RELATIVE BIOAVAILABILITY OF ARSENIC IN SOILS FROM EL PASO COUNTY, TEXAS

Prepared for:

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May 2003

ACKNOWLEDGEMENTS

The work described in this report is the product of a team effort involving a number of people. In particular, the authors would like to acknowledge the efforts and support of the following:

- Margaret E. Dunsmore, BS, for helping with all aspects of animal handling and dosing, as well as urine collection and sample preparation.

- Dr. Edward Hinderberger of L.E.T., Inc., Columbia, Missouri, for providing prompt and reliable chemical analysis of all of the biological samples for total arsenic concentrations.

- Weston Solutions, Inc., for collecting the soil samples.

- Severn Trent Laboratories, Inc., for sieving and analyzing the soil samples.

EXECUTIVE SUMMARY

A study using juvenile swine as test animals was performed to measure the gastrointestinal absorption of arsenic from two soil samples from El Paso County, Texas (Test Material 1 and Test Material 2). The relative bioavailability of arsenic was assessed by comparing the absorption of arsenic from the test materials to that of a reference material (sodium arsenate). The arsenic concentrations of Test Material 1 and Test Material 2 were 74 ppm and 73 ppm, respectively. Groups of five swine were given oral doses of sodium arsenate or a test material twice a day for 15 days. The amount of arsenic absorbed by each animal was evaluated by measuring the amount of arsenic excreted in the urine (as measured on days 8, 11, and 14). The urinary excretion fraction (UEF) (the ratio of the amount excreted per 24 hours divided by the dose given per 24 hours) was calculated for sodium arsenate and the test materials using linear regression analysis. The relative bioavailability (RBA) of arsenic in the test material compared to that in sodium arsenate was calculated as:

$$RBA = \frac{UEF(test\ material)}{UEF(sodium\ arsenate)}$$

The results are summarized below:

Material Administered	UEF ± SEM (n)	RBA (90% CI)
Sodium Arsenate (reference material)	0.825 ± 0.045 (37)	[1.00]
Test Material 1	0.362 ± 0.031 (51)	0.44 (0.37-0.52)
Test Material 2	0.302 ± 0.021 (52)	0.37 (0.32-0.42)

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

Using sodium arsenate as a relative frame of reference, the RBA estimate for Test Material 1 is 44% (90^{th} % CI = 37% - 52%) and 37% (32% - 42%) for Test Material 2. These values are significantly lower than the default value of 80%-100% that is usually employed when reliable site-specific data are lacking. This indicates that the arsenic in these soil samples is not as well absorbed as soluble arsenic. Use of these data is likely to improve the accuracy of risk estimates for humans who may incidentally ingest these soils.

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RELATIVE BIOAVAILABILITY OF ARSENIC IN SOILS FROM EL PASO COUNTY, TEXAS

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. This information on absorption may be described either in absolute or relative terms:

Absolute Bioavailability (ABA) is the ratio of the amount of arsenic absorbed to the amount ingested:

$$ABA = \frac{Absorbed\ Dose}{Ingested\ Dose}$$

This ratio is also referred to as the oral absorption fraction (AF_o).

Relative Bioavailability (RBA) is the ratio of the absolute bioavailability of arsenic present in some test material to the absolute bioavailability of arsenic in some appropriate reference material:

$$RBA = \frac{ABA\ (test\ material)}{ABA\ (reference\ material)}$$

Usually the form of arsenic used as the reference material is an arsenic compound dissolved in water or some readily soluble form (e.g., sodium arsenate) that is expected to completely dissolve when ingested.

For example, if 100 µg of arsenic dissolved in drinking water were ingested and a total of 90 µg were absorbed into the body, the ABA would be 0.90 (90%). Likewise, if 100 µg of arsenic contained in soil were ingested and 30 µg were absorbed into the body, the ABA for soil would be 0.30 (30%). If the arsenic dissolved in water was used as the frame of reference for describing the relative amount of arsenic absorbed from soil, the RBA would be 0.30/0.90, or 0.33 (33%).

Using Relative Bioavailability Data to Improve Risk Calculations for Arsenic

When reliable data are available on the relative bioavailability of arsenic in a site medium (e.g., soil), this information can be used to adjust the default toxicity values (RfD_{IRIS}, SF_{IRIS}) for arsenic to account for differences in absorption between arsenic ingested in water and arsenic ingested in site media, as follows:

$$RfD_{adj} = \frac{RfD_{IRIS}}{RBA}$$

$$SF_{adj} = SF_{IRIS} \cdot RBA$$

Alternatively, it is also acceptable to adjust the dose (rather than the toxicity factors) as follows:

$$Dose_{adj} = Dose_{default} \cdot RBA$$

This dose adjustment is mathematically equivalent to adjusting the toxicity factors as described above.

Purpose of This Study

The objective of this study was to use juvenile swine as a test system in order to determine the oral bioavailability of arsenic in two soil samples from El Paso, Texas, relative to the bioavailability of a soluble form of arsenic. The relative bioavailability estimates may be used to improve accuracy and decrease uncertainty in estimating exposures to arsenic in soil in human health risk assessments for these test materials.

2.0 STUDY DESIGN

This investigation of arsenic relative bioavailability 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 soil samples (Test Material 1 and Test Material 2). The reference material was administered to groups of five animals at two different dose levels and the test materials were administered to groups of five animals at three different dose levels, each for 15 days (a detailed schedule is presented in Appendix A, Table A-1). Additionally, the study included a non-treated group of three animals to serve as a control for determining background arsenic levels. All doses were administered orally.

2.1 Test Material

2.1.1 Sample Description

The two soil samples were collected from locations approximately 1.5 miles east of the American Canal in El Paso County, Texas.

2.1.2 Sample Preparation

The soil samples were sieved through a 250 μm sieve prior to test substance analysis and characterization. Only materials that passed through the sieve (corresponding to particles smaller than about 250 μm) were used in the bioavailability study. The study was limited to this fine-grained soil fraction because it is believed that soil particles less than about 250 μm are most likely to adhere to the hands and be ingested by hand-to-mouth contact, especially in young children.

2.1.3 Arsenic Concentration

The concentration of arsenic in the sieved test materials was measured by Severn Trent Laboratories, Inc., in duplicate by inductively coupled plasma atomic emission spectroscopy (ICP-AES). The resulting arsenic values were 74 ppm for Test Material 1 (TM1) and 73 ppm for Test Material 2 (TM2).

2.2 Experimental Animals

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

The number of animals purchased for the study was several more than required by the protocol. These animals were purchased at an age of about 4-5 weeks (weaning occurs at age 3 weeks) and housed in individual stainless steel cages with a 12/12 light/dark cycle. Ambient temperatures ranged from 82-86°F and exhaust fans were activated several times a day. The

animals were held under quarantine for one week to observe their health before beginning exposure to test materials. Each animal was examined by a certified veterinary clinician (swine specialist) and any animals that appeared to be in poor health during this quarantine period were excluded from the study. To minimize weight variations between animals and groups, extra animals most different in body weight (either heavier or lighter) four days prior to exposure (day -6) were also excluded from the study. 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 12.7 kg. The animals were weighed every three days during the course of the study. On average, animals gained about 0.45 kg/day and the rate of weight gain was comparable in all groups, ranging from 0.40 to 0.54 kg/day. These body weight data are summarized in Figure 2-1 and are also presented in Appendix A, Table A-3. All animals were examined daily by an attending veterinarian while on study.

2.3 Diet

Animals were weaned onto standard pig chow (purchased from MFA Inc., Columbia, MO) by the supplier. In order to minimize arsenic exposure from the diet, the animals were transitioned from the MFA feed to a special feed (Zeigler Brothers, Inc., Gardners, PA), and this feed was maintained for the duration of the study. The feed was nutritionally complete and met all requirements of the National Institutes of Health–National Research Council. The typical nutritional components and chemical analysis of the feed is presented in Table 2-2. Each day every animal was given an amount of feed equal to 4% of the mean body weight of all animals on study. Feed amounts were adjusted every three days, when pigs were weighed. Feed was administered in two equal portions at 11:00 AM and 5:00 PM daily. Analysis of a single feed sample indicated that the arsenic level was below the detection limit (50 ng/g), which corresponds to a dose contribution from food of less than 2 μg/kg-day. In addition, previous analysis of feed samples indicated that the arsenic level was generally below the detection limit.

Drinking water was provided *ad libitum* via self-activated watering nozzles within each cage. Analysis of samples from randomly selected drinking water nozzles indicated the arsenic concentration was less than or equal to the quantitation limit (about 1 μg/L). Assuming water intake of about 0.1 L/kg-day, this corresponds to a dose contribution from water of less than 0.1 μg/kg-day.

2.4 Dosing

Animals were exposed to sodium arsenate (abbreviated in this report as "NaAs") or a test material for 15 days, with the dose for each day being administered in two equal portions beginning at 9:00 AM and 3:00 PM (two hours before feeding), with two minute intervals allowed for individual pig dosing. Dose material was placed in the center of one or more small portions (about 5 grams) of moistened feed (this is referred to as a “doughball”), and this was administered to the animals by hand[1]. Because the arsenic concentrations of the test materials

[1] Doses for Days 0-2 were prepared using an alternative method that involved mixing the test material soil with dry feed, then moistening the mixture and forming it into doughballs.

were relatively low in this study, it was necessary to use as many as 5-10 doughballs to administer the doses. In these instances, the amount of feed administered was adjusted accordingly. If uneaten portions of doughballs were discovered, these were retrieved and offered again for consumption. Occasionally, some animals did not consume some or all of their dose. In these instances, the missed doses were estimated and recorded and the time-weighted average dose calculation for each animal was adjusted downward accordingly (see Appendix A, Table A-3).

The dose levels administered were based on the arsenic content of the test material, with target doses of 25 and 50 µg/kg-day for the reference material and 40, 80, and 160 µg/kg-day for each test material. The actual administered arsenic doses are presented in Appendix A, Table A-3.

2.5 Collection and Preservation of Urine Samples

Samples of urine were collected from each animal for 24-hour periods on days 0, 5, 8, 11, and 14 of the study. Collection began at 9:00 AM and ended 24 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 periodically (typically twice daily) into a separate holding container to ensure that there was no loss of sample due to overflow.

At the end of each collection period, the total urine volume for each animal was measured (see Appendix A, Table A-4) and three 60-mL portions were removed and acidified with 0.6 mL concentrated nitric acid. Two of the aliquots were archived in the refrigerator and one aliquot was sent for arsenic analysis. All samples were refrigerated until arsenic analysis.

2.6 Arsenic Analysis

Urine samples were assigned random chain-of-custody tag numbers and submitted to the analytical laboratory for analysis in a blind fashion. Details of urine sample preparation and analysis are provided in USEPA (1999). In brief, 25 mL samples of urine 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. Preliminary tests of this method established that each of the different forms of arsenic that may occur in urine, including trivalent inorganic arsenic (As+3), pentavalent inorganic arsenic (As+5), monomethyl arsenic (MMA) and dimethyl arsenic (DMA), are all recovered with high efficiency. Urine analytical results are presented in Appendix A, Table A-5.

2.6.1 Laboratory Quality Assurance

A number of quality assurance (QA) steps were taken during this project to evaluate the accuracy of the analytical procedures. Steps performed by the analytical laboratory included:

Spike Recovery

Randomly selected urine samples were spiked with known amounts of arsenic (usually 400 µg, as sodium arsenate) and the recovery of the added arsenic was measured. Recovery for individual samples ranged from 100% to 113%, with an average across all analyses of 104 ± 3% (N = 25).

Duplicate Analysis

The laboratory analyst selected random urine samples for duplicate analysis. Duplicate results had a relative percent difference (RPD) of 0% to 12.0%, with an average of 2.4% ± 3.7% (N = 24).

Laboratory Control Standards

Five different types of laboratory control standards were tested periodically during the analysis. These are samples for which a certified concentration of arsenic has been established. Results for these standards are summarized below:

Check Sample	Certified Value	Average Recovery	SEM	n
E.R.A. P081 - Metals WasteWatR	366 ng/ml	99%	1.7%	92
N.R.C.C. Dolt-2 Dogfish Liver	16.6 +/- 1.1 Mcg/g dry wt	93%	3.5%	4
N.R.C.C. Tort-2 Lobster	21.6 +/- 1.8 Mcg/g dry wt	102%	3.8%	4
N.I.S.T. Oyster 1566b	7.65 +/- 0.65 Mcg/g dry wt	105%	6.4%	4
N.I.S.T. 1640	0.0267 +/- 0.0004	97%	--	1

SEM = Standard error of the mean (standard deviation)
n = Number of data points used in curve fitting

As seen, recovery of arsenic from these standards was generally good.

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 ng of arsenic (N = 13).

2.6.2 Blind Quality Assurance Samples

In addition to these laboratory-sponsored QA samples, an additional series of QA samples were 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. As seen, there was good recovery of the arsenic in all cases.

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

Based on the results of all of the quality assurance samples and steps described above, it is concluded that the analytical results for samples of urine are of high quality and are suitable for derivation of reliable estimates of arsenic absorption from test materials.

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) 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 (i.e., a 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:

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

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 (µg/24 hrs) = Concentration (µg/L) · Volume (L/24 hrs)

- Because previous swine arsenic bioavailability studies have shown that urinary arsenic excretion patterns are stable after five days of dosing (USEPA, 1997), UEF and RBA calculations were based on data from days 8, 11, and 14 only (not days 0 and 5).

- For each test material, the amount of arsenic excreted by each animal was plotted as a function of the amount administered (µg/24 hours), and the best fit straight line (calculated by linear regression) through the data (µg excreted per µg administered) was used as the best estimate of the urinary excretion fraction (UEF).

- The relative bioavailability of arsenic in a 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 calculated using Monte Carlo simulation. The probability density function describing the confidence around each slope (UEF) term 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 the 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

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 the study.

4.2 Data Exclusions

Occasionally, the dilution of urine by spilled water is so large that the concentration of arsenic in the urine cannot be quantified. These instances are defined by having a urine arsenic concentration at or below the quantitation limit (2 µg/L) and a total urine volume greater than 5000 mL. When both of these conditions are met, the data are deemed unreliable and excluded from further calculations. In this study, data from one animal on two different days (pig #1550 from group 1 on days 11 and 14) were deemed unreliable for this reason and excluded.

In addition, the datum for pig #80 (group 4, low dose of TM1) on day 14 was excluded because the amount of arsenic excreted was substantially higher than for the other four animals in that group, as well as all other animals in the study. This datum is indicated as an outlier in Figure 4-2.

4.3 Urinary Excretion Fractions and Relative Bioavailability

Detailed results from the study are presented in Appendix A. The urinary excretion results on days 8, 11, and 14 for NaAs, TM1, and TM2 are summarized in Figures 4-1, 4-2, and 4-3, respectively. (Urinary excretion results for all days, including days 0 and 5, are presented in Appendix A, Figures A-1, A-2, and A-3.) Although there is variability in the data, all of 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). As discussed previously, the relative bioavailability of arsenic in a specific test material is calculated as follows:

$$\text{RBA(test } \textit{vs.} \text{ NaAs)} = \text{UEF(test)} / \text{UEF(NaAs)}$$

The following table summarizes the best fit slopes (urinary excretion fractions) for sodium arsenate and the utility pole soil, as well as the estimated RBA:

Material Administered	UEF ± SEM (n)	RBA (90% CI)
Sodium Arsenate (reference material)	0.825 ± 0.045 (37)	[1.00]
Test Material 1	0.362 ± 0.031 (51)	0.44 (0.37-0.52)
Test Material 2	0.302 ± 0.021 (52)	0.37 (0.32-0.42)

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

As seen, using sodium arsenate as a relative frame of reference, the RBA estimate is 44% for TM1 and 37% for TM2.

The RBA estimates for the two test materials are markedly lower than the default value range of 80%-100% that is usually employed for arsenic in soil when reliable site-specific data are lacking. This indicates that the arsenic in these soils is not as well absorbed as soluble arsenic, and it is appropriate to take this into account when evaluating potential risks to humans from incidental ingestion of these soils.

5.0 REFERENCES

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Weis, C.P., and J. M. LaVelle. 1991. Characteristics to consider when choosing an animal model for the study of lead bioavailability. In: The Proceedings of the International Symposium on the Bioavailability and Dietary Uptake of Lead. Science and Technology Letters 3:113-119.

APPENDIX A

DETAILED RESULTS

TABLE 2-1 STUDY DESIGN

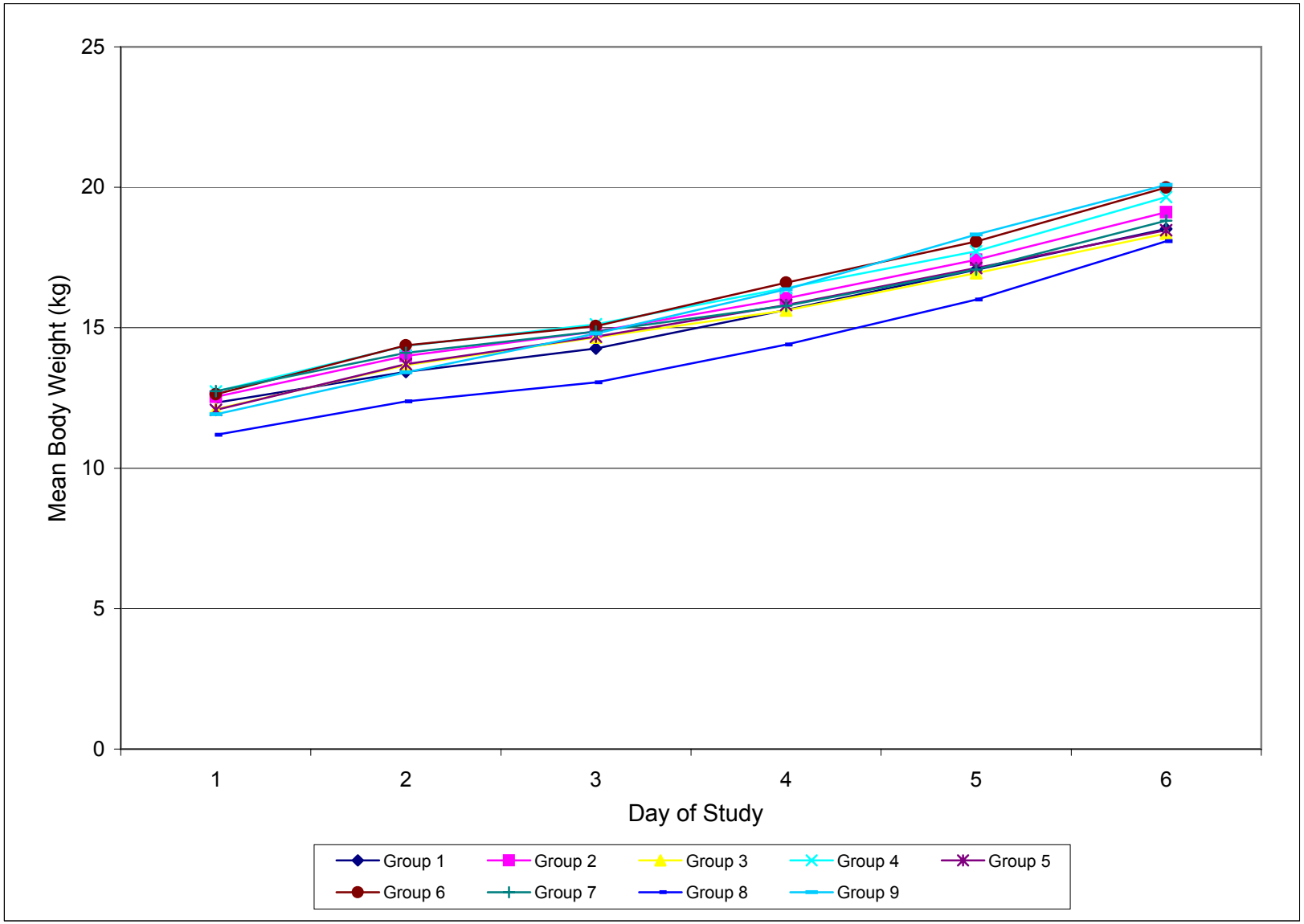
Group	Number of Animals	Dose Material Administered	Target Elemental Arsenic Dose (ug/kg-day)
1	3	Control	0
2	5	Sodium Arsenate	25
3	5	Sodium Arsenate	50
4	5	TM1	40
5	5	TM1	80
6	5	TM1	160
7	5	TM2	40
8	5	TM2	80
9	5	TM2	160

TABLE 2-2 TYPICAL FEED COMPOSITION

Nutrient Name	Amount	Nutrient Name	Amount
Protein	20.1021%	Chlorine	0.1911%
Arginine	1.2070%	Magnesium	0.0533%
Lysine	1.4690%	Sulfur	0.0339%
Methionine	0.8370%	Manganese	20.4719 ppm
Met+Cys	0.5876%	Zinc	118.0608 ppm
Tryptophan	0.2770%	Iron	135.3710 ppm
Histidine	0.5580%	Copper	8.1062 ppm
Leucine	1.8160%	Cobalt	0.0110 ppm
Isoleucine	1.1310%	Iodine	0.2075 ppm
Phenylalanine	1.1050%	Selenium	0.3196 ppm
Phe+Tyr	2.0500%	Nitrogen Free Extract	60.2340%
Threonine	0.8200%	Vitamin A	5.1892 kIU/kg
Valine	1.1910%	Vitamin D3	0.6486 kIU/kg
Fat	4.4440%	Vitamin E	87.2080 IU/kg
Saturated Fat	0.5590%	Vitamin K	0.9089 ppm
Unsaturated Fat	3.7410%	Thiamine	9.1681 ppm
Linoleic 18:2:6	1.9350%	Riboflavin	10.2290 ppm
Linoleic 18:3:3	0.0430%	Niacin	30.1147 ppm
Crude Fiber	3.8035%	Pantothenic Acid	19.1250 ppm
Ash	4.3347%	Choline	1019.8600 ppm
Calcium	0.8675%	Pyridoxine	8.2302 ppm
Phos Total	0.7736%	Folacin	2.0476 ppm
Available Phosphorous	0.7005%	Biotin	0.2038 ppm
Sodium	0.2448%	Vitamin B12	23.4416 ppm
Potassium	0.3733%		

Feed obtained from and nutritional values provided by Zeigler Bros., Inc

FIGURE 2-1 BODY WEIGHT GAIN



EP Weights.xls (Fig2-1_group weights)

FIGURE 2-2 PERFORMANCE EVALUATION SAMPLES

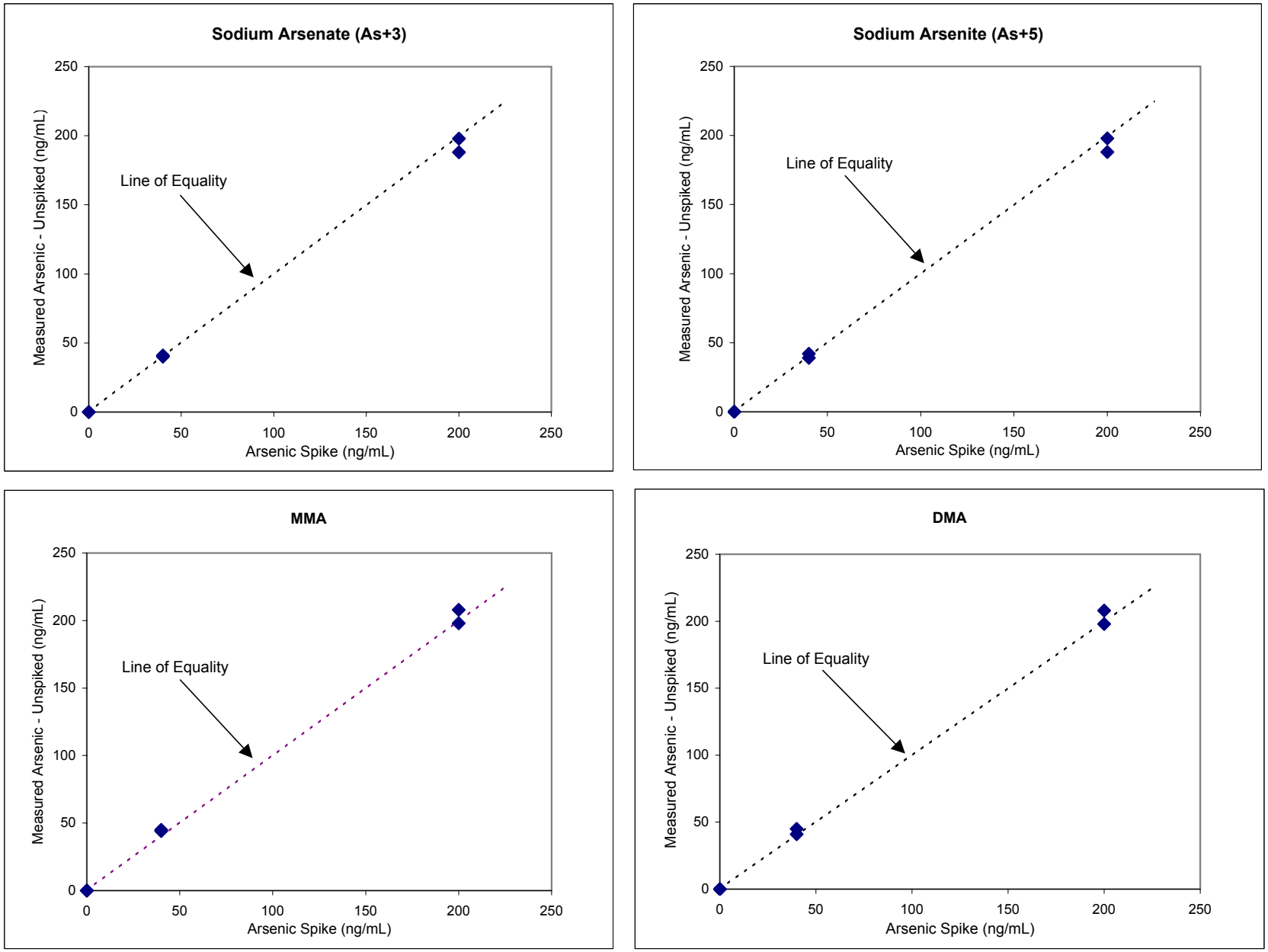
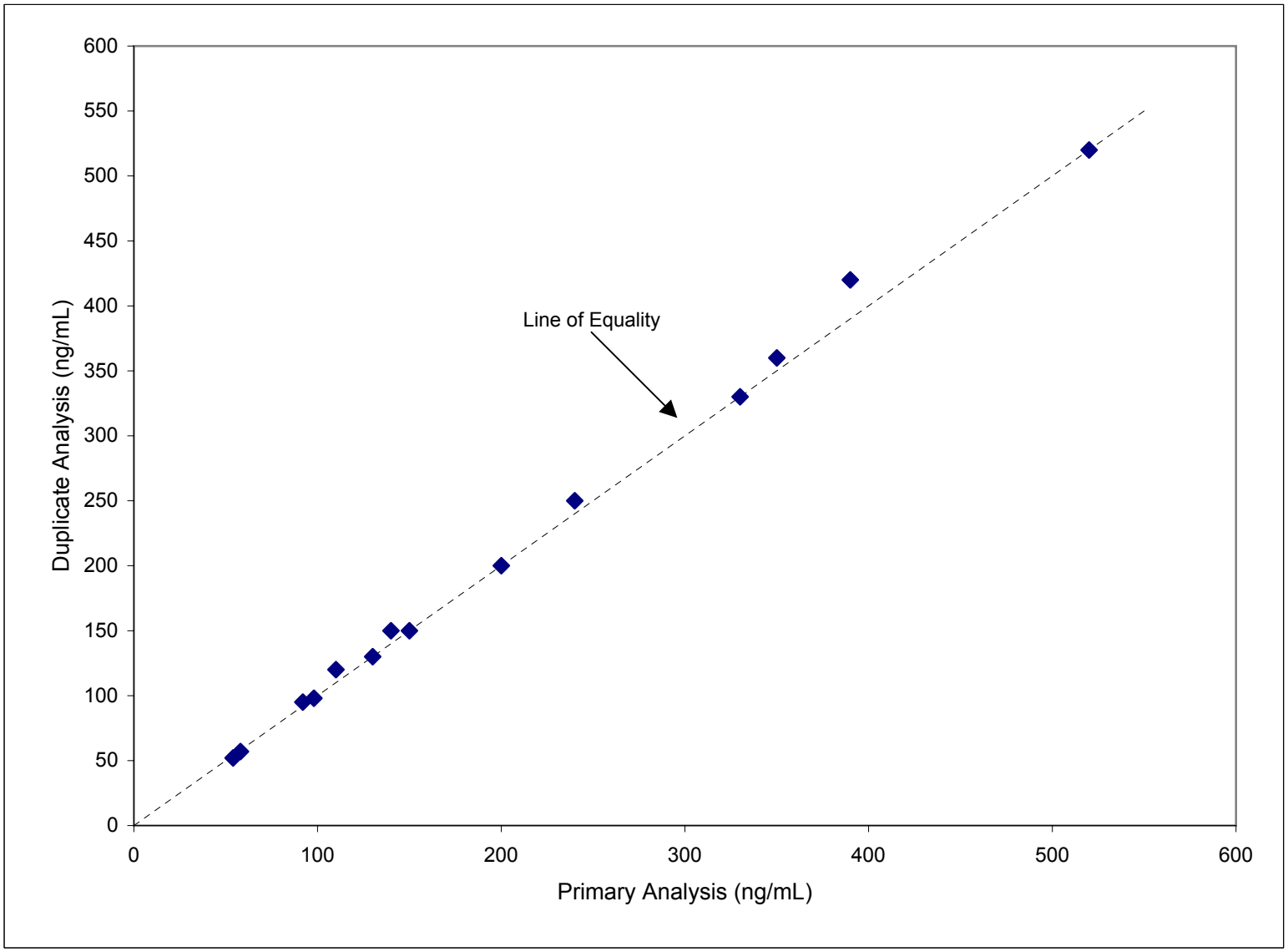
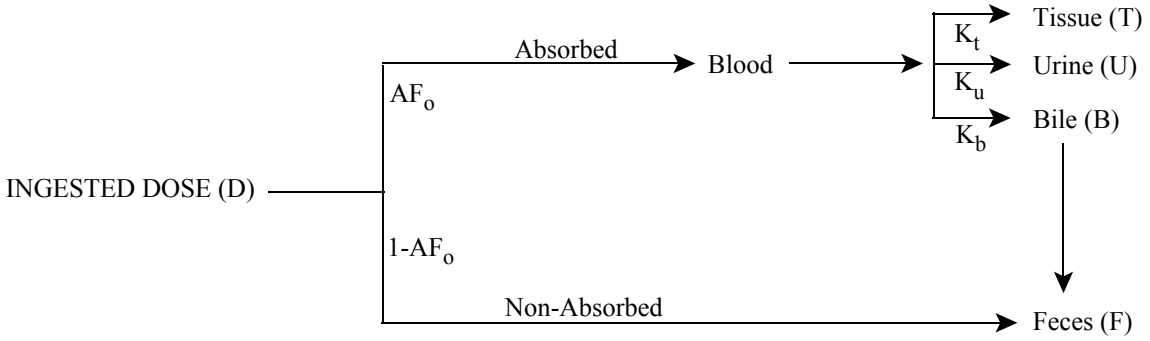


FIGURE 2-3 BLIND DUPLICATE SAMPLES



EP Blind QC analysis.xls (Fig2-3_Dup)

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 URINARY EXCRETION OF ARSENIC FROM SODIUM ARSENATE

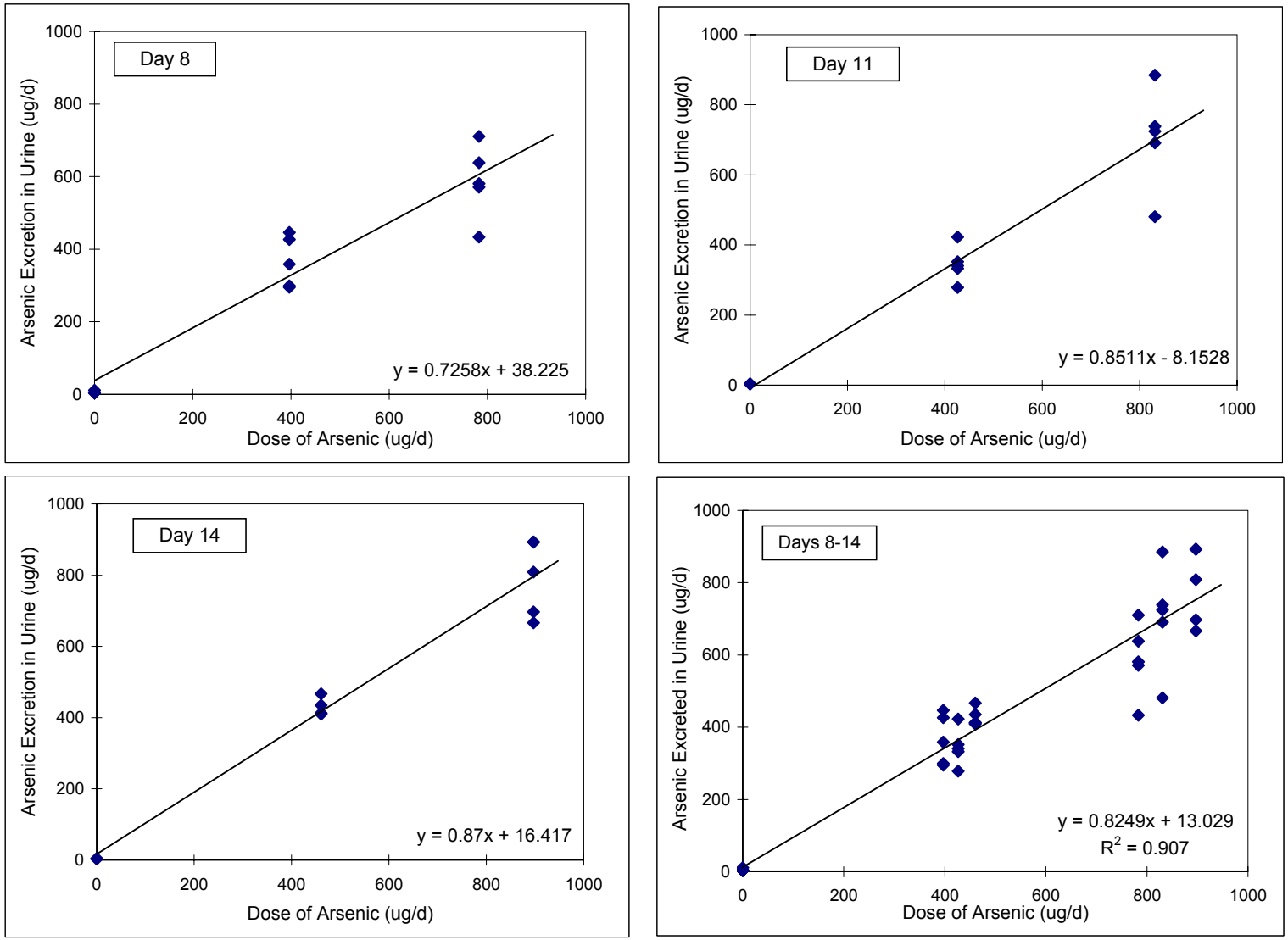


FIGURE 4-2 URINARY EXCRETION OF ARSENIC FROM TEST MATERIAL 1

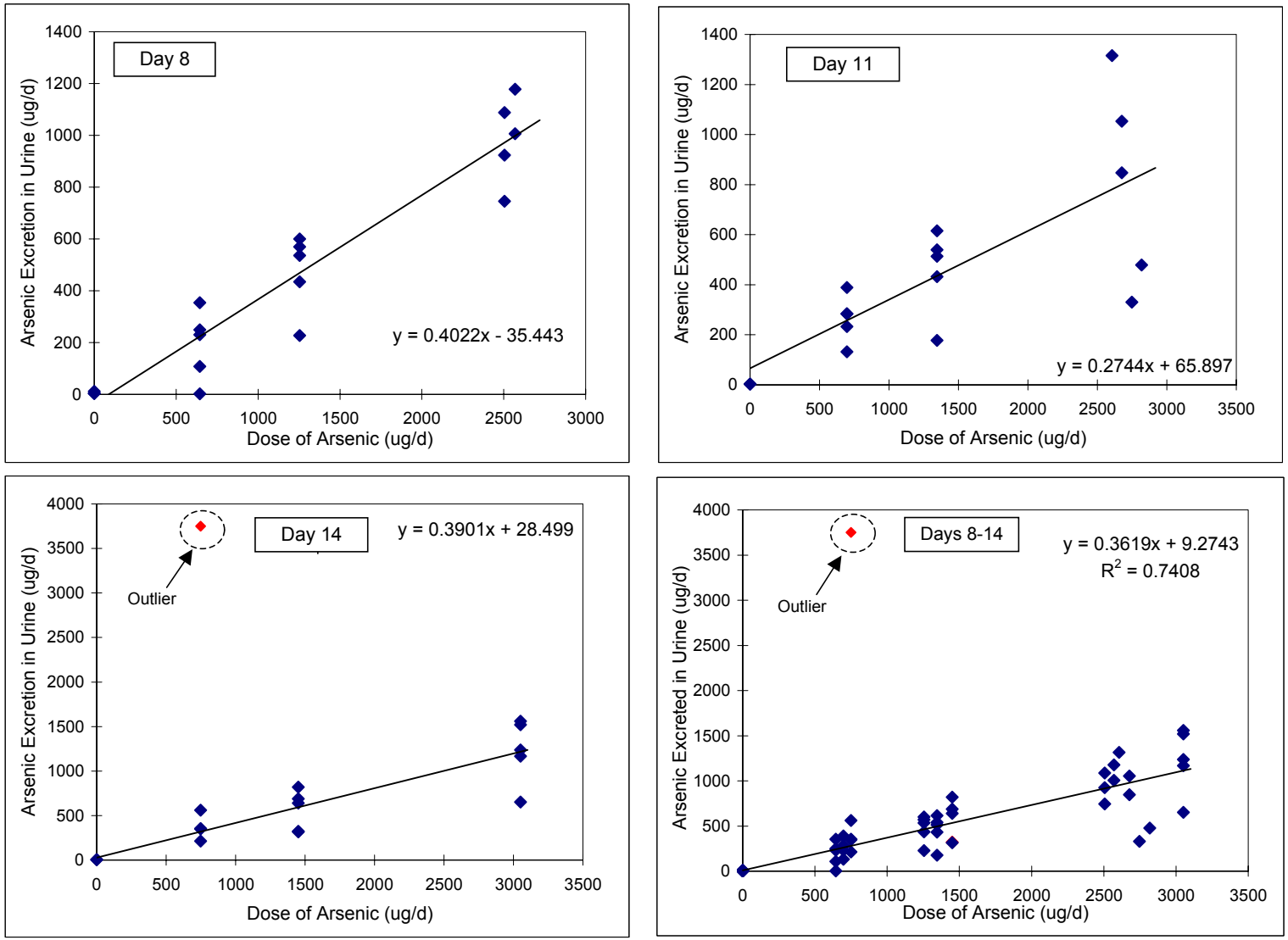
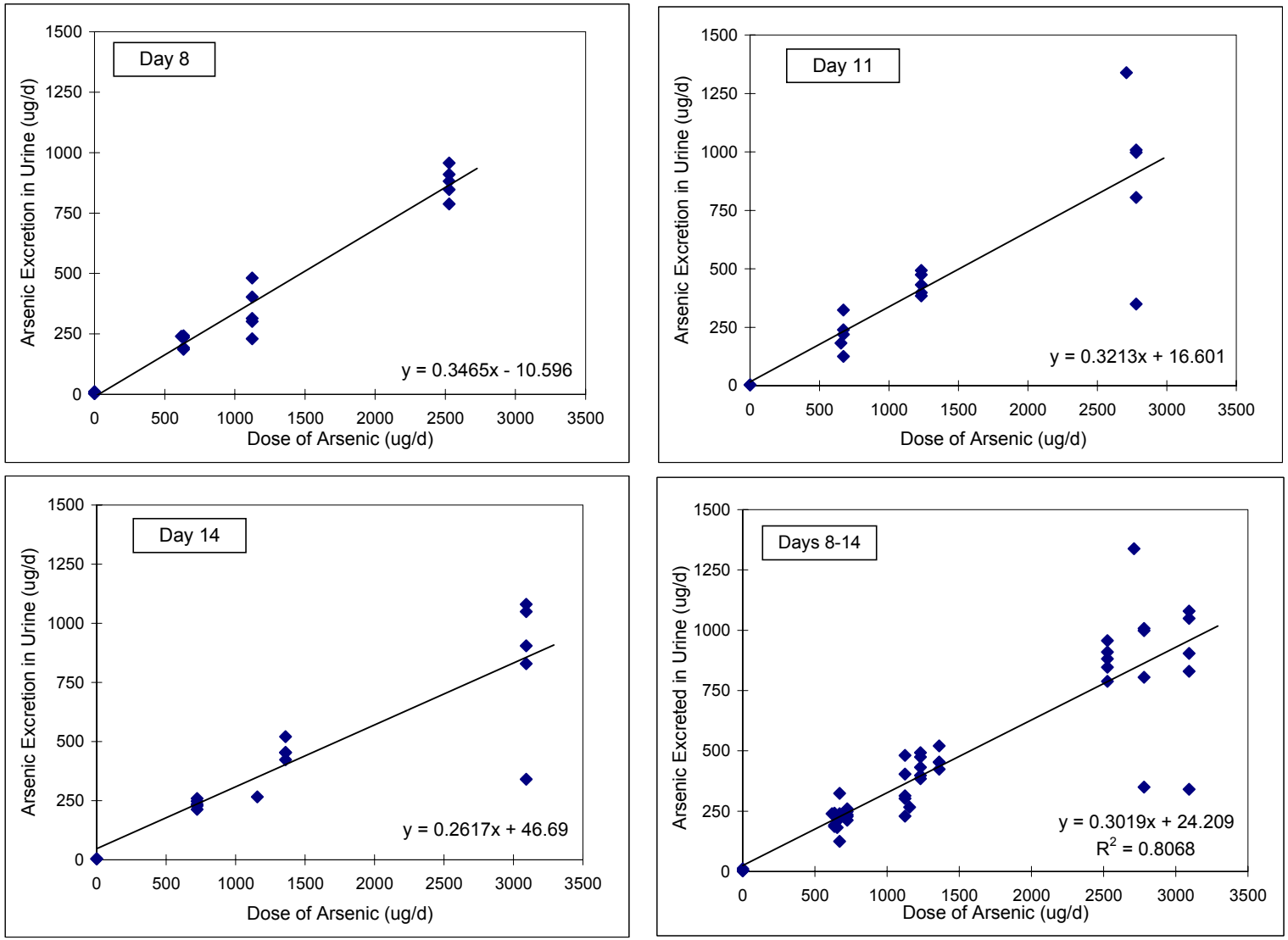


FIGURE 4-3 URINARY EXCRETION OF ARSENIC FROM TEST MATERIAL 2



APPENDIX A

DETAILED RESULTS

TABLE A-1 SCHEDULE

Study Day	Day	Date	Dose Administration	Feed Special Diet	Weigh	Dose Prep	Cull Pigs/ Assign Dose Group	24 hr Urine Collection	Bleed	Sacrifice/ Necropsy
-6	Tuesday	11/26/02		X	X		X			
-5	Wednesday	11/27/02		X						
-4	Thursday	11/28/02		X						
-3	Friday	11/29/02		X						
-2	Saturday	11/30/02		X						
-1	Sunday	12/01/02		X	X	X				
0	Monday	12/02/02	X	X				X	X	
1	Tuesday	12/03/02	X	X						
2	Wednesday	12/04/02	X	X	X	X				
3	Thursday	12/05/02	X	X						
4	Friday	12/06/02	X	X						
5	Saturday	12/07/02	X	X	X	X		X		
6	Sunday	12/08/02	X	X						
7	Monday	12/09/02	X	X						
8	Tuesday	12/10/02	X	X	X	X		X		
9	Wednesday	12/11/02	X	X						
10	Thursday	12/12/02	X	X					X	
11	Friday	12/13/02	X	X	X	X		X		
12	Saturday	12/14/02	X	X						
13	Sunday	12/15/02	X	X						
14	Monday	12/16/02	X	X	X			X		
15	Tuesday	12/17/02								X

TABLE A-2 GROUP ASSIGNMENTS

Pig Number	Dose Group	Material Administered	Target Dose of Arsenic (ug/kg-day)
84 91 1550	1	Control	0
76 90 1542 1547 1562	2	NaAs	25
70 73 81 1541 1556	3	NaAs	50
64 77 80 92 1548	4	TM1	40
87 97 1543 1546 1553	5	TM1	80
66 68 86 1545 1561	6	TM1	160
69 75 78 98 1564	7	TM2	40
88 89 99 100 1563	8	TM2	80
65 82 95 1549 1558	9	TM2	160

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

Body weights were measured on days -1, 2, 5, 8, 11, and 14. Weights for other days are estimated, based on linear interpolation between measured values.

Group	Pig #	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		Day 12	
		BW (kg)	As Dose (ug/kg-d)	BW (kg)	As Dose (ug/kg-d)	BW (kg)	As Dose (ug/kg-d)	BW (kg)	As Dose (ug/kg-d)	BW (kg)	As Dose (ug/kg-d)	BW (kg)	As Dose (ug/kg-d)	BW (kg)	As Dose (ug/kg-d)	BW (kg)	As Dose (ug/kg-d)	BW (kg)	As Dose (ug/kg-d)	BW (kg)	As Dose (ug/kg-d)	BW (kg)	As Dose (ug/kg-d)	BW (kg)	As Dose (ug/kg-d)	BW (kg)	As Dose (ug/kg-d)	BW (kg)	As Dose (ug/kg-d)
1	84	10.6	0.00	10.8	0.00	11.0	0.00	11.2	0.00	11.4	0.00	11.7	0.00	11.9	0.00	12.4	0.00	12.9	0.00	13.5	0.00	13.8	0.00	14.1	0.00	14.4	0.00	15.1	0.00
1	91	14.3	0.00	14.7	0.00	15.1	0.00	15.6	0.00	16.0	0.00	16.4	0.00	16.8	0.00	17.2	0.00	17.6	0.00	18.0	0.00	18.5	0.00	19.0	0.00	19.6	0.00	20.1	0.00
1	1550	12.1	0.00	12.6	0.00	13.1	0.00	13.6	0.00	13.8	0.00	13.9	0.00	14.1	0.00	14.6	0.00	15.0	0.00	15.5	0.00	16.1	0.00	16.7	0.00	17.3	0.00	17.5	0.00
2	76	12.6	0.00	13.1	25.94	13.5	25.07	14.0	24.27	14.3	26.19	14.7	25.54	15.1	24.92	15.5	25.65	15.9	24.98	16.3	24.34	16.8	25.42	17.2	24.73	17.7	24.08	18.2	25.26
2	90	12.0	0.00	12.5	27.19	13.0	26.14	13.5	25.17	13.6	27.51	13.8	27.14	14.0	26.79	14.4	27.65	14.7	26.99	15.1	26.36	15.6	27.35	16.1	26.45	16.7	25.60	17.2	26.77
2	1542	14.5	0.00	15.1	22.47	15.7	21.58	16.3	20.77	16.5	22.70	16.7	22.41	17.0	22.12	17.4	22.85	17.8	22.31	18.2	21.80	18.6	22.88	19.1	22.36	19.5	21.86	19.9	23.16
2	1547	11.5	0.00	11.9	28.57	12.2	27.75	12.6	26.97	12.9	29.11	13.2	28.37	13.6	27.68	13.9	28.51	14.3	27.78	14.7	27.08	15.1	28.20	15.6	27.35	16.1	26.56	17.0	27.11
2	1562	12.2	0.00	12.7	26.62	13.2	25.58	13.8	24.62	14.1	26.60	14.5	25.95	14.8	25.34	15.1	26.25	15.4	25.71	15.8	25.19	16.2	26.26	16.7	25.50	17.2	24.78	17.6	26.14
3	70	13.7	0.00	14.3	45.96	14.8	44.26	15.4	42.67	15.8	46.57	16.2	45.42	16.6	44.32	16.9	46.33	17.3	45.39	17.6	44.49	18.0	46.08	18.5	45.00	18.9	43.97	19.5	46.04
3	73	12.5	0.00	12.8	51.04	13.2	49.56	13.6	48.16	13.9	52.77	14.2	51.65	14.5	50.59	14.8	52.91	15.1	51.85	15.4	50.84	15.9	52.37	16.3	50.88	16.8	49.46	17.3	52.00
3	81	12.7	0.00	13.4	49.06	14.1	46.62	14.8	44.41	15.0	48.85	15.3	47.99	15.6	47.17	15.9	49.35	16.2	48.38	16.5	47.45	17.2	48.45	17.8	46.69	18.5	45.04	18.9	47.46
3	1541	11.8	0.00	12.2	53.84	12.6	52.05	13.0	50.38	13.4	54.74	13.8	53.15	14.2	51.65	14.5	54.12	14.7	53.14	15.0	52.20	15.3	54.25	15.6	53.16	16.0	52.10	16.4	54.81
3	1556	10.0	0.00	10.5	62.28	11.1	59.10	11.7	56.22	11.9	61.47	12.2	60.04	12.5	58.68	12.9	60.85	13.2	59.17	13.6	57.57	13.9	59.64	14.3	58.25	14.6	56.92	15.1	59.60
4	64	12.5	0.00	13.2	41.50	14.0	39.32	14.7	37.36	14.9	41.21	15.1	40.66	15.3	40.13	15.7	41.07	16.1	40.05	16.5	39.08	17.0	41.09	17.4	40.02	17.9	39.01	18.5	40.44
4	77	14.2	0.00	14.6	37.66	15.0	36.57	15.5	35.55	15.7	39.11	16.0	38.50	16.2	37.90	16.7	38.57	17.2	37.42	17.8	36.33	18.1	38.44	18.5	37.68	18.9	36.94	19.5	38.43
4	80	10.8	0.00	11.4	48.03	12.1	45.33	12.8	42.91	13.0	47.23	13.2	46.52	13.4	45.82	13.8	46.78	14.2	45.52	14.6	44.32	15.1	46.22	15.6	44.69	16.1	43.25	16.7	44.97
4	92	13.3	0.00	13.9	39.51	14.5	37.88	15.1	36.37	15.3	40.04	15.6	39.44	15.8	38.86	16.2	39.93	16.5	39.08	16.9	38.27	17.4	40.10	17.9	38.94	18.4	37.85	19.1	39.31
4	1548	13.0	0.00	13.2	41.61	13.5	40.83	13.7	40.09	14.1	43.55	14.5	42.34	14.9	41.21	15.4	41.87	15.9	40.55	16.4	39.32	16.7	41.62	17.1	40.80	17.4	40.02	18.1	41.33
5	87	9.9	0.00	10.5	99.74	11.1	94.06	11.8	88.99	12.1	97.06	12.5	94.21	12.9	91.52	13.3	94.67	13.7	91.90	14.1	89.28	14.5	92.64	15.0	89.75	15.5	87.04	16.0	90.56
5	97	11.4	0.00	11.8	88.49	12.3	85.12	12.8	82.01	13.1	89.66	13.5	87.22	13.9	84.91	14.3	87.62	14.8	84.85	15.3	82.26	15.6	86.02	16.0	83.96	16.4	82.00	17.0	85.49
5	1543	11.3	0.00	11.7	89.62	12.1	86.53	12.5	83.65	12.9	90.93	13.4	87.98	13.8	85.22	14.0	89.49	14.2	88.13	14.5	86.81	15.0	89.85	15.5	86.85	16.0	84.05	16.4	88.62
5	1546	13.9	0.00	14.3	73.12	14.8	70.89	15.2	68.79	15.4	76.45	15.6	75.55	15.8	74.67	16.2	77.67	16.6	75.79	17.0	74.01	17.3	77.58	17.7	75.91	18.1	74.30	18.5	78.61
5	1553	14.1	0.00	14.8	70.65	15.6	67.24	16.3	64.15	16.6	70.91	16.9	69.72	17.2	68.57	17.6	71.48	18.0	69.88	18.4	68.36	18.8	71.53	19.3	69.86	19.7	68.26	20.1	72.22
6	66	12.4	0.00	13.0	167.54	13.6	159.96	14.3	153.04	14.3	171.77	14.4	170.98	14.5	170.19	15.1	170.36	15.7	159.41	16.4	153.23	16.9	166.72	17.5	161.47	18.0	148.71	18.6	164.49
6	68	13.3	0.00	13.8	158.41	14.3	152.68	14.8	147.35	15.0	164.31	15.1	162.50	15.3	160.73	15.7	147.30	16.1	155.61	16.5	151.84	17.0	166.07	17.4	161.62	17.9	149.54	18.3	166.88
6	86	10.6	0.00	11.0	197.66	11.5	190.19	11.9	183.26	12.2	201.30	12.5	196.21	12.9	191.38	13.3	192.96	13.8	167.79	14.3	175.81	14.6	193.65	14.9	189.74	15.2	181.33	15.9	192.10
6	1545	13.5	0.00	14.0	155.40	14.6	149.20	15.2	143.47	15.5	159.17	15.7	156.64	16.0	154.18	16.5	155.89	17.0	151.00	17.6	146.42	18.1	155.67	18.7	151.08	19.2	135.74	20.0	152.31
6	1561	13.5	0.00	14.2	153.58	15.0	145.87	15.7	138.90	16.1	153.22	16.4	149.95	16.8	146.82	17.3	148.53	17.9	143.96	18.4	139.65	19.0	148.56	19.5	144.25	20.1	140.18	20.8	146.69
7	69	13.7	0.00	14.2	38.75	14.7	37.35	15.3	36.04	15.6	38.87	15.9	38.13	16.2	37.42	16.4	38.75	16.6	38.20	16.9	37.67	17.4	38.65	17.9	37.53	18.4	35.57	18.9	38.18
7	75	13.3	0.00	13.7	40.17	14.1	39.07	14.5	38.03	14.8	40.79	15.2	39.81	15.6	38.87	15.9	40.01	16.2	39.23	16.5	38.47	16.8	39.87	17.2	39.10	17.5	38.35	18.2	39.82
7	78	10.6	0.00	11.2	49.29	11.7	46.97	12.3	44.87	12.3	49.20	12.3	49.07	12.4	48.94	12.7	49.98	13.1	48.64	13.4	46.19	13.9	48.29	14.4	46.61	14.9	45.05	15.4	46.88
7	98	12.7	0.00	13.2	41.64	13.7	40.12	14.2	38.70	14.5	41.63	14.8	40.75	15.2	39.89	15.2	41.76	15.3	41.63	15.3	41.49	15.8	42.48	16.3	41.18	16.8	39.95	16.6	43.50
7	1564	13.5	0.00	13.8	39.92	14.1	39.02	14.4	38.17	14.7	41.26	14.9	40.56	15.2	39.89	15.7	40.39	16.3	38.98	16.9	37.67	17.2	39.14	17.5	38.46	17.8	37.81	19.1	37.78
8	88	10.6	0.00	10.9	44.87	11.1	87.59	11.4	85.54	11.7	91.23	12.1	88.71	12.4	86.32	12.7	88.27	13.1	86.02	13.4	83.88	13.6	90.92	13.7	89.93	13.9	88.95	14.3	94.99
8	89	13.6	0.00	13.9	70.24	14.2	68.60	14.6	41.89	14.7	7.27	14.9	71.92	15.1	71.12	15.7	71.82	16.3	69.17	16.9	66.71	17.5	70.53	18.1	68.13	18.7	65.88	19.1	71.14
8	99	10.2	0.00	10.6	69.22	10.9	89.20	11.3	86.30	11.5	93.08	11.7	91.49	11.9	89.95	12.2	92.38	12.4	90.40	12.7	88.50	13.4	92.05	14.1	87.58	14.8	83.53	15.6	87.46
8	100	9.8	0.00	10.3	94.53	10.8	90.02	11.4	85.92	11.5	93.35	11.6	92.41	11.7	91.49	12.3	91.51	12.9	87.36	13.5	83.57	14.1	87.69	14.7	84.10	15.3	80.79	15.8	86.35
8	1563	11.8	0.00	12.3	79.28	12.8	76.19	13.3	73.32	13.6	78.71	13.9	77.01	14.2	75.38	14.7	76.64	15.1	74.27	15.6	72.05	16.2	75.97	16.8	73.19	17.5	70.60	18.7	72.60
9	65	13.7	0.00	14.1	146.61	14.5	142.57	14.9	138.74	15.3	150.37	15.8	146.23	16.2	142.32	16.9	149.79	17.5	144.09	18.2	138.81	18.9	146.92	19.6	141.56	20.4	136.57	20.8	148.97
9	82	11.0	0.00	11.5	179.50	12.0	171.79	12.6	164.72	13.1	176.45	13.6	169.74	14.1	163.52	14.6	172.65	15.2	166.58	15.7	160.92	16.4	169.98	17.0	163.48	17.7	153.53	18.1	153.42
9	95	12.9	0.00	13.7	113.58	14.5	89.41	15.3	135.55	15.5	148.91	15.7	132.03	16.0	144.55	16.6	152.50	17.2	147.03	17.8	141.93	18.5	150.50	19.1	145.25	19.8	140.36	20.3	152.03
9	1549	11.9	0.00	12.1	149.08	12.4	104.47	12.6	102.54	13.3	173.79	13.9	153.06	14.6	157.92	15.2	166.76	15.7	160.92	16.3	155.47	17.1	146.70	17.9	155.70	18.7	149.02	19.5	158.79
9	1558	10.2	0.00	10.7	193.50	11.2	184.30	11.8	175.93	12.2	188.98	12.7	182.26	13.1	176.00	13.4	189.01	13.6	185.31	13.9	181.76	14.3	194.12	14.7	188.63	15.2	183.45	15.9	195.03

Missed Doses:

Day 0 - Pig 95 did not eat entire AM dose (ate approximately 50%). Daily dose adjusted to 75%.
Day 0 - Pig 1549 did not eat entire AM dose (ate approximately 75%). Daily dose adjusted to 87.5%.
Day 0 - Pig 88 did not eat entire PM dose (ate approximately 0%). Daily dose adjusted to 50%.
Day 0 - Pig 99 did not eat entire PM dose (ate approximately 50%). Daily dose adjusted to 75%.
Day 1 - Pig 95 did not eat entire PM dose (ate approximately 25%). Daily dose adjusted to 62.5%.
Day 1 - Pig 1549 did not eat entire PM dose (ate approximately 25%). Daily dose adjusted to 62.5%.
Day 2 - Pig 1549 did not eat entire PM dose (ate approximately 25%). Daily dose adjusted to 62.5%.
Day 2 - Pig 89 did not eat entire PM dose (ate approximately 25%). Daily dose adjusted to 62.5%.
Day 3 - Pig 89 did not eat entire AM or PM dose (ate approximately 10% of each). Daily dose adjusted to 10%.
Day 4 - Pig 95 did not eat entire AM dose (ate approximately 80%). Daily dose adjusted to 90%.
Day 4 - Pig 1549 did not eat entire AM dose (ate approximately 85%). Daily dose adjusted to 92.5%.
Day 6 - Pig 68 did not eat entire PM dose (ate approximately 80%). Daily dose adjusted to 90%.
Day 7 - Pig 86 did not eat entire PM dose (ate approximately 80%). Daily dose adjusted to 90%.
Day 7 - Pig 68 did not eat entire PM dose (ate approximately 95%). Daily dose adjusted to 97.5%.
Day 7 - Pig 66 did not eat entire PM dose (ate approximately 95%). Daily dose adjusted to 97.5%.
Day 8 - Pig 66 did not eat entire PM dose (ate approximately 95%). Daily dose adjusted to 97.5%.
Day 8 - Pig 68 did not eat entire PM dose (ate approximately 95%). Daily dose adjusted to 97.5%.
Day 8 - Pig 78 did not eat entire PM dose (ate approximately 95%). Daily dose adjusted to 97.5%.
Day 8 - Pig 86 did not eat entire PM dose (ate approximately 95%). Daily dose adjusted to 97.5%.
Day 9 - Pig 1549 did not eat entire PM dose (ate approximately 80%). Daily dose adjusted to 90%.
Day 11 - Pig 66 did not eat entire PM dose (ate approximately 90%). Daily dose adjusted to 95%.
Day 11 - Pig 68 did not eat entire PM dose (ate approximately 90%). Daily dose adjusted to 95%.
Day 11 - Pig 1545 did not eat entire PM dose (ate approximately 85%). Daily dose adjusted to 92.5%.
Day 11 - Pig 69 did not eat entire PM dose (ate approximately 95%). Daily dose adjusted to 97.5%.
Day 11 - Pig 86 did not eat entire PM dose (ate approximately 95%). Daily dose adjusted to 97.5%.
Day 11 - Pig 82 did not eat entire PM dose (ate approximately 95%). Daily dose adjusted to 97.5%.
Day 12 - Pig 82 did not eat entire PM dose (ate approximately 80%). Daily dose adjusted to 90%.
Day 13 - Pig 68 did not eat entire AM dose (ate approximately 80%). Daily dose adjusted to 90%.
Day 13 - Pig 82 did not eat entire AM dose (ate approximately 95%). Daily dose adjusted to 97.5%.
Day 14 - Pig 88 did not eat entire AM dose (ate approximately 70%). Daily dose adjusted to 85%.

TABLE A-4 URINE VOLUMES - 24 HOUR COLLECTIONS

Units of Volume: mls

Group	Pig ID	Urine Collection			
		Day 0 12/02/02	Day 8 12/10/02	Day 11 12/13/02	Day 14 12/16/02
1	84	910	720	720	1540
	91	220	720	1200	620
	1550	800	3700	17600	7680
2	76	1010	1380	1100	3440
	90	3140	3720	9240	6580
	1542	2260	9700	8800	8060
	1547	1440	2720	2320	4500
	1562	2640	2980	2840	5080
3	70	1880	5280	7320	6740
	73	3050	6380	3700	4700
	81	3050	4080	6320	8300
	1541	3020	4440	3140	4760
	1556	3120	6880	5680	9700
4	64	3000	3720	21140	17000
	77	640	6740	4500	5800
	80	2380	4600	3540	5000
	92	2560	2300	2580	3100
	1548	1320	980	11060	6840
5	87	4740	4000	8800	16920
	97	820	1260	5460	11300
	1543	3200	6190	6000	6940
	1546	970	6900	1480	3820
	1553	1820	2680	2400	5860
6	66	720	1280	2700	3000
	68	1070	1320	2420	4000
	86	1400	2260	6740	12080
	1545	820	2340	2740	10300
	1561	7020	9060	17100	22880
7	69	900	1920	1840	5340
	75	2520	4400	2720	8000
	78	1420	2180	1840	1900
	98	2740	2920	5580	2660
	1564	980	4800	6080	7200
8	88	500	1640	2400	4100
	89	2680	3200	4000	4280
	99	240	1120	1420	2740
	100	5840	10240	6400	10060
	1563	1950	3320	8960	5040
9	65	980	1540	2440	6000
	82	1000	1840	1940	1520
	95	2200	4200	4340	2840
	1549	4220	6060	6300	7540
	1558	960	1400	920	4760

Volume measured by:	TRN	CA	CA	CA
Date:	12/3/2002	12/11/2002	12/14/2002	12/17/2002

TABLE A-5 URINE ANALYTICAL RESULTS

Tag Number	Pig Number	Group	Day	Material Administered	Target Dose (ug/kg-d)	24-hr BWAdj Dose (ug/kg-d)	Urine Volume (mls/d)	Q	Arsenic Conc in Urine	DL	Units
EP-1-0103	84	1	0	Control	0	0	910		3	1	Ng/ml
EP-1-0137	91	1	0	Control	0	0	220		6.9	1	Ng/ml
EP-1-0145	1550	1	0	Control	0	0	800		4.4	1	Ng/ml
EP-1-0106	76	2	0	NaAs	25	25.94	1010		260	5	Ng/ml
EP-1-0105	90	2	0	NaAs	25	27.19	3140		83	1	Ng/ml
EP-1-0111	1542	2	0	NaAs	25	22.47	2260		120	2	Ng/ml
EP-1-0139	1547	2	0	NaAs	25	28.57	1440		150	2	Ng/ml
EP-1-0127	1562	2	0	NaAs	25	26.62	2640		92	1	Ng/ml
EP-1-0138	70	3	0	NaAs	50	45.96	1880		240	5	Ng/ml
EP-1-0108	73	3	0	NaAs	50	51.04	3050		170	5	Ng/ml
EP-1-0117	81	3	0	NaAs	50	49.06	3050		190	5	Ng/ml
EP-1-0119	1541	3	0	NaAs	50	53.84	3020		120	2	Ng/ml
EP-1-0102	1556	3	0	NaAs	50	62.28	3120		170	5	Ng/ml
EP-1-0115	64	4	0	TM1	40	41.5	3000		68	1	Ng/ml
EP-1-0250	1563	8	11	TM2	80	70.6	8960		53	1	Ng/ml
EP-1-0276	65	9	11	TM2	160	136.57	2440		330	10	Ng/ml
EP-1-0274	82	9	11	TM2	160	153.53	1940		690	10	Ng/ml
EP-1-0292	95	9	11	TM2	160	140.36	4340		230	5	Ng/ml
EP-1-0259	1549	9	11	TM2	160	149.02	6300		160	2	Ng/ml
EP-1-0295	1558	9	11	TM2	160	183.45	920		380	10	Ng/ml
EP-1-0338	84	1	14	Control	0	0	1540		3	1	Ng/ml
EP-1-0334	91	1	14	Control	0	0	620		5.5	1	Ng/ml
EP-1-0319	1550	1	14	Control	0	0	7680		1	1	Ng/ml
EP-1-0340	76	2	14	NaAs	25	23.86	3440		120	2	Ng/ml
EP-1-0317	90	2	14	NaAs	25	25.16	6580		71	1	Ng/ml
EP-1-0305	1542	2	14	NaAs	25	22.3	8060		54	1	Ng/ml
EP-1-0302	1547	2	14	NaAs	25	24.43	4500		91	1	Ng/ml
EP-1-0321	1562	2	14	NaAs	25	24.96	5080		81	1	Ng/ml
EP-1-0325	70	3	14	NaAs	50	43.44	6740		120	2	Ng/ml
EP-1-0310	73	3	14	NaAs	50	49.42	4700		190	5	Ng/ml
EP-1-0345	81	3	14	NaAs	50	45.3	8300		84	1	Ng/ml
EP-1-0331	1541	3	14	NaAs	50	52.15	4760		140	2	Ng/ml
EP-1-0309	1556	3	14	NaAs	50	56.24	9700		92	1	Ng/ml
EP-1-0306	64	4	14	TM1	40	37.72	17000		33	1	Ng/ml
EP-1-0136	77	4	0	TM1	40	37.66	640		260	5	Ng/ml
EP-1-0148	80	4	0	TM1	40	48.03	2380		96	2	Ng/ml
EP-1-0128	92	4	0	TM1	40	39.51	2560		76	1	Ng/ml
EP-1-0123	1548	4	0	TM1	40	41.61	1320		140	2	Ng/ml
EP-1-0142	87	5	0	TM1	80	99.74	4740		70	1	Ng/ml
EP-1-0134	97	5	0	TM1	80	88.49	820		260	5	Ng/ml
EP-1-0114	1543	5	0	TM1	80	89.62	3200		63	1	Ng/ml
EP-1-0146	1546	5	0	TM1	80	73.12	970		300	5	Ng/ml
EP-1-0149	1553	5	0	TM1	80	70.65	1820		210	5	Ng/ml
EP-1-0126	66	6	0	TM1	160	167.54	720		1200	20	Ng/ml
EP-1-0109	68	6	0	TM1	160	158.41	1070		730	20	Ng/ml
EP-1-0141	86	6	0	TM1	160	197.66	1400		410	10	Ng/ml
EP-1-0116	1545	6	0	TM1	160	155.4	820		750	20	Ng/ml
EP-1-0130	1561	6	0	TM1	160	153.58	7020		110	2	Ng/ml
EP-1-0125	69	7	0	TM2	40	38.75	900		150	2	Ng/ml
EP-1-0133	75	7	0	TM2	40	40.17	2520		60	1	Ng/ml
EP-1-0120	78	7	0	TM2	40	49.29	1420		120	2	Ng/ml
EP-1-0144	98	7	0	TM2	40	41.64	2740		71	1	Ng/ml
EP-1-0140	1564	7	0	TM2	40	39.92	980		110	2	Ng/ml
EP-1-0147	88	8	0	TM2	80	44.87	500		86	1	Ng/ml
EP-1-0113	89	8	0	TM2	80	70.24	2680		67	1	Ng/ml
EP-1-0107	99	8	0	TM2	80	69.22	240		170	5	Ng/ml
EP-1-0135	100	8	0	TM2	80	94.53	5840		55	1	Ng/ml
EP-1-0110	1563	8	0	TM2	80	79.28	1950		120	2	Ng/ml
EP-1-0122	65	9	0	TM2	160	146.61	980		490	20	Ng/ml
EP-1-0143	82	9	0	TM2	160	179.5	1000		500	10	Ng/ml
EP-1-0121	95	9	0	TM2	160	113.58	2200		150	2	Ng/ml
EP-1-0118	1549	9	0	TM2	160	149.08	4220		59	1	Ng/ml
EP-1-0132	1558	9	0	TM2	160	193.5	960		590	10	Ng/ml
EP-1-0198	84	1	5	Control	0	0	540		5.3	1	Ng/ml
EP-1-0170	91	1	5	Control	0	0	420		7.6	1	Ng/ml
EP-1-0168	1550	1	5	Control	0	0	5200		2	1	Ng/ml
EP-1-0159	76	2	5	NaAs	25	24.92	630		520	10	Ng/ml
EP-1-0176	90	2	5	NaAs	25	26.79	2040		140	2	Ng/ml
EP-1-0199	1542	2	5	NaAs	25	22.12	4900		80	1	Ng/ml
EP-1-0189	1547	2	5	NaAs	25	27.68	2310		140	2	Ng/ml
EP-1-0194	1562	2	5	NaAs	25	25.34	3220		110	2	Ng/ml
EP-1-0161	70	3	5	NaAs	50	44.32	3580		190	5	Ng/ml
EP-1-0190	73	3	5	NaAs	50	50.59	3060		220	5	Ng/ml
EP-1-0158	81	3	5	NaAs	50	47.17	2800		270	5	Ng/ml
EP-1-0195	1541	3	5	NaAs	50	51.65	5220		110	2	Ng/ml
EP-1-0162	1556	3	5	NaAs	50	58.68	6920		92	1	Ng/ml
EP-1-0184	64	4	5	TM1	40	40.13	6300		62	1	Ng/ml
EP-1-0188	77	4	5	TM1	40	37.9	2770		96	2	Ng/ml
EP-1-0157	80	4	5	TM1	40	45.82	6680		44	1	Ng/ml
EP-1-0192	92	4	5	TM1	40	38.86	2340		120	2	Ng/ml
EP-1-0178	1548	4	5	TM1	40	41.21	1470		160	2	Ng/ml
EP-1-0165	87	5	5	TM1	80	91.52	7400		97	1	Ng/ml
EP-1-0154	97	5	5	TM1	80	84.91	1210		250	5	Ng/ml
EP-1-0186	1543	5	5	TM1	80	85.22	3020		140	2	Ng/ml
EP-1-0179	1546	5	5	TM1	80	74.67	1760		220	5	Ng/ml
EP-1-0171	1553	5	5	TM1	80	68.57	3000		130	2	Ng/ml

Tag Number	Pig Number	Group	Day	Material Administered	Target Dose (ug/kg-d)	24-hr BWAdj Dose (ug/kg-d)	Urine Volume (mls/d)	Q	Arsenic Conc in Urine	DL	Units
EP-1-0180	66	6	5	TM1	160	170.19	730		1080	10	Ng/ml
EP-1-0153	68	6	5	TM1	160	160.73	1520		650	10	Ng/ml
EP-1-0182	86	6	5	TM1	160	191.38	2440		390	10	Ng/ml
EP-1-0169	1545	6	5	TM1	160	154.18	1290		690	10	Ng/ml
EP-1-0185	1561	6	5	TM1	160	146.82	4900		240	5	Ng/ml
EP-1-0177	69	7	5	TM2	40	37.42	1740		87	1	Ng/ml
EP-1-0196	75	7	5	TM2	40	38.87	1390		120	2	Ng/ml
EP-1-0174	78	7	5	TM2	40	48.94	1200		180	2	Ng/ml
EP-1-0150	98	7	5	TM2	40	39.89	1340		110	2	Ng/ml
EP-1-0172	1564	7	5	TM2	40	39.89	2330		89	1	Ng/ml
EP-1-0173	88	8	5	TM2	80	86.32	1330		220	5	Ng/ml
EP-1-0183	89	8	5	TM2	80	71.12	2420		120	2	Ng/ml
EP-1-0163	99	8	5	TM2	80	89.95	520		530	10	Ng/ml
EP-1-0167	100	8	5	TM2	80	91.49	7900		54	1	Ng/ml
EP-1-0164	1563	8	5	TM2	80	75.38	2650		160	2	Ng/ml
EP-1-0181	65	9	5	TM2	160	142.32	610		1100	10	Ng/ml
EP-1-0156	82	9	5	TM2	160	163.52	1100		590	10	Ng/ml
EP-1-0152	95	9	5	TM2	160	144.55	2560		370	10	Ng/ml
EP-1-0166	1549	9	5	TM2	160	157.92	3160		220	5	Ng/ml
EP-1-0175	1558	9	5	TM2	160	176	1220		680	10	Ng/ml
EP-1-0224	84	1	8	Control	0	0	720		5.3	1	Ng/ml
EP-1-0200	91	1	8	Control	0	0	720		4.8	1	Ng/ml
EP-1-0205	1550	1	8	Control	0	0	3700		3	1	Ng/ml
EP-1-0202	76	2	8	NaAs	25	24.34	1380		260	5	Ng/ml
EP-1-0209	90	2	8	NaAs	25	26.36	3720		120	2	Ng/ml
EP-1-0218	1542	2	8	NaAs	25	21.8	9700		44	1	Ng/ml
EP-1-0201	1547	2	8	NaAs	25	27.08	2720		110	2	Ng/ml
EP-1-0221	1562	2	8	NaAs	25	25.19	2980		99	2	Ng/ml
EP-1-0238	70	3	8	NaAs	50	44.49	5280		110	2	Ng/ml
EP-1-0222	73	3	8	NaAs	50	50.84	6380		100	2	Ng/ml
EP-1-0206	81	3	8	NaAs	50	47.45	4080		140	2	Ng/ml
EP-1-0236	1541	3	8	NaAs	50	52.2	4440		160	2	Ng/ml
EP-1-0247	1556	3	8	NaAs	50	57.57	6880		63	1	Ng/ml
EP-1-0207	64	4	8	TM1	40	39.08	3720	<	1	1	Ng/ml
EP-1-0246	77	4	8	TM1	40	36.33	6740		37	1	Ng/ml
EP-1-0249	80	4	8	TM1	40	44.32	4600		77	1	Ng/ml
EP-1-0220	92	4	8	TM1	40	38.27	2300		100	2	Ng/ml
EP-1-0243	1548	4	8	TM1	40	39.32	980		110	2	Ng/ml
EP-1-0216	87	5	8	TM1	80	89.28	4000		150	2	Ng/ml
EP-1-0210	97	5	8	TM1	80	82.26	1260		180	2	Ng/ml
EP-1-0227	1543	5	8	TM1	80	86.81	6190		92	1	Ng/ml
EP-1-0239	1546	5	8	TM1	80	74.01	6900		63	1	Ng/ml
EP-1-0225	1553	5	8	TM1	80	68.36	2680		200	5	Ng/ml
EP-1-0223	66	6	8	TM1	160	153.23	1280		850	10	Ng/ml
EP-1-0241	68	6	8	TM1	160	151.84	1320		700	10	Ng/ml
EP-1-0203	86	6	8	TM1	160	175.81	2260		330	5	Ng/ml
EP-1-0242	1545	6	8	TM1	160	146.42	2340		430	10	Ng/ml
EP-1-0214	1561	6	8	TM1	160	139.65	9060		130	2	Ng/ml
EP-1-0213	69	7	8	TM2	40	37.67	1920		97	2	Ng/ml
EP-1-0208	75	7	8	TM2	40	38.47	4400		55	1	Ng/ml
EP-1-0219	78	7	8	TM2	40	46.19	2180		110	2	Ng/ml
EP-1-0228	98	7	8	TM2	40	41.49	2920		66	1	Ng/ml
EP-1-0231	1564	7	8	TM2	40	37.67	4800		49	1	Ng/ml
EP-1-0244	88	8	8	TM2	80	83.88	1640		140	2	Ng/ml
EP-1-0237	89	8	8	TM2	80	66.71	3200		98	1	Ng/ml
EP-1-0204	99	8	8	TM2	80	88.5	1120		360	5	Ng/ml
EP-1-0234	100	8	8	TM2	80	83.57	10240		47	1	Ng/ml
EP-1-0245	1563	8	8	TM2	80	72.05	3320		91	1	Ng/ml
EP-1-0232	65	9	8	TM2	160	138.81	1540		550	10	Ng/ml
EP-1-0229	82	9	8	TM2	160	160.92	1840		520	10	Ng/ml
EP-1-0215	95	9	8	TM2	160	141.93	4200		210	5	Ng/ml
EP-1-0230	1549	9	8	TM2	160	155.47	6060		130	2	Ng/ml
EP-1-0212	1558	9	8	TM2	160	181.76	1400		650	10	Ng/ml
EP-1-0265	84	1	11	Control	0	0	720		4.1	1	Ng/ml
EP-1-0252	91	1	11	Control	0	0	1200		3	1	Ng/ml
EP-1-0297	1550	1	11	Control	0	0	17600		1	1	Ng/ml
EP-1-0263	76	2	11	NaAs	25	24.08	1100		320	5	Ng/ml
EP-1-0257	90	2	11	NaAs	25	25.6	9240		36	1	Ng/ml
EP-1-0287	1542	2	11	NaAs	25	21.86	8800		48	1	Ng/ml
EP-1-0260	1547	2	11	NaAs	25	26.56	2320		120	2	Ng/ml
EP-1-0258	1562	2	11	NaAs	25	24.78	2840		120	2	Ng/ml
EP-1-0256	70	3	11	NaAs	50	43.97	7320		99	1	Ng/ml
EP-1-0288	73	3	11	NaAs	50	49.46	3700		130	2	Ng/ml
EP-1-0270	81	3	11	NaAs	50	45.04	6320		140	2	Ng/ml
EP-1-0261	1541	3	11	NaAs	50	52.1	3140		220	5	Ng/ml
EP-1-0273	1556	3	11	NaAs	50	56.92	5680		130	2	Ng/ml
EP-1-0291	64	4	11	TM1	40	39.01	21140		11	1	Ng/ml
EP-1-0285	77	4	11	TM1	40	36.94	4500		63	1	Ng/ml
EP-1-0290	80	4	11	TM1	40	43.25	3540		110	2	Ng/ml
EP-1-0262	92	4	11	TM1	40	37.85	2580		110	2	Ng/ml
EP-1-0254	1548	4	11	TM1	40	40.02	11060		12	1	Ng/ml
EP-1-0289	87	5	11	TM1	80	87.04	8800		70	1	Ng/ml
EP-1-0282	97	5	11	TM1	80	82	5460		94	1	Ng/ml
EP-1-0269	1543	5	11	TM1	80	84.05	6000		90	1	Ng/ml
EP-1-0266	1546	5	11	TM1	80	74.3	1480		120	2	Ng/ml
EP-1-0296	1553	5	11	TM1	80	68.26	2400		180	2	Ng/ml
EP-1-0277	66	6	11	TM1	160	148.71	2700		390	10	Ng/ml
EP-1-0267	68	6	11	TM1	160	149.54	2420		350	5	Ng/ml

Tag Number	Pig Number	Group	Day	Material Administered	Target Dose (ug/kg-d)	24-hr BWAdj Dose (ug/kg-d)	Urine Volume (mls/d)	Q	Arsenic Conc in Urine	DL	Units
EP-1-0264	86	6	11	TM1	160	181.33	6740		49	1	Ng/ml
EP-1-0286	1545	6	11	TM1	160	135.74	2740		480	10	Ng/ml
EP-1-0283	1561	6	11	TM1	160	140.18	17100		28	1	Ng/ml
EP-1-0293	69	7	11	TM2	40	35.57	1840		99	1	Ng/ml
EP-1-0268	75	7	11	TM2	40	38.35	2720		46	1	Ng/ml
EP-1-0271	78	7	11	TM2	40	45.05	1840		130	2	Ng/ml
EP-1-0281	98	7	11	TM2	40	39.95	5580		58	1	Ng/ml
EP-1-0279	1564	7	11	TM2	40	37.81	6080		36	1	Ng/ml
EP-1-0298	88	8	11	TM2	80	88.95	2400		180	5	Ng/ml
EP-1-0275	89	8	11	TM2	80	65.88	4000		96	2	Ng/ml
EP-1-0272	99	8	11	TM2	80	83.53	1420		280	5	Ng/ml
EP-1-0280	100	8	11	TM2	80	80.79	6400		77	1	Ng/ml
EP-1-0304	77	4	14	TM1	40	36.09	5800		61	1	Ng/ml
EP-1-0347	80	4	14	TM1	40	42.19	5000		750	10	Ng/ml
EP-1-0348	92	4	14	TM1	40	36.8	3100		69	1	Ng/ml
EP-1-0300	1548	4	14	TM1	40	38.3	6840		51	1	Ng/ml
EP-1-0339	87	5	14	TM1	80	84.57	16920		19	1	Ng/ml
EP-1-0311	97	5	14	TM1	80	80.13	11300		28	1	Ng/ml
EP-1-0307	1543	5	14	TM1	80	84.82	6940		92	1	Ng/ml
EP-1-0301	1546	5	14	TM1	80	75.74	3820		180	5	Ng/ml
EP-1-0313	1553	5	14	TM1	80	69.56	5860		140	2	Ng/ml
EP-1-0320	66	6	14	TM1	160	155.28	3000		520	10	Ng/ml
EP-1-0327	68	6	14	TM1	160	160.17	4000		380	5	Ng/ml
EP-1-0330	86	6	14	TM1	160	175.86	12080		54	1	Ng/ml
EP-1-0343	1545	6	14	TM1	160	140.61	10300		120	2	Ng/ml
EP-1-0314	1561	6	14	TM1	160	137.44	22880		51	1	Ng/ml
EP-1-0324	69	7	14	TM2	40	36.14	5340		44	1	Ng/ml
EP-1-0329	75	7	14	TM2	40	37.16	8000		31	1	Ng/ml
EP-1-0328	78	7	14	TM2	40	43.94	1900		120	2	Ng/ml
EP-1-0303	98	7	14	TM2	40	44.48	2660		80	1	Ng/ml
EP-1-0326	1564	7	14	TM2	40	33	7200		36	1	Ng/ml
EP-1-0346	88	8	14	TM2	80	75.8	4100		65	1	Ng/ml
EP-1-0323	89	8	14	TM2	80	68.17	4280		99	2	Ng/ml
EP-1-0344	99	8	14	TM2	80	79.3	2740		190	5	Ng/ml
EP-1-0335	100	8	14	TM2	80	81.19	10060		45	1	Ng/ml
EP-1-0342	1563	8	14	TM2	80	63.85	5040		90	1	Ng/ml
EP-1-0336	65	9	14	TM2	160	143.44	6000		180	2	Ng/ml
EP-1-0332	82	9	14	TM2	160	161.84	1520		690	10	Ng/ml
EP-1-0322	95	9	14	TM2	160	144.45	2840		120	2	Ng/ml
EP-1-0341	1549	9	14	TM2	160	146.5	7540		110	2	Ng/ml
EP-1-0308	1558	9	14	TM2	160	179.2	4760		190	5	Ng/ml

Tag Number	QC Type	QC Identifier	Orginal Pig #	Material Administered	Group	Target Dose (ug/kg-d)	DL	Q	As Conc	AdjConc (ng/ml)	OrigAdjConc (ng/ml)
EP-1-0284	Blind Duplicate	268	68	TM1	6	160	5		360	360	350
EP-1-0251	Blind Duplicate	298	98	TM2	7	40	1		57	57	58
EP-1-0253	Blind Duplicate	265	65	TM2	9	160	5		330	330	330
EP-1-0124	Blind Duplicate	21547	1547	NaAs	2	25	2		150	150	150
EP-1-0131	Blind Duplicate	276	76	NaAs	2	25					260
EP-1-0129	Blind Duplicate	282	1564	TM2	7	40	2		120	120	110
EP-1-0187	Blind Duplicate	286	86	TM1	6	160	10		420	420	390
EP-1-0160	Blind Duplicate	21561	1561	TM1	6	160	5		250	250	240
EP-1-0197	Blind Duplicate	2100	100	TM2	8	80	1		52	52	54
EP-1-0211	Blind Duplicate	21553	1553	TM1	5	80	5		200	200	200
EP-1-0235	Blind Duplicate	289	89	TM2	8	80	1		98	98	98
EP-1-0240	Blind Duplicate	21549	1549	TM2	9	160	2		130	130	130
EP-1-0312	Blind Duplicate	21541	1541	NaAs	3	50	2		150	150	140
EP-1-0318	Blind Duplicate	21556	1556	NaAs	3	50	1		95	95	92
EP-1-0337	Blind Duplicate	266	66	TM1	6	160	10		520	520	520

Tag Number	QC Type	QC Identifier	Material Administered	PE Conc (ug/L)	DL	Q	As Conc	AdjConc	Units
EP-1-0294	PE Sample	AsIB40-a	Sodium arsenite	40	1		44	44	Ng/ml
EP-1-0255	PE Sample	AsIB40-b	Sodium arsenite	40	1		41	41	Ng/ml
EP-1-0299	PE Sample	AsOA200-b	Disodium methylarsenate	200	5		200	200	Ng/ml
EP-1-0278	PE Sample	AsIB200-a	Sodium arsenite	200	5		200	200	Ng/ml
EP-1-0104	PE Sample	AsOB200-b	Dimethyl arsenic acid	200	5		200	200	Ng/ml
EP-1-0112	PE Sample	AsOB200-a	Dimethyl arsenic acid	200	5		210	210	Ng/ml
EP-1-0101	PE Sample	AsOA40-b	Disodium methylarsenate	40	1		43	43	Ng/ml
EP-1-0193	PE Sample	AsIA40-b	Sodium arsenate	40	1		43	43	Ng/ml
EP-1-0151	PE Sample	AsOB40-a	Dimethyl arsenic acid	40	1		46	46	Ng/ml
EP-1-0191	PE Sample	AsIA200-b	Sodium arsenate	200	5		190	190	Ng/ml
EP-1-0155	PE Sample	AsOA200-a	Disodium methylarsenate	200	5		210	210	Ng/ml
EP-1-0217	PE Sample	AsCtrl-b	Control Urine	0	1		2	2	Ng/ml
EP-1-0233	PE Sample	AsIA200-a	Sodium arsenate	200	5		200	200	Ng/ml
EP-1-0226	PE Sample	AsOA40-a	Disodium methylarsenate	40	1		47	47	Ng/ml
EP-1-0248	PE Sample	AsCtrl-a	Control Urine	0	1		2	2	Ng/ml
EP-1-0333	PE Sample	AsOB40-b	Dimethyl arsenic acid	40	1		47	47	Ng/ml
EP-1-0316	PE Sample	AsIB200-b	Sodium arsenite	200	5		190	190	Ng/ml
EP-1-0315	PE Sample	AsIA40-a	Sodium arsenate	40	1		42	42	Ng/ml

FIGURE A-1 URINARY EXCRETION OF ARSENIC FROM SODIUM ARSENATE (ALL DAYS)

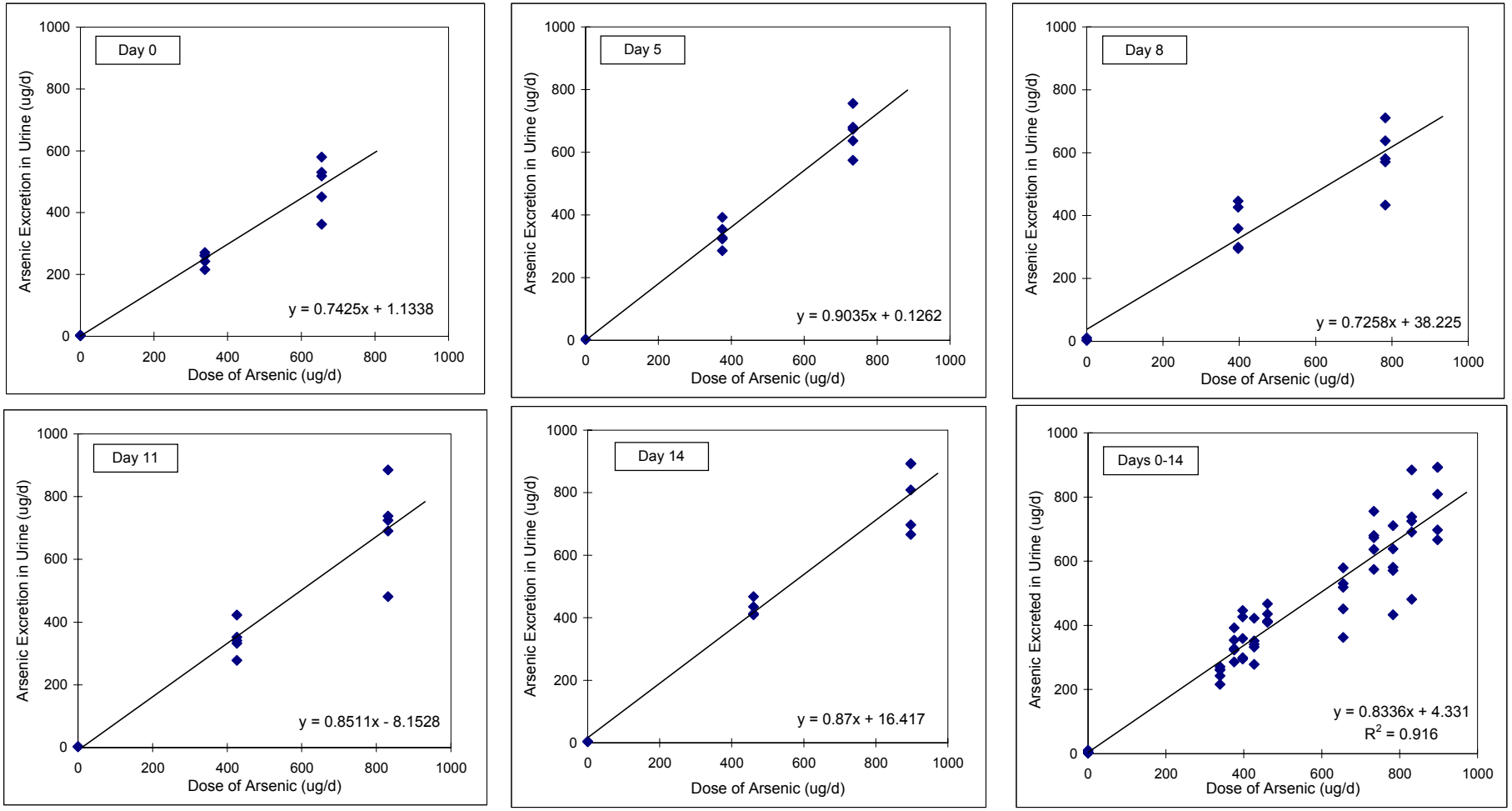


FIGURE A-2 URINARY EXCRETION OF ARSENIC FROM TEST MATERIAL 1 (ALL DAYS)

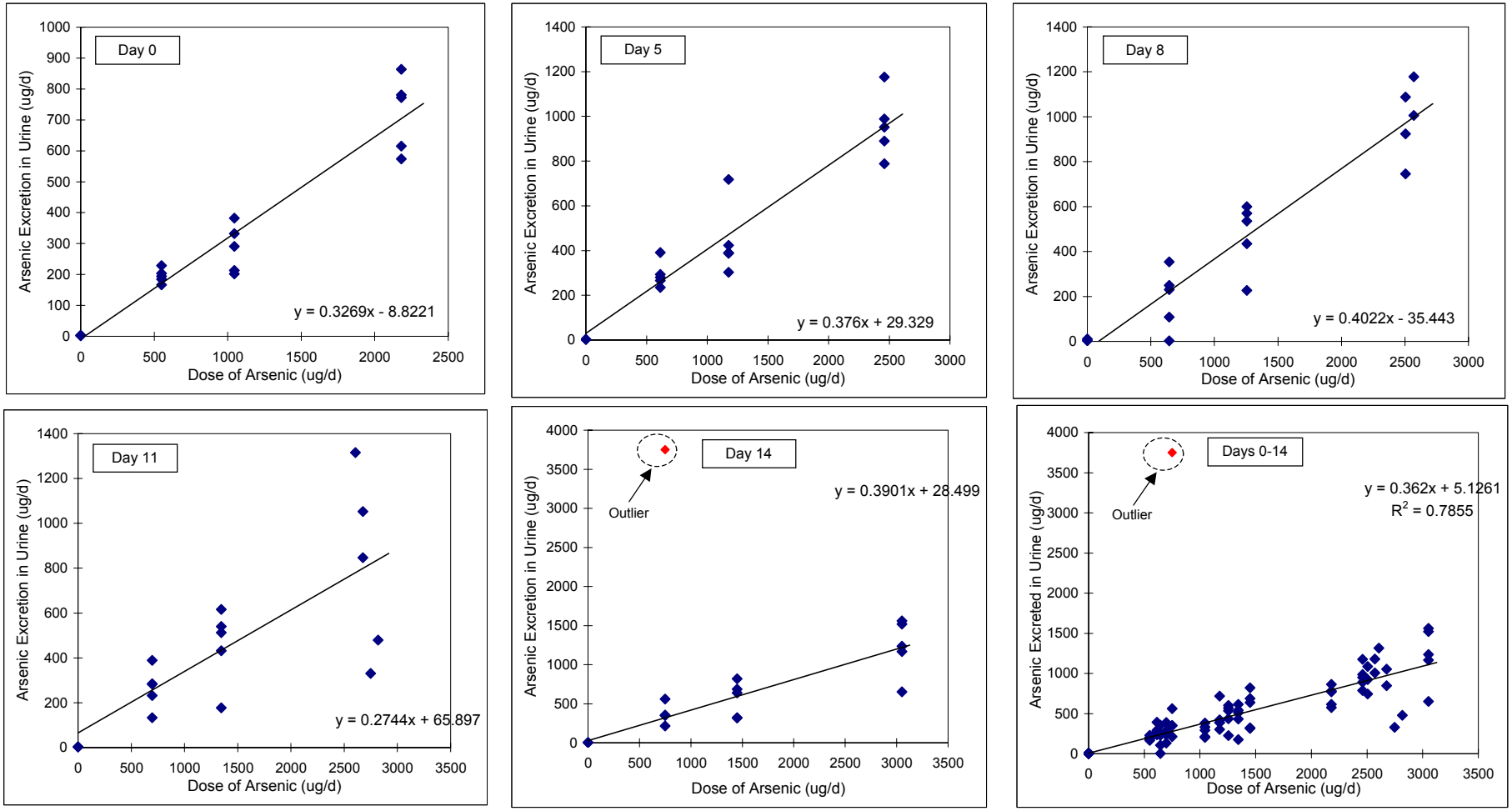


FIGURE A-3 URINARY EXCRETION OF ARSENIC FROM TEST MATERIAL 2 (ALL DAYS)