistic	2.062
Anderson-Darling 5% Critical Value	0.754
Kolmogorov-Smirnov Test Statistic	0.205
Kolmogorov-Smirnov 5% Critical Value	0.137

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL	0.404
95% Jackknife UCL	0.405
95% Standard Bootstrap UCL	0.404
95% Bootstrap-t UCL	0.41
95% Hall's Bootstrap UCL	0.411
95% Percentile Bootstrap UCL	0.404
95% BCA Bootstrap UCL	0.404
95% Chebyshev(Mean, Sd) UCL	0.474
97.5% Chebyshev(Mean, Sd) UCL	0.523
99% Chebyshev(Mean, Sd) UCL	0.619

Assuming Gamma Distribution

95% Approximate Gamma UCL	0.418
95% Adjusted Gamma UCL	0.42

Potential UCL to Use

Use 95% Chebyshev (Mean, Sd) UCL 0.474

Mo (Molybdenum)

General Statistics

Number of Valid Observations 42

Number of Distinct Observations 41

Raw Statistics

Minimum	0.982
Maximum	16.15
Mean	5.879
Median	4.765
SD	3.281
Coefficient of Variation	0.558
Skewness	1.486

Log-transformed Statistics

Minimum of Log Data	-0.0182
Maximum of Log Data	2.782
Mean of log Data	1.63
SD of log Data	0.553

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.842
Shapiro Wilk Critical Value	0.942

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.935
Shapiro Wilk Critical Value	0.942

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	6.731

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL	6.836
95% Modified-t UCL	6.751

Assuming Lognormal Distribution

95% H-UCL	7.024
95% Chebyshev (MVUE) UCL	8.251
97.5% Chebyshev (MVUE) UCL	9.26
99% Chebyshev (MVUE) UCL	11.24

Gamma Distribution Test

k star (bias corrected)	3.438
Theta Star	1.71
nu star	288.8
Approximate Chi Square Value (.05)	250.4
Adjusted Level of Significance	0.0443
Adjusted Chi Square Value	249.1
Anderson-Darling Test Statistic	0.482
Anderson-Darling 5% Critical Value	0.753
Kolmogorov-Smirnov Test Statistic	0.106
Kolmogorov-Smirnov 5% Critical Value	0.137

Data appear Gamma Distributed at 5% Significance Level

Data Distribution

Data appear Gamma Distributed at 5% Significance Level

Assuming Gamma Distribution

95% Approximate Gamma UCL	6.78
95% Adjusted Gamma UCL	6.814

Nonparametric Statistics

95% CLT UCL	6.712
95% Jackknife UCL	6.731
95% Standard Bootstrap UCL	6.714
95% Bootstrap-t UCL	6.89
95% Hall's Bootstrap UCL	6.931
95% Percentile Bootstrap UCL	6.706
95% BCA Bootstrap UCL	6.795
95% Chebyshev(Mean, Sd) UCL	8.086
97.5% Chebyshev(Mean, Sd) UCL	9.041
99% Chebyshev(Mean, Sd) UCL	10.92

Potential UCL to Use

Use 95% Approximate Gamma UCL 6.78

Ni (Nickel)

General Statistics

Number of Valid Observations 42

Number of Distinct Observations 41

Raw Statistics

Minimum	21.6
Maximum	609
Mean	69.09
Median	45.5
SD	93.96
Coefficient of Variation	1.36
Skewness	4.99

Log-transformed Statistics

Minimum of Log Data	3.073
Maximum of Log Data	6.412
Mean of log Data	3.929
SD of log Data	0.645

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.428
Shapiro Wilk Critical Value	0.942

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.835
Shapiro Wilk Critical Value	0.942

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	93.48

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL	104.9
95% Modified-t UCL	95.34

Assuming Lognormal Distribution

95% H-UCL	76.65
95% Chebyshev (MVUE) UCL	91.4
97.5% Chebyshev (MVUE) UCL	104
99% Chebyshev (MVUE) UCL	128.8

Gamma Distribution Test

k star (bias corrected)	1.67
Theta Star	41.38
nu star	140.3
Approximate Chi Square Value (.05)	113.9
Adjusted Level of Significance	0.0443
Adjusted Chi Square Value	113
Anderson-Darling Test Statistic	3.554
Anderson-Darling 5% Critical Value	0.763
Kolmogorov-Smirnov Test Statistic	0.255
Kolmogorov-Smirnov 5% Critical Value	0.138

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Assuming Gamma Distribution

95% Approximate Gamma UCL	85.08
95% Adjusted Gamma UCL	85.72

Nonparametric Statistics

95% CLT UCL	92.93
95% Jackknife UCL	93.48
95% Standard Bootstrap UCL	93.11
95% Bootstrap-t UCL	139.2
95% Hall's Bootstrap UCL	186.3
95% Percentile Bootstrap UCL	95.72
95% BCA Bootstrap UCL	109.6
95% Chebyshev(Mean, Sd) UCL	132.3
97.5% Chebyshev(Mean, Sd) UCL	159.6
99% Chebyshev(Mean, Sd) UCL	213.3

Potential UCL to Use

Use 95% Chebyshev (Mean, Sd) UCL 132.3

Se (Selinium)

General Statistics

Number of Valid Observations 42

Number of Distinct Observations 39

Raw Statistics

Minimum	0.0575
Maximum	4.82
Mean	1.631
Median	1.72
SD	1.142
Coefficient of Variation	0.7
Skewness	0.539

Log-transformed Statistics

Minimum of Log Data	-2.856
Maximum of Log Data	1.573
Mean of log Data	0.103
SD of log Data	1.064

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.892
Shapiro Wilk Critical Value	0.942

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.848
Shapiro Wilk Critical Value	0.942

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	1.927

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL	1.936
95% Modified-t UCL	1.93

Assuming Lognormal Distribution

95% H-UCL	2.916
95% Chebyshev (MVUE) UCL	3.535
97.5% Chebyshev (MVUE) UCL	4.237
99% Chebyshev (MVUE) UCL	5.616

Gamma Distribution Test

k star (bias corrected)	1.353
Theta Star	1.205
nu star	113.6
Approximate Chi Square Value (.05)	90.04
Adjusted Level of Significance	0.0443
Adjusted Chi Square Value	89.29
Anderson-Darling Test Statistic	0.965
Anderson-Darling 5% Critical Value	0.768
Kolmogorov-Smirnov Test Statistic	0.162
Kolmogorov-Smirnov 5% Critical Value	0.139

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL	1.921
95% Jackknife UCL	1.927
95% Standard Bootstrap UCL	1.913
95% Bootstrap-t UCL	1.943
95% Hall's Bootstrap UCL	1.928
95% Percentile Bootstrap UCL	1.931
95% BCA Bootstrap UCL	1.922
95% Chebyshev(Mean, Sd) UCL	2.399
97.5% Chebyshev(Mean, Sd) UCL	2.732
99% Chebyshev(Mean, Sd) UCL	3.385

Assuming Gamma Distribution

95% Approximate Gamma UCL	2.059
95% Adjusted Gamma UCL	2.076

Potential UCL to Use

Use 99% Chebyshev (Mean, Sd) UCL 3.385

Ag (Silver)

General Statistics

Number of Valid Observations 42

Number of Distinct Observations 37

Raw Statistics

Minimum	0.0575
Maximum	3.235
Mean	0.564
Median	0.334
SD	0.745
Coefficient of Variation	1.321
Skewness	2.795

Log-transformed Statistics

Minimum of Log Data	-2.856
Maximum of Log Data	1.174
Mean of log Data	-1.019
SD of log Data	0.854

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.533
Shapiro Wilk Critical Value	0.942

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.869
Shapiro Wilk Critical Value	0.942

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	0.757

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL	0.806
95% Modified-t UCL	0.765

Assuming Lognormal Distribution

95% H-UCL	0.697
95% Chebyshev (MVUE) UCL	0.848
97.5% Chebyshev (MVUE) UCL	0.992
99% Chebyshev (MVUE) UCL	1.275

Gamma Distribution Test

k star (bias corrected)	1.189
Theta Star	0.474
nu star	99.91
Approximate Chi Square Value (.05)	77.85
Adjusted Level of Significance	0.0443
Adjusted Chi Square Value	77.15
Anderson-Darling Test Statistic	3.891
Anderson-Darling 5% Critical Value	0.772
Kolmogorov-Smirnov Test Statistic	0.282
Kolmogorov-Smirnov 5% Critical Value	0.14

Data not Gamma Distributed at 5% Significance Level

Data Distribution

Data do not follow a Discernable Distribution (0.05)

Nonparametric Statistics

95% CLT UCL	0.753
95% Jackknife UCL	0.757
95% Standard Bootstrap UCL	0.755
95% Bootstrap-t UCL	0.864
95% Hall's Bootstrap UCL	0.768
95% Percentile Bootstrap UCL	0.772
95% BCA Bootstrap UCL	0.828
95% Chebyshev(Mean, Sd) UCL	1.065
97.5% Chebyshev(Mean, Sd) UCL	1.281
99% Chebyshev(Mean, Sd) UCL	1.707

Assuming Gamma Distribution

95% Approximate Gamma UCL	0.723
95% Adjusted Gamma UCL	0.73

Potential UCL to Use

Use 95% Chebyshev (Mean, Sd) UCL 1.065

Tl (Thallium)

General Statistics

Number of Valid Observations 42

Number of Distinct Observations 41

Raw Statistics

Minimum	0.194
Maximum	1.735
Mean	0.562
Median	0.519
SD	0.325
Coefficient of Variation	0.578
Skewness	2.219

Log-transformed Statistics

Minimum of Log Data	-1.64
Maximum of Log Data	0.551
Mean of log Data	-0.697
SD of log Data	0.479

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.751
Shapiro Wilk Critical Value	0.942

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.926
Shapiro Wilk Critical Value	0.942

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	0.647

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL	0.663
95% Modified-t UCL	0.65

Assuming Lognormal Distribution

95% H-UCL	0.643
95% Chebyshev (MVUE) UCL	0.744
97.5% Chebyshev (MVUE) UCL	0.826
99% Chebyshev (MVUE) UCL	0.985

Gamma Distribution Test

k star (bias corrected)	3.974
Theta Star	0.142
nu star	333.8
Approximate Chi Square Value (.05)	292.5
Adjusted Level of Significance	0.0443
Adjusted Chi Square Value	291.1
Anderson-Darling Test Statistic	0.911
Anderson-Darling 5% Critical Value	0.753
Kolmogorov-Smirnov Test Statistic	0.128
Kolmogorov-Smirnov 5% Critical Value	0.137

Data follow Appr. Gamma Distribution at 5% Significance Level

Data Distribution

Data Follow Appr. Gamma Distribution at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	0.645
95% Jackknife UCL	0.647
95% Standard Bootstrap UCL	0.643
95% Bootstrap-t UCL	0.682
95% Hall's Bootstrap UCL	0.682
95% Percentile Bootstrap UCL	0.651
95% BCA Bootstrap UCL	0.661
95% Chebyshev(Mean, Sd) UCL	0.781
97.5% Chebyshev(Mean, Sd) UCL	0.876
99% Chebyshev(Mean, Sd) UCL	1.061

Assuming Gamma Distribution

95% Approximate Gamma UCL	0.642
95% Adjusted Gamma UCL	0.645

Potential UCL to Use

Use 95% Approximate Gamma UCL 0.642

Zn (Zinc)

General Statistics

Number of Valid Observations 42

Number of Distinct Observations 42

Raw Statistics

Minimum	84.8
Maximum	1670
Mean	497
Median	396.5
SD	369
Coefficient of Variation	0.743
Skewness	1.478

Log-transformed Statistics

Minimum of Log Data	4.44
Maximum of Log Data	7.421
Mean of log Data	5.937
SD of log Data	0.782

Relevant UCL Statistics

Normal Distribution Test

Shapiro Wilk Test Statistic	0.823
Shapiro Wilk Critical Value	0.942

Data not Normal at 5% Significance Level

Lognormal Distribution Test

Shapiro Wilk Test Statistic	0.912
Shapiro Wilk Critical Value	0.942

Data not Lognormal at 5% Significance Level

Assuming Normal Distribution

95% Student's-t UCL	592.8

95% UCLs (Adjusted for Skewness)

95% Adjusted-CLT UCL	604.5
95% Modified-t UCL	595

Assuming Lognormal Distribution

95% H-UCL	666.5
95% Chebyshev (MVUE) UCL	806.9
97.5% Chebyshev (MVUE) UCL	935.6
99% Chebyshev (MVUE) UCL	1189

Gamma Distribution Test

k star (bias corrected)	1.863
Theta Star	266.8
nu star	156.5
Approximate Chi Square Value (.05)	128.6
Adjusted Level of Significance	0.0443
Adjusted Chi Square Value	127.7
Anderson-Darling Test Statistic	0.303
Anderson-Darling 5% Critical Value	0.76
Kolmogorov-Smirnov Test Statistic	0.067
Kolmogorov-Smirnov 5% Critical Value	0.138

Data appear Gamma Distributed at 5% Significance Level

Data Distribution

Data appear Gamma Distributed at 5% Significance Level

Nonparametric Statistics

95% CLT UCL	590.6
95% Jackknife UCL	592.8
95% Standard Bootstrap UCL	589.5
95% Bootstrap-t UCL	604.4
95% Hall's Bootstrap UCL	613.9
95% Percentile Bootstrap UCL	596.7
95% BCA Bootstrap UCL	603.6
95% Chebyshev(Mean, Sd) UCL	745.2
97.5% Chebyshev(Mean, Sd) UCL	852.6
99% Chebyshev(Mean, Sd) UCL	1064

Assuming Gamma Distribution

95% Approximate Gamma UCL	604.9
95% Adjusted Gamma UCL	609.1

Potential UCL to Use

Use 95% Approximate Gamma UCL 604.9

APPENDIX F

Air Dispersion Modeling

Emission Rate Calculations - Sample PVT-EndCap-PM10

Soil Disposal Emission Rate

$Q = (E_{10} \times h \times u_{mean})/(L \times 10^6)$

where:	Q:	PM_{10} emission rate (g/s-m^2)
	E10:	PM_{10} concentration (µg/m^3)
	h:	mixing height
	u_{mean}:	mean wind speed (m/s), and
	L:	landfill length.

E_{10} =	1100	
L =	45	site-specific
h =	2	
u_{mean} =	2.8	site-specific
Q=	0.000136889	

Unlimited Erosion Model Emission Rate

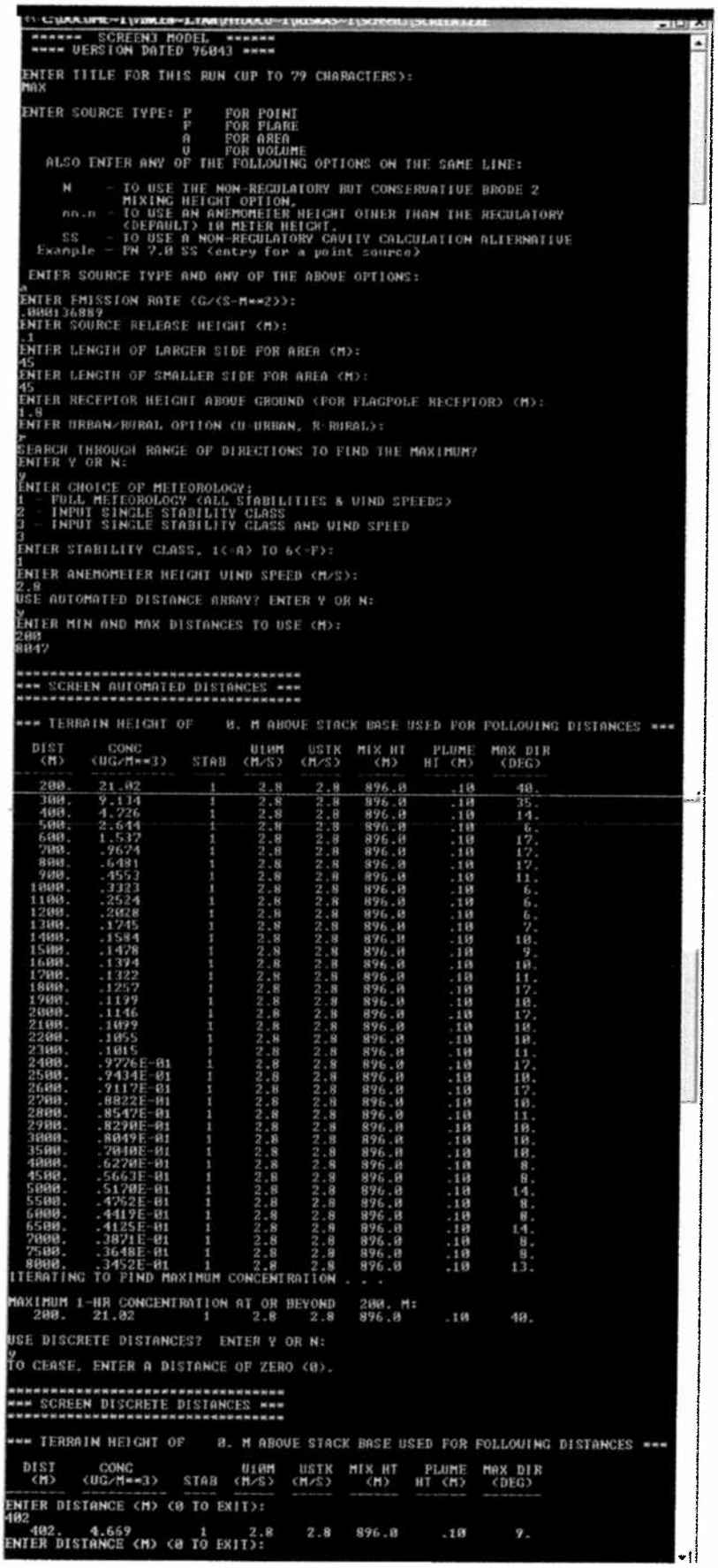
$Q=0.036 \times (1-V) \times (u_{mean}/u_t)^3 \times F(y) \times (1/3600)$

where:	Q:	PM_{10} emission rate (g/s-m^2)
	V:	fraction of surface vegetation cover, V = 0 (assumption)
	u_{mean}:	mean wind speed (m/s), umean = 2.8m/s (site-specific data)
	u_t:	threshold value of wind speed at 7m (m/s)
	y:	$y = 0.886\ u_t / u_{mean}$ (dimentionless ratio), and
	F(y):	function of y (USEPA 1985)

V =	0	
u_{mean} =	2.8	site-specific
u_t =	11.32	default (USEPA 1996)
F(y) =	0.194	default (USEPA 1996)
Q=	2.93587E-08	

USEPA 1996 Soil Screening Guidance: User's Guide. Office of Emergency and Remedial Response. Washington, DC. OSWER No. 9355.4-23

SCREEN3 - Soil Disposal PM10 Emission Rate



```
 ******  SCREEN3 MODEL  ******
 **** VERSION DATED 96043 ****

ENTER TITLE FOR THIS RUN (UP TO 79 CHARACTERS):
MAX

ENTER SOURCE TYPE: P    FOR POINT
                   F    FOR FLARE
                   A    FOR AREA
                   V    FOR VOLUME
   ALSO ENTER ANY OF THE FOLLOWING OPTIONS ON THE SAME LINE:

     N     - TO USE THE NON-REGULATORY BUT CONSERVATIVE BRODE 2
             MIXING HEIGHT OPTION.
     nn.n  - TO USE AN ANEMOMETER HEIGHT OTHER THAN THE REGULATORY
             (DEFAULT) 10 METER HEIGHT.
     SS    - TO USE A NON-REGULATORY CAVITY CALCULATION ALTERNATIVE
  Example - PN 7.0 SS (entry for a point source)

 ENTER SOURCE TYPE AND ANY OF THE ABOVE OPTIONS:
a
ENTER EMISSION RATE (G/(S-M**2)):
.000136889
ENTER SOURCE RELEASE HEIGHT (M):
.1
ENTER LENGTH OF LARGER SIDE FOR AREA (M):
45
ENTER LENGTH OF SMALLER SIDE FOR AREA (M):
45
ENTER RECEPTOR HEIGHT ABOVE GROUND (FOR FLAGPOLE RECEPTOR) (M):
1.8
ENTER URBAN/RURAL OPTION (U-URBAN, R-RURAL):
r
SEARCH THROUGH RANGE OF DIRECTIONS TO FIND THE MAXIMUM?
ENTER Y OR N:
y
ENTER CHOICE OF METEOROLOGY:
1 - FULL METEOROLOGY (ALL STABILITIES & WIND SPEEDS)
2 - INPUT SINGLE STABILITY CLASS
3 - INPUT SINGLE STABILITY CLASS AND WIND SPEED
3
ENTER STABILITY CLASS, 1(=A) TO 6(=F):
1
ENTER ANEMOMETER HEIGHT WIND SPEED (M/S):
2.8
USE AUTOMATED DISTANCE ARRAY? ENTER Y OR N:
y
ENTER MIN AND MAX DISTANCES TO USE (M):
200
8047

*********************************
*** SCREEN AUTOMATED DISTANCES ***
*********************************

*** TERRAIN HEIGHT OF     0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

  DIST      CONC                  U10M   USTK  MIX HT    PLUME   MAX DIR
   (M)   (UG/M**3)    STAB      (M/S)  (M/S)    (M)     HT (M)   (DEG)
------  ----------    ----      -----  -----  ------    ------   -------
   200.   21.02          1        2.8    2.8   896.0       .10      40.
   300.   9.114          1        2.8    2.8   896.0       .10      35.
   400.   4.726          1        2.8    2.8   896.0       .10      14.
   500.   2.644          1        2.8    2.8   896.0       .10       6.
   600.   1.537          1        2.8    2.8   896.0       .10      17.
   700.   .9674          1        2.8    2.8   896.0       .10      17.
   800.   .6481          1        2.8    2.8   896.0       .10      17.
   900.   .4553          1        2.8    2.8   896.0       .10      11.
  1000.   .3323          1        2.8    2.8   896.0       .10       6.
  1100.   .2524          1        2.8    2.8   896.0       .10       6.
  1200.   .2028          1        2.8    2.8   896.0       .10       6.
  1300.   .1745          1        2.8    2.8   896.0       .10       7.
  1400.   .1584          1        2.8    2.8   896.0       .10      10.
  1500.   .1478          1        2.8    2.8   896.0       .10       9.
  1600.   .1394          1        2.8    2.8   896.0       .10      10.
  1700.   .1322          1        2.8    2.8   896.0       .10      11.
  1800.   .1257          1        2.8    2.8   896.0       .10      12.
  1900.   .1199          1        2.8    2.8   896.0       .10      10.
  2000.   .1146          1        2.8    2.8   896.0       .10      12.
  2100.   .1099          1        2.8    2.8   896.0       .10      10.
  2200.   .1055          1        2.8    2.8   896.0       .10      10.
  2300.   .1015          1        2.8    2.8   896.0       .10      11.
  2400.   .9776E-01      1        2.8    2.8   896.0       .10      12.
  2500.   .9434E-01      1        2.8    2.8   896.0       .10      10.
  2600.   .9117E-01      1        2.8    2.8   896.0       .10      12.
  2700.   .8822E-01      1        2.8    2.8   896.0       .10      10.
  2800.   .8547E-01      1        2.8    2.8   896.0       .10      11.
  2900.   .8290E-01      1        2.8    2.8   896.0       .10      10.
  3000.   .8049E-01      1        2.8    2.8   896.0       .10      10.
  3500.   .7040E-01      1        2.8    2.8   896.0       .10      10.
  4000.   .6220E-01      1        2.8    2.8   896.0       .10       8.
  4500.   .5563E-01      1        2.8    2.8   896.0       .10       8.
  5000.   .5170E-01      1        2.8    2.8   896.0       .10      14.
  5500.   .4762E-01      1        2.8    2.8   896.0       .10       8.
  6000.   .4419E-01      1        2.8    2.8   896.0       .10       8.
  6500.   .4125E-01      1        2.8    2.8   896.0       .10      14.
  7000.   .3871E-01      1        2.8    2.8   896.0       .10       8.
  7500.   .3648E-01      1        2.8    2.8   896.0       .10       8.
  8000.   .3452E-01      1        2.8    2.8   896.0       .10      13.
ITERATING TO FIND MAXIMUM CONCENTRATION . . .

MAXIMUM 1-HR CONCENTRATION AT OR BEYOND   200. M:
   200.   21.02          1        2.8    2.8   896.0       .10      40.

USE DISCRETE DISTANCES?  ENTER Y OR N:
y
TO CEASE, ENTER A DISTANCE OF ZERO (0).

*********************************
*** SCREEN DISCRETE DISTANCES ***
*********************************

*** TERRAIN HEIGHT OF     0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

  DIST      CONC                  U10M   USTK  MIX HT    PLUME   MAX DIR
   (M)   (UG/M**3)    STAB      (M/S)  (M/S)    (M)     HT (M)   (DEG)
------  ----------    ----      -----  -----  ------    ------   -------
ENTER DISTANCE (M) (0 TO EXIT):
402
   402.   4.669          1        2.8    2.8   896.0       .10       9.
ENTER DISTANCE (M) (0 TO EXIT):
```

APPENDIX G

Risk Characterization Spreadsheets

Summary of Dose-Response Information
Activity Description

Constituent	EPC Concentration in Ash (mg/kg)	Oral CSF (mg/kg-d)^-1		Inhalation CSF (mg/kg-d)^-1		Inhalation URF (ug/m3)^-1		Oral TDI/RfD (mg/kg-d)		Inhalation TC/RfC (ug/m3)		Inhalation RFDi (mg/kg/day)		Inhalation RAF Cancer	Inhalation RAF Noncancer Chronic	Oral Soil/Sediment/Water Cancer	Oral Soil/Sediment/Water Noncancer Chronic		Dermal Soil/Sediment Cancer	Dermal Soil/Sediment Noncancer Chronic	
METALS																					
Antimony	0.719	NA		NA		NA		4.00E-04	a	NA		4.00E-04	d	1	1	NA	0.15	y	NA	1	
Arsenic	18.17	1.50E+00	a	1.51E+01	g	4.30E-03	a	3.00E-04	a	1.50E-02	a	4.29E-06	c	1	1	0.51	0.51	x	0.0004	0.0004	z
Barium	645.2	NA		NA		NA		2.00E-01	a	5.00E-01	b	1.43E-04	c	1	1	NA	0.07	y	NA	1	
Beryllium	3.121	NA		8.40E+00	g	2.40E-03	a	2.00E-03	a	2.00E-02	a	5.71E-06	c	1	1	NA	0.007	y	NA	0.14	y
Boron	769.7	NA		NA		NA		2.00E-01	a	2.00E+01	b	5.71E-03	c	1	1	NA	1	y	NA	1	
Cadmium	0.606	NA		6.62E+00	g	1.89E-03	a	1.00E-03	a	1.00E-03	e	2.86E-07	c	1	1	NA	0.025	y	NA	0.001	y
Chromium VI (1:6 VI:III Ratio	8.231666667	NA		NA		NA		3.00E-03	a	1.00E-01		2.86E-05	c	1	1	NA	0.025	w	NA	0.04	x
Copper	35.39	NA		NA		NA		NA		NA		NA		1	1	NA	1	y	NA	1	
Iron	25350	NA		NA		NA		NA		NA		NA		1	1	NA	1	y	NA	1	
Lead	21.64	NA		NA		NA		NA		NA		NA		1	1	NA	1	w	NA	NA	
Mercury, Divalent	0.404	NA		NA		NA		NA		3.00E-01	a	8.57E-05	c	1	1	NA	0.07	y	NA	0.01	y
Molybdenum	6.741	NA		NA		NA		5.00E-03	a	NA		5.00E-03	d	1	1	NA	1	y	NA	1	
Nickel	95.72	NA		9.10E-01		2.60E-04		2.00E-02	a	9.00E-02	e	2.57E-05	c	1	1	NA	0.04	y	NA	1	
Selenium	1.931	NA		NA		NA		5.00E-03	a	2.00E+01	f	5.71E-03	c	1	1	NA	1	y	NA	1	
Silver	0.772	NA		NA		NA		5.00E-03	a	NA		5.00E-03	d	1	1	NA	0.04	y	NA	1	
Thallium	0.651	NA		NA		NA		NA		NA		NA		1	1	NA	1	y	NA	1	
Zinc	596.7	NA		NA		NA		3.00E-01	a	NA		3.00E-01	d	1	1	NA	1	y	NA	0.003	x

NA - Not Applicable
(a) U.S. EPA (2009). IRIS.
(b) HEAST
(c) Derived from Inhalation RfC
(d) Derived from Oral RfD.
(e) ASTDR
(f) Cal EPA
(g) derived from Inhalation URF
(w) RAIS
(x) AMEC Derived
(y) EPA Region 9 RSL Table (2009)
(z) Hawaii DOH EAL Table H (2009)

WORKER - DUST INHALATION - ASH EXPOSURES
RISK CHARACTERIZATION
PVT LANDFILL

Scenario:	Subactivity name
Receptor:	Worker
Medium:	Dust from ash
Exposure Pathway:	Inhalation

Chemical Concentration in Air = CS * RP

ADD (mg/kg/day) = $\frac{Cdust \times IR \times RAF \times ET \times EF \times ED}{AT \times BW}$

Hazard Quotient (HQ) = ADD (mg/kg/day) / RfDi (mg/kg/day)
Cancer Risk (ELCR) = ADD (mg/kg/day) * CSFi [1/(mg/kg/day)]

Parameter (units)	Value	
ADD: Average Daily Dose (mg/kg/day)	See Below	
CS: Chemical Concentration in Soil (mg/kg)	Chemical-Specific	
Cdust: Concentration of dust-bound chemical in air (mg/m3)	Calculated	
RAF: Relative Absorption Factor (Inhalation) (unitless)	Chemical-Specific	
ET: Exposure Time - dust (hr/d)	8	
EF: Exposure Frequency (days/year)	250	
ED: Exposure Duration (years)	25	
IR: Inhalation Rate (m3/hr)	0.833	
AT: Averaging Time (days) (ED x 365 days/yr, noncancer)	9125	
AT: Averaging Time (days) (75 yr. x 365 days/yr, cancer)	25550	
BW: Body Weight (kg)	70	
RfDi: Reference Dose Inhalation (mg/kg/day)	Chemical-Specific	
CSFi: Cancer Slope Factor Inhalation [1/(mg/kg/day)]	Chemical-Specific	
RP: Respirable particulate conc. in air (mg/m3)	5.90E-01	(Maximum PM10 Concentration)
CF: Conversion Factor (kg/mg)	1.00E-06	

Compound	Soil Concentration (mg/kg)	Chemical Concentration in Air (mg/m3)	Noncancer Hazard Quotient				Excess Lifetime Cancer Risk			
			Inhalation RAF (noncancer)	ADD (noncancer) (mg/kg/day)	RFDi (non-cancer) (mg/kg/day)	Soil-Dust HQ	Inhalation RAF (cancer)	ADD (cancer) (mg/kg/day)	CSFi [1/(mg/kg/day)]	Soil- Dust Risk
METALS										
Antimony	7.19E-01	4.24E-07	1	2.77E-08	4.00E-04	6.92E-05	1	NA	NA	NA
Arsenic	1.82E+01	1.07E-05	1	6.99E-07	4.29E-06	1.63E-01	1	2.50E-07	1.51E+01	3.76E-06
Barium	6.45E+02	3.81E-04	1	2.48E-05	1.43E-04	1.74E-01	1	NA	NA	NA
Beryllium	3.12E+00	1.84E-06	1	1.20E-07	5.71E-06	2.10E-02	1	4.29E-08	8.40E+00	3.60E-07
Boron	7.70E+02	4.54E-04	1	2.96E-05	5.71E-03	5.18E-03	1	NA	NA	NA
Cadmium	6.06E-01	3.58E-07	1	2.33E-08	2.86E-07	8.16E-02	1	8.33E-09	6.62E+00	5.51E-08
Chromium VI (1:6 VI:III Ratio)*	8.23E+00	4.86E-06	1	3.17E-07	2.86E-05	1.11E-02	1	NA	NA	NA
Copper	3.54E+01	2.09E-05	1	NA	NA	NA	1	NA	NA	NA
Iron	2.54E+04	1.50E-02	1	NA	NA	NA	1	NA	NA	NA
Lead	2.16E+01	1.28E-05	1	NA	NA	NA	1	NA	NA	NA
Mercury, Divalent	4.04E-01	2.38E-07	1	1.55E-08	8.57E-05	1.81E-04	1	NA	NA	NA
Molybdenum	6.74E+00	3.98E-06	1	2.59E-07	5.00E-03	5.19E-05	1	NA	NA	NA
Nickel	9.57E+01	5.65E-05	1	3.68E-06	2.57E-05	1.43E-01	1	1.32E-06	9.10E-01	1.20E-06
Selenium	1.93E+00	1.14E-06	1	7.43E-08	5.71E-03	1.30E-05	1	NA	NA	NA
Silver	7.72E-01	4.55E-07	1	2.97E-08	5.00E-03	5.94E-06	1	NA	NA	NA
Thallium	6.51E-01	3.84E-07	1	NA	NA	NA	1	NA	NA	NA
Zinc	5.97E+02	3.52E-04	1	2.30E-05	3.00E-01	7.65E-05	1	NA	NA	NA
						5.99E-01				5.37E-06

WORKER - DUST INHALATION - 1 HR END CAP ASH EXPOSURES
RISK CHARACTERIZATION
PVT LANDFILL

Scenario:	Subactivity name
Receptor:	Worker
Medium:	Dust from ash
Exposure Pathway:	Inhalation

Chemical Concentration in Air = CS * RP

$$\text{ADD (mg/kg/day)} = \frac{\text{Cdust x IR x RAF x ET x EF x ED}}{\text{AT x BW}}$$

Hazard Quotient (HQ) = ADD (mg/kg/day) / RfDi (mg/kg/day)
Cancer Risk (ELCR) = ADD (mg/kg/day) * CSFi [1/(mg/kg/day)]

Parameter (units)	Value	
ADD: Average Daily Dose (mg/kg/day)	See Below	
CS: Chemical Concentration in Soil (mg/kg)	Chemical-Specific	
Cdust: Concentration of dust-bound chemical in air (mg/m3)	Calculated	
RAF: Relative Absorption Factor (Inhalation) (unitless)	Chemical-Specific	
ET: Exposure Time - dust (hr/d)	1	
EF: Exposure Frequency (days/year)	250	
ED: Exposure Duration (years)	25	
IR: Inhalation Rate (m3/hr)	0.833	
AT: Averaging Time (days) (ED x 365 days/yr, noncancer)	9125	
AT: Averaging Time (days) (75 yr. x 365 days/yr, cancer)	25550	
BW: Body Weight (kg)	70	
RfDi: Reference Dose Inhalation (mg/kg/day)	Chemical-Specific	
CSFi: Cancer Slope Factor Inhalation [1/(mg/kg/day)]	Chemical-Specific	
RP: Respirable particulate conc. in air (mg/m3)	1.10E+00	(End Cap PM10 Concentration)
CF: Conversion Factor (kg/mg)	1.00E-06	

			Noncancer Hazard Quotient				Excess Lifetime Cancer Risk			
Compound	Soil Concentration (mg/kg)	Chemical Concentration in Air (mg/m3)	Inhalation RAF (noncancer)	ADD (noncancer) (mg/kg/day)	RFDi (non-cancer) (mg/kg/day)	Soil-Dust HQ	Inhalation RAF (cancer)	ADD (cancer) (mg/kg/day)	CSFi [1/(mg/kg/day)]	Soil- Dust Risk
METALS										
Antimony	7.19E-01	7.91E-07	1	6.45E-09	4.00E-04	1.61E-05	1	NA	NA	NA
Arsenic	1.82E+01	2.00E-05	1	1.63E-07	4.29E-06	3.80E-02	1	5.82E-08	1.51E+01	8.76E-07
Barium	6.45E+02	7.10E-04	1	5.78E-06	1.43E-04	4.05E-02	1	NA	NA	NA
Beryllium	3.12E+00	3.43E-06	1	2.80E-08	5.71E-06	4.90E-03	1	9.99E-09	8.40E+00	8.39E-08
Boron	7.70E+02	8.47E-04	1	6.90E-06	5.71E-03	1.21E-03	1	NA	NA	NA
Cadmium	6.06E-01	6.67E-07	1	5.43E-09	2.86E-07	1.90E-02	1	1.94E-09	6.62E+00	1.28E-08
Chromium VI (1:6 VI:III Ratio)	8.23E+00	9.05E-06	1	7.38E-08	2.86E-05	2.58E-03	1	NA	NA	NA
Copper	3.54E+01	3.89E-05	1	NA	NA	NA	1	NA	NA	NA
Iron	2.54E+04	2.79E-02	1	NA	NA	NA	1	NA	NA	NA
Lead	2.16E+01	2.38E-05	1	NA	NA	NA	1	NA	NA	NA
Mercury, Divalent	4.04E-01	4.44E-07	1	3.62E-09	8.57E-05	4.23E-05	1	NA	NA	NA
Molybdenum	6.74E+00	7.42E-06	1	6.04E-08	5.00E-03	1.21E-05	1	NA	NA	NA
Nickel	9.57E+01	1.05E-04	1	8.58E-07	2.57E-05	3.34E-02	1	3.07E-07	9.10E-01	2.79E-07
Selenium	1.93E+00	2.12E-06	1	1.73E-08	5.71E-03	3.03E-06	1	NA	NA	NA
Silver	7.72E-01	8.49E-07	1	6.92E-09	5.00E-03	1.38E-06	1	NA	NA	NA
Thallium	6.51E-01	7.16E-07	1	NA	NA	NA	1	NA	NA	NA
Zinc	5.97E+02	6.56E-04	1	5.35E-06	3.00E-01	1.78E-05	1	NA	NA	NA
						1.40E-01				1.25E-06

WORKER - DIRECT CONTACT - ASH EXPOSURES
RISK CHARACTERIZATION
PVT LANDFILL

Scenario:	Subactivity name
Receptor:	Industrial Worker
Medium:	Ash
Exposure Pathway:	Ingestion and Dermal Contact

ADD (mg/kg-day) = $\frac{CS \times [(IR \times FI \times RAF) + (SA \times AF \times FA \times RAF \times EFD)] \times EF \times ED \times CF}{BW \times AT}$

Hazard Quotient (HQ) = ADD (mg/kg-day) / RfD (mg/kg-day)
Cancer Risk (ELCR) = ADD (mg/kg-day) * CSF [1/(mg/kg-day)]

Parameter (units)	Value
ADD: Average Daily Dose (mg/kg-day)	See Below
CS: Chemical Concentration in Soil (mg/kg)	Chemical-Specific
IR: Ingestion Rate (mg/day)	100
RAF: Relative Absorption Factor (Oral-Soil) (unitless)	Chemical-Specific
FI: Fraction Ingested from Site (unitless)	1
SA: Skin Surface Area (cm2)	3300
AF: Adherence Factor (mg/cm2/event)	0.29
RAF: Relative Absorption Factor (Dermal-Soil) (unitless)	Chemical-Specific
FA: Fraction Absorbed from Site (unitless)	1
EFD: Exposure Frequency - Dermal (event/day)	1
EF: Exposure Frequency (days/year)	250
ED: Exposure Duration (years)	25
BW: Body Weight (kg)	70
AT: Averaging Time (days) (ED x 365 days/yr, noncancer)	9125
AT: Averaging Time (days) (75 yr. x 365 days/yr, cancer)	25550
CF: Conversion factor (kg/mg)	1.00E-06
RfD: Reference Dose (mg/kg-day)	Chemical-Specific
CSF: Cancer Slope Factor [1/(mg/kg-day)]	Chemical-Specific

		Noncancer Hazard Quotient					Excess Lifetime Cancer Risk				
Compound	Soil Concentration (mg/kg)	Oral-Soil RAF (noncancer)	Dermal-Soil RAF (noncancer)	ADD (noncancer) (mg/kg-day)	Chronic TDI/RfD (mg/kg-day)	Soil HQ	Oral-Soil RAF (cancer)	Dermal-Soil RAF (cancer)	ADD (cancer) (mg/kg-day)	CSF [1/(mg/kg-day)]	Soil Risk
METALS											
Antimony	7.19E-01	0.15	1	6.84E-06	4.00E-04	1.71E-02	NA	NA	NA	NA	NA
Arsenic	1.82E+01	0.51	0.0004	9.14E-06	3.00E-04	3.05E-02	0.51	0.0004	3.26E-06	1.50E+00	4.89E-06
Barium	6.45E+02	0.07	1	6.09E-03	2.00E-01	3.04E-02	NA	NA	NA	NA	NA
Beryllium	3.12E+00	0.007	0.14	4.11E-06	2.00E-03	2.06E-03	NA	NA	NA	NA	NA
Boron	7.70E+02	1	1	7.96E-03	2.00E-01	3.98E-02	NA	NA	NA	NA	NA
Cadmium	6.06E-01	0.025	0.001	2.05E-08	1.00E-03	2.05E-05	NA	NA	NA	NA	NA
Chromium VI (1:6 VI:III Ratio)	8.23E+00	0.025	0.04	3.28E-06	3.00E-03	1.09E-03	NA	NA	NA	NA	NA
Copper	3.54E+01	1	1	NA	NA	NA	NA	NA	NA	NA	NA
Iron	2.54E+04	1	1	NA	NA	NA	NA	NA	NA	NA	NA
Lead	2.16E+01	1	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury, Divalent	4.04E-01	0.07	0.01	NA	NA	NA	NA	NA	NA	NA	NA
Molybdenum	6.74E+00	1	1	6.97E-05	5.00E-03	1.39E-02	NA	NA	NA	NA	NA
Nickel	9.57E+01	0.04	1	9.00E-04	2.00E-02	4.50E-02	NA	NA	NA	NA	NA
Selenium	1.93E+00	1	1	2.00E-05	5.00E-03	3.99E-03	NA	NA	NA	NA	NA
Silver	7.72E-01	0.04	1	7.26E-06	5.00E-03	1.45E-03	NA	NA	NA	NA	NA
Thallium	6.51E-01	1	1	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	5.97E+02	1	0.003	6.01E-04	3.00E-01	2.00E-03	NA	NA	NA	NA	NA
						1.87E-01					4.89E-06

CHILD RESIDENT - DUST INHALATION - ASH EXPOSURES
RISK CHARACTERIZATION
PVT LANDFILL

Scenario:	Subactivity name
Receptor:	Child Resident
Medium:	Dust from ash
Exposure Pathway:	Inhalation

Chemical Concentration in Air = CS * RP

ADD (mg/kg/day) = $\frac{\text{Cdust x IR x RAF x ET x EF x ED}}{\text{AT x BW}}$

Hazard Quotient (HQ) = ADD (mg/kg/day) / RfDi (mg/kg/day)
Cancer Risk (ELCR) = ADD (mg/kg/day) * CSFi [1/(mg/kg/day)]

Parameter (units)	Value	
ADD: Average Daily Dose (mg/kg/day)	See Below	
CS: Chemical Concentration in Soil (mg/kg)	Chemical-Specific	
Cdust: Concentration of dust-bound chemical in air (mg/m3)	Calculated	
RAF: Relative Absorption Factor (Inhalation) (unitless)	Chemical-Specific	
ET: Exposure Time - dust (hr/d)	24	
EF: Exposure Frequency (days/year)	350	
ED: Exposure Duration (years)	6	
IR: Inhalation Rate (m3/hr)	0.417	
AT: Averaging Time (days) (ED x 365 days/yr, noncancer)	2190	
AT: Averaging Time (days) (75 yr. x 365 days/yr, cancer)	25550	
BW: Body Weight (kg)	15	
RfDi: Reference Dose Inhalation (mg/kg/day)	Chemical-Specific	
CSFi: Cancer Slope Factor Inhalation [1/(mg/kg/day)]	Chemical-Specific	
RP: Respirable particulate conc. in air (mg/m3)	9.34E-04	(SCREEN 3 Results)
CF: Conversion Factor (kg/mg)	1.00E-06	

			Noncancer Hazard Quotient				Excess Lifetime Cancer Risk			
Compound	Soil Concentration (mg/kg)	Chemical Concentration in Air (mg/m3)	Inhalation RAF (noncancer)	ADD (noncancer) (mg/kg/day)	RFDi (non-cancer) (mg/kg/day)	Soil-Dust HQ	Inhalation RAF (cancer)	ADD (cancer) (mg/kg/day)	CSFi [1/(mg/kg/day)]	Soil- Dust Risk
METALS										
Antimony	7.19E-01	6.71E-10	1	4.30E-10	4.00E-04	1.07E-06	1	NA	NA	NA
Arsenic	1.82E+01	1.70E-08	1	1.09E-08	4.29E-06	2.53E-03	1	9.30E-10	1.51E+01	1.40E-08
Barium	6.45E+02	6.02E-07	1	3.85E-07	1.43E-04	2.70E-03	1	NA	NA	NA
Beryllium	3.12E+00	2.91E-09	1	1.86E-09	5.71E-06	3.26E-04	1	1.60E-10	8.40E+00	1.34E-09
Boron	7.70E+02	7.19E-07	1	4.60E-07	5.71E-03	8.05E-05	1	NA	NA	NA
Cadmium	6.06E-01	5.66E-10	1	3.62E-10	2.86E-07	1.27E-03	1	3.10E-11	6.62E+00	2.05E-10
Chromium VI (1:6 VI:III Ratio)	8.23E+00	7.69E-09	1	4.92E-09	2.86E-05	1.72E-04	1	NA	NA	NA
Copper	3.54E+01	3.30E-08	1	NA	NA	NA	1	NA	NA	NA
Iron	2.54E+04	2.37E-05	1	NA	NA	NA	1	NA	NA	NA
Lead	2.16E+01	2.02E-08	1	NA	NA	NA	1	NA	NA	NA
Mercury, Divalent	4.04E-01	3.77E-10	1	2.41E-10	8.57E-05	2.82E-06	1	NA	NA	NA
Molybdenum	6.74E+00	6.29E-09	1	4.03E-09	5.00E-03	8.05E-07	1	NA	NA	NA
Nickel	9.57E+01	8.94E-08	1	5.72E-08	2.57E-05	2.22E-03	1	4.90E-09	9.10E-01	4.46E-09
Selenium	1.93E+00	1.80E-09	1	1.15E-09	5.71E-03	2.02E-07	1	NA	NA	NA
Silver	7.72E-01	7.21E-10	1	4.61E-10	5.00E-03	9.22E-08	1	NA	NA	NA
Thallium	6.51E-01	6.08E-10	1	NA	NA	NA	1	NA	NA	NA
Zinc	5.97E+02	5.57E-07	1	3.56E-07	3.00E-01	1.19E-06	1	NA	NA	NA
						9.31E-03				2.00E-08

ADULT RESIDENT - DUST INHALATION - ASH EXPOSURES
RISK CHARACTERIZATION
PVT LANDFILL

Scenario:	Subactivity name
Receptor:	Adult Resident
Medium:	Dust from ash
Exposure Pathway:	Inhalation

Chemical Concentration in Air = CS * RP * CF

$$\text{ADD (mg/kg/day)} = \frac{\text{Cdust x IR x RAF x ET x EF x ED}}{\text{AT x BW}}$$

Hazard Quotient (HQ) = ADD (mg/kg/day) / RfDi (mg/kg/day)
Cancer Risk (ELCR) = ADD (mg/kg/day) * CSFi [1/(mg/kg/day)]

Parameter (units)	Value	
ADD: Average Daily Dose (mg/kg/day)	See Below	
CS: Chemical Concentration in Soil (mg/kg)	Chemical-Specific	
Cdust: Concentration of dust-bound chemical in air (mg/m3)	Calculated	
RAF: Relative Absorption Factor (Inhalation) (unitless)	Chemical-Specific	
ET: Exposure Time - dust (hr/d)	24	
EF: Exposure Frequency (days/year)	350	
ED: Exposure Duration (years)	24	
IR: Inhalation Rate (m3/hr)	0.833	
AT: Averaging Time (days) (ED x 365 days/yr, noncancer)	8760	
AT: Averaging Time (days) (75 yr. x 365 days/yr, cancer)	25550	
BW: Body Weight (kg)	70	
RfDi: Reference Dose Inhalation (mg/kg/day)	Chemical-Specific	
CSFi: Cancer Slope Factor Inhalation [1/(mg/kg/day)]	Chemical-Specific	
RP: Respirable particulate conc. in air (mg/m3)	9.34E-04	(SCREEN 3 Results)
CF: Conversion Factor (kg/mg)	1.00E-06	

Compound	Soil Concentration (mg/kg)	Chemical Concentration in Air (mg/m3)	Noncancer Hazard Quotient: Inhalation RAF (noncancer)	ADD (noncancer) (mg/kg/day)	RFDi (non-cancer) (mg/kg/day)	Soil-Dust HQ	Excess Lifetime Cancer Risk: Inhalation RAF (cancer)	ADD (cancer) (mg/kg/day)	CSFi [1/(mg/kg/day)]	Soil- Dust Risk
METALS										
Antimony	7.19E-01	6.71E-10	1	1.84E-10	4.00E-04	4.60E-07	1	NA	NA	NA
Arsenic	1.82E+01	1.70E-08	1	4.65E-09	4.29E-06	1.08E-03	1	1.59E-09	1.51E+01	2.40E-08
Barium	6.45E+02	6.02E-07	1	1.65E-07	1.43E-04	1.15E-03	1	NA	NA	NA
Beryllium	3.12E+00	2.91E-09	1	7.98E-10	5.71E-06	1.40E-04	1	2.74E-10	8.40E+00	2.30E-09
Boron	7.70E+02	7.19E-07	1	1.97E-07	5.71E-03	3.44E-05	1	NA	NA	NA
Cadmium	6.06E-01	5.66E-10	1	1.55E-10	2.86E-07	5.42E-04	1	5.31E-11	6.62E+00	3.51E-10
Chromium VI (1:6 VI:III Ratio)	8.23E+00	7.69E-09	1	2.11E-09	2.86E-05	7.37E-05	1	NA	NA	NA
Copper	3.54E+01	3.30E-08	1	NA	NA	NA	1	NA	NA	NA
Iron	2.54E+04	2.37E-05	1	NA	NA	NA	1	NA	NA	NA
Lead	2.16E+01	2.02E-08	1	NA	NA	NA	1	NA	NA	NA
Mercury, Divalent	4.04E-01	3.77E-10	1	1.03E-10	8.57E-05	1.21E-06	1	NA	NA	NA
Molybdenum	6.74E+00	6.29E-09	1	1.72E-09	5.00E-03	3.45E-07	1	NA	NA	NA
Nickel	9.57E+01	8.94E-08	1	2.45E-08	2.57E-05	9.52E-04	1	8.39E-09	9.10E-01	7.64E-09
Selenium	1.93E+00	1.80E-09	1	4.94E-10	5.71E-03	8.64E-08	1	NA	NA	NA
Silver	7.72E-01	7.21E-10	1	1.97E-10	5.00E-03	3.95E-08	1	NA	NA	NA
Thallium	6.51E-01	6.08E-10	1	NA	NA	NA	1	NA	NA	NA
Zinc	5.97E+02	5.57E-07	1	1.53E-07	3.00E-01	5.09E-07	1	NA	NA	NA
						3.98E-03				3.43E-08

APPENDIX H

Relative Absorption Factors Derivation

ARSENIC

The oral reference dose for noncarcinogenic effects of arsenic is 3E-04 mg/kg-day, and the oral cancer slope factor for carcinogenic effects is 1.5 per mg/kg-day (IRIS-U.S. EPA, 2001). Both values are based on epidemiological studies that characterized health effects in a large population of Taiwanese who consumed drinking water containing arsenic. The exact form of the ingested arsenic is unknown.

Estimation of Absorption in the Dose-Response Study

The relevant dose-response study characterized health effects in a large population of Taiwanese who consumed drinking water containing arsenic. Several studies investigating the absorption of arsenic have been performed in humans and various animal species. Human studies are sufficiently extensive to strongly suggest that close to 100% of soluble inorganic arsenic in water is absorbed from the gastrointestinal tract. These human studies are reviewed in detail here.

One direct indication of absorption of an orally administered dose of a chemical is its urinary excretion. Several studies show that urinary excretion can account for the majority of an orally administered dose of arsenic. Buchet et al. (1981a) administered aqueous sodium arsenite (NaAsO2) as a single dose to three human volunteers. An average of 45% of the dose was excreted in the urine in four days. In a second study (Buchet et al., 1981b), four individuals given 125, 250, 500, or 1000 Ug As/day orally for five days excreted 54, 73, 74, and 64% of the dose in urine, respectively, over 14 days. The average urinary excretion of arsenic for the four subjects was 66% of the administered dose. Crecelius (1977) reports that approximately 50% and 80% of orally administered aqueous arsenic was excreted in urine within 61 hours by a single individual in two experiments. The results of these studies represent the minimum amount of arsenic absorbed since the balance of the dose was not accounted for.

Data for human fecal excretion of arsenic do exist. Pomroy et al. (1980) gave 6 male subjects radiolabelled arsenic acid ($[^{74}As]H_3AsO_4$) in gelatin capsules followed by a glass of water. The presence of arsenic in the body, urine, and feces was measured using a whole body radiation counter. The authors report that for the six subjects the average total excretion over 7 days was $6.1 \pm 2.8\%$ in feces. It is not possible to determine how much of this arsenic was first absorbed and then excreted. The total recovery of arsenic (urine plus feces) was $68.4 \pm 4.0\%$ of the single oral dose. The remaining arsenic was reported to be present in the body tissues; virtually the entire dose could be accounted for. This suggests a minimum absorption of 94% (100% - 6%) of orally ingested arsenic.

A study by Bettley and O'Shea (1975) also reports excretion of arsenic in both urine and feces. Three subjects were exposed to 8.52 mg As (as 1.25 ml of Liq. Arsenicalis B.P.) in three portions 8 hours apart on one day. They found that at most 3.5% of the dose was excreted in feces over ten days. This suggests a minimum absorption of 96%. Urinary excretion averaged $52 \pm 4\%$ of the exposure dose over 10 days (n=3). The remaining half of the dose was unaccounted for, although small amounts of arsenic were found in blood and hair.

In the Coulson study (Coulson et al., 1935), results from two humans each ingesting two forms of arsenic are reported. Less than 5% of an oral dose was excreted in feces whether the arsenic was taken as arsenic trioxide (As_2O_3) or as natural arsenic present in shrimp.

The remainder of the dose, more than 95%, was recovered in urine in three experiments where total recoveries ranged from 74 to 115%. Based on the fecal excretion data from this study, it can be estimated that at least 95% of the ingested arsenic was absorbed. The fecal excretion data are consistent with those of Pomroy et al. (1980) and Bettley and O'Shea (1975).

Fecal excretion data from oral studies provide a minimum estimate of absorption, because it cannot be determined how much of the dose was first absorbed and then excreted into the feces. However, a study in humans injected intravenously with arsenic suggests that absorbed arsenic may be excreted, presumably from bile, into the feces. Mealy et al. (1959) administered radiolabelled arsenic by intravenous injection. Between 57% and 90% of the injected dose was recovered in urine in 10 days. Fecal excretion accounted for 1.3% of the dose after seventeen days in one individual. A second subject excreted 0.2% of the intravenous dose into the feces in one week. Both results indicate some excretion of arsenic into the feces. Virtually all of the remaining dose was recovered in the urine. Biliary excretion of arsenic has been demonstrated in rats, rabbits, and dogs (Klaassen, 1974; Gregus and Klaassen, 1986). This indicates that a portion of the arsenic found in feces in studies using oral dosing may have been first absorbed and then excreted.

The urinary excretion data from the oral studies discussed above provide minimum estimates of arsenic absorption ranging from 45% to 95%. The fecal excretion data suggest that, at a minimum, 95-96% of an orally administered dose of arsenic is absorbed. The study of intravenously administered arsenic suggest that biliary excretion can occur. Therefore, it can conservatively be concluded from the above studies that virtually 100% of an orally administered dose of soluble inorganic arsenic can be absorbed in humans.

RAF (Oral-Soil)

The oral-soil RAF for arsenic is defined as: (absorption of arsenic in humans from ingested soil) / (absorption of arsenic in humans in the epidemiological study from ingested water). There are many forms of inorganic arsenic, and these have widely varying solubilities. While it is appropriate to assume that arsenic present in water would be a soluble form of arsenic, this is not necessarily the case for arsenic present in soil or ash. Arsenic present in soils can either be in a relatively insoluble mineral form, such as would be expected in slags, mine tailings, and ash; or, the arsenic can be present in a more soluble form such as might be present at hazardous waste sites where arsenic salts were either disposed of or accidentally released. Even soluble species, however, become bound tightly to soils after years of weathering.

Ruby et al. (1999) Literature Review

Ruby et al. (1999) have recently summarized the available bioavailability studies from arsenic-containing media from metal mining and processing sites. Twenty two Relative Absorption Factors have been summarized from studies in swine, rats, rabbits and monkeys. The RAFs range from 0.03 to 0.51. It should be noted that two samples from Aspen, CO were rejected because the arsenic levels were too low to produce reliable estimates of the RAF by the method used. The mean value for arsenic RAF from these 22 studies was 0.26. The values are summarized below.

TABLE 1
SUMMARY OF ORAL-SOIL RAFS FOR ARSENIC FROM THE LITERATURE

Source of Sample	Study Type	Arsenic Level (mg/kg)	RAF
Aspen soil (berm)	EPA Region VIII Swine Study	67	Rejected as unreliable
Aspen soil (residential)	EPA Region VIII Swine Study	17	Rejected as unreliable
Bingham Creek tailings (channel)	EPA Region VIII Swine Study	149	0.37
Butte soil	EPA Region VIII Swine Study	239	0.10
Leadville soil (residential)	EPA Region VIII Swine Study	203	0.08
Leadville soil (Fe-Mn-Pb oxide)	EPA Region VIII Swine Study	110	0.28
Leadville soil (AV)	EPA Region VIII Swine Study	1050	0.15
Midvale slag	EPA Region VIII Swine Study	591	0.18
Murray Smelter (slag)	EPA Region VIII Swine Study	695	0.51
Murray Smelter (soil)	EPA Region VIII Swine Study	310	0.34
Palmerton soil (location 2)	EPA Region VIII Swine Study	110	0.39
Palmerton soil (location 4)	EPA Region VIII Swine Study	134	0.52
Clark Fork tailings (GK)	EPA Region VIII Swine Study	181	0.49
Oklahoma calcine/soil 1	U. MO. Swine Study	11300	0.03
Oklahoma calcine/soil 2	U. MO. Swine Study	17500	0.03
Oklahoma calcine/soil 3	U. MO. Swine Study	13500	0.08
Oklahoma calcine/soil 4	U. MO. Swine Study	11500	0.22
Oklahoma calcine/soil 5	U. MO. Swine Study	6250	0.30
Oklahoma iron slag 3	U. MO. Swine Study	1180	0.29
Oklahoma Iron slag 4	U. MO. Swine Study	5020	0.30
Oklahoma Iron slag 5	U. MO. Swine Study	4650	0.16
Anaconda soil	Battelle Rabbit Study	3900	0.48
Anaconda soil	Battelle Monkey	410	0.20

(residential)	Study		
Anaconda House Dust	Battelle Monkey Study	170	0.28
Pure arsenic trioxide in rat food	Harrison et al. (1956) Rat Study	Not known	0.11
Soil in vicinity of historical sheep dip	Ng et al. (1998) Rat Study	32-295	0.10

There are few studies in the literature of the bioavailability of arsenic from aged soil matrices into which soluble arsenic compounds were historically released. It is known that such compounds bind to soil. For instance, WHO (1981) states:

> Arsenate ions are readily sorbed by hydrous oxides of iron and aluminum and thus leaching of arsenate is slow. Absorption appears to be a major factor in the retention of arsenic in soils. Similarly, Hindmarsh and McCurdy (1986) state:
>
> These arsenicals form very insoluble and stable complexes in soil systems which contribute to their long residence time (9400 years). Organic and inorganic arsenicals in soil behave similarly. They react with iron in conjunction wit clay and other particles or with various cations in soil to form insoluble complexes.

Only four studies were found in the literature. As presented below, RAFs are derived from each.

Harrison et al. (1956) Study

Harrison et al. (1956) determined the LD_{50} in albino rats of crude arsenic trioxide (97.7% pure) and purearsenic trioxide (99.999+% pure). In one experiment, the arsenic trioxide was dissolved in water and given by gavage to 40 animals in four dose groups of ten animals each. In another experiment, the arsenic trioxide was given in dry form as a supplement to the food in 140 animals in seven dose groups of twenty each. The 96-hour LD_{50} was determined for each of the four experiments. As shown below, the LD_{50} was markedly reduced when given in food as compared to aqueous solution. All animals in the highest dose groups were dead at 96 hours, so sufficient time was allowed for the acute toxic effects of trivalent arsenic to manifest.

TABLE 2
COMPARISON OF LETHAL DOSES TO RATS OF ARSENIC TRIOXIDE

Compound Tested	LD_{50} Aqueous Solution	LD_{50} Food Supplement
Crude Arsenic Trioxide	23.6 mg/kg	214 mg/kg
Pure Arsenic Trioxide	15.1 mg/kg	145.2 mg/kg

Because the dose-response values for arsenic are based on ingestion of dissolved arsenic in drinking water, estimates of relative bioavailability of trivalent arsenic can be made from the above data. For the crude arsenic trioxide, the ratio of the lethal dose for food administration versus administration of an aqueous solution is 0.11. For the pure arsenic, the ratio is similar, 0.10. Accordingly, the estimate of the RAF for pure trivalent arsenic compounds is 0.11.

In this experiment, no soil was used, but the addition of the soluble arsenic species to food and administered immediately to animals without aging greatly overestimates the binding that would be expected to soil after years of ageing. Accordingly, this estimate is appropriate to use for the RAF of soluble arsenicals in soil.

Ng et al. (1998) Study

Ng et al. (1998) measured the absolute absorption of arsenic in soils near a former sheep dip. Five soil samples near the sheep dip site contained arsenic at concentrations of 55, 32, 165, 295, and 67 mg/kg total arsenic. It should be noted that native soils in this area may also be naturally high in arsenic due to the presence of specific geological formations that are known to occur elsewhere in Australia.

Male Wistar rats were given soil suspended in water by gavage in groups of five rats at a dose of 0.5 mg As/kg body weight. As positive controls, groups of four rats were given the equivalent dose of arsenic by intravenous injection of 0.5 mg As/kg body weight in the form od a solution of sodium arsenite (As III) or sodium arsenate (As III). All animals were given water and food *ad libitum.* 24- hour urine samples free from fecal contamination were collected daily for four days post dosing. Absolute absorption was determined by calculating the area under the urinary arsenic curve (AUC) for measurements taken at 0, 24, 48 , 72 and 96 hours. The absolute absorption was determined as:

% Absolute Absorption (Bioavailabilty) = 100 x AUC_{oral} / $AUC_{intravenous}$

TABLE 3
ABSOLUTE ABSORPTION OF ARSENIC IN SOIL NEAR SHEEP DIP

Soil Sample Near Sheep Dip	Absolute Absorption (%)
C1	10.81
C2	5.57
C3	12.55
C4	7.00
C5	12.56

The average absolute absorption (absolute bioavailability) of arsenic from soils near a former sheep dip site is 10%. Because the estimated absolute absorption of arsenic in humans from drinking water in the dose-response studies is 100%, the RAF is 10%/100% = 0.10.

This RAF is based on an animal study of aged soils in which soluble trivalent arsenic compounds were released due to the former use of the area as a sheep dip. However, it cannot be ruled out that some of the arsenic present in the soil was naturally present from rock and soil formations.

Roberts, et al. (2002) Study

Roberts, et al. (2002) measured arsenic bioavailability from soils affected by releases of soluble arsenic salts in Cebus apella monkeys in a study for the Florida Department of Environmental Protection. Soil samples were taken from five sites with arsenic contaminated soil from different sources, but all from arsenical salts: (1) electrical substation, (2) cattle dip site, (3) pesticide site #1, (4) wood treatment site, and (5) pesticide site #2. Relative bioavailability was assessed based on urinary excretion following an oral dose in solution. Relative bioavailability for the five sites was: (1) 0.146 +/ 0.05, (2) 0.247 +/- 0.03, (3) 0.107 +/- 0.05, (4) 0.163 +/- 0.07, and (5) 0.17 +/- 0.10. The mean of these five soil types was 0.17. Relative bioavailability of the soil from the wood treatment site was 0.16.

Casteel et al. (2001) Study

Casteel et al. measured the relative bioavailability of arsenic in soils affected by a release of the arsenical herbicide PAX in swine in a study for the U.S. EPA. The relative bioavailability compared to arsenic salts in water varied from 0.18 to 0.45 in five samples.

Summary

RAFs presented above range from 0.03 to 0.51. The most health-protective use of the above data is to use the maximum value listed above, 0.51, as a conservative default oral-soil RAF.

RAF (Dermal-Soil)

The RAF (dermal-soil) for this chemical is defined as: (absorption in humans from dermal contact with soil) / (absorption of arsenic in humans in the epidemiological study from ingested water). The RAF (dermal-soil) of 0.009 is derived below.

To derive the RAF (dermal-soil), AMEC uses the estimates of the fractional dermal absorption of arsenic from soil reported by Wester et al. (1993). Wester et al. (1993) measured the skin uptake of soluble arsenic (H_3AsO_4) from soil in monkey skin *in vivo* and in human skin *in vitro*. Radiolabelled arsenic was mixed with Yolo County 65-California-57-8 soil at two concentrations: 0.001 mg/kg and 15 mg/kg. The soil retained by an 80-mesh sieve was 26% sand, 26% clay, 48% silt, and 0.9% organic matter. Soil load on the skin was 40 mg/cm^2. For each dose of arsenic, four female Rhesus monkeys were administered the arsenic containing soil on abdominal skin. The area was covered with a nonocclusive cover. After 24 hours, the soil was removed from the skin, and the area was washed with soap and water. Urine was collected for 7 days. *In vivo* percutaneous absorption was determined by the ratio of urinary excretion following topical administration to that following intravenous administration. Percutaneous absorption of arsenic from soil was 4.5 +/- 3.2% from the low dose and 3.2 +/- 1.9% from the high dose. Soap and water washes removed most of the admistered dose after the 24 hour exposure period.

Percutaneous absorption was also measured in viable human cadaver skin dermatomed to 500 um. The skin was preserved and used within five days of collection. Measurements were taken in triplicate for each of three skin samples. The arsenic dose

was 0.001 mg/kg and the soil loading was 40 mg/cm^2. After a 24-hour exposure period, the amount of arsenic present in the receptor fluid (phosphate buffered saline) plus the amount in the skin that was not removed by a surface wash was 0.76% of the administered dose.

The dermal-soil RAF is calculated by using all three results from Wester et al. (1993):

4.5% monkey *in vivo*, low dose
3.2% monkey *in vivo*, high dose
0.8% human *in vitro*, low dose

The average fractional absorption over 24 hours is 2.8%. Typical exposures at industrial sites are not 24 hours in length. Thus, the above data are prorated to a more reasonable exposure period of 8 hours. The average fractional absorption over 8 hours is 0.94%. The dermal-soil RAF is calculated as follows:

RAF (Dermal-Soil) = (0.944%) / (100%) = 0.009.

Summary of Derived RAFs for Arsenic

Oral-Soil	0.51
Dermal-Soil	0.009

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