COMPARISON OF RELATIVE BIOAVAILABILITY OF ARSENIC IN SOIL ESTIMATED USING DATA DERIVED WITH TWO ALTERNATIVE ANALYTICAL METHODS

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EXECUTIVE SUMMARY

The estimation of arsenic absorption from orally administered materials is usually evaluated by measuring the amount of arsenic excreted in urine. This is characterized by the urinary excretion fraction (UEF), defined as the amount or arsenic excreted in urine divided by the amount administered. Previous USEPA investigations of arsenic absorption from soil utilized an analytical method for arsenic in urine that was subsequently found to have low recovery of the methyl urinary metabolites of arsenic, especially dimethylarsinic acid (DMA). This resulted in an underestimation of the UEF. However, relative bioavailability (RBA) of arsenic is calculated as the ratio of two UEF measurements, so if both UEF values are underestimated by the same relative amount, then the ratio should not be influenced by the poor recovery of arsenic.

In order to determine if this expectation was correct, the RBA of arsenic was measured in two different test soils using both the original analytical procedure (known to yield low recovery of methyl metabolites) and a revised analytical procedure (known to yield good recovery of all urinary metabolites). The results are summarized below:

Material Administered	UEF ± SEM (N)		RBA (90% CI)	
	Method 1	Method 2	Method 1	Method 2
Sodium Arsenate	0.223 ± 0.027 (42)	0.907 ± 0.110 (43)	[1.00]	[1.00]
Test Soil 1	0.048 ± 0.004 (42)	0.154 ± 0.009 (41)	0.22 (0.17-0.28)	0.17 (0.14-0.22)
Test Soil 2	0.060 ± 0.005 (39)	0.202 ± 0.018 (43)	0.27 (0.21-0.35)	0.22 (0.17-0.29)

SEM = Standard error of the mean (standard deviation)
N = Number of data points used in curve-fitting
CI = Confidence interval

As seen, although there is a 3- to 4-fold difference in the UEFs between methods for all materials administered (sodium arsenate and both test soils), the two analytical methods yielded approximately the same RBA value for each test material utilized in this study. Additionally, the 90% confidence intervals around the RBA values were observed to overlap between methods. Therefore, although studies performed using the original analytical method (Method 1) yielded a low recovery of organic forms of arsenic in the urine, it is considered likely that the RBA values calculated in previous studies are nevertheless accurate and reliable.

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COMPARISON OF RELATIVE BIOAVAILABILITY OF ARSENIC IN SOIL ESTIMATED USING DATA DERIVED WITH TWO ALTERNATIVE ANALYTICAL METHODS

1.0 INTRODUCTION

Accurate assessment of the health risks resulting from oral exposure to arsenic requires knowledge of the amount of arsenic absorbed from the gastrointestinal tract into the body. When reliable data are available on the bioavailability of arsenic in a site medium (e.g., soil, dust) this information can be used to improve the accuracy of exposure and risk calculations at that site.

For over a decade, USEPA Region 8 has been using juvenile swine as a model for lead and arsenic bioavailability from soils. The early studies conducted by USEPA to evaluate arsenic excretion in urine were conducted using a hot acid digestion method that was later shown to have poor recovery of organic forms of arsenic, including monomethylarsonic acid (MMA) and especially dimethylarsinic acid (DMA) (Hammon, 2000). As a result, in late 1999, a new method using magnesium nitrate ashing was established for the digestion and analysis of arsenic in urine and other biological media.

Because of the low recovery associated with the original hot acid analytical method, the amount of arsenic excreted in urine was underestimated in these studies. However, because relative bioavailability (RBA) is calculated as the ratio of two arsenic measurements, if both measurements are underestimated by the same relative amount, the ratio (RBA) is expected to be correct. Thus, the main objective of this study was to test this expectation by comparing the RBA values of test materials estimated using both the old and the new analytical procedures to determine if the same results are achieved by both methods.

2.0 STUDY DESIGN

This investigation of arsenic absorption and excretion was performed according to the basic design presented in Table 2-1. As shown, the study investigated arsenic absorption from sodium arsenate (the reference material) and from two test materials (site-specific soils), each administered to groups of animals at three different dose levels for 12 days (a detailed schedule is presented in Appendix A, Table A-1). Additionally, the study included a non-treated group to serve as a control for determining background arsenic levels. All doses were administered orally.

2.1 Test Materials

2.1.1 Test Material Description and Preparation

The test materials used in this investigation are two soil samples from Butte, Montana. Test Material 1 (USEPA sample number 8-37926) has been tested previously in the swine bioassay system (USEPA, 1996), and sufficient material existed to repeat the analysis using the same material. This soil sample is a composite collected from the Butte Priority Soils Operable Unit (BPSOU) of the Silver Bow Creek/Butte Area NPL Site in Butte, Montana. The sampling investigation focused on four source areas: the Little Mina-1, Little Mina-2, West Ruby, and North Emma waste rock dumps. At each source area, five sub-samples were collected and composited, and these were then further composited across source areas to yield the sample used in the study.

Test Material 2 (USEPA sample number BPSOU-0501-ASBIO) was collected by CDM in May 2001 (CDM Federal, 2001). This soil sample is a composite collected from a residential property located adjacent to a railroad grade in Butte, Montana. A total of 5 soil samples from this property were combined in order to prepare the arsenic bioavailability composite sample.

Both composite samples were prepared for administration to the animals by air-drying (maximum temperature = 40°C) followed by sieving through a nylon mesh to yield particles less than about 250 um. This was done because it is believed that fine particles are most likely to adhere to the hands and be ingested by hand-to-mouth contact, and are most likely to be available for absorption. Grinding was not employed.

2.1.2 Detailed Characterization of Test Materials

Aliquots of each test material were analyzed for arsenic by inductively coupled plasma (ICP) spectroscopy. The results from these analyses are presented below.

Test Material	Sample ID	Arsenic Concentration (mg/kg)
Test Material 1	8-37926 (previously tested)	234 [a]
Test Material 2	BPSOU-0501-ASBIO	367 [b]

[a] Based on quadruplicate analyses via ICP
[b] Based on triplicate analyses via ICP

Detailed chemical composition and descriptions of test materials are provided in USEPA (2003).

2.2 Experimental Animals

Juvenile swine were selected for use in these studies because they are considered to be a good physiological model for gastrointestinal absorption in children (Weis and LaVelle, 1991). The animals were intact males from the Pig Improvement Corporation (PIC) genetically defined Line 26, and were purchased from Chinn Farms, Clarence, MO.

The animals were housed in individual stainless steel cages. All animals were held for several days prior to beginning exposure to test materials to allow them to adapt to their new environment and to ensure that all of the animals were healthy. In order to help minimize weight variations between animals and groups, three animals most different in body weight on day -4 (either heavier or lighter) were excluded. The remaining animals were assigned to dose groups at random (group assignments are presented in Appendix A, Table A-2). When exposure began (day zero), the animals were about 5-6 weeks old and weighed an average of about 8.6 kg. Animals were weighed every three days during the course of the study. The average weight of animals in Group 8 were slightly higher throughout the course of the study. On average, animals gained about 0.3 to 0.4 kg/day, and the rate of weight gain was comparable in all groups. These body weight data are summarized in Figure 2-1 and are also presented in Appendix A, Table A-3.

2.3 Diet

Each day every animal was given an amount of standard swine chow (University Feed Mill S II (2) starter ration without added antibiotics) equal to 5% of the mean body weight of all animals on study. Feed was administered in two equal portions (2.5% of the mean body weight) at 11:00 AM and 5:00 PM daily. Drinking water was provided *ad libitum* via self-activated watering nozzles within each cage.

Based on data from previous arsenic studies, the estimated intake of arsenic in unexposed animals is less than 0.1 ug/kg-day via water and about 10 ug/kg-day via the diet.

2.4 Dosing

Animals were exposed to sodium arsenate (abbreviated in this report as “NaAs”) or a test material (site soil) for 12 days, with the dose for each day being administered in two equal portions given at 9:00 AM and 3:00 PM (two hours before feeding). Dose material was placed in the center of a small portion (about 5 grams) of moistened feed (this is referred to as a “doughball”), and this was administered to the animals by hand.

The dose levels administered were based on the arsenic content of the test material, with target doses of 300, 600 and 900 ug/day for NaAs and each test material. After completion of the study, body weights were estimated by interpolation for those days when measurements were not collected and the actual administered doses were calculated for each day and then averaged across all days. The actual administered arsenic doses are presented in Appendix A, Table A-3, and the body-weight adjusted doses are presented in Appendix A, Table A-4. These actual administered doses were used for all RBA calculations.

2.5 Collection and Preparation of Urine Samples

Samples of urine were collected from each animal for three consecutive 48-hour periods, on days 6-7, 8-9, and 10-11, with one exception. It was determined during the first few days of dosing that there were insufficient quantities of Test Material 1 available for dosing according to the protocol. In order to account for this shortage of test material, the dosing for groups 5, 6, and 7 was modified to end one day earlier than originally scheduled. As a result, urine collection for these animals was altered to consist of a 24-hour collection (rather than 48-hour) on day 10, with all other collections being conducted according to schedule.

Urine collections began at 9:00AM and ended 48 hours later. The urine was collected in a stainless steel pan placed beneath each cage, which drained into a plastic storage bottle. Each collection pan was fitted with a nylon screen to minimize contamination with feces, spilled food, or other debris. Plastic diverters were used to minimize urine dilution with drinking water spilled by the animals from the watering nozzle into the collection pan, although this was not always effective in preventing dilution of the urine with water. Due to the length of the collection period, collection containers were emptied at least twice daily into a separate holding container. This ensured that there was no loss of sample due to overflow.

At the end of each collection period, the urine volume was measured (see Appendix A, Table A-5) and 60-mL portions were removed for analysis. A separate 250-mL aliquot was retained as an archive sample. Each sample was acidified by the addition of concentrated nitric acid. The samples were stored refrigerated until arsenic analysis.

2.6 Arsenic Analysis

Urine samples were arranged in a random sequence and submitted to the laboratory for analysis in a blind fashion. As discussed in the introduction to this report, the purpose of this study was to compare RBA results obtained using two different urinary arsenic analytical methods: the hot acid digestion method used in earlier studies (Method 1) and the magnesium nitrate ashing method (Method 2) that is currently used.

Details of urine sample preparation and analysis are provided in the study project plan (USEPA, 2001) and are summarized in brief below.

<u>Method 1</u>

Acidified urine samples (25 mL aliquots) were digested by refluxing in the presence of concentrated nitric acid and concentrated perchloric acid, then heating to drive off the nitric acid and to cause the perchloric acid to fume. Following hot acid digestion, the samples were cooled slightly and diluted with 20 mL distilled water. The diluted samples were heated until clear or boiling, and then cooled slightly and diluted to 50 mL. The samples were then diluted with a solution of hydrochloric acid, potassium iodide, and ascorbic acid and analyzed by the hydride generation technique using a Perkin-Elmer 3100 atomic absorption spectrometer.

<u>Method 2</u>

Urine samples (25 mL aliquots) were digested by refluxing and then heating to dryness in the presence of magnesium nitrate and concentrated nitric acid. Following magnesium nitrate digestion, samples were transferred to a muffle furnace and ashed at 500°C. The digested and ashed residue was dissolved in hydrochloric acid and analyzed by the hydride generation technique using a Perkin-Elmer 3100 atomic absorption spectrometer.

2.7 Quality Assurance

A number of quality assurance steps were taken during this project to evaluate the accuracy of the analytical procedures.

2.7.1 Laboratory Quality Assurance

Quality assurance steps performed by the analytical laboratory included:

Spike Recovery

Randomly selected urine samples were spiked with known amounts of arsenic (usually 5-10 ug, as sodium arsenate) and the recovery of the added arsenic was measured. Using analytical Method 1, recovery for individual samples typically ranged from 103% to 114%, with an average across all analyses of 107 ± 3% (N=15). With the new analytical method (Method 2), recovery for individual samples typically ranged from 101-110%, with an average across all analyses of 106 ± 3.2% (N=15).

Duplicate Analysis

The laboratory analyst selected random urine samples for duplicate analysis. Using Method 1, duplicate results typically had a relative percent difference (RPD) of 0-6%, with an average of 1.6% (N=15). Using Method 2, duplicate results typically had a relative percent difference (RPD) of 0-13%, with an average of 2.2% (N=15).

Laboratory Control Standards

Laboratory Control Samples (LCS) were run with each set of test samples. For Method 1, the standard was a solution of inorganic arsenic in deionized water obtained from ERA (sample 9978) with a nominal arsenic concentration of 92.9 ug/L. Arsenic results for this standard ranged from 88 to 98 ug/L, with a mean across all samples of 92.5 ± 2 ug/L (N=37). For Method 2, the standard was a solution of arsenic in deionized water obtained from ERA (sample 99106) with a nominal arsenic concentration of 347 ug/L. Arsenic results for this standard ranged from 311 to 348 ug/L, with a mean across all samples of 328 ± 6.7 ug/L (N=38).

Blanks

Blank samples run along with each batch of samples never yielded a measurable level of arsenic, with all values being reported as less than 1 ug/L of arsenic using both analytical methods.

2.7.2 Blind Quality Assurance Steps

In addition to the non-blind QA steps implemented by the laboratory, an additional series of QA samples was submitted to the laboratory in a blind fashion. This included a number of Performance Evaluation (PE) samples (control urine spiked with a known amount of arsenic in the form of As+3, As+5, MMA, or DMA) and a number of blind duplicates.

The results for the PE samples are shown in Figure 2-2. With Method 1, good recoveries were observed for both sodium arsenate and sodium arsenite. Unexpectedly, recoveries were somewhat high for MMA, even though previous results indicated recovery of MMA was generally 67-75%. As has been observed previously, recovery was extremely low for DMA. With Method 2, good recovery of the arsenic was demonstrated for all four forms of arsenic.

The results for blind duplicates are shown in Figure 2-3. As seen, there was good agreement between results for the duplicate pairs by both analytical methods.

3.0 DATA ANALYSIS

Figure 3-1 shows a conceptual model for the toxicokinetic fate of ingested arsenic. Key points of this model are as follows:

In most animals (including humans), absorbed arsenic is excreted mainly in the urine over the course of several days. Thus, the urinary excretion fraction (UEF), defined as the amount excreted in the urine divided by the amount given, is usually a reasonable approximation of the oral absorption fraction or ABA. However, this ratio will underestimate total absorption, because some absorbed arsenic is excreted in the feces via the bile, and some absorbed arsenic enters tissue compartments (e.g., skin, hair, etc.) from which it is cleared very slowly or not at all. Thus the urinary excretion fraction should not be equated with the absolute absorption fraction.

- The relative bioavailability (RBA) of two orally administered materials (e.g., test material and reference material) can be calculated from the ratio of the urinary excretion fraction of the two materials. This calculation is independent of the extent of tissue binding and of biliary excretion:

$$RBA(test\ vs\ ref) = \frac{AF_o(test)}{AF_o(ref)} = \frac{D \cdot AF_o(test) \cdot K_u}{D \cdot AF_o(ref) \cdot K_u} = \frac{UEF(test)}{UEF(ref)}$$

  where K_u represents the fraction of absorbed arsenic that is excreted in the urine.

Based on the conceptual model above, raw data from this study were reduced and analyzed as follows:

- The amount of arsenic excreted in urine by each animal over each collection period was calculated by multiplying the urine volume by the urine concentration:

  Excreted (ug/48hr) = Conc (ug/L) · Volume (L/48hr)

- For each test material, the amount of arsenic excreted by each animal was plotted as a function of the amount administered (ug/48 hours), and the best fit straight line (calculated by linear regression) through the data (ug excreted per ug administered) was used as the best estimate of the urinary excretion fraction (UEF).

- The relative bioavailability of arsenic in test material was calculated as:

  RBA = UEF(test) / UEF(NaAs)

  where sodium arsenate (NaAs) is used as the frame of reference.

- As noted above, each RBA value is calculated as the ratio of two slopes (UEFs), each of which is estimated by linear regression through a set of data points. Because of the variability in the data, there is uncertainty in the estimated slope (UEF) for each material. This uncertainty in the slope is described by the standard error of the mean (SEM) for the slope parameter. Given the best estimate and the SEM for each slope, the uncertainty in the ratio may be estimated using Monte Carlo simulation. The probability density function (PDF) describing the confidence around each slope term (UEF) was assumed to be characterized by a t-distribution with n-2 degrees of freedom :

$$\frac{UEF(measured) - UEF(true)}{SEM} \sim t_{n-2}$$

For convenience, this PDF is abbreviated T(slope, sem, n), where slope = best estimate of the slope derived by linear regression, sem = standard deviation in the best estimate of the slope, and n = number of data points upon which the regression analysis was performed. Thus, the confidence distribution around each ratio was simulated as:

$$PDF(RBA) = \frac{T(slope, sem, n)_{test}}{T(slope, sem, n)_{ref}}$$

Using this equation, a Monte Carlo simulation was run for each RBA calculation. The 5th and 95th percentile values from the simulated distribution of RBA values were then taken to be the 90% confidence interval for the RBA.

4.0 RESULTS

Detailed results are presented in Appendix A Table A-6 and are discussed below.

4.1 Clinical Signs

The doses of arsenic administered in this study are below a level that is expected to cause toxicological responses in swine, and no clinical signs of arsenic-induced toxicity were noted in any of the animals used in this study.

4.2 Data Exclusions

Occasionally, the dilution of urine by spilled water was so large that the concentration of arsenic in the urine could not be quantified. These instances were defined by having a urine arsenic concentration at or below the quantitation limit (2 ug/L) and a total urine volume greater than 5000 mL. When both of these conditions were met, the data were deemed unreliable and excluded from further calculations. In this study, several data points were deemed unreliable for this reason and excluded. They included 7 data from the Method 1 analytical results (pigs 157 and 126 on days 6-7; pig 126 on days 8-9; and pigs 108, 126, and 135 on days 10-11) and two data from the Method 2 analytical results (pig 157 on days 6-7 and pig 108 on days 10-11). No additional urinary data were excluded.

4.3 Urinary Arsenic Concentrations

As discussed previously, this study was conducted to compare results using two alternative analytical methods. Figure 4-1 shows a graph plotting the results from Method 1 versus those from Method 2 for each of the urine samples. As expected, the arsenic concentrations obtained using Method 2 are consistently higher than those from Method 1.

4.4 Urinary Excretion Fractions and Relative Bioavailability

The urinary excretion results for NaAs, Test Material 1, and Test Material 2 as analyzed by Method 1 are summarized in Figures 4-2, 4-3, and 4-4, respectively. The urinary excretion results for each material as analyzed by Method 2 are summarized in Figures 4-5, 4-6, and 4-7. Although there is variability in the data, the dose-response curves are approximately linear, with the slope of the best-fit straight line being equal to the best estimate of the urinary excretion fraction (UEF). This finding is consistent with results from both animals and humans, which suggest that there is no threshold for arsenic absorption or excretion up to doses of at least 5,000 ug/day (USEPA, 1995).

As discussed above, the relative bioavailability of arsenic in a specific test material is calculated as follows:

RBA(test *vs* NaAs) = UEF(test) / UEF(NaAs,oral)

The following table summarizes the best fit slopes (urinary excretion fractions) for sodium arsenate and each of the test materials as measured by both analytical methods, as well as the resulting RBA estimates:

Material Administered	UEF ± SEM (N)		RBA (90% CI)	
	Method 1	Method 2	Method 1	Method 2
Sodium Arsenate	0.223 ± 0.027 (42)	0.907 ± 0.110 (43)	[1.00]	[1.00]
Test Material 1	0.048 ± 0.004 (42)	0.154 ± 0.009 (41)	0.22 (0.17-0.28)	0.17 (0.14-0.22)
Test Material 2	0.060 ± 0.005 (39)	0.202 ± 0.018 (43)	0.27 (0.21-0.35)	0.22 (0.17-0.29)

SEM = Standard error of the mean (standard deviation)
N = Number of data points used in curve-fitting
CI = Confidence interval

As seen, the UEF values varied significantly by method of analysis, with Method 1 having much lower slope values. This is expected, since it is known that Method 1 results in much lower recoveries of DMA and, hence, of total urinary arsenic.

However, the RBA results are approximately the same for each method of arsenic analysis, and the confidence intervals overlap. This indicates that RBA values derived from earlier studies are likely to be accurate and may continue to be utilized as calculated.

5.0 CONCLUSION AND RECOMMENDATIONS

Based on the results presented above, it is concluded that arsenic RBA values derived from previous studies using analytical Method 1 are reliable, even though the recovery of arsenic in urine in these studies was low. This is because both the numerator and the denominator of the ratio used to estimate RBA were underestimated by approximately the same relative amount, so the effect of the underestimation cancels. Nevertheless, all future studies of arsenic bioavailability should use the new analytical procedure to increase sensitivity and to avoid any uncertainties associated with the low recovery of arsenic.

6.0 REFERENCES

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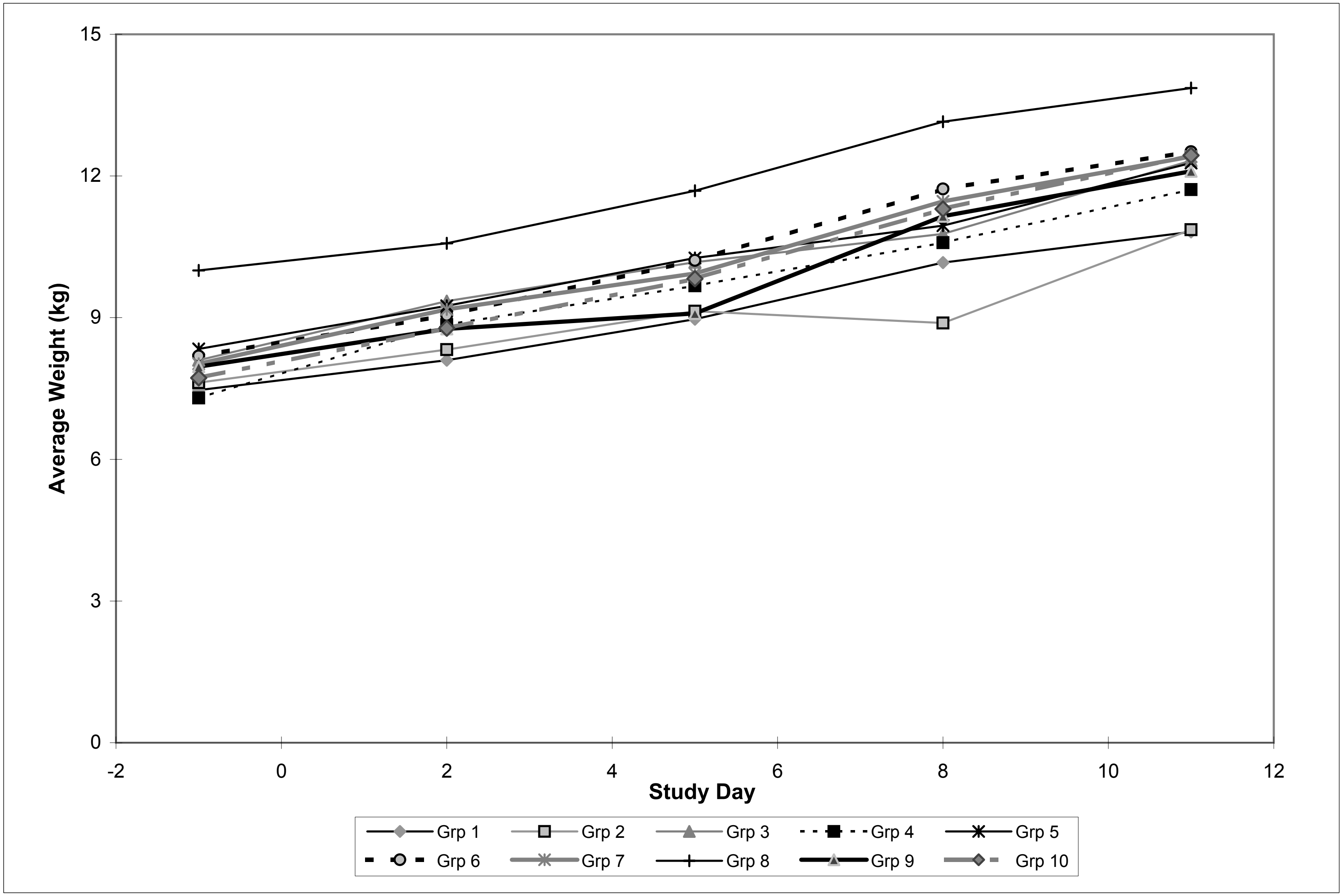
TABLE

TABLE 2-1 STUDY DESIGN

Group	Number of Animals	Material Administered	Target Arsenic Dose (µg/day)
1	3	Control	0
2	4	Sodium Arsenate	300
3	4	Sodium Arsenate	600
4	4	Sodium Arsenate	900
5	4	Test Material 1	300
6	4	Test Material 1	600
7	4	Test Material 1	900
8	4	Test Material 2	300
9	4	Test Material 2	600
10	4	Test Material 2	900

FIGURES

FIGURE 2-1 BODY WEIGHTS OF TEST ANIMALS



BAurinemast_Method Comparison_v4.xls (Weights (Missouri))

FIGURE 2-2 PERFORMANCE EVALUATION SAMPLES

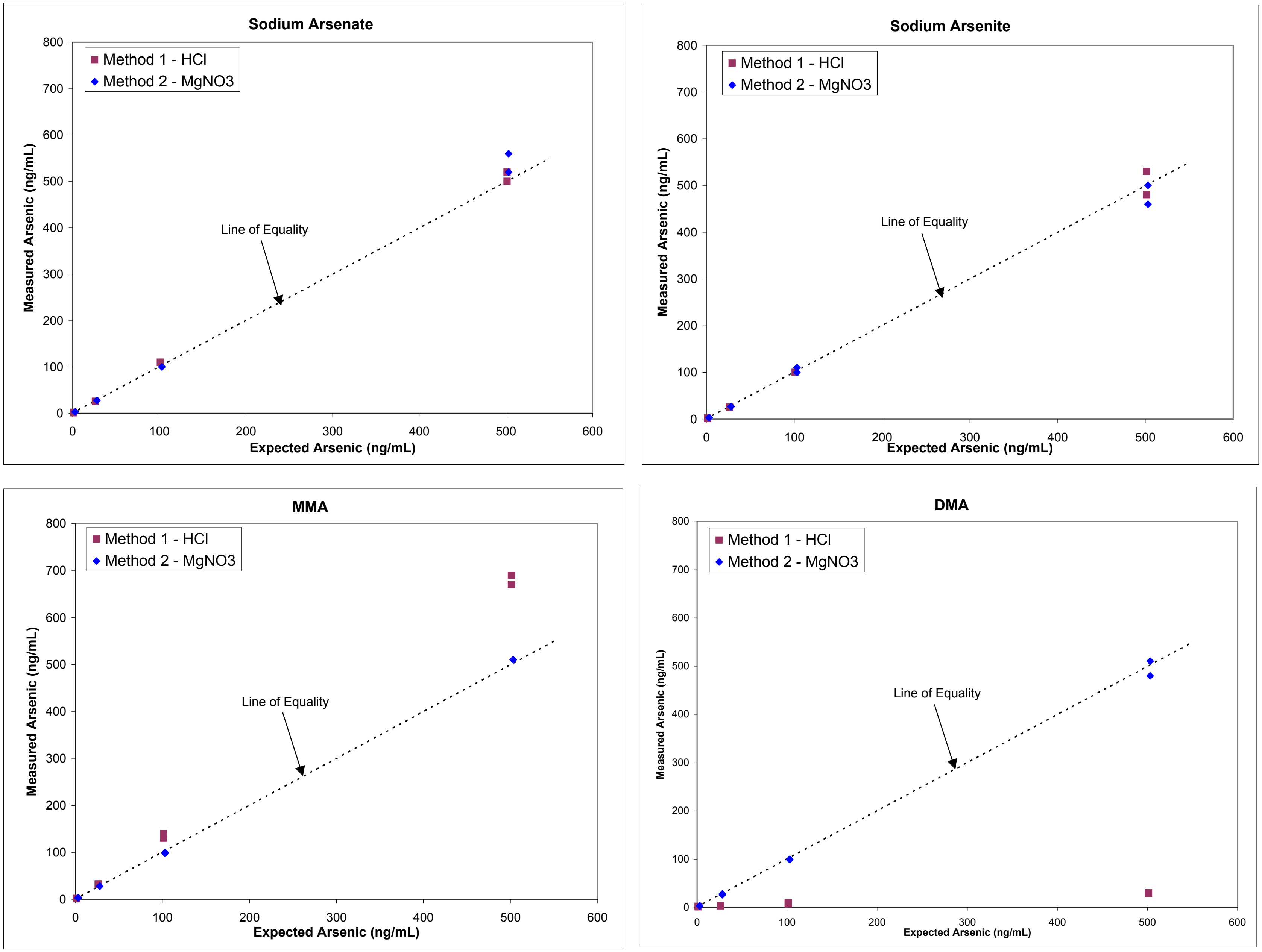
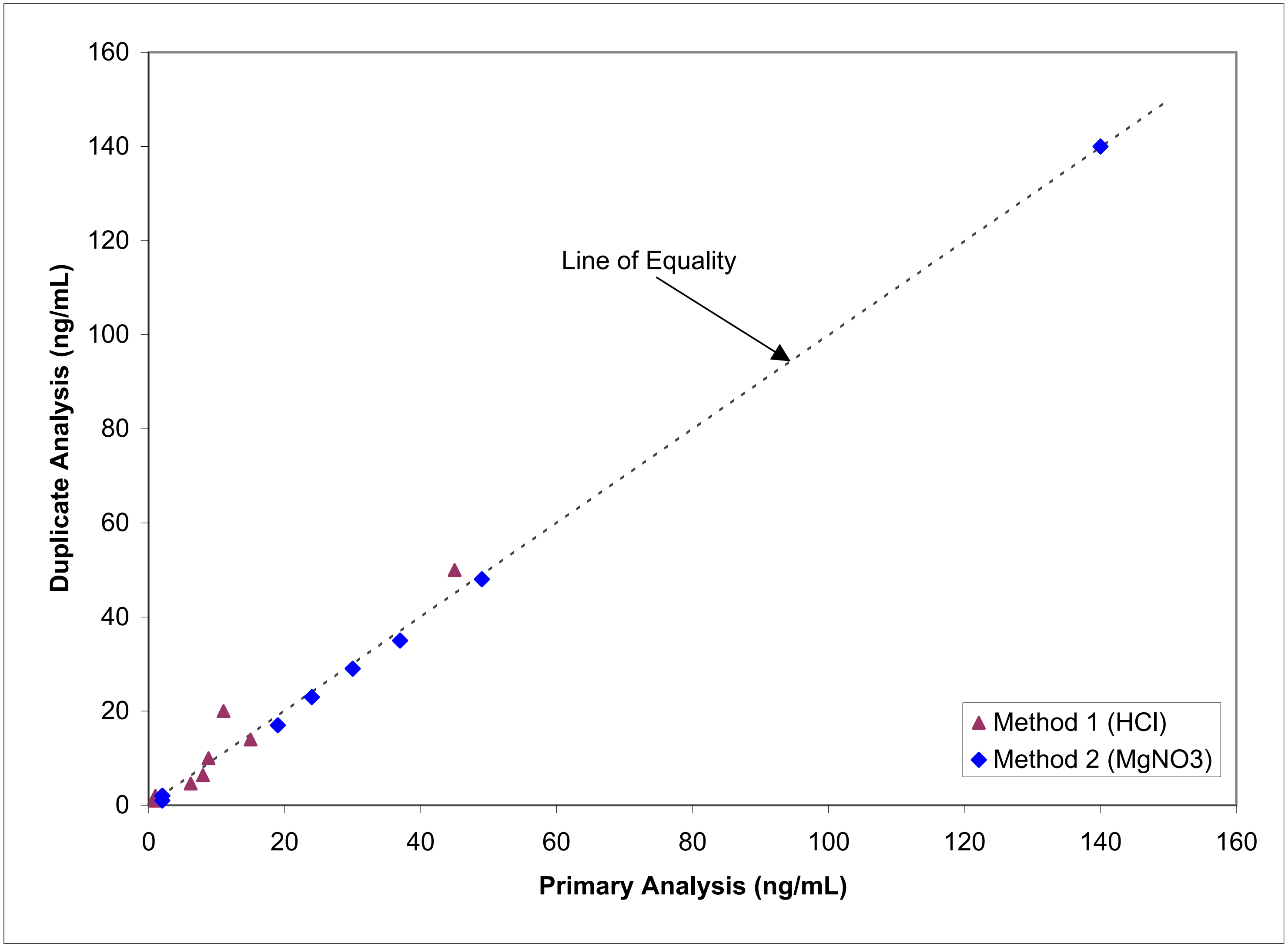
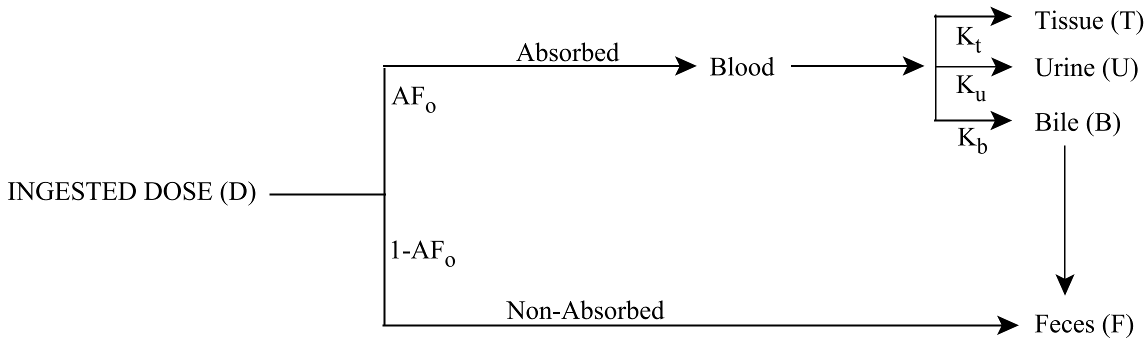


FIGURE 2-3 BLIND DUPLICATE SAMPLES FOR URINE



BAurinemast_Method Comparison_v4.xls (Blind Duplicates)

Figure 3-1. Conceptual Model for Arsenic Toxicokinetics



where:

- D = Ingested dose (ug)
- AF_o = Oral Absorption Fraction
- K_t = Fraction of absorbed arsenic which is retained in tissues
- K_u = Fraction of absorbed arsenic which is excreted in urine
- K_b = Fraction of absorbed arsenic which is excreted in the bile

BASIC EQUATIONS:

Amount Absorbed (ug) $= D \cdot AF_o$

Amount Excreted (ug) $=$ Amount absorbed $\cdot K_u$

$= D \cdot AF_o \cdot K_u$

Urinary Excretion Fraction (UEF) $=$ Amount excreted / Amount Ingested

$= (D \cdot AF_o \cdot K_u) / D$

$= AF_o \cdot K_u$

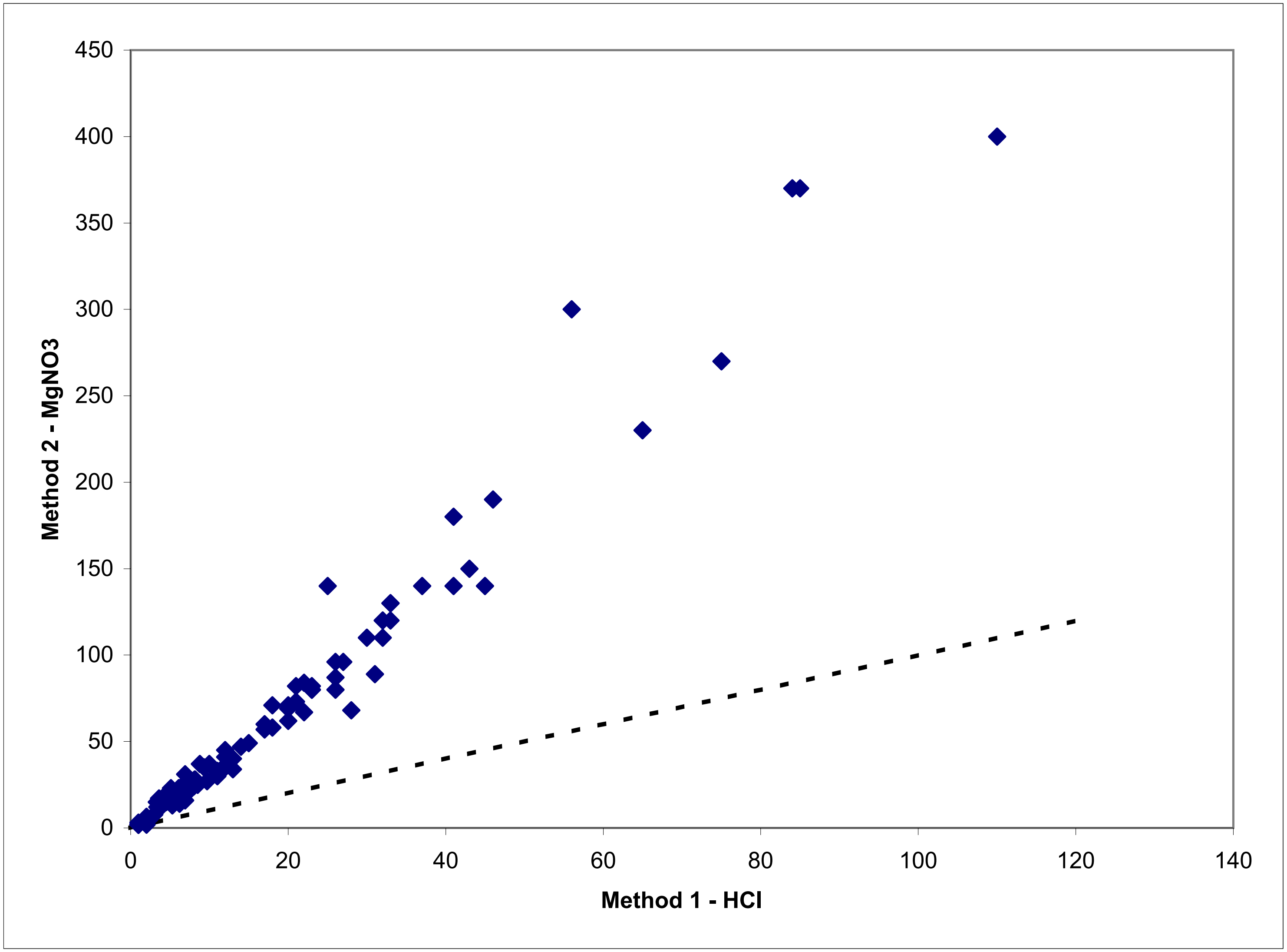
Relative Bioavailability (x vs. y) $= UEF(x) / UEF(y)$

$= (AF_o(x) \cdot K_u) / (AF_o(y) \cdot K_u)$

$= AF_o(x) / AF_o(y)$

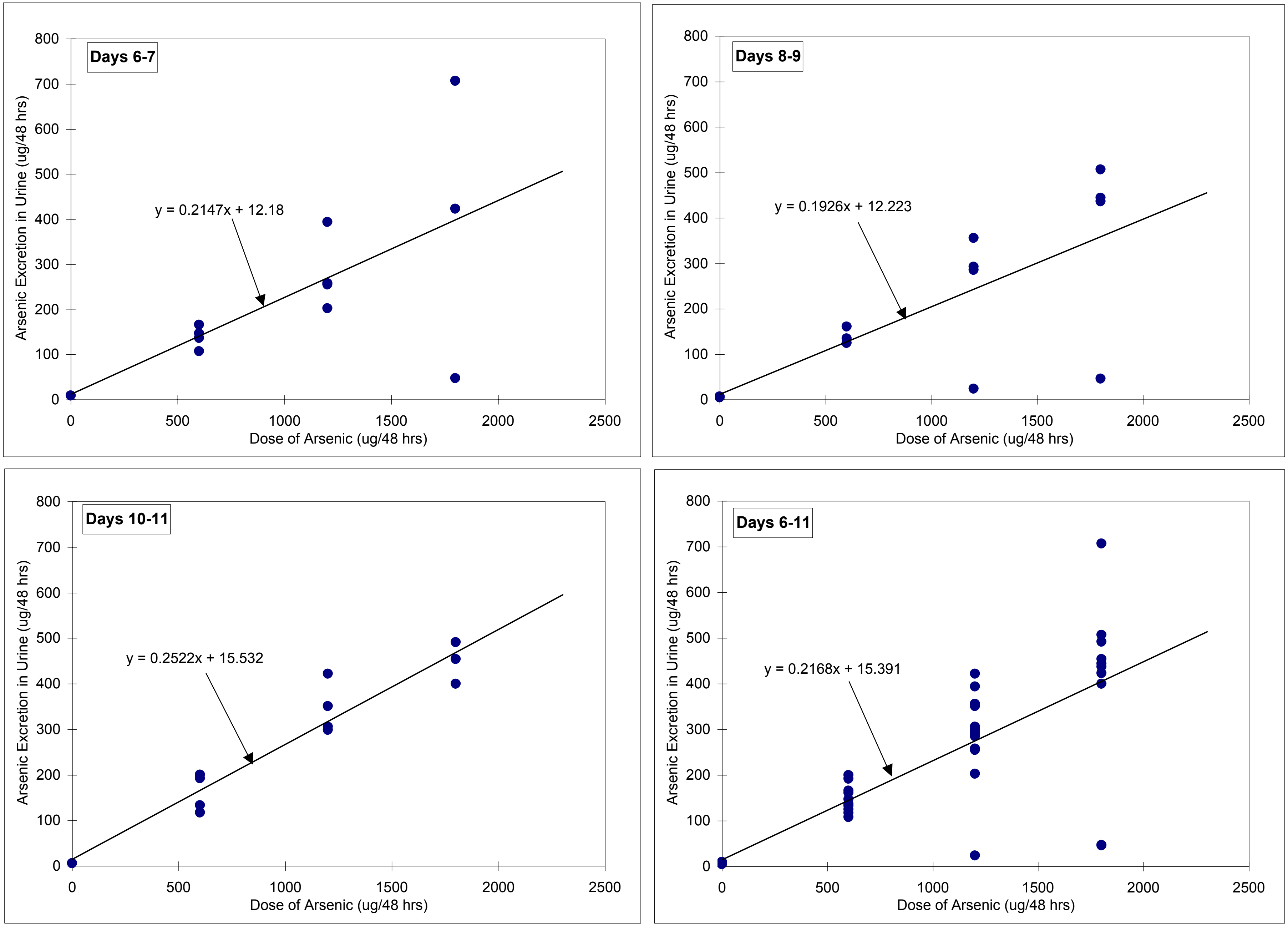
Fig 3-1_Toxicokinetics.wpd

FIGURE 4-1 INTER-METHOD COMPARISON OF ARSENIC CONCENTRATIONS IN URINE



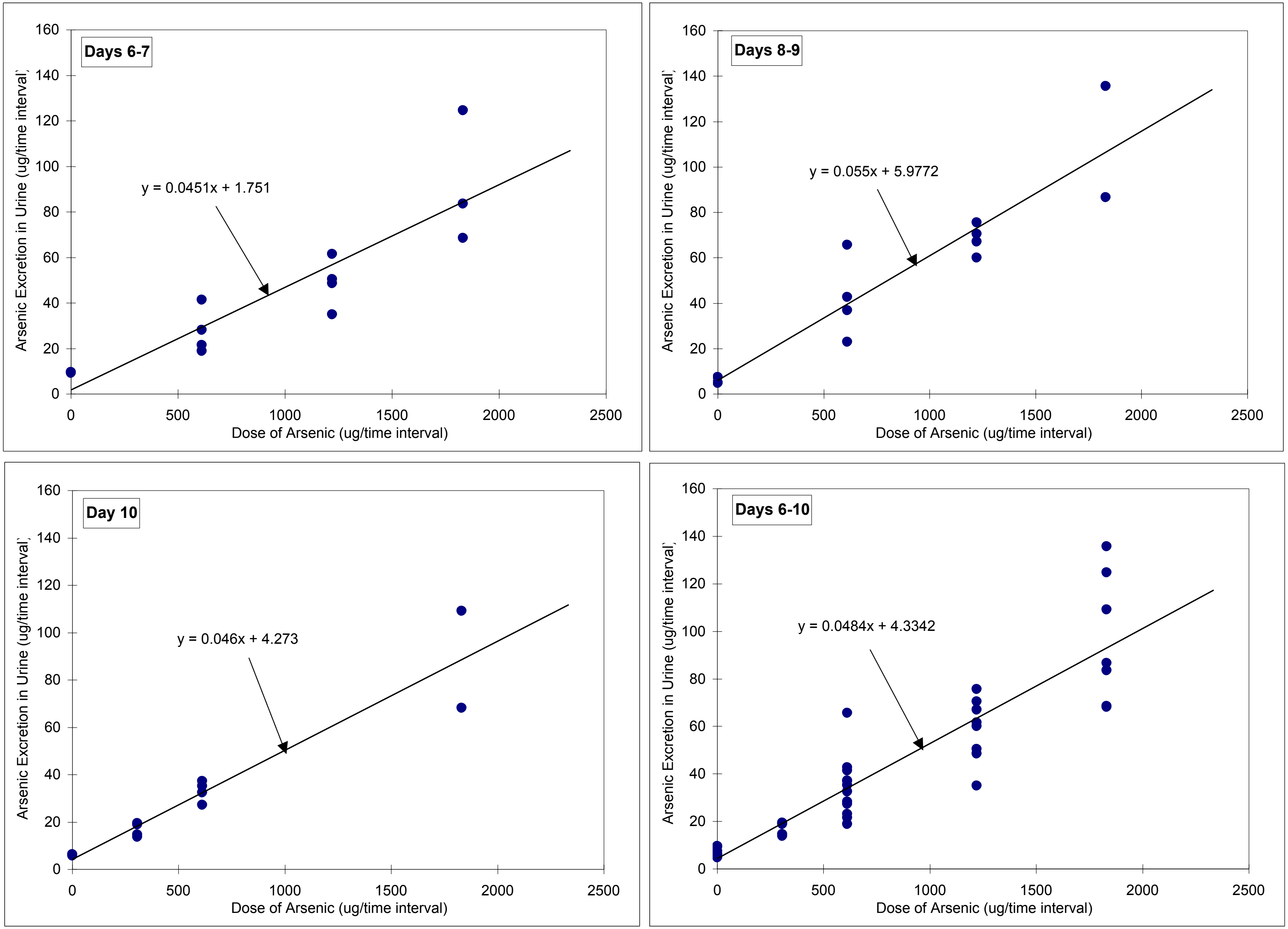
BAurinemast_Method Comparison_v4.xls (Fig4-1_Urine Data)

FIGURE 4-2 URINARY EXCRETION OF ARSENIC FROM SODIUM ARSENATE ANALYZED VIA METHOD 1



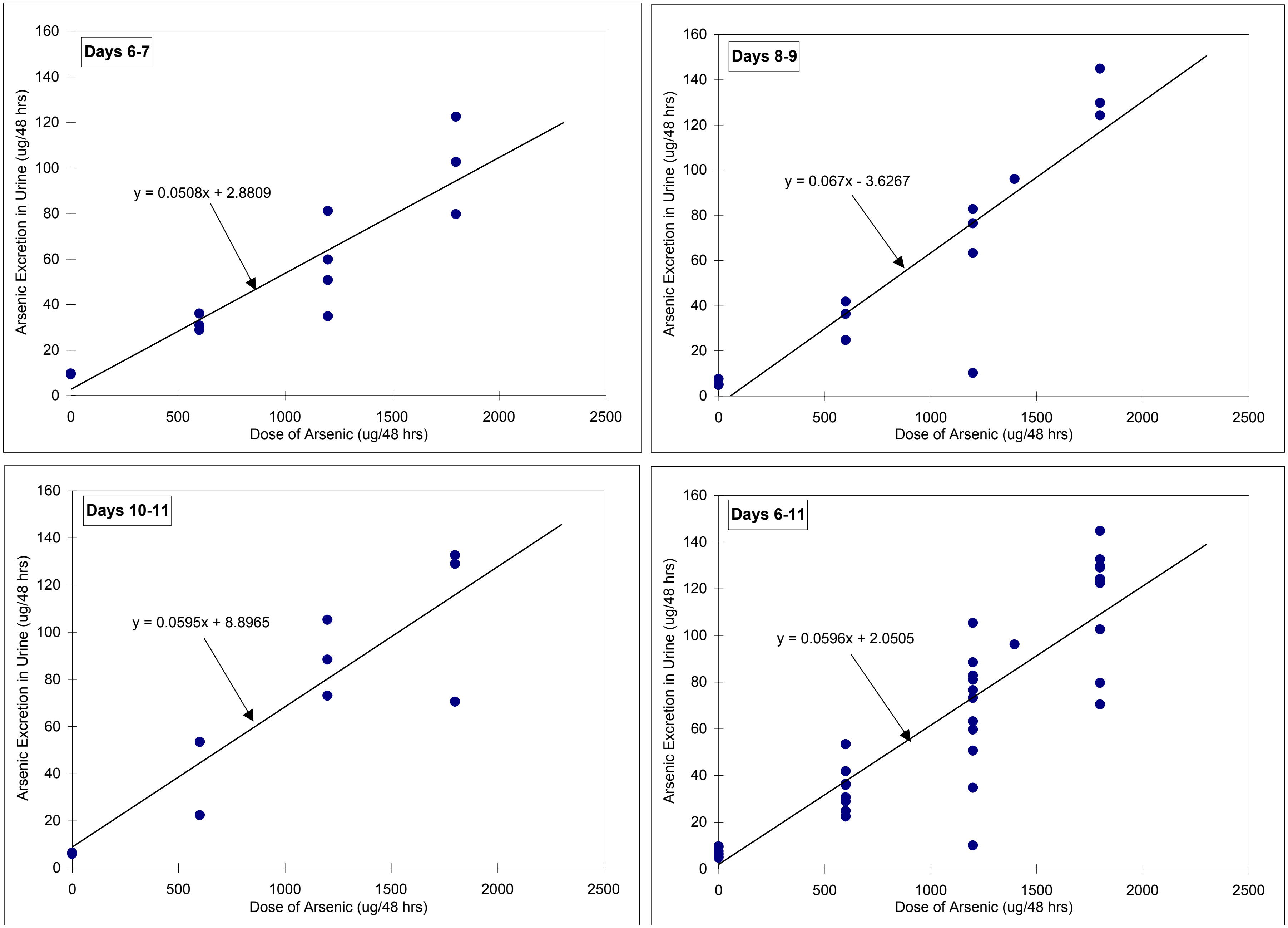
BAurinemast_Method Comparison_v4.xls (M1_NaAs)

FIGURE 4-3 URINARY EXCRETION OF ARSENIC FROM TEST MATERIAL 1 ANALYZED VIA METHOD 1



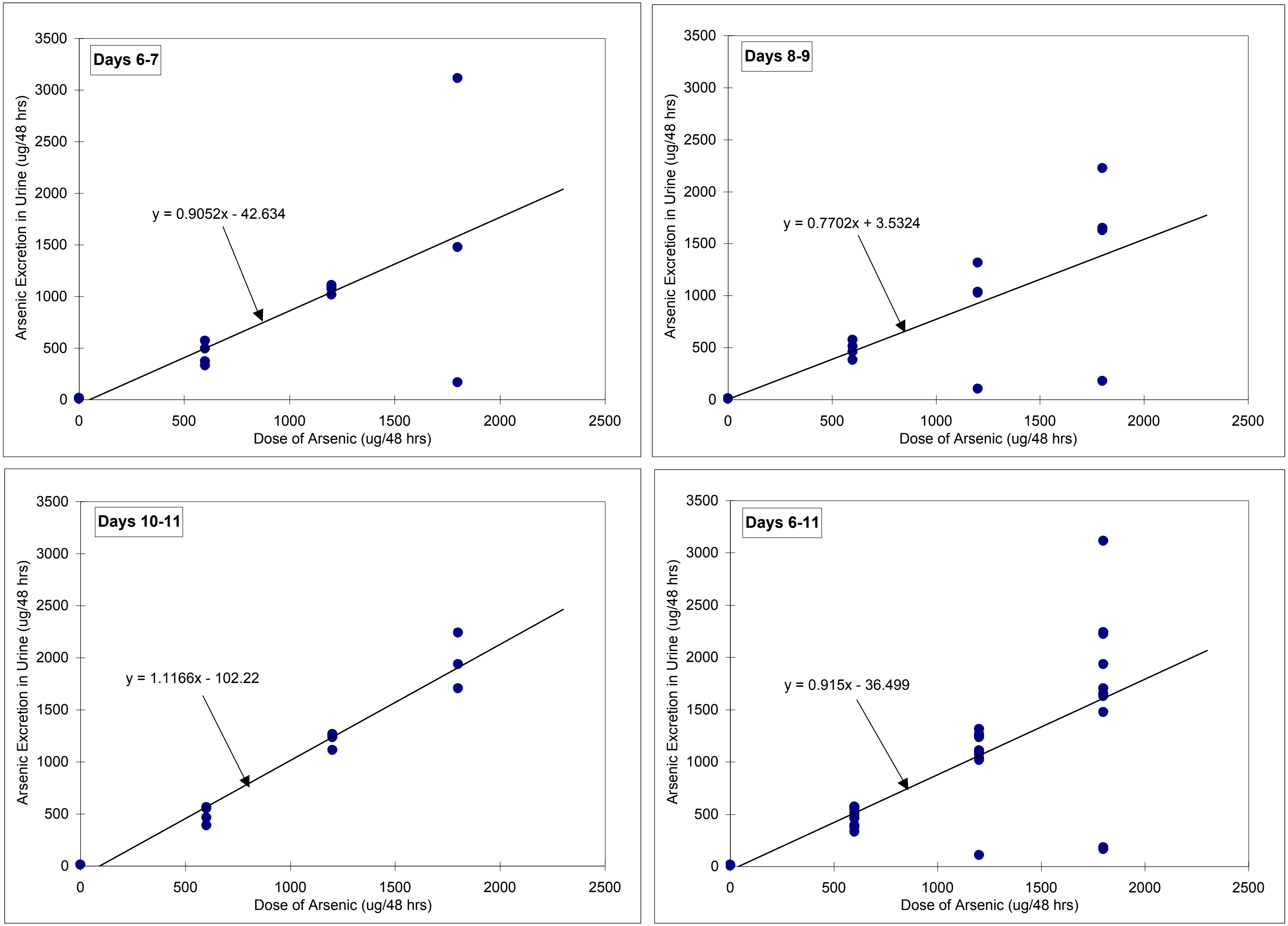
BAurinemast_Method Comparison_v4.xls (M1_TM1)

FIGURE 4-4 URINARY EXCRETION OF ARSENIC FROM TEST MATERIAL 2 ANALYZED VIA METHOD 1



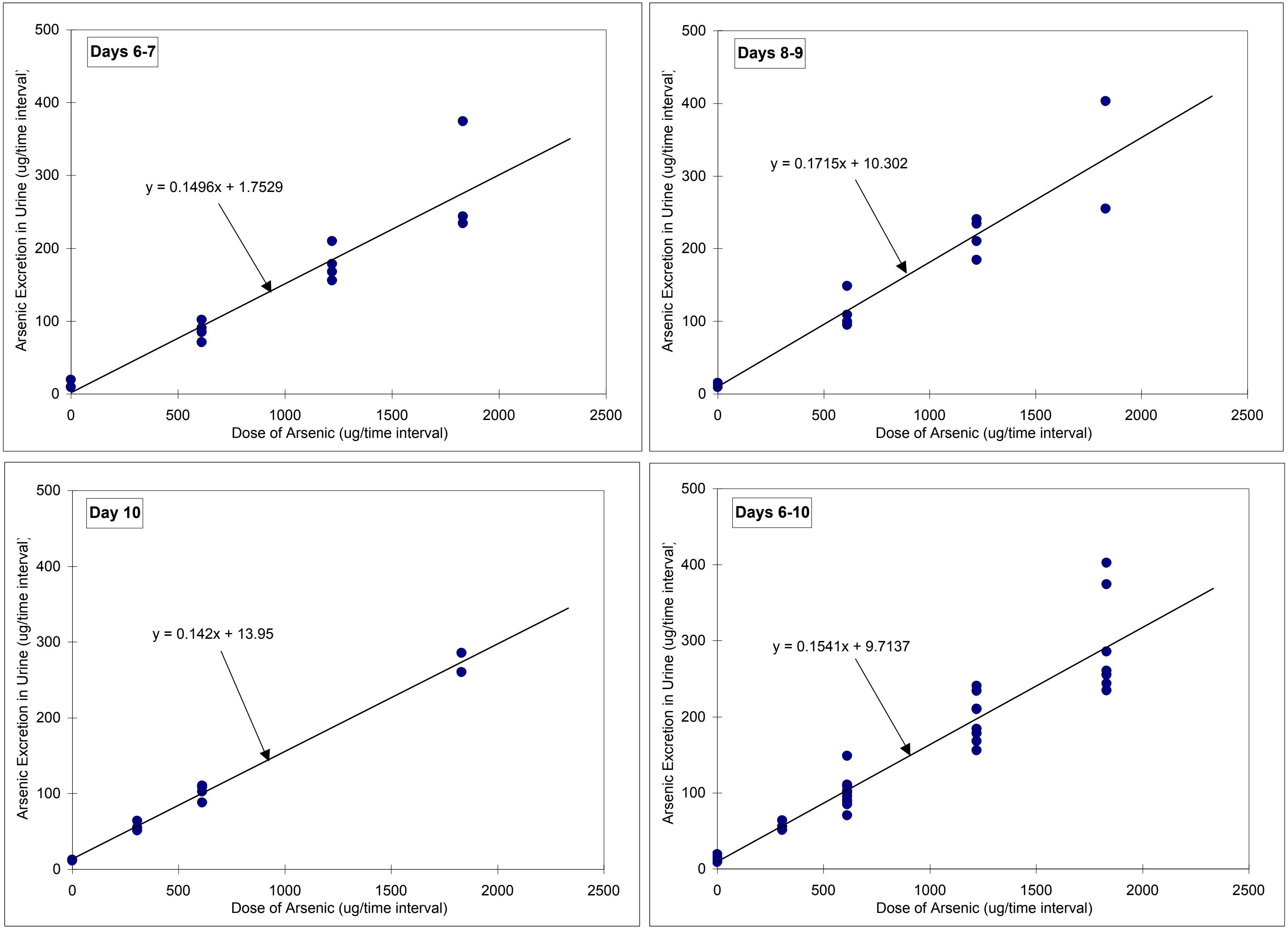
BAurinemast_Method Comparison_v4.xls (M1_TM2)

FIGURE 4-5 URINARY EXCRETION OF ARSENIC FROM SODIUM ARSENATE ANALYZED VIA METHOD 2



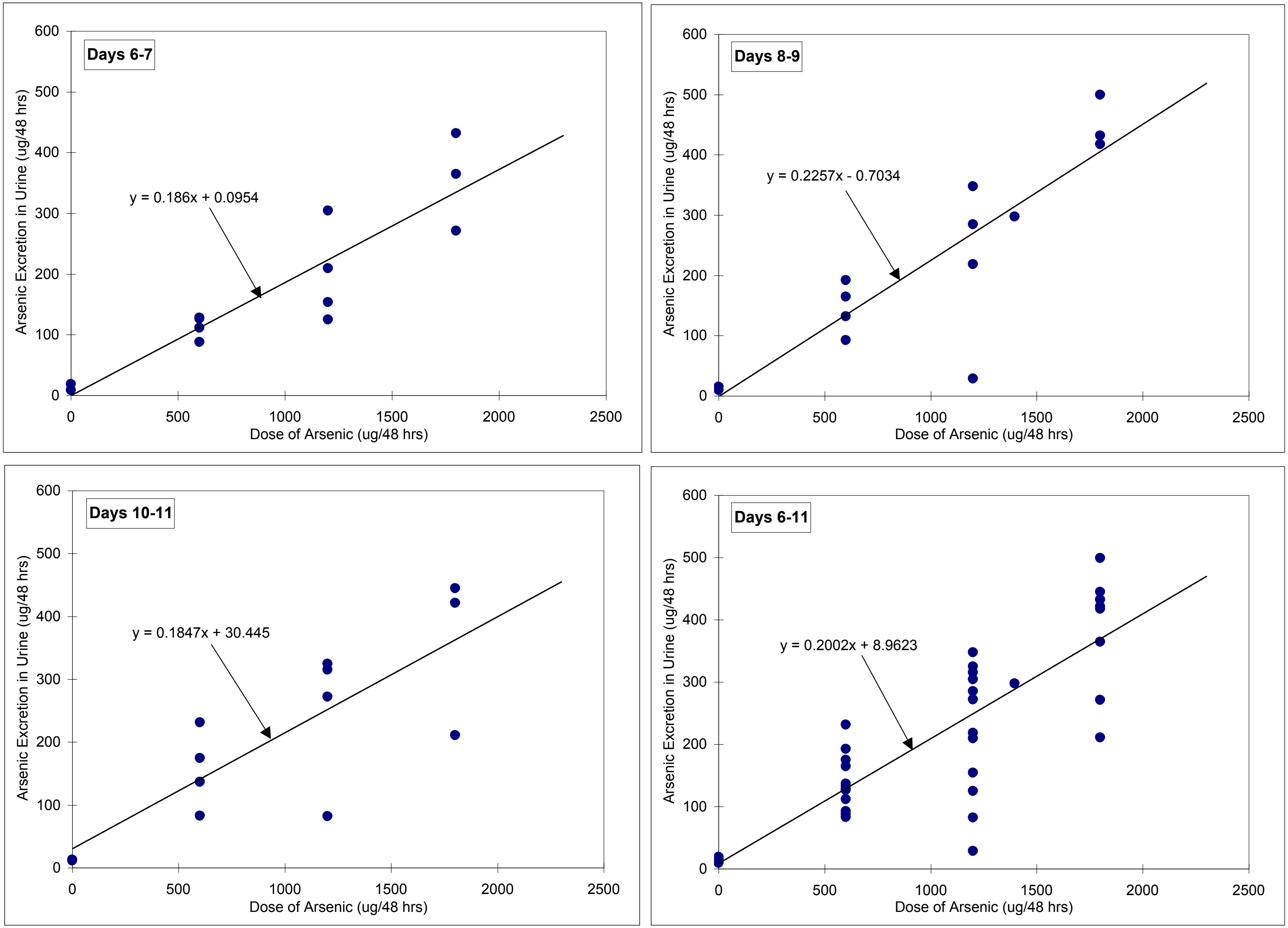
BAurinemast_Method Comparison_v4.xls (M2_NaAs)

FIGURE 4-6 URINARY EXCRETION OF ARSENIC FROM TEST MATERIAL 1 ANALYZED VIA METHOD 2



BAurinemast_Method Comparison_v4.xls (M2_TM1)

FIGURE 4-7 URINARY EXCRETION OF ARSENIC FROM TEST MATERIAL 2 ANALYZED VIA METHOD 2



BAurinemast_Method Comparison_v4.xls (M2_TM2)

APPENDIX A

DETAILED STUDY RESULTS

TABLE A-1 SCHEDULE

Study Day	Day	Date	Dose Administration	Feed	Weigh	Dose Prep	Cull Pigs/Assign Dose Group	48 hr Urine Collection	Sacrifice
-4	Saturday	6/16/2001		X	X				
-3	Sunday	6/17/2001		X					
-2	Monday	6/18/2001		X			X		
-1	Tuesday	6/19/2001		X	X	X			
0	Wednesday	6/20/2001	X	X					
1	Thursday	6/21/2001	X	X					
2	Friday	6/22/2001	X	X	X				
3	Saturday	6/23/2001	X	X					
4	Sunday	6/24/2001	X	X					
5	Monday	6/25/2001	X	X	X				
6	Tuesday	6/26/2001	X	X				↑	
7	Wednesday	6/27/2001	X	X				↓	
8	Thursday	6/28/2001	X	X	X			↑	
9	Friday	6/29/2001	X	X				↓	
10	Saturday	6/30/2001	X	X				↑	
11	Sunday	7/1/2001	X	X	X			↓	
12	Monday	7/2/2001							X

TABLE A-2 GROUP ASSIGNMENTS

Pig Number	Group	Material Administered	Target Dose of Arsenic (ug/kg-day)
108	1	Control	0
145			
157			
122	2	NaAs	25
123			
147			
156			
101	3	NaAs	50
115			
119			
151			
121	4	NaAs	75
136			
140			
148			
104	5	TM1	25
106			
128			
155			
103	6	TM1	50
110			
116			
142			
120	7	TM1	75
125			
138			
150			
102	8	TM2	25
114			
117			
126			
112	9	TM2	50
113			
135			
154			
124	10	TM2	75
133			
158			
160			

TABLE A-3. BODY WEIGHTS AND ADMINISTERED DOSES, BY DAY

Body weights were measured on days -1, 2, 5, 8, 11. Weights for other days are estimated, based on linear interpolation between measured values.

Group	ID #	Day -1		Day 0		Day 1		Day 2		Day 3		Day 4		Day 5		Day 6		Day 7		Day 8		Day 9		Day 10		Day 11	
		BW (kg)	ug As per day	BW (kg)	ug As per day	BW (kg)	ug As per day	BW (kg)	ug As per day	BW (kg)	ug As per day	BW (kg)	ug As per day	BW (kg)	ug As per day	BW (kg)	ug As per day	BW (kg)	ug As per day	BW (kg)	ug As per day	BW (kg)	ug As per day	BW (kg)	ug As per day	BW (kg)	ug As per day
1	108	7.35	0	7.5	0	7.6	0	7.75	0	7.9	0	8.1	0	8.3	0	8.8	0	9.2	0	9.65	0	9.8	0	10.0	0	10.15	0
1	145	7.8	0	7.9	0	8.1	0	8.2	0	8.6	0	9.0	0	9.45	0	9.8	0	10.1	0	10.35	0	10.7	0	11.0	0	11.25	0
1	157	7.25	0	7.6	0	8.0	0	8.35	0	8.6	0	8.9	0	9.15	0	9.6	0	10.1	0	10.5	0	10.7	0	10.9	0	11.05	0
2	122	8.1	0	8.4	300	8.7	300	8.95	300	9.3	300	9.7	300	10.05	300	9.4	300	8.8	300	8.15	300	9.6	300	11.1	300	12.5	300
2	123	7.25	0	7.6	300	7.9	300	8.25	300	8.6	300	9.0	300	9.4	300	9.7	300	10.0	300	10.35	300	10.7	300	11.0	300	11.3	300
2	147	7.85	0	8.0	300	8.1	300	8.15	300	8.4	300	8.6	300	8.8	300	8.8	300	8.8	300	8.85	300	9.3	300	9.8	300	10.2	300
2	156	7.3	0	7.5	300	7.7	300	7.95	300	8.1	300	8.2	300	8.3	300	8.3	300	8.2	300	8.2	300	8.6	300	9.0	300	9.45	300
3	101	7.75	0	8.4	600	9.1	600	9.8	600	10.2	600	10.6	600	10.95	600	11.2	600	11.4	600	11.55	600	12.2	600	12.8	600	13.35	600
3	115	7.55	0	8.0	600	8.4	600	8.85	600	9.2	600	9.5	600	9.8	600	9.9	600	9.9	600	10	600	10.6	600	11.2	600	11.75	600
3	119	9	0	9.3	600	9.5	600	9.8	600	10.0	600	10.3	600	10.5	600	10.6	600	10.6	600	10.7	600	11.5	600	12.2	600	12.95	600
3	151	8.1	0	8.4	600	8.7	600	8.95	600	9.1	600	9.3	600	9.45	600	9.9	600	10.4	600	10.85	600	11.0	600	11.1	600	11.25	600
4	121	5.15	0	6.03	900	6.9	900	7.8	900	8.0	900	8.1	900	8.3	900	9.0	900	9.6	900	10.3	900	10.5	900	10.7	900	10.85	900
4	136	9.35	0	9.5	900	9.6	900	9.75	900	10.2	900	10.6	900	10.95	900	11.2	900	11.4	900	11.6	900	12.0	900	12.4	900	12.8	900
4	140	6.95	0	7.6	900	8.2	900	8.75	900	9.0	900	9.2	900	9.4	900	9.4	900	9.4	900	9.4	900	10.0	900	10.6	900	11.2	900
4	148	7.75	0	8.2	900	8.7	900	9.1	900	9.4	900	9.7	900	10.05	900	10.4	900	10.7	900	11.05	900	11.4	900	11.7	900	12	900
5	104	8.55	0	8.8	305	9.0	305	9.15	305	9.5	306	9.9	306	10.3	306	10.3	306	10.3	306	10.3	306	10.9	306	11.5	306	12.15	306
5	106	8.6	0	8.7	305	8.7	305	8.8	305	9.2	306	9.5	306	9.85	306	10.5	306	11.1	306	11.65	306	11.9	306	12.2	306	12.4	306
5	128	8.85	0	9.4	305	9.9	305	10.45	305	10.8	306	11.1	306	11.35	306	11.0	306	10.7	306	10.3	306	11.1	306	11.9	306	12.7	306
5	155	7.35	0	7.8	305	8.2	305	8.6	305	8.9	306	9.2	306	9.55	306	10.2	306	10.9	306	11.55	306	11.7	306	11.8	306	11.85	306
6	103	7.35	0	7.6	610	7.8	610	8.05	610	8.4	611	8.8	611	9.2	611	9.7	611	10.1	611	10.6	611	10.9	611	11.2	611	11.5	611
6	110	8.5	0	9.1	610	9.7	610	10.35	610	10.7	611	11.1	611	11.45	611	12.0	611	12.5	611	12.95	611	13.3	611	13.6	611	13.95	611
6	116	9.6	0	9.8	610	10.0	610	10.15	610	10.7	611	11.2	611	11.75	611	12.4	611	13.0	611	13.6	611	13.8	611	14.1	611	14.3	611
6	142	7.3	0	7.4	610	7.5	610	7.65	610	7.9	611	8.2	611	8.45	611	8.9	611	9.3	611	9.75	611	9.9	611	10.1	611	10.3	611
7	120	6.9	0	7.8	916	8.6	916	9.45	916	10.0	917	10.6	917	11.15	917	11.5	917	11.8	917	12.05	917	12.4	917	12.7	917	12.95	917
7	125	8.85	0	9.3	916	9.7	916	10.05	916	9.8	917	9.6	917	9.4	917	10.4	917	11.4	917	12.35	917	12.6	917	12.9	917	13.15	917
7	138	8.6	0	8.7	916	8.8	916	8.9	916	9.0	917	9.0	917	9.05	917	9.7	917	10.4	917	11.05	917	11.6	917	12.1	917	12.55	917
7	150	7.75	0	7.9	916	8.1	916	8.3	916	8.9	917	9.5	917	10.15	917	10.2	917	10.3	917	10.4	917	10.6	917	10.8	917	11	917
8	102	8.75	0	8.9	300	9.1	300	9.3	300	10.2	300	11.0	300	11.85	300	11.5	300	11.1	300	10.7	300	11.0	300	11.4	300	11.7	300
8	114	10.1	0	10.4	300	10.6	300	10.9	300	11.3	300	11.8	300	12.2	300	12.8	300	13.5	300	14.1	300	14.3	300	14.6	300	14.8	300
8	117	10.5	0	10.7	300	11.0	300	11.2	300	11.5	300	11.7	300	11.95	300	12.5	300	13.1	300	13.65	300	13.9	300	14.1	300	14.3	300
8	126	10.65	0	10.7	300	10.8	300	10.9	300	10.9	300	10.8	300	10.75	300	11.9	300	13.0	300	14.15	300	14.3	300	14.5	300	14.65	300
9	112	8.75	0	8.9	600	9.1	600	9.3	600	10.2	600	11.0	600	11.85	600	11.5	600	11.1	600	10.7	600	11.0	600	11.4	600	11.7	600
9	113	10.1	0	10.4	600	10.6	600	10.9	600	11.3	600	11.8	600	12.2	600	12.8	600	13.5	600	14.1	600	14.3	600	14.6	600	14.8	600
9	135	10.5	0	10.7	600	11.0	600	11.2	600	11.5	600	11.7	600	11.95	600	12.5	600	13.1	600	13.65	600	13.9	600	14.1	600	14.3	600
9	154	10.65	0	10.7	600	10.8	600	10.9	600	10.9	600	10.8	600	10.75	600	11.9	600	13.0	600	14.15	600	14.3	600	14.5	600	14.65	600
10	124	8.5	0	9.0	900	9.5	900	10	900	9.7	900	9.5	900	9.21	900	10.5	900	11.8	900	13.1	900	13.3	900	13.4	900	13.55	900
10	133	7.15	0	7.4	900	7.6	900	7.8	900	8.3	900	8.8	900	9.25	900	9.6	900	9.9	900	10.2	900	10.5	900	10.8	900	11.15	900
10	158	8.55	0	8.8	900	9.0	900	9.25	900	9.3	900	9.3	900	9.35	900	10.1	900	10.9	900	11.6	900	11.9	900	12.2	900	12.5	900
10	160	7.65	0	7.8	900	7.9	900	8	900	8.2	900	8.4	900	8.55	900	8.9	900	9.3	900	9.7	900	10.2	900	10.7	900	11.2	900

TABLE A-4 BODY WEIGHT ADJUSTED DOSES (ug/kg-day)

(Dose for Day/BW for Day)

Group	Pig #	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Avg Dose	Avg Dose per Group
1	108	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
1	145	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
1	157	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	122	35.79	34.62	33.52	32.20	30.98	29.85	31.86	34.16	36.81	31.25	27.15	24.00	31.85	
2	123	39.56	37.89	36.36	34.75	33.27	31.91	30.87	29.90	28.99	28.13	27.31	26.55	32.13	
2	147	37.74	37.27	36.81	35.86	34.95	34.09	34.03	33.96	33.90	32.26	30.77	29.41	34.25	
2	156	39.91	38.79	37.74	37.19	36.66	36.14	36.29	36.44	36.59	34.82	33.21	31.75	36.29	33.63
3	101	71.15	65.81	61.22	58.92	56.78	54.79	53.81	52.86	51.95	49.38	47.06	44.94	55.72	
3	115	75.16	71.29	67.80	65.45	63.27	61.22	60.81	60.40	60.00	56.69	53.73	51.06	62.24	
3	119	64.75	62.94	61.22	59.80	58.44	57.14	56.78	56.43	56.07	52.40	49.18	46.33	56.79	
3	151	71.57	69.23	67.04	65.81	64.63	63.49	60.50	57.78	55.30	54.63	53.97	53.33	61.44	59.05
4	121	149.17	130.12	115.38	112.97	110.66	108.43	100.37	93.43	87.38	85.85	84.38	82.95	105.09	
4	136	94.90	93.59	92.31	88.67	85.31	82.19	80.60	79.06	77.59	75.00	72.58	70.31	82.68	
4	140	119.21	110.43	102.86	100.37	98.00	95.74	95.74	95.74	95.74	90.00	84.91	80.36	97.43	
4	148	109.76	104.05	98.90	95.58	92.47	89.55	86.68	83.98	81.45	79.18	77.03	75.00	89.47	93.66
5	104	34.88	34.10	33.36	32.05	30.81	29.66	29.66	29.66	29.66	27.99	26.49	25.15	30.29	
5	106	35.22	34.95	34.68	33.39	32.16	31.02	29.24	27.65	26.23	25.68	25.15	24.64	30.00	
5	128	32.53	30.78	29.21	28.42	27.65	26.92	27.78	28.69	29.66	27.53	25.68	24.06	28.24	
5	155	39.30	37.30	35.49	34.27	33.09	31.99	29.91	28.07	26.45	26.23	26.00	25.78	31.16	29.92
6	103	80.50	78.09	75.83	72.46	69.31	66.42	63.22	60.30	57.65	56.06	54.56	53.14	65.63	
6	110	66.96	62.72	58.98	57.02	55.14	53.37	51.14	49.08	47.19	46.00	44.88	43.81	53.02	
6	116	62.40	61.25	60.14	57.20	54.48	52.01	49.41	47.07	44.93	44.17	43.44	42.73	51.60	
6	142	82.31	81.03	79.80	77.19	74.67	72.32	68.79	65.59	62.68	61.52	60.40	59.33	70.47	60.18
7	120	118.15	106.47	96.89	91.51	86.61	82.21	80.06	78.01	76.07	74.22	72.46	70.78	86.12	
7	125	98.99	94.89	91.11	93.22	95.32	97.51	88.28	80.64	74.22	72.65	71.15	69.71	85.64	
7	138	105.25	104.05	102.88	102.42	101.85	101.29	94.34	88.28	82.95	79.36	76.07	73.04	92.65	
7	150	115.42	112.81	110.32	102.80	96.15	90.31	89.57	88.85	88.14	86.47	84.87	83.33	95.75	90.04
8	102	33.58	32.91	32.26	29.56	27.27	25.32	26.16	27.07	28.04	27.19	26.39	25.64	28.45	
8	114	28.94	28.21	27.52	26.47	25.50	24.59	23.38	22.28	21.28	20.93	20.59	20.27	24.16	
8	117	27.95	27.36	26.79	26.20	25.64	25.10	23.97	22.93	21.98	21.63	21.30	20.98	24.32	
8	126	27.95	27.73	27.52	27.65	27.78	27.91	25.25	23.05	21.20	20.95	20.71	20.48	24.85	25.44
9	112	67.16	65.81	64.52	59.11	54.55	50.63	52.33	54.14	56.07	54.38	52.79	51.28	56.90	
9	113	57.88	56.43	55.05	52.94	50.99	49.18	46.75	44.55	42.55	41.86	41.19	40.54	48.33	
9	135	55.90	54.71	53.57	52.40	51.28	50.21	47.94	45.86	43.96	43.27	42.60	41.96	48.64	
9	154	55.90	55.47	55.05	55.30	55.56	55.81	50.49	46.09	42.40	41.91	41.43	40.96	49.70	50.89
10	124	100.00	94.74	90.00	92.43	95.00	97.72	85.66	76.25	68.70	67.92	67.16	66.42	83.50	
10	133	122.17	118.68	115.38	108.65	102.66	97.30	94.08	91.06	88.24	85.58	83.08	80.72	98.97	
10	158	102.47	99.82	97.30	96.95	96.60	96.26	89.11	82.95	77.59	75.63	73.77	72.00	88.37	
10	160	115.88	114.16	112.50	109.98	107.57	105.26	100.75	96.60	92.78	88.24	84.11	80.36	100.68	92.88

TABLE A-5 URINE VOLUMES - 48 HOUR COLLECTIONS

Units of Volume: mL

Group	Pig #	Day 6-7 6/26-6/28	Day 8-9 6/28-6/30	Day 10-11 6/30-7/2
1	108	9580	4800	13600
	145	4640	5000	5800
	157	10100	7500	6400
2	122	6980	7000	6200
	123	24780	28600	28200
	147	4880	9000	5800
	156	5120	4800	4500
3	101	14360	3470	59500
	115	35820	35600	35200
	119	3000	3800	2780
	151	3620	4500	6500
4	121	8420	1400	16000
	136	2364	14800	14200
	140	9840	11800	14840
	148	12360	14900	10200
5	104	3700	6400	2700
	106	3720	6200	2400
	128	7820	10600	5000
	155	3920	5600	3200
6	103	9740	9700	4200
	110	8100	8600	3200
	116	14000	15600	6500
	142	14000	7800	3100
7	120	5720	9800	3500
	125	15590	21200	14600
	138	6960	3100	1200
	150	10200	8400	6000
8	102	4640	6200	5200
	114	8520	11000	9200
	117	10560	11000	17800
	126	20640	29600	42860
9	112	8700	11400	13000
	113	11040	1600	16600
	135	6940	9400	14000
	154	2300	7800	6800
10	124	3800	5400	6400
	133	7200	7200	8600
	158	1940	4800	4300
	160	7240	7800	7600

[shaded box] = Volumes are for a 24-hour collection on Day 10. (Shaded: Day 10-11 values for Groups 5, 6 and 7.)

TABLE A-6 URINE ANALYTICAL RESULTS

ID	pig number	group	dosage	day	date collected	sample number	tag number1	HCl04 Q	HClO4 ng/mL	tag number2	MgNO3 Q	MgNO3 ng/mL
1	108	1	0	6/7	26-Jun-01	BA1-108-(6/7)-U	BA-01-00052	<	1	BA-01-00205		2
2	145	1	0	6/7	26-Jun-01	BA1-145-(6/7)-U	BA-01-00056		2	BA-01-00209		2
3	157	1	0	6/7	26-Jun-01	BA1-157-(6/7)-U	BA-01-00079		2	BA-01-00232		2
4	122	2	25	6/7	26-Jun-01	BA1-122-(6/7)-U	BA-01-00085		21	BA-01-00238		82
5	123	2	25	6/7	26-Jun-01	BA1-123-(6/7)-U	BA-01-00034		6.7	BA-01-00187		20
6	147	2	25	6/7	26-Jun-01	BA1-147-(6/7)-U	BA-01-00039		28	BA-01-00192		68
7	156	2	25	6/7	26-Jun-01	BA1-156-(6/7)-U	BA-01-00069		21	BA-01-00222		73
8	101	3	50	6/7	26-Jun-01	BA1-101-(6/7)-U	BA-01-00037		18	BA-01-00190		71
9	115	3	50	6/7	26-Jun-01	BA1-115-(6/7)-U	BA-01-00042		11	BA-01-00195		30
10	119	3	50	6/7	26-Jun-01	BA1-119-(6/7)-U	BA-01-00057		85	BA-01-00210		370
11	151	3	50	6/7	26-Jun-01	BA1-151-(6/7)-U	BA-01-00080		56	BA-01-00233		300
12	121	4	75	6/7	26-Jun-01	BA1-121-(6/7)-U	BA-01-00035		84	BA-01-00188		370
13	136	4	75	6/7	26-Jun-01	BA1-136-(6/7)-U	BA-01-00036		20	BA-01-00189		71
14	140	4	75	6/7	26-Jun-01	BA1-140-(6/7)-U	BA-01-00060		43	BA-01-00213		150
15	148	4	75	6/7	26-Jun-01	BA1-148-(6/7)-U	BA-01-00051		41	BA-01-00204		180
16	104	5	25	6/7	26-Jun-01	BA1-104-(6/7)-U	BA-01-00055		5.1	BA-01-00208		23
17	106	5	25	6/7	26-Jun-01	BA1-106-(6/7)-U	BA-01-00045		5.8	BA-01-00198		19
18	128	5	25	6/7	26-Jun-01	BA1-128-(6/7)-U	BA-01-00033		5.3	BA-01-00186		13
19	155	5	25	6/7	26-Jun-01	BA1-155-(6/7)-U	BA-01-00050		7.2	BA-01-00203		23
20	103	6	50	6/7	26-Jun-01	BA1-103-(6/7)-U	BA-01-00064		3.6	BA-01-00217		16
21	110	6	50	6/7	26-Jun-01	BA1-110-(6/7)-U	BA-01-00031		6	BA-01-00184		22
22	116	6	50	6/7	26-Jun-01	BA1-116-(6/7)-U	BA-01-00062		4.4	BA-01-00215		15
23	142	6	50	6/7	26-Jun-01	BA1-142-(6/7)-U	BA-01-00066		3.6	BA-01-00219		12
24	120	7	75	6/7	26-Jun-01	BA1-120-(6/7)-U	BA-01-00044		12	BA-01-00197		41
25	125	7	75	6/7	26-Jun-01	BA1-125-(6/7)-U	BA-01-00067		8	BA-01-00220		24
26	138	7	75	6/7	26-Jun-01	BA1-138-(6/7)-U	BA-01-00083		12	BA-01-00236		35
27	150	7	75	6/7	26-Jun-01	BA1-150-(6/7)-U	BA-01-00063		8.5	BA-01-00216		25
28	102	8	25	6/7	26-Jun-01	BA1-102-(6/7)-U	BA-01-00048		6.2	BA-01-00201		19
29	114	8	25	6/7	26-Jun-01	BA1-114-(6/7)-U	BA-01-00081		3.6	BA-01-00234		15
30	117	8	25	6/7	26-Jun-01	BA1-117-(6/7)-U	BA-01-00072		3.4	BA-01-00225		12
31	126	8	25	6/7	26-Jun-01	BA1-126-(6/7)-U	BA-01-00071		2	BA-01-00224		5.4
32	112	9	50	6/7	26-Jun-01	BA1-112-(6/7)-U	BA-01-00047		9.3	BA-01-00200		35
33	113	9	50	6/7	26-Jun-01	BA1-113-(6/7)-U	BA-01-00038		5.4	BA-01-00191		19
34	135	9	50	6/7	26-Jun-01	BA1-135-(6/7)-U	BA-01-00043		5	BA-01-00196		18
35	154	9	50	6/7	26-Jun-01	BA1-154-(6/7)-U	BA-01-00077		22	BA-01-00230		67
36	124	10	75	6/7	26-Jun-01	BA1-124-(6/7)-U	BA-01-00054		27	BA-01-00207		96
37	133	10	75	6/7	26-Jun-01	BA1-133-(6/7)-U	BA-01-00082		17	BA-01-00235		60
38	158	10	75	6/7	26-Jun-01	BA1-158-(6/7)-U	BA-01-00046		41	BA-01-00199		140
39	160	10	75	6/7	26-Jun-01	BA1-160-(6/7)-U	BA-01-00065		20	BA-01-00218		69
40	2108	1	0	6/7	26-Jun-01	BA1-2108-(6/7)-U	BA-01-00058		2	BA-01-00211		2
41	2125	7	75	6/7	26-Jun-01	BA1-2125-(6/7)-U	BA-01-00078		6.4	BA-01-00231		23
42	2115	3	50	6/7	26-Jun-01	BA1-2115-(6/7)-U	BA-01-00032		20	BA-01-00185		29
43	AsCtrl			6/7	26-Jun-01	BA1-AsCtrl-(6/7)-U	BA-01-00041		1	BA-01-00194		3
44	AsIA500			6/7	26-Jun-01	BA1-AsIA500-(6/7)-U	BA-01-00076		500	BA-01-00229		520
45	AsIB500			6/7	26-Jun-01	BA1-AsIB500-(6/7)-U	BA-01-00061		480	BA-01-00214		500
46	AsOA500			6/7	26-Jun-01	BA1-AsOA500-(6/7)-U	BA-01-00073		670	BA-01-00226		510
47	AsOB500			6/7	26-Jun-01	BA1-AsOB500-(6/7)-U	BA-01-00074		29	BA-01-00227		510
48	AsIA100			6/7	26-Jun-01	BA1-AsIA100-(6/7)-U	BA-01-00053		110	BA-01-00206		100
49	AsIB100			6/7	26-Jun-01	BA1-AsIB100-(6/7)-U	BA-01-00068		100	BA-01-00221		100
50	AsOA100			6/7	26-Jun-01	BA1-AsOA100-(6/7)-U	BA-01-00084		130	BA-01-00237		100
51	AsOB100			6/7	26-Jun-01	BA1-AsOB100-(6/7)-U	BA-01-00075		6.8	BA-01-00228		100
52	AsIA25			6/7	26-Jun-01	BA1-AsIA25-(6/7)-U	BA-01-00059		26	BA-01-00212		28
53	AsIB25			6/7	26-Jun-01	BA1-AsIB25-(6/7)-U	BA-01-00070		26	BA-01-00223		27
54	AsOA25			6/7	26-Jun-01	BA1-AsOA25-(6/7)-U	BA-01-00049		31	BA-01-00202		28
55	AsOB25			6/7	26-Jun-01	BA1-AsOB25-(6/7)-U	BA-01-00040		3.1	BA-01-00193		28
56	108	1	0	8/9	28-Jun-01	BA1-108-(8/9)-U	BA-01-00135	<	1	BA-01-00288		2
57	145	1	0	8/9	28-Jun-01	BA1-145-(8/9)-U	BA-01-00128	<	1	BA-01-00281		3
58	157	1	0	8/9	28-Jun-01	BA1-157-(8/9)-U	BA-01-00112	<	1	BA-01-00265		2
59	122	2	25	8/9	28-Jun-01	BA1-122-(8/9)-U	BA-01-00090		23	BA-01-00243		82
60	123	2	25	8/9	28-Jun-01	BA1-123-(8/9)-U	BA-01-00120		4.7	BA-01-00273		18
61	147	2	25	8/9	28-Jun-01	BA1-147-(8/9)-U	BA-01-00138		missing	BA-01-00291		51
62	156	2	25	8/9	28-Jun-01	BA1-156-(8/9)-U	BA-01-00116		26	BA-01-00269		80
63	101	3	50	8/9	28-Jun-01	BA1-101-(8/9)-U	BA-01-00092		6.9	BA-01-00245		31
64	115	3	50	8/9	28-Jun-01	BA1-115-(8/9)-U	BA-01-00104		10	BA-01-00257		37
65	119	3	50	8/9	28-Jun-01	BA1-119-(8/9)-U	BA-01-00129		75	BA-01-00282		270
66	151	3	50	8/9	28-Jun-01	BA1-151-(8/9)-U	BA-01-00136		65	BA-01-00289		230
67	121	4	75	8/9	28-Jun-01	BA1-121-(8/9)-U	BA-01-00139		33	BA-01-00292		130
68	136	4	75	8/9	28-Jun-01	BA1-136-(8/9)-U	BA-01-00108		30	BA-01-00261		110
69	140	4	75	8/9	28-Jun-01	BA1-140-(8/9)-U	BA-01-00100		37	BA-01-00253		140
70	148	4	75	8/9	28-Jun-01	BA1-148-(8/9)-U	BA-01-00094		33	BA-01-00247		130
71	104	5	25	8/9	28-Jun-01	BA1-104-(8/9)-U	BA-01-00091		3.6	BA-01-00244		17
72	106	5	25	8/9	28-Jun-01	BA1-106-(8/9)-U	BA-01-00098		6.9	BA-01-00251		16

TABLE A-6 URINE ANALYTICAL RESULTS

ID	pig number	group	dosage	day	date collected	sample number	tag number1	HCl04 Q	HClO4 ng/mL	tag number2	MgNO3 Q	MgNO3 ng/mL
73	128	5	25	8/9	28-Jun-01	BA1-128-(8/9)-U	BA-01-00087		6.2	BA-01-00240		14
74	155	5	25	8/9	28-Jun-01	BA1-155-(8/9)-U	BA-01-00097		6.6	BA-01-00250		17
75	103	6	50	8/9	28-Jun-01	BA1-103-(8/9)-U	BA-01-00099		6.2	BA-01-00252		19
76	110	6	50	8/9	28-Jun-01	BA1-110-(8/9)-U	BA-01-00086		8.2	BA-01-00239		28
77	116	6	50	8/9	28-Jun-01	BA1-116-(8/9)-U	BA-01-00103		4.3	BA-01-00256		15
78	142	6	50	8/9	28-Jun-01	BA1-142-(8/9)-U	BA-01-00137		9.7	BA-01-00290		27
79	120	7	75	8/9	28-Jun-01	BA1-120-(8/9)-U	BA-01-00123		missing	BA-01-00276		missing
80	125	7	75	8/9	28-Jun-01	BA1-125-(8/9)-U	BA-01-00105		6.4	BA-01-00258		19
81	138	7	75	8/9	28-Jun-01	BA1-138-(8/9)-U	BA-01-00115		22	BA-01-00268		84
82	150	7	75	8/9	28-Jun-01	BA1-150-(8/9)-U	BA-01-00133		13	BA-01-00286		34
83	102	8	25	8/9	28-Jun-01	BA1-102-(8/9)-U	BA-01-00140		4	BA-01-00293		15
84	114	8	25	8/9	28-Jun-01	BA1-114-(8/9)-U	BA-01-00088		3.3	BA-01-00241		15
85	117	8	25	8/9	28-Jun-01	BA1-117-(8/9)-U	BA-01-00089		3.8	BA-01-00242		12
86	126	8	25	8/9	28-Jun-01	BA1-126-(8/9)-U	BA-01-00119		2	BA-01-00272		6.5
87	112	9	50	8/9	28-Jun-01	BA1-112-(8/9)-U	BA-01-00109		6.7	BA-01-00262		25
88	113	9	50	8/9	28-Jun-01	BA1-113-(8/9)-U	BA-01-00114		6.3	BA-01-00267		18
89	135	9	50	8/9	28-Jun-01	BA1-135-(8/9)-U	BA-01-00124		8.8	BA-01-00277		37
90	154	9	50	8/9	28-Jun-01	BA1-154-(8/9)-U	BA-01-00134		8.1	BA-01-00287		28
91	124	10	75	8/9	28-Jun-01	BA1-124-(8/9)-U	BA-01-00118		23	BA-01-00271		80
92	133	10	75	8/9	28-Jun-01	BA1-133-(8/9)-U	BA-01-00130		18	BA-01-00283		58
93	158	10	75	8/9	28-Jun-01	BA1-158-(8/9)-U	BA-01-00106		20	BA-01-00259		62
94	160	10	75	8/9	28-Jun-01	BA1-160-(8/9)-U	BA-01-00117		17	BA-01-00270		57
95	2135	9	50	8/9	28-Jun-01	BA1-2135-(8/9)-U	BA-01-00096		10	BA-01-00249		35
96	2103	6	50	8/9	28-Jun-01	BA1-2103-(8/9)-U	BA-01-00095		4.6	BA-01-00248		17
97	2157	1	0	8/9	28-Jun-01	BA1-2157-(8/9)-U	BA-01-00121		1	BA-01-00274		2
98	AsCtrl			8/9	28-Jun-01	BA1-AsCtrl-(8/9)-U	BA-01-00127		2	BA-01-00280		3
99	AsIA500			8/9	28-Jun-01	BA1-AsIA500-(8/9)-U	BA-01-00131		520	BA-01-00284		560
100	AsIB500			8/9	28-Jun-01	BA1-AsIB500-(8/9)-U	BA-01-00101		530	BA-01-00254		460
101	AsOA500			8/9	28-Jun-01	BA1-AsOA500-(8/9)-U	BA-01-00125		690	BA-01-00278		510
102	AsOB500			8/9	28-Jun-01	BA1-AsOB500-(8/9)-U	BA-01-00126		30	BA-01-00279		480
103	AsIA100			8/9	28-Jun-01	BA1-AsIA100-(8/9)-U	BA-01-00113		110	BA-01-00266		100
104	AsIB100			8/9	28-Jun-01	BA1-AsIB100-(8/9)-U	BA-01-00132		100	BA-01-00285		110
105	AsOA100			8/9	28-Jun-01	BA1-AsOA100-(8/9)-U	BA-01-00102		140	BA-01-00255		98
106	AsOB100			8/9	28-Jun-01	BA1-AsOB100-(8/9)-U	BA-01-00107		9.3	BA-01-00260		99
107	AsIA25			8/9	28-Jun-01	BA1-AsIA25-(8/9)-U	BA-01-00111		25	BA-01-00264		28
108	AsIB25			8/9	28-Jun-01	BA1-AsIB25-(8/9)-U	BA-01-00093		25	BA-01-00246		27
109	AsOA25			8/9	28-Jun-01	BA1-AsOA25-(8/9)-U	BA-01-00122		33	BA-01-00275		28
110	AsOB25			8/9	28-Jun-01	BA1-AsOB25-(8/9)-U	BA-01-00110		3.1	BA-01-00263		26
111	108	1	0	10/11	30-Jun-01	BA1-108-(10/11)-U	BA-01-00173	<	1	BA-01-00326		1.8
112	145	1	0	10/11	30-Jun-01	BA1-145-(10/11)-U	BA-01-00161	<	1	BA-01-00314		2
113	157	1	0	10/11	30-Jun-01	BA1-157-(10/11)-U	BA-01-00144	<	1	BA-01-00297		2
114	122	2	25	10/11	30-Jun-01	BA1-122-(10/11)-U	BA-01-00147		31	BA-01-00300		89
115	123	2	25	10/11	30-Jun-01	BA1-123-(10/11)-U	BA-01-00175		7.1	BA-01-00328		20
116	147	2	25	10/11	30-Jun-01	BA1-147-(10/11)-U	BA-01-00181		23	BA-01-00334		80
117	156	2	25	10/11	30-Jun-01	BA1-156-(10/11)-U	BA-01-00156		26	BA-01-00309		87
118	101	3	50	10/11	30-Jun-01	BA1-101-(10/11)-U	BA-01-00182		5.9	BA-01-00335		21
119	115	3	50	10/11	30-Jun-01	BA1-115-(10/11)-U	BA-01-00151		12	BA-01-00304		36
120	119	3	50	10/11	30-Jun-01	BA1-119-(10/11)-U	BA-01-00179		110	BA-01-00332		400
121	151	3	50	10/11	30-Jun-01	BA1-151-(10/11)-U	BA-01-00152		46	BA-01-00305		190
122	121	4	75	10/11	30-Jun-01	BA1-121-(10/11)-U	BA-01-00169		25	BA-01-00322		140
123	136	4	75	10/11	30-Jun-01	BA1-136-(10/11)-U	BA-01-00168		32	BA-01-00321		120
124	140	4	75	10/11	30-Jun-01	BA1-140-(10/11)-U	BA-01-00153		32	BA-01-00306		110
125	148	4	75	10/11	30-Jun-01	BA1-148-(10/11)-U	BA-01-00158		45	BA-01-00311		140
126	104	5	25	10/11	30-Jun-01	BA1-104-(10/11)-U	BA-01-00163		5.1	BA-01-00316		19
127	106	5	25	10/11	30-Jun-01	BA1-106-(10/11)-U	BA-01-00150		6.1	BA-01-00303		23
128	128	5	25	10/11	30-Jun-01	BA1-128-(10/11)-U	BA-01-00141		3.9	BA-01-00294		missing
129	155	5	25	10/11	30-Jun-01	BA1-155-(10/11)-U	BA-01-00160		5.9	BA-01-00313		20
130	103	6	50	10/11	30-Jun-01	BA1-103-(10/11)-U	BA-01-00148		6.5	BA-01-00301		21
131	110	6	50	10/11	30-Jun-01	BA1-110-(10/11)-U	BA-01-00165		11	BA-01-00318		32
132	116	6	50	10/11	30-Jun-01	BA1-116-(10/11)-U	BA-01-00176		5	BA-01-00329		17
133	142	6	50	10/11	30-Jun-01	BA1-142-(10/11)-U	BA-01-00145		12	BA-01-00298		35
134	120	7	75	10/11	30-Jun-01	BA1-120-(10/11)-U	BA-01-00177		12	BA-01-00330		45
135	125	7	75	10/11	30-Jun-01	BA1-125-(10/11)-U	BA-01-00155		4.5	BA-01-00308		15
136	138	7	75	10/11	30-Jun-01	BA1-138-(10/11)-U	BA-01-00162		33	BA-01-00315		120
137	150	7	75	10/11	30-Jun-01	BA1-150-(10/11)-U	BA-01-00166		6.2	BA-01-00319		23
138	102	8	25	10/11	30-Jun-01	BA1-102-(10/11)-U	BA-01-00167		4.3	BA-01-00320		16
139	114	8	25	10/11	30-Jun-01	BA1-114-(10/11)-U	BA-01-00164		5.8	BA-01-00317		19
140	117	8	25	10/11	30-Jun-01	BA1-117-(10/11)-U	BA-01-00149		3	BA-01-00302		7.7
141	126	8	25	10/11	30-Jun-01	BA1-126-(10/11)-U	BA-01-00180		2	BA-01-00333		5.4
142	112	9	50	10/11	30-Jun-01	BA1-112-(10/11)-U	BA-01-00172		8.1	BA-01-00325		25
143	113	9	50	10/11	30-Jun-01	BA1-113-(10/11)-U	BA-01-00170		4.4	BA-01-00323		19
144	135	9	50	10/11	30-Jun-01	BA1-135-(10/11)-U	BA-01-00171		2	BA-01-00324		5.9

TABLE A-6 URINE ANALYTICAL RESULTS

ID	pig number	group	dosage	day	date collected	sample number	tag number1	HCl04 Q	HClO4 ng/mL	tag number2	MgNO3 Q	MgNO3 ng/mL
145	154	9	50	10/11	30-Jun-01	BA1-154-(10/11)-U	BA-01-00146		13	BA-01-00299		40
146	124	10	75	10/11	30-Jun-01	BA1-124-(10/11)-U	BA-01-00159		11	BA-01-00312		33
147	133	10	75	10/11	30-Jun-01	BA1-133-(10/11)-U	BA-01-00143		15	BA-01-00296		49
148	158	10	75	10/11	30-Jun-01	BA1-158-(10/11)-U	BA-01-00174		26	BA-01-00327		96
149	160	10	75	10/11	30-Jun-01	BA1-160-(10/11)-U	BA-01-00142		14	BA-01-00295		47
150	2145	1	0	10/11	30-Jun-01	BA1-2145-(10/11)-U	BA-01-00157	<	1	BA-01-00310		1
151	2133	10	75	10/11	30-Jun-01	BA1-2133-(10/11)-U	BA-01-00154		14	BA-01-00307		48
152	2148	4	75	10/11	30-Jun-01	BA1-2148-(10/11)-U	BA-01-00183		50	BA-01-00336		140
153	AsCtrl			10/11	30-Jun-01	BA1-AsCtrl-(10/11)-U	BA-01-00178		1	BA-01-00331		3