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RELATIVE BIOAVAILABILITY OF ARSENIC IN MINING WASTES

December 1997

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Dr. Timothy M. Barry of the USEPA helped with the statistical analysis of the data and developed the computer software needed for calculating confidence limits around the estimates of absolute and relative bioavailability.

Mr. Gerald Almquist at Roy F. Weston provided overall program management for the project, including management of subcontractors and coordination of interactions between team members.

Ross P. Cowart, DVM, MS, University of Missouri, Columbia, provided expert evaluation of the health of the animals on study.

James R. Turk, DVM, PhD, University of Missouri, Columbia, performed necropsy and pathological examination of all animals.

John T. Payne, DVM, MS, University of Missouri, Columbia, performed the surgery to implant intravenous catheters and vascular access ports.

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MEMORANDUM

SUBJECT: Intended and Proper Scientific Uses of the EPA Report: *Relative Bioavailability of Arsenic in Mining Wastes*, Dec 1997, Casteel et al.

FROM: Gerry M. Henningsen, DVM, PhD, DABT/DABVT
Chris P. Weis, PhD, DABT
Regional Senior Toxicologists

TO: Recipients and Users of Subject Report

Important scientific understandings are required for the proper interpretation and possible application of the attached Dec 1997 report on arsenic bioavailability. EPA R8 toxicologists desire to have the data and results of recent EPA studies on bioavailability of arsenic used in a reasonable and correct scientific manner; conversely, we do not want to have the data or results misinterpreted or misapplied for health-risk assessments where bioavailabilty of arsenic is a concern. In this regard, the following points are requisite:

1. Design. These arsenic studies were only undertaken by EPA as efficient opportunities to obtain potentially useful, but preliminary, data on the uptake of varieties of arsenic types and levels in soils from Superfund sites. This work was a secondary effort that ran concurrently with scientifically stronger and more definitive studies on bioavailability of lead wastes in soils from those same sites. A lack of knowledge on the ranges of potential arsenic bioavailability from varied mining wastes, and the possible usefulness of the immature swine model to quantitatively measure arsenic uptake, were the main impetus for pursuing this precursory work. No one should infer more definitive design implications for this initial phase of studies on arsenic bioavailabilty in young swine.

2. Results. Because this work was meant to both characterize the relative usefulness of the immature swine model for arsenic bioavailabilty plus evaluate the relative ranges of arsenic absorption, the results can only be used in a "semi-quantitative" manner. Rather than being able to reasonably quantitatively adjust bioavailability as done in the concurrent lead studies, acknowledged limitations in the arsenic study design and results only permit and support a ***relative*** adjustment in terms high vs medium vs low range of arsenic bioavailability. Transparent exclusion of implausible data points (e.g., huge urine volumes) with defined criteria was used, since analytical confidence was substantially less for these data. While the report presents the best point-estimates of measured arsenic bioavailability for site soils, these values should be considered as semi-quantitative ranges with uncertainty for adjusting default arsenic bioavailability.

[over]

3. Predictiveness. The swine model has not been adequately characterized for full use in estimating quantitative bioavailability of arsenic, and it may or may not become a reasonable animal model for such studies. The limited design and preliminary results of this work do, however, have an amount of scientific predictive ability to qualitatively support site-specific adjustments of bioavailability for arsenic waste in soils. As clearly pointed out on page 1 of the report, the immature swine model cannot be used as an "absolute" model for human bioavailability of arsenic for several scientific reasons; but, the results per this protocol can be used as a "relative" model to the limited extent that sound science supports. These relative comparisons are made to orally administered soluble arsenic salt (sodium nitrate) which is presumed to have 100% RBA and about 85-90% ABA. Because of known limitations of these EPA studies, a study-specific absolute arsenic bioavailability value cannot be confidently estimated, although a semi-quantitative relative estimate is scientifically supportable for most site-specific results.

4. Conclusions. Risk assessors and risk managers who wish to use these site-specific estimates of bioavailability of arsenic are encouraged to do so in a semi-quantitative manner and with the above precautions as well as with those found in the report. While these results are not quantitative for use in risk assessment, they are reasonable and scientifically defensible estimates that should be able to help support qualitative adjustments to site-specific arsenic bioavailability. The strengths of this work are the standardized comparisons of a variety of site-specific arsenic soil samples, as opposed to trying to extrapolate data from other studies that use different materials and protocols. Reasonable dose-responsiveness and quasi-steady state results were usually achieved during the last week of the 14-day exposures, which supports the scientific usefulness. Other obvious known limitations in the study design and results preclude using these data beyond the semi-quantitative manner described above. Further research on the characterization of the swine model is required before results can ever be used with more quantitative confidence. These results are compatible, although not exactly comparable at this time, with known mammalian pharmacodynamics of arsenic; and, as such, can be used at sites as strength and weight of evidence for bioavailability.

For answers to questions about this memorandum or about details and interpretation of the EPA arsenic report, please contact the EPA R8 toxicologists at (303) 312-6673 or -6671 and ask for Gerry Henningsen or Chris Weis.

attachment: *Relative Bioavailability of Arsenic in Mining Wastes*, Dec 1997, Casteel et al.

copy: EPA R8 Administrative Record

EXECUTIVE SUMMARY

Introduction

Accurate assessment of the human health risks resulting from oral exposure to metals requires knowledge of the amount of metal absorbed from the gastrointestinal tract into the body. This information is especially important for environmental media such as soil or mine wastes, because metals in these media may exist, at least in part, in a variety of poorly water soluble minerals, and may also exist inside particles of inert matrix such as rock or slag. These chemical and physical properties may tend to influence (usually decrease) the absorption (bioavailability) of the metals when ingested. Therefore, reliable site-specific data on metal bioavailability in environmental media of concern may be expected to increase the accuracy and decrease the uncertainty in human health risk estimates.

The USEPA has been engaged in a multi-year investigation of the bioavailability of metals in soil and mine waste. This study has focused mainly on lead, but a number of studies were performed to investigate the relative bioavailability (RBA) of arsenic in a variety of test materials compared to a fully soluble form of arsenic (sodium arsenate). This report presents the results of these studies on arsenic absorption.

Study Design

Studies were performed using young swine as the test species because the gastrointestinal system of swine is more nearly similar to humans than most other animal models. Groups of animals (usually 4 or 5) were given oral doses of test material for 15 days. For comparison, other groups of animals were given oral doses of sodium arsenate (abbreviated here as NaAs), either mixed with a small amount of food or by gavage. The amount of arsenic absorbed was evaluated by measuring the amount of arsenic which was excreted in urine. Urine samples (24-hour) were collected on several different days during each study, and were analyzed for total arsenic content by hydride generation.

Results

Arsenic excretion in urine was found to be a linear function of arsenic intake for all treatment conditions. In addition, urinary excretion was found to be approximately independent of time after study day 5. Therefore, the urinary excretion fraction (UEF, ug/day excreted per ug/day administered) for each treatment group was estimated by finding the slope of the best-fit linear regression line through the dose-response data for all days after day 5. Estimates of RBA were then calculated from the urinary excretion fractions as follows:

RBA(x) = UEF(test material)/ UEF(NaAs)

Table ES-1 summarizes the results. As seen, estimates of RBA for arsenic in different types of test material range from near zero to about 70%. All of these values are lower than the default RBA value of 80%-100% that is usually employed for arsenic in the absence of reliable site-specific data, supporting the view that arsenic in some types of soils and solid wastes may be less-well absorbed (and hence less hazardous to humans) than arsenic dissolved in drinking water.

A potential limitation to this study is that the recovery of arsenic in urine, feces and tissues was only about 25%-35% of the amount given. The basis for this low recovery is not known. However, it is thought that the RBA values derived in this study are likely to be fairly insensitive to this phenomenon.

Conclusions

The results of this investigation support the following main conclusions:

- Young swine can be used to evaluate gastrointestinal absorption of arsenic from different test materials, using urinary arsenic excretion as the measurement endpoint. Use of a repeated dosing protocol more accurately reflects a realistic human exposure scenario than does a single dose protocol, and allows multiple measurements of urinary excretion in a single study. In addition, these measurements can be performed at the same time as measurements designed to quantify lead bioavailability.

- The RBA results for different test materials investigated strongly support the view that arsenic in most soils and mine wastes is not as well absorbed as soluble arsenic. The detailed chemical mechanism accounting for this reduced bioavailability of arsenic is not known, but almost certainly is related to the chemical and/or physical form of arsenic in the samples.

- Because arsenic in most test materials is absorbed less-extensively than soluble forms of arsenic, use of default toxicity factors for assessing human health risk from arsenic in soil or other soil-like materials may often lead to an overestimate of hazard. Therefore, measurement and application of site-specific RBA values is expected to increase the accuracy and decrease the uncertainty in human health risk assessments for arsenic.

TABLE ES-1 RBA ESTIMATES FOR ARSENIC IN SOIL AND MINE WASTE

Site	Sample	Arsenic Conc. (ppm)	Arsenic Dose (ug/kg-d)	UEF ± SEM (n)	RBA ± SEM
Murray Smelter	Slag	695	13.4	0.090 ± 0.015 (16)	0.51 ± 0.09
	Soil	310	65.4	0.060 ± 0.004 (19)	0.34 ± 0.03
Aspen/ Smuggler	Berm	67	1.1	0.109 ± 0.089 (16)	0.62 ± 0.55[a]
	Residential	17	1.0	0.172 ± 0.140 (15)	0.98 ± 0.86[a]
Midvale Slag	Slag Composite	591	16.8	0.032 ± 0.007 (19)	0.18 ± 0.04
Butte	Soil Composite	238	6.3	0.017 ± 0.008 (17)	0.10 ± 0.05
California Gulch	Residential Soil	203	6.1	-0.013 ± 0.015 (16)	-0.08 ± 0.09
	FeMnPb Oxide	110	5.7	0.050 ± 0.023 (14)	0.28 ± 0.15
	AV Slag (test 1)	1050	22.3	0.012 ± 0.008 (17)	0.07 ± 0.05
	AV Slag (test 2)	1050	20, 50, 125	0.026 ± 0.002 (43)	0.15 ± 0.01
Palmerton	Location 2	110	7.7	0.069 ± 0.014 (19)	0.39 ± 0.09
	Location 4	134	14.0	0.092 ± 0.024 (19)	0.52 ± 0.15
Clark Fork	Grant Kohrs tailings	181	20, 50	0.086 ± 0.007 (31)	0.49 ± 0.05
Bingham Creek	Channel Soil	149	15.8	0.066 ± 0.029 (12)	0.37 ± 0.19

Abbreviations:

UEF = Urinary Excretion Fraction (ug/day excreted per ug/day administered)
SEM = Standard Error of the Mean
n = Number of individual data points used to estimate the UEF
RBA = Relative Bioavailability (compared to sodium arsenate administered orally)

[a] These estimates are based on very low doses of arsenic and are considered to be highly uncertain.

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BIOAVAILABILITY OF ARSENIC IN MINING WASTES

1.0 INTRODUCTION

Accurate assessment of the human 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 gastrointestinal absorption may be described either in absolute or relative terms:

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

ABA = 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 compared the absolute bioavailability of arsenic in some appropriate reference material:

RBA = ABA(test)/ABA(reference)

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

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

Using Bioavailability Data to Improve Risk Calculations for Arsenic

When reliable data are available on the bioavailability of arsenic in soil, dust, or other soil-like waste material at a site, this information can be used to improve the accuracy of exposure and risk calculations at that site. If the bioavailability data are derived from reliable studies in humans, either the ABA or the RBA value may be used. However, if the data are obtained from measurements in animals (as is the case here), adjustments based on the RBA are preferred because an adjustment based on an ABA measured in an animal is applicable only if the animal has precisely the same gastrointestinal absorption characteristics for the reference material (arsenic dissolved in water) as the human. In contrast, the applicability of an RBA value measured in an animal depends only on the similarity of the gastrointestinal processes governing solubilization of the test material (e.g., gastric pH, holding time), and does not depend on whether the rate and extent of arsenic absorption, distribution and excretion are or are not similar to that in humans.

When a reliable RBA value is available from studies in animals (and assuming the RBA is based on a fully soluble form of arsenic), the RBA can be used to modify the default Reference Dose (RfD) and default oral Slope Factor (oSF) for arsenic to account for differences in absorption between arsenic ingested in water and arsenic ingested in site media (soil, slag, etc.), as follows:

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

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

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

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

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

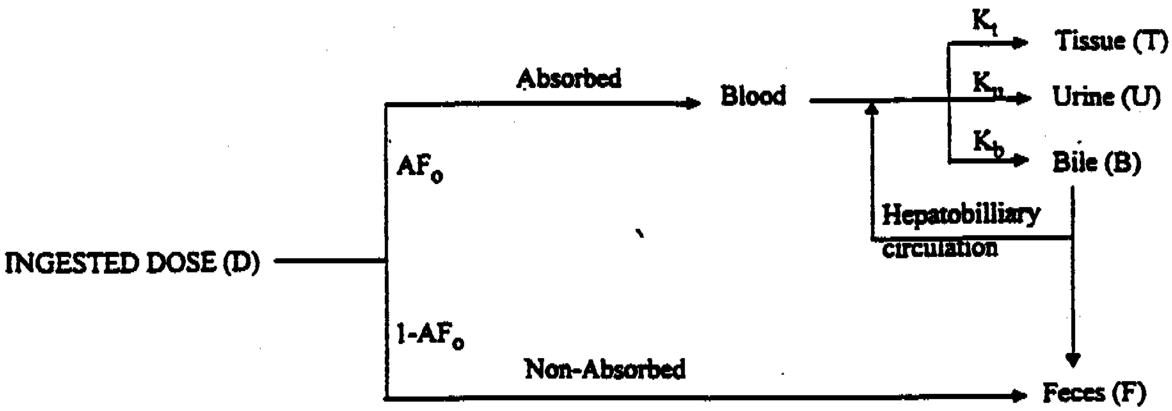
Methods for Measuring RBA

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

- In most animals (including humans), absorbed arsenic is excreted mainly in the urine over the course of several days (Coulson et al. 1935, Crecelius 1977, Buchet et al 1981a, 1981b, Vahter and Norin 1980, Vahter 1981). The mass of arsenic excreted in urine appears to be a linear function of ingested dose in both humans and animals up to intake levels of at least 5,000 ug/day (EPA 1995). This indicates that both absorption and urinary excretion are linear processes.

- The urinary excretion fraction (UEF), defined as the amount excreted in the urine divided by the amount given, should not be used as a direct estimate of the amount absorbed 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.

FIGURE 1-1 CONCEPTUAL MODEL FOR ARSENIC TOXICOKINETICS



where:

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 in Urine

$$U_{oral} = D \bullet AF_o \bullet K_u$$

Urinary Excretion Fraction (UEF)

$$UEF_{oral} = \frac{U_{oral}}{D_{oral}} = AF_o \bullet K_u$$

Relative Bioavailability

$$RBA(x\ vs.\ y) = \frac{UEF_{x,oral}}{UEF_{y,oral}} = \frac{AF_o(x) \bullet K_u}{AF_o(y) \bullet K_u} = \frac{AF_o(x)}{AF_o(y)}$$

- The relative bioavailability (RBA) of a test material compared to sodium arsenate 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:

$$RBA(x \text{ vs } y) = \frac{UEF(x)}{UEF(y)} = \frac{D \cdot AF_o(x) \cdot K_u}{D \cdot AF_o(y) \cdot K_u} = \frac{AF_o(x)}{AF_o(y)}$$

Purpose of These Studies

Arsenic (and other metals) in soils and mine wastes may exist, at least in part, in a variety of poorly water soluble minerals, and may also exist inside particles of inert matrix such as rock or slag. These chemical and physical properties may tend to influence (usually decrease) the solubility (bioaccessability) and the absorption (bioavailability) of arsenic when ingested. The studies reported here were designed to investigate the feasibility of using young swine as an animal model for measuring oral arsenic absorption from soils and mine wastes, and to obtain preliminary estimates of RBA for arsenic in a variety of samples of soil and other solid media from Superfund sites. Preliminary data on the toxicokinetics of sodium arsenate following intravenous injection collected during these studies will be presented elsewhere.

2.0 METHODS

The studies performed to investigate arsenic bioavailability were part of a larger program sponsored by the USEPA in which the bioavailability of lead in soils and mine wastes was quantified using young swine as an animal model for young children. Detailed descriptions of these studies on lead bioavailability have been prepared and are presented elsewhere.

All studies were performed as nearly as possible within the spirit and guidelines of Good Laboratory Practices (GLP: 40 CFR 792). Standard Operating Procedures (SOPs) that included detailed methods for all of the components to each study were prepared, approved, and distributed to all team members prior to the study. All SOPs are documented in a project notebook that is available through the administrative record.

2.1 Study Designs

The most common approach for studying arsenic absorption is to administer a single oral dose of test material and then measure the amount of arsenic which is excreted in urine over the next several days (e.g., Coulson et al. 1935, Crecelius 1977, Tam et al. 1979, Buchet et al. 1981a, Vahter and Norin 1980, Vahter 1981, Yamauchi and Yamamura 1985, Marafante and Vahter 1987). In this study, a repeated-dose protocol was employed. That is, groups of animals were exposed to either sodium arsenate (used as the reference material) or test material (e.g., soil, tailings, slag, etc.) for 15 days. Urine samples (24-hour) were collected at several times throughout the study period. This protocol was employed because it is similar to the repeated exposure protocol established for studying lead absorption in young swine. This allowed measurement of both lead and arsenic absorption from a test material in the same experiment.

The main investigations of arsenic absorption and excretion were performed in two pilot studies. The protocols for these two studies are shown in Table 2-1. As shown, each Pilot Study investigated arsenic absorption from sodium arsenate and from a single test material. In Pilot Study 1 the test material was a sample of slag collected at the AV Smelter located near Leadville, Colorado. In the second Pilot Study, the test material was a sample of tailings or "slickens" collected from the bank of the Clark Fork River on the property of the Grant Kohrs Ranch, located near Deer Lodge, Montana. Because these pilot studies only evaluated arsenic absorption in two different test materials, urine was also collected from animals exposed to a variety of other test materials in the studies which were performed primarily to measure lead absorption. In these studies, urine was collected only on days 7 and 14, and only from control animals and animals exposed to the highest dose of test material. These studies did not include any groups exposed to sodium arsenate.

ıs seen, using sodium arsenate as a relative frame of reference, the RBA estimates for the two ɛst materials are 15% and 49%, respectively. Both of these values are significantly lower than ɪe default value of 80%-100% that is usually employed when reliable site-specific data are ıcking.

.4 RBA Estimates for Other Test Materials

ıs noted above, urine samples were collected on days 7 and 14 from animals exposed to a ariety of different test materials employed in studies of lead bioavailability. Because the doses f test material used in these studies were selected to yield a specified exposure to lead (not rsenic), arsenic exposure levels ranged from around 1 ug/kg-day to 65 ug/kg-day. The detailed ata and calculations for each test material are presented in Appendix B, and the results are ummarized in Table 3-1. Estimates of RBA were calculated for each test material using the JEF for sodium arsenate given orally, as described above. The results are shown graphically n Figure 3-8. Note that a second sample of AV slag was tested in one of these studies.

ls seen, estimated RBA values range from near zero to close to 100%. Two of the test naterials (those from the Aspen site) contained relatively low levels of arsenic and dose levels vere so low (about 1 ug/kg-day) that the results for these samples are considered to be especially ıncertain. Excluding these two samples, estimated RBA values range from near zero to about i0%.

ı.5 Correlation of RBA with Arsenic Geochemistry

Ͻne of the most interesting and important objectives of this project was to obtain preliminary nformation on which chemical forms of arsenic tend to have high bioavailability and which tend o have low bioavailability. At present, detailed geochemical speciation data for arsenic are ıvailable for five of the materials tested. These data are presented in Appendix C and are ;ummarized in Table 3-2.

nspection of this table reveals that arsenic may exist in a variety of different forms. In all of he samples, most of the arsenic that is present exists in particles or grains that are partly or ɛntirely exposed on their outer surfaces (these are referred to as "liberated"), and a relatively ;mall fraction of the particles are entirely enclosed within a larger particle of rock or slag (these ıre referred to as "included"). By mass, most of the arsenic usually occurs in particles of lead ırsenic oxide or ferric arsenic oxide. Notice that slag particles usually do not account for the ɔulk of the arsenic (even in pure slag samples), since the concentration of arsenic in the glassy ɔhase of most slags is quite low.

Simple visual inspection of the data in Table 3-2 suggests that the RBA of lead-arsenic oxide is probably fairly low (e.g., see AV slag, Midvale slag and Murray soil), while the value for ferric arsenic oxide is probably relative high (see the Grant Kohrs sample). A more objective

As seen, estimates of the UEF for sodium arsenate administered orally in doughballs (Pilot Studies 1 and 2) and by gavage (Pilot Study 2) are all approximately equal. Therefore, the final UEF for oral sodium arsenate was estimated by combining all of the data across these three treatment groups. The results are shown in Figure 3-7.

Confidence Limits Around RBA Estimates

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 (Sachs 1984):

$$\frac{UEF_{est} - UEF_{true}}{SEM} \sim t_{n-2}$$

For convenience, the PDF defined by the relationship above is referred to as T(Slope,SEM,n), where "Slope" is the estimated value of UEF (UEF_{est}), "SEM" is the standard error of the estimated slope, and "n" is the number of data points used in the linear regression to derive the slope and SEM. Thus, the confidence distribution around each ratio was simulated as:

$$PDF(RBA)_{x\ vs\ y} \sim \frac{T(Slope_x, SEM_x, n_x)}{T(Slope_y, SEM_y, n_y)}$$

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.

Results for Pilot Studies

Appendix A presents the detailed data for Pilot Studies 1 and 2. The results are summarized below:

Treatment Group	UEF ± SEM (n)	RBA ± SEM
NaAs - (doughball or gavage)	0.176 ± 0.007 (105)	[1.00]
AV Slag (pilot 1)	0.026 ± 0.002 (43)	0.15 ± 0.01
Grant Kohrs tailings (pilot 2)	0.086 ± 0.007 (31)	0.49 ± 0.05

n = Number of data points used in curve fitting

FIGURE 3-7 ESTIMATION OF UEF FOR SODIUM ARSENATE INGESTED ORALLY

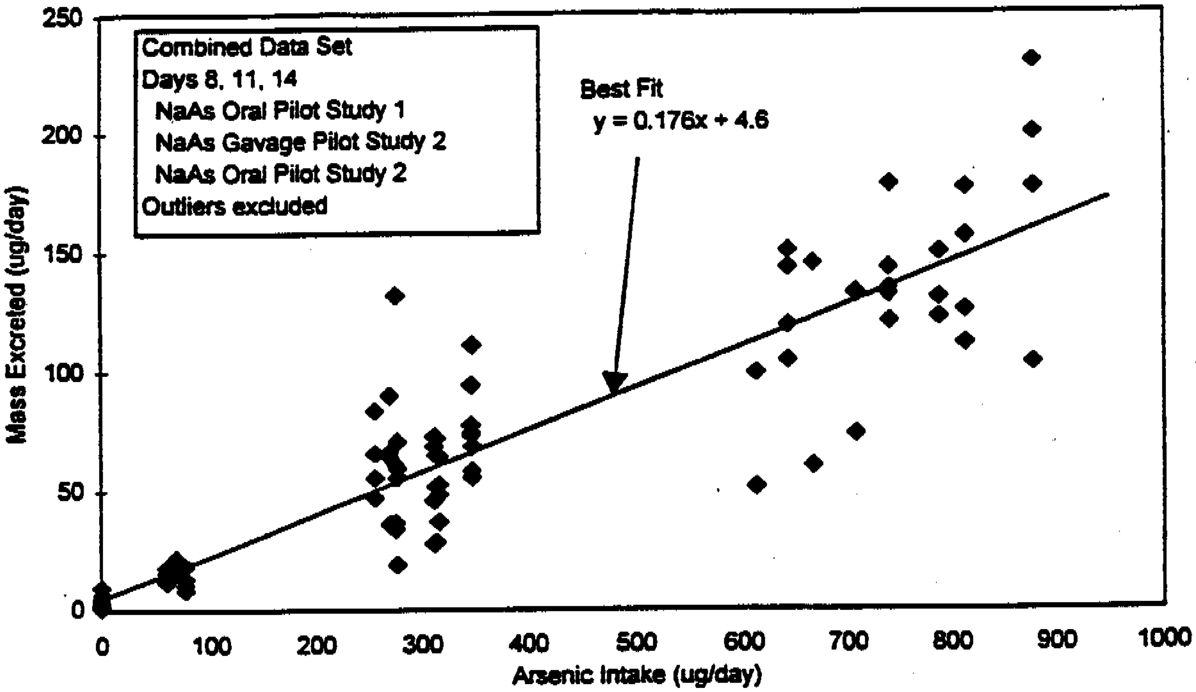


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FIGURE 3-6 ESTIMATION OF UEFs - PILOT STUDY 2

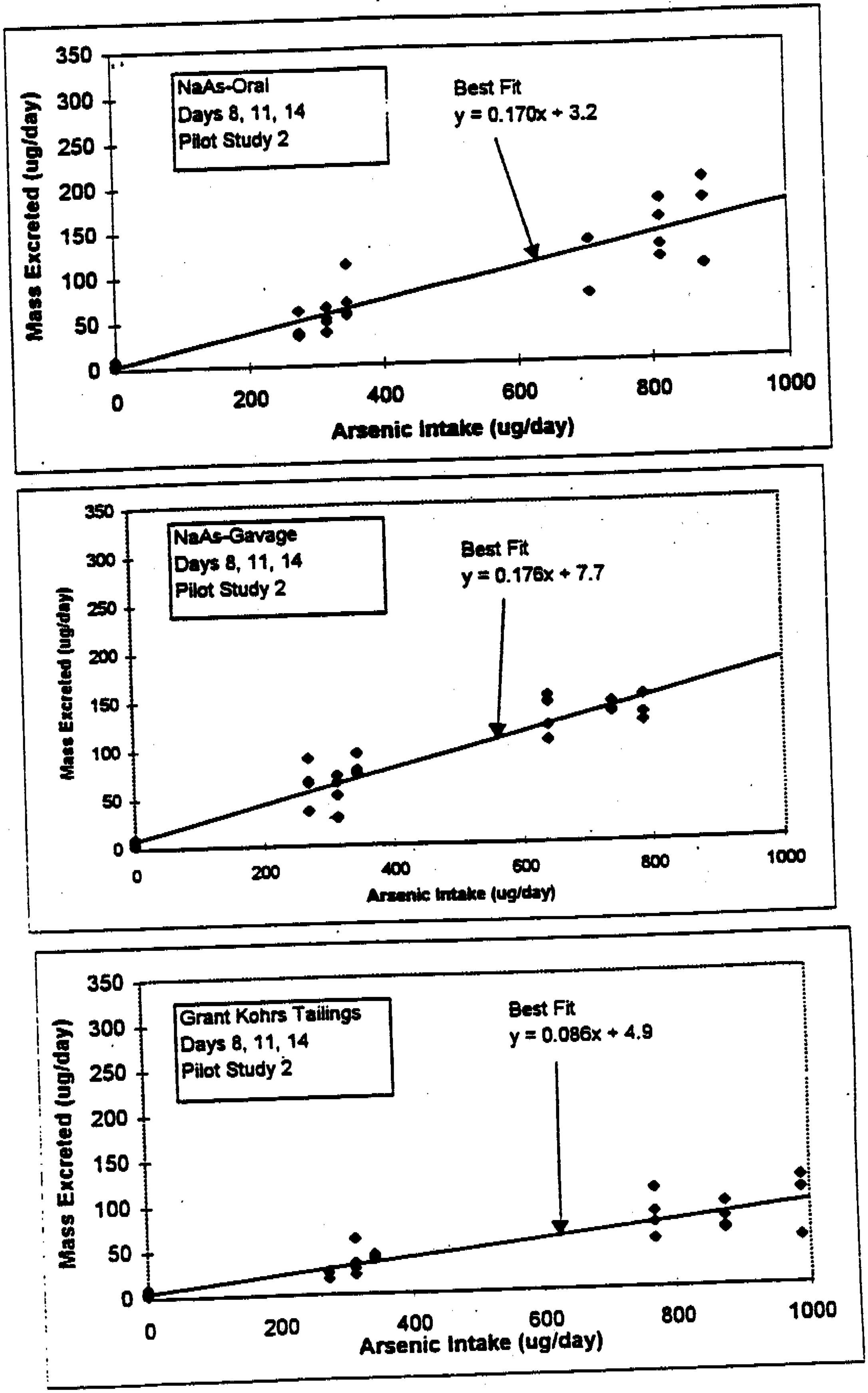

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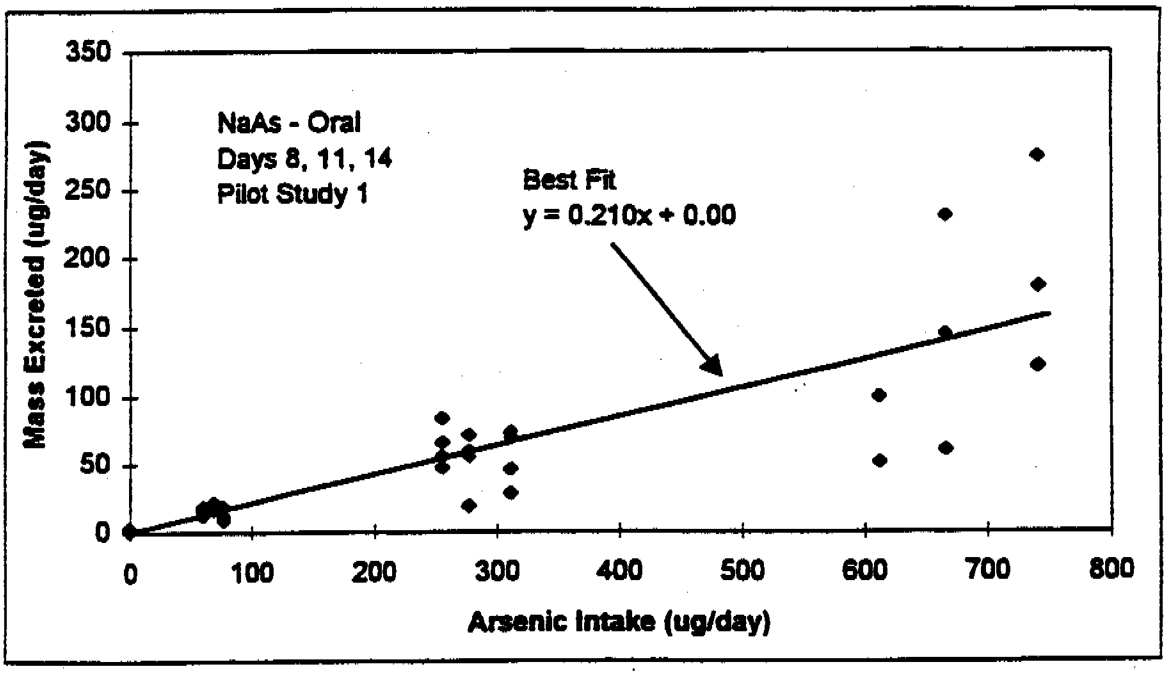
FIGURE 3-5 ESTIMATION OF UEFs - PILOT STUDY 1



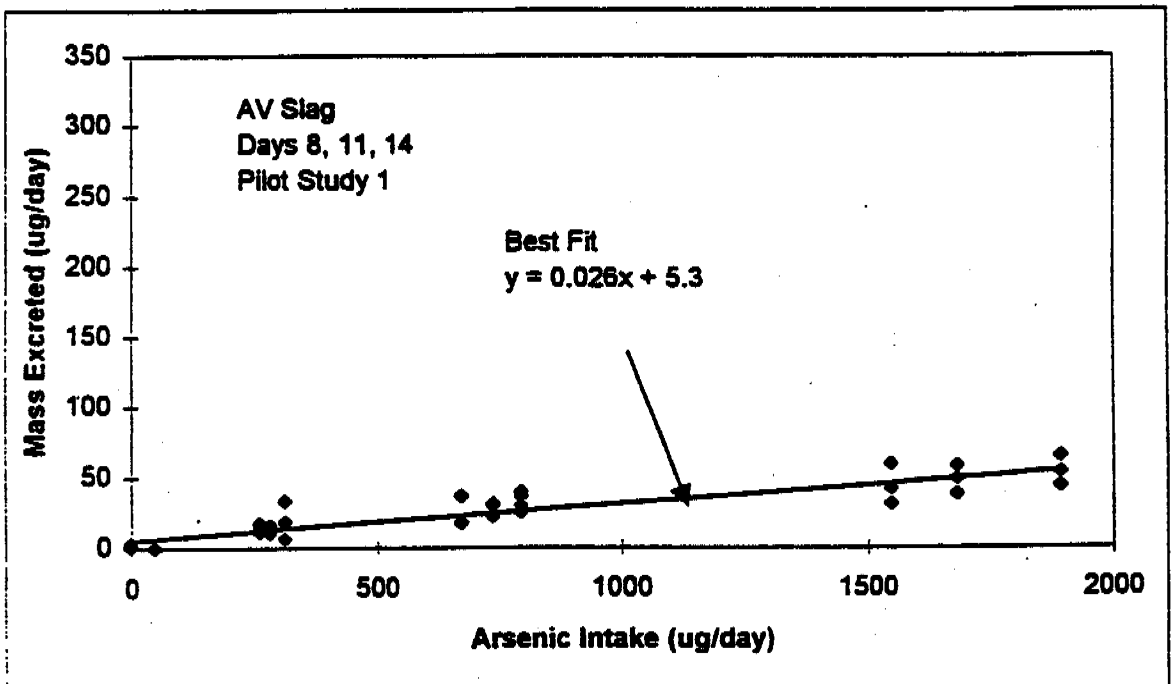


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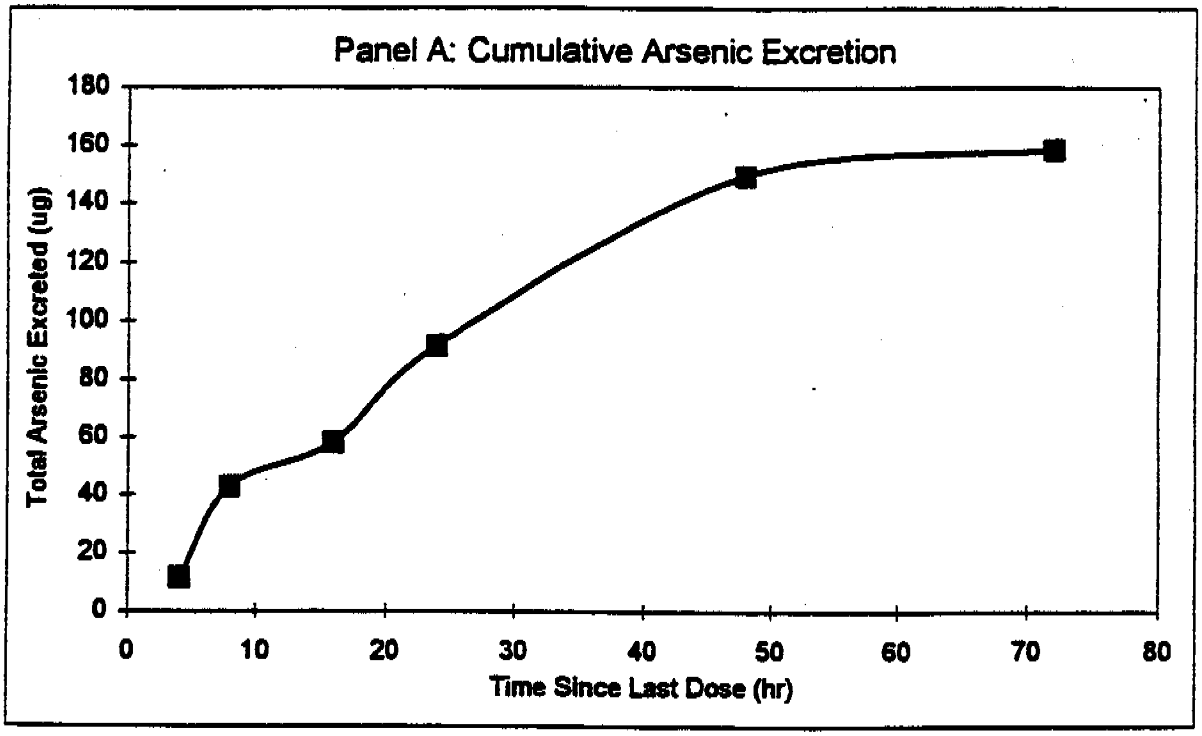
FIGURE 3-4 RATE OF ARSENIC DEPURATION IN URINE



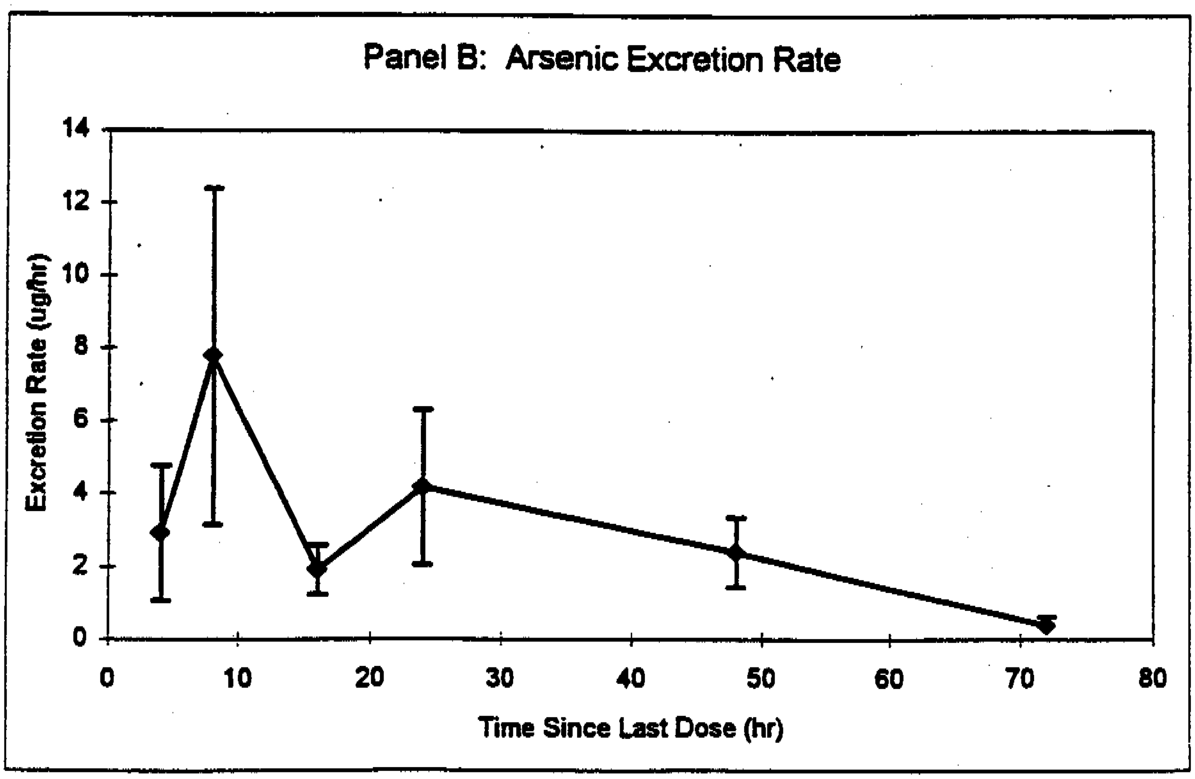


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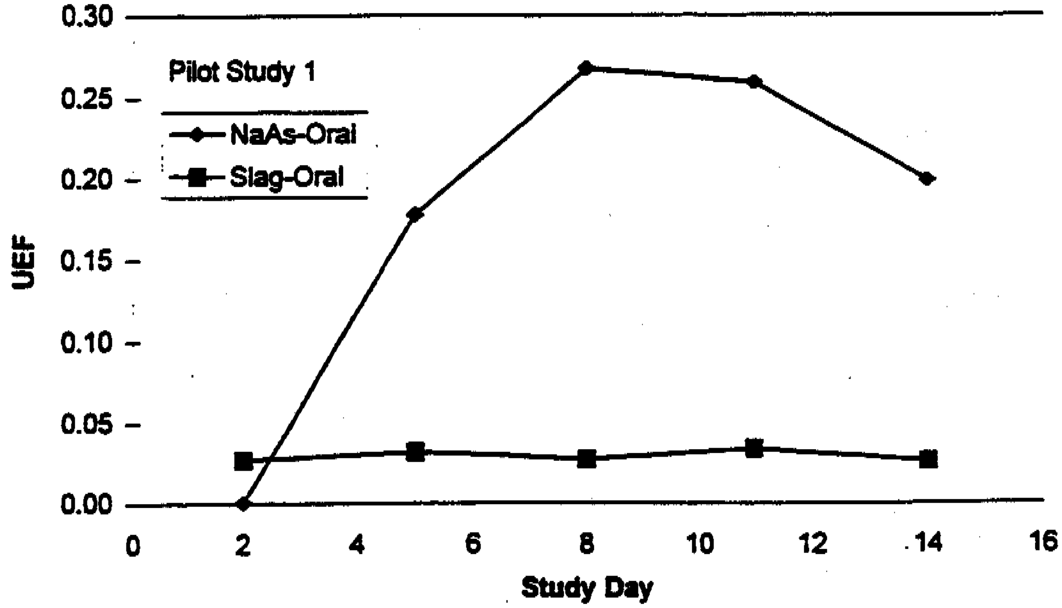
FIGURE 3-3 TIME COURSE OF ARSENIC EXCRETION



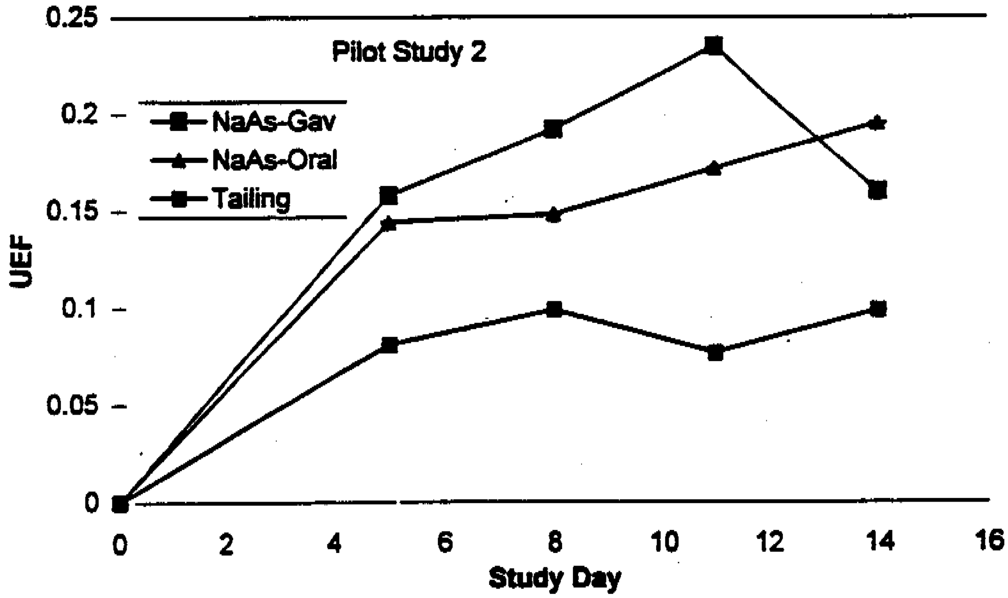


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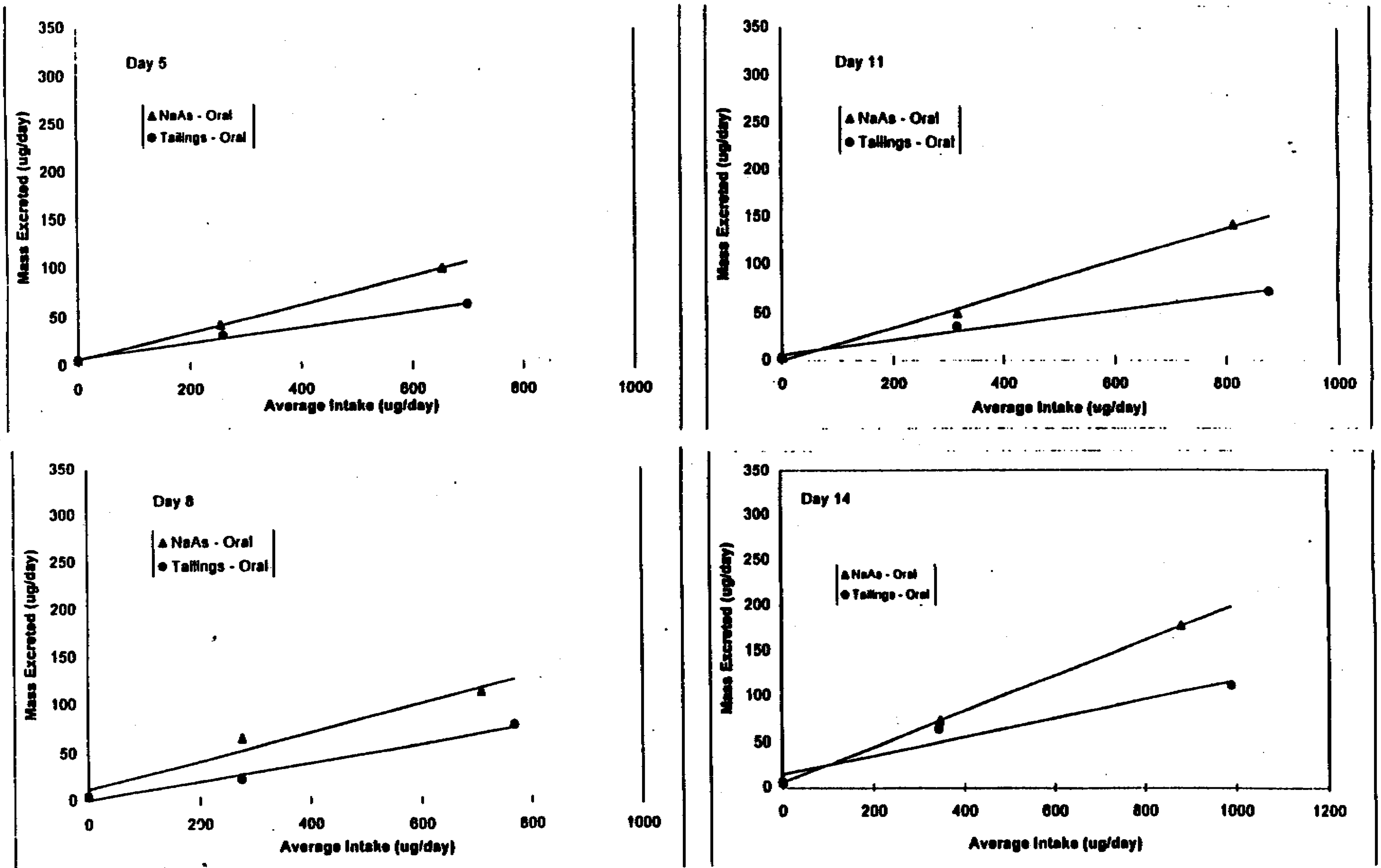
FIGURE 3-2 DOSE-RESPONSE PATTERNS
PILOT STUDY 2



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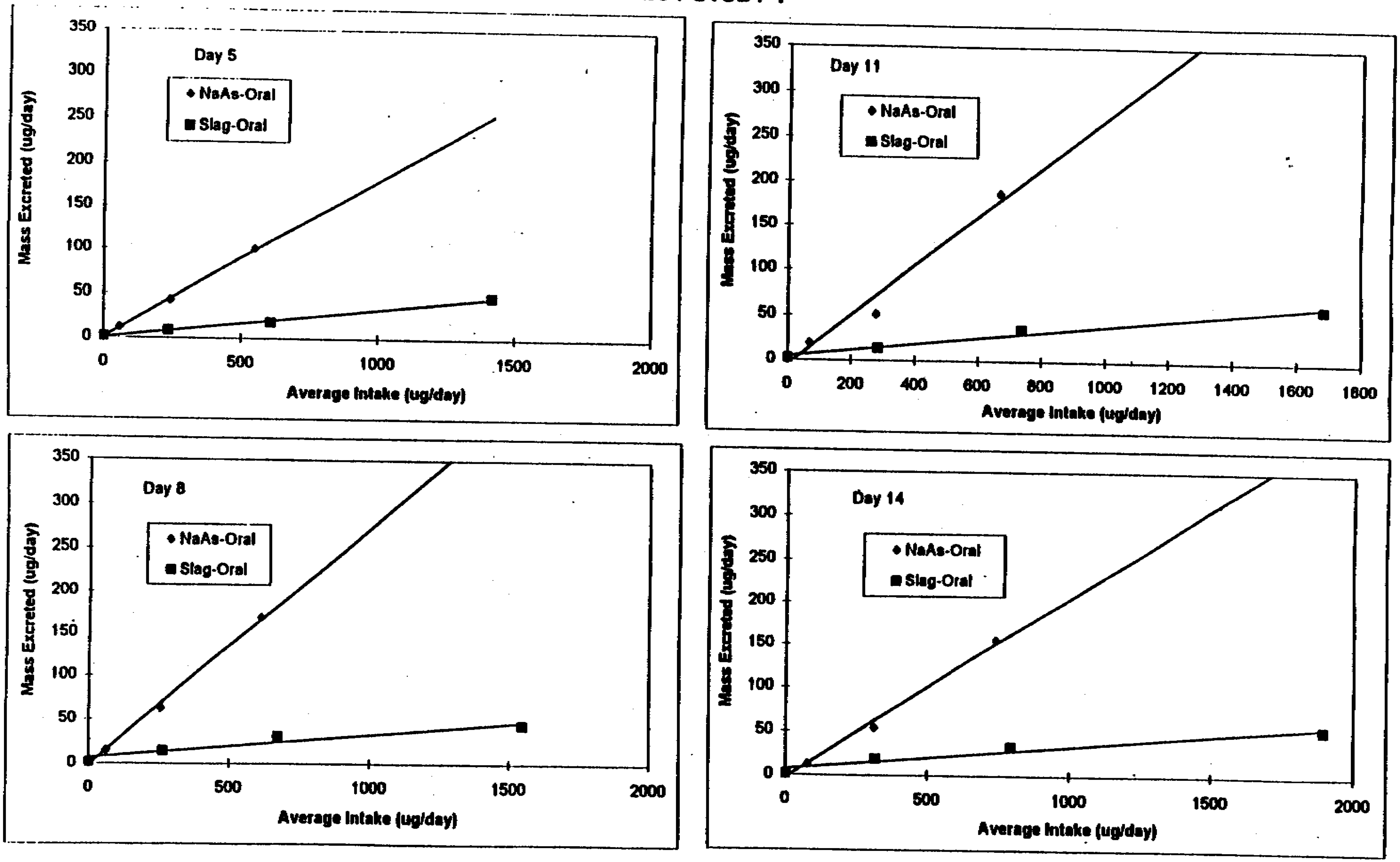
DOSE RESPONSE PATTERNS
PILOT STUDY 1



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3.0 RESULTS

3.1 Dose Response of Arsenic Excretion in Urine

Figures 3-1 and 3-2 show group mean arsenic excretion rates (ug/day) plotted as a function of arsenic intake (ug/day) for a number of different treatment groups employed in Pilot Studies 1 and 2, each on a number of different treatment days. As expected, the relationship between excretion and intake is approximately linear in nearly all cases. Based on this, the slope of the best-fit linear regression line through the dose-response data is taken as the most robust estimate of the UEF (ug/day excreted per ug/day administered) for a given treatment group on a given day.

3.2 Time Dependence of Arsenic Excretion

As noted earlier, the study design employed in these investigations employed a repeated-dosing protocol. This protocol is based on the expectation that repeated exposures will result in a sort of "steady state" in an exposed animal, with the amount of arsenic excreted each day being a constant fraction of the amount administered. To investigate whether this is so, the UEF (calculated as described above) was plotted as a function of exposure duration for several different treatment groups. The results are shown in Figure 3-3. As seen, the excretion rate appears to become approximately constant after about Day 5. This is supported by the finding that arsenic excretion in urine falls to near zero within about two days after dosing is halted following 15 days of oral exposure (Figure 3-4), and is also consistent with observations in humans that steady state is reached in about five days (Mappes 1977). Based on the finding that animals come to steady state by about day 5, all calculations of UEF were based only on excretion measurements collected after day 5.

3.3 RBA Calculations for Pilot Studies

As discussed above, the relative bioavailability of an arsenic-containing material are calculated from the ratio of urinary excretion fractions (UEFs) for test material and sodium arsenate, as follows:

$$RBA(test) = UEF(test)/UEF(NaAs)$$

UEF Values

Figures 3-5 and 3-6 show the combined data sets for a number of different treatment groups, along with the final best fit straight lines through the data. The slope of the line through each data set is the estimate of UEF for that group.

In some cases, some of the measured data points (i.e., estimated mass excreted) were judged to be unreliable and were excluded from the UEF regression analysis. Data points were excluded according to the following guidelines:

1. In some cases (mainly in the initial studies), the diverter used to deflect spilled drinking water away from the urine collecting pan did not work effectively; and some urine samples became highly diluted. Cases where total urine volume was more than 5 L (typical 24-hour urine volumes are about 1-2 L) and the measured urine concentration of arsenic was at or below the detection limit (2 ug/L) were judged to be unreliable and were excluded from the quantitative analysis.

2. For control animals (not administered arsenic), the mass of arsenic recovered in urine averaged across all studies was about 6.7 ug/day, with a 95th percentile value of about 19.9 ug/day. Control animals which yielded estimates higher than 20 ug/day were therefore judged to be outliers and were excluded.

3. Data points which fell outside the 95% prediction interval for the best-fit straight line (determined by the curve-fitting software) were judged to be outliers, and were excluded from the final linear regression.

FIGURE 2-3 DOSE VERIFICATION SAMPLES

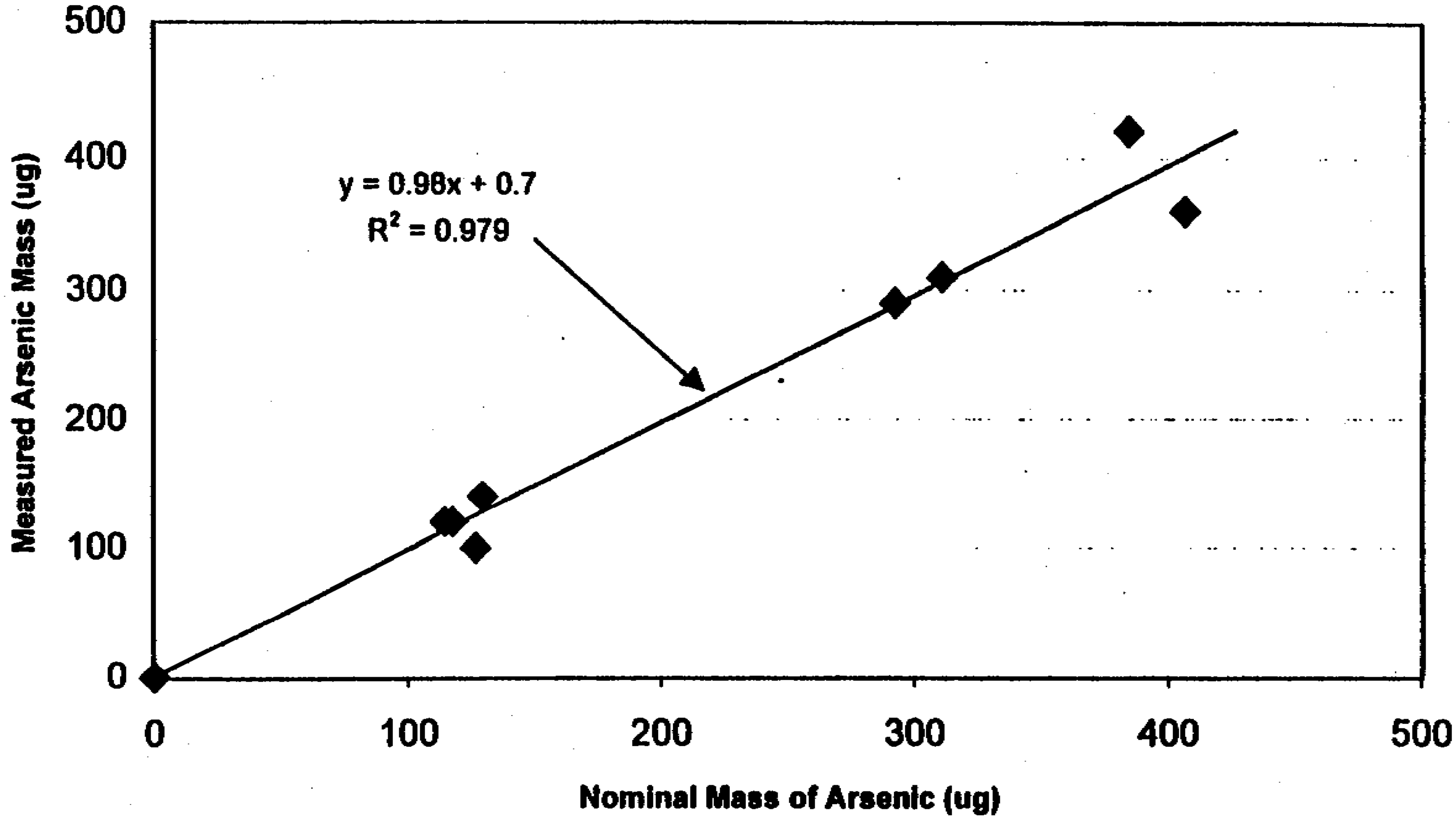

FIGURE 2-2 ANALYTICAL QUALITY ASSURANCE DATA
PILOT STUDY 2

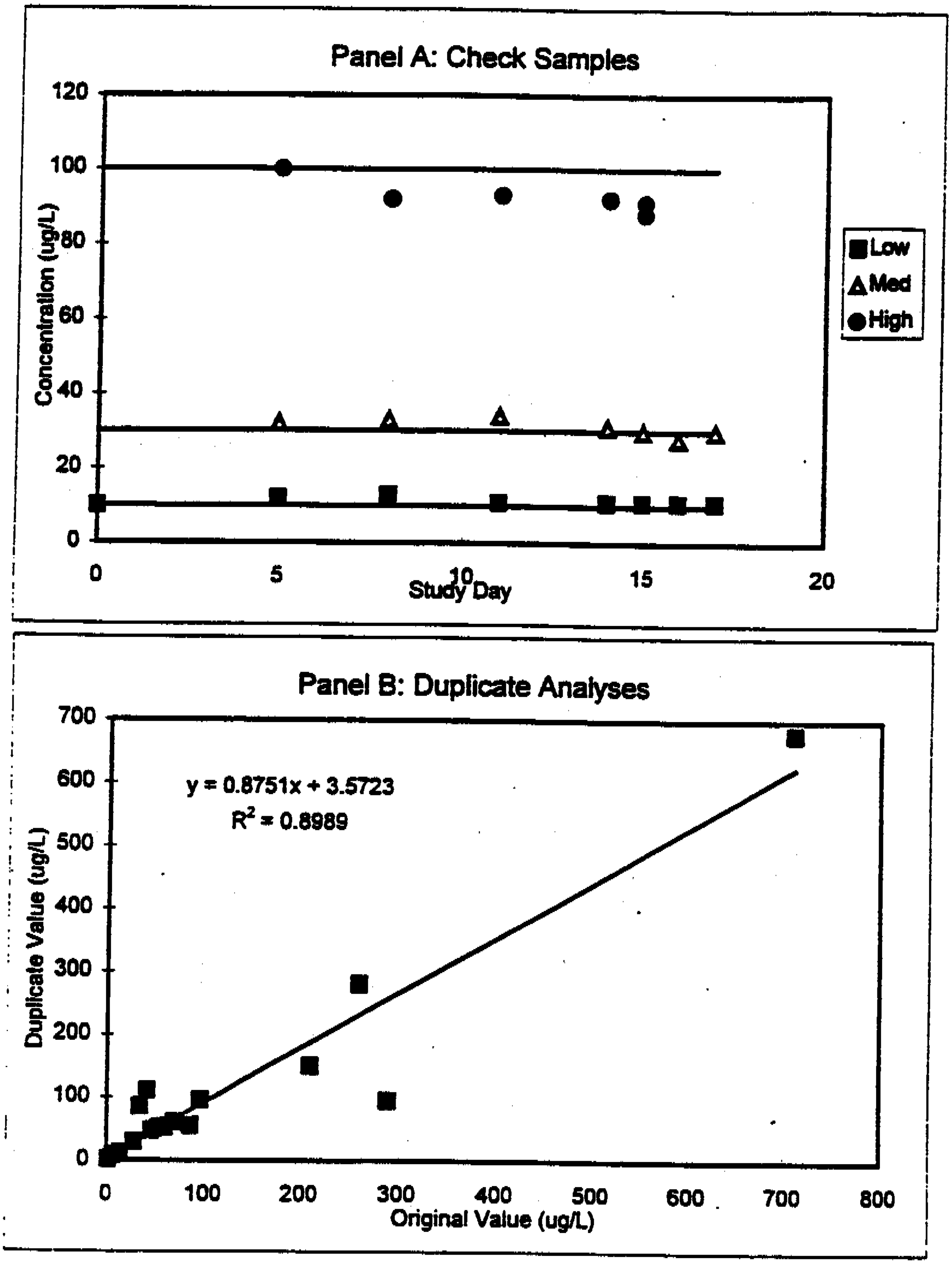

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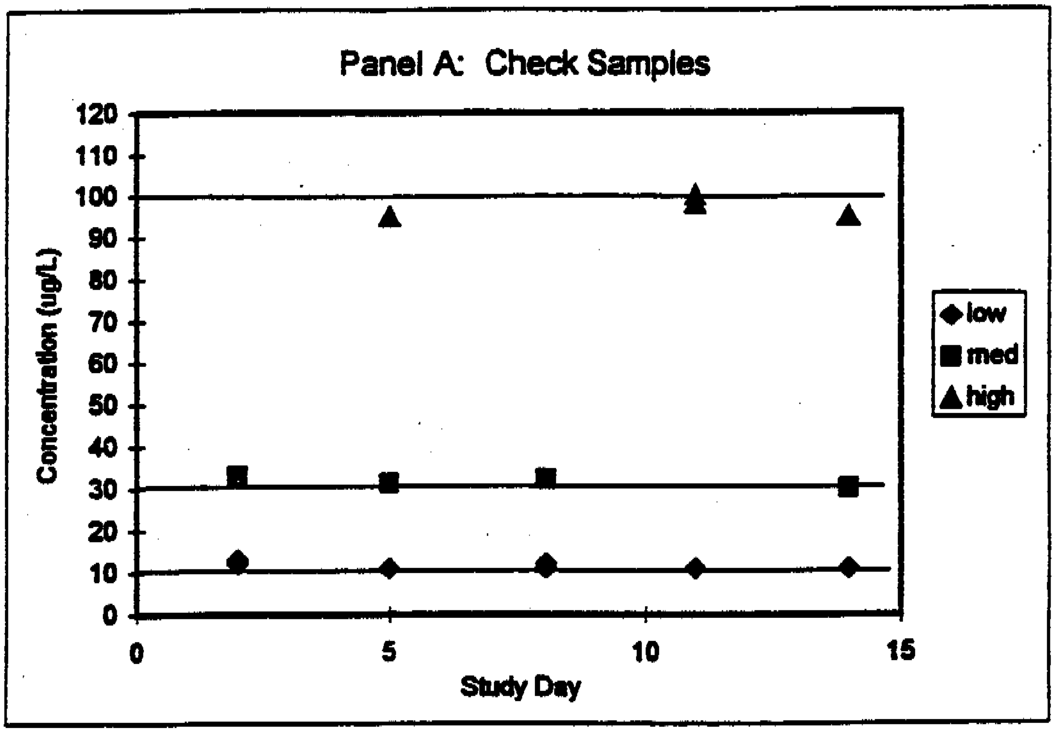
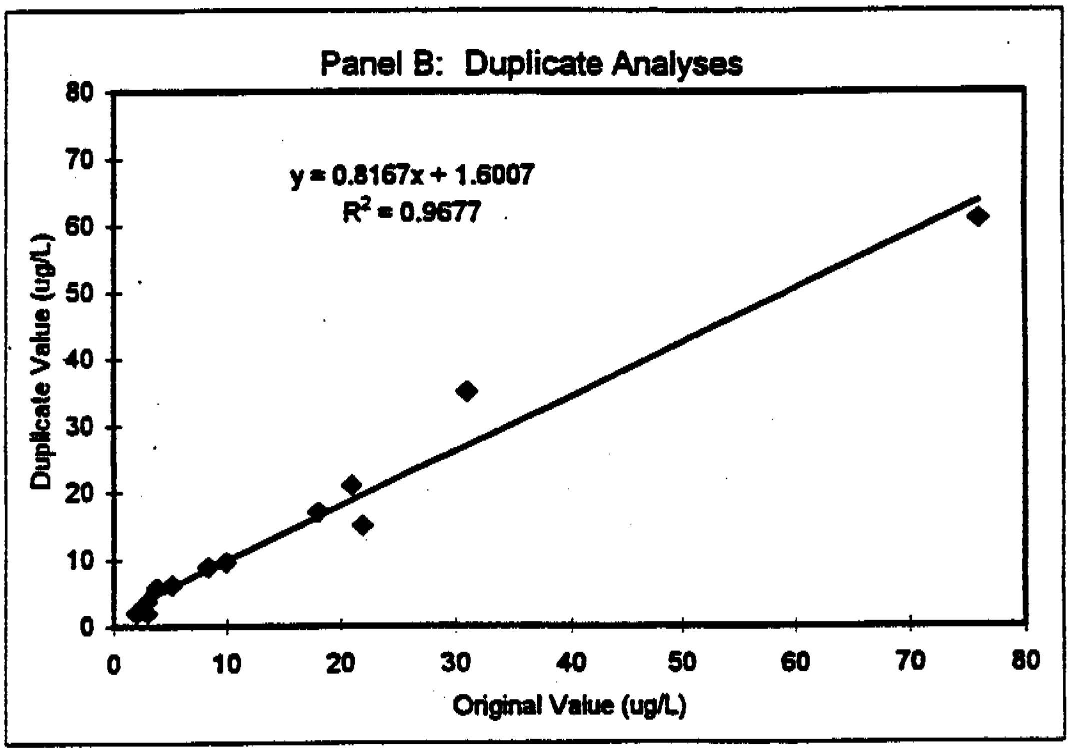
FIGURE 2-1 ANALYTICAL QUALITY ASSURANCE DATA
PILOT STUDY 1





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For samples close to or below the detection limit, all duplicate pairs were within two-times the detection limit.

Standards

Samples of a urine standard obtained from NIST (sample number 2670 Elevated, nominal arsenic concentration = 480 ± 100 ug/L) were run as part of each set of analyses. Results for this standard ranged from 440 to 480 ug/L, with a mean across all samples of 451 ± 13 ug/L (N = 26).

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 0.05 ug of arsenic.

In addition to these laboratory-sponsored QA procedures, an additional series of standards ("check samples") and duplicates were submitted to the laboratory in a random and blind fashion, commingled with normal test samples. The results are shown in Figure 2-1 and Figure 2-2. As seen in Panel A of each figure, there was good accuracy on blind check samples (10, 30, and 100 ug/L) throughout the duration of the study. As shown in Panel B of each figure, there was also good reproducibility between blind duplicate samples, with an average absolute difference between pairs of about 1.3 ug/L, and an average relative percent difference of about 3.8%.

Finally, as a check of the accuracy of the doses administered to the animals, random doughballs prepared during the studies were analyzed for arsenic content. The results are shown in Figure 2-3. As seen, measured arsenic levels in the doughballs were very close to the target dose levels, indicating that administered doses were close to the nominal values called for in the protocols.

2.7 Data Reduction

The basic approach used to estimate the urinary excretion fraction for a particular test or reference material was to plot the mass of arsenic excreted in the urine in a day (calculated as the concentration in urine times the 24-hour urine volume) as a function of the daily mass of arsenic administered. Urine samples whose concentration was below the detection limit (about 2 ug/L) were evaluated by assuming a concentration equal to the detection limit. The slope of the best-fit straight line through the all the data points was taken as the best estimate of UEF (ug/day excreted per ug/day administered) for that form of arsenic. All linear regression data-fitting was performed using TableCurve 2D (Jandel Scientific).

covered with a watch glass and heated on a hot-plate at 70-80°C overnight. The watch glass was then removed and the temperature increased to 200°C until the sample was completely dry (about 8-12 hours). The dried sample was transferred to a muffle furnace and heated at 1 degree/minute up to 500°C, which was then held for three hours. After cooling, 20 mL of 50% HCl was added and gently boiled for 1 hour on a hotplate. After 1 hour, 50% HCl was added to restore the volume to 20 mL, and this was diluted with water to 100 mL.

Tissues

In one study, samples of blood, bile, liver, kidney, lung, muscle, and skin were collected for the purposes of supporting a mass balance analysis. These tissues were collected at sacrifice (day 15) and prepared for analysis using the same method as described above for feces.

2.6 Arsenic Analysis

Samples of urine, feces, or tissues prepared as described above were diluted either 1/5 or 1/10 (v/v) with a solution containing 10% hydrochloric acid, 10% potassium iodide, and 5% ascorbic acid. Arsenic standards (0, 1.0, 5.0 and 15.0 ug As/L) were prepared by dilution in the same diluent. Arsenic in the sample was converted to the volatile hydride by addition of sodium borohydride and separated from the bulk sample by a pulse of argon gas. The amount of arsenic in the vapor pulse was measured with a Perkin-Elmer 3100 atomic absorption spectrophotometer.

The detection limit of the method was evaluated by performing 10 replicate analyses of a low standard (about 1 ug/L). The detection limit was defined as three-times the standard deviation of these 10 analyses. Typically, the detection limit was about 1-2 ug/L for urine samples, about 50-100 ug/kg for feces, and about 10-20 ug/kg for soft tissues.

A number of quality assurance 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 samples were spiked with known amounts of arsenic (5-20 ug) and the recovery of the added arsenic was measured. Recovery for individual urine samples ranged from 77% to 110%, with an average across all analyses of $97 \pm 5\%$ ($N = 47$). Recovery of spiked arsenic from feces ranged from 94% to 102% with a mean recovery of 99% ($N = 8$).

Duplicate Analysis

Random samples were selected for duplicate analysis by the analyst. For samples with concentrations above the detection limit, duplicate results were typically within 2-3 ug/L.

2.4 Dosing

Animals were administered oral doses of test material or sodium arsenate (abbreviated in this report as "NaAs") for 15 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). Doses were based on measured group mean body weights, and were adjusted every three days to account for animal growth.

In most cases, dose material was placed in the center of a small portion (about 5 grams) of moistened feed (referred to as a "doughball"), and this was administered to the animals by hand. In one study, sodium arsenate was administered by gavage as an aqueous solution.

2.5 Collection and Preparation of Biological Samples

Urine

Samples of urine were collected from each animal on several different days during each study (the exact days varying from study to study). Collection began at 7:00 A.M and ended 24 hours later. The urine was collected in a stainless steel pan place 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. At the end of each collection period, the urine volume was measured and two 60-mL portions were removed for analysis. Each 60 mL sample was acidified by addition of 0.6 mL concentrated nitric acid. These samples were stored refrigerated until sample preparation, as follows.

A 25 mL aliquot of acidified urine was removed and placed in a clean 100 mL glass beaker. To this was added 20 mL of concentrated nitric acid and 2.5 mL of concentrated perchloric acid. The beaker was covered with a watch glass and was placed on a hot plate to reflux for 4-12 hours. After this period, the heat was increased to drive off the nitric acid and to cause the perchloric acid to fume. After about 10 minutes of fuming, the digestate was slightly cooled and diluted with 20 mL of distilled water. This was heated until clear or boiling, and then cooled and diluted to 50 mL.

Feces

In one study, 24-hour samples of feces were collected on the same days as urine collection. The feces for each animal were frozen and freeze-dried until all moisture was removed. One gram of the dry residue was placed in a 100 mL beaker along with 3 mL of methanol, 5 drops of anti-foaming agent, 10 mL of 40% (w/v) magnesium nitrate hexahydrate, 10 mL of trace metal grade concentrated nitric acid, and 2 mL of trace metal grade hydrochloric acid. The beaker was

TABLE 2-2 TYPICAL FEED COMPOSITION[a]

Nutrient Name	Amount	Nutrient Name	Amount
Protein	20.1021%	Magnesium	0.0533%
Arginine	1.2070%	Sulfur	0.0339%
Lysine	1.4690%	Manganese	20.4719 ppm
Methionine	0.8370%	Zinc	118.0608 ppm
Met+Cys	0.5876%	Iron	135.3710 ppm
Tryptophan	0.2770%	Copper	8.1062 ppm
Histidine	0.5580%	Cobalt	0.0110 ppm
Leucine	1.8160%	Iodine	0.2075 ppm
Isoleucine	1.1310%	Selenium	0.3196 ppm
Phenylalanine	1.1050%	Nitrogen Free Extract	60.2340%
Phe+Tyr	2.0500%	Vitamin A	5.1892 kIU/kg
Threonine	0.8200%	Vitamin D3	0.6486 kIU/kg
Valine	1.1910%	Vitamin E	87.2080 IU/kg
Fat	4.4440%	Vitamin K	0.9089 ppm
Saturated Fat	0.5590%	Thiamine	9.1681 ppm
Unsaturated Fat	3.7410%	Riboflavin	10.2290 ppm
Linoleic 18:2:6	1.9350%	Niacin	30.1147 ppm
Linoleic 18:3:3	0.0430%	Pantothenic Acid	19.1250 ppm
Crude Fiber	3.8035%	Choline	1019.8600 ppm
Ash	4.3347%	Pyridoxine	8.2302 ppm
Calcium	0.8675%	Folacin	2.0476 ppm
Phos Total	0.7736%	Biotin	0.2038 ppm
Available Phosphorous	0.7005%	Vitamin B12	23.4416 ppm
Sodium	0.2448%	Moisture	5.7%
Potassium	0.3733%	Fiber	1.7%
Chlorine	0.1911%	Metabolizable energy	3.4 kcal/gram

[a] Nutritional values provided by Zeigler Bros., Inc.

TABLE 2-1 STUDY DESIGN FOR ARSENIC PILOT STUDIES

Pilot Study 1

Group	Number of Animals	Material Administered	Dose Route	Dose (ug As/kg-day)
1	5	NaAs	IV[a]	5
2	5	NaAs	Oral	50
3	5	NaAs	Oral	50
4	4	Control	Oral	0
5	4	NaAs	Oral	5
6	4	NaAs	Oral	20
7	4	NaAs	Oral	50
8	4	AV Slag[b]	Oral	20
9	4	AV Slag	Oral	50
10	4	AV Slag	Oral	125

Pilot Study 2

Group	Number of Animals	Material Administered	Dose Route	Dose (ug As/kg-day)
1	3	Control	Oral	0
2	5	NaAs	IV[a]	20
3	5	NaAs	IV[a]	50
4	4	NaAs	Gavage	20
5	4	NaAs	Gavage	50
6	4	NaAs	Oral	20
7	4	NaAs	Oral	50
8	4	Grant Kohrs Tailings[c]	Oral	20
9	4	Grant Kohrs Tailings	Oral	50

[a] Data from animals exposed by intravenous injection will be presented elsewhere.

[b] This sample was collected from slag deposits at the former AV Smelter at the California Gulch Superfund Site. The arsenic concentration in the test material was 1,050 ppm. Group 2 was used to study the rate of arsenic depuration from blood and Group 3 was used to follow the rate of arsenic depuration from urine following 15 days of exposure.

[c] This sample was collected from a tailings deposit along the banks of the Clark Fork River on the property of the Grant Kohrs Ranch in Deer Lodge, Montana. The arsenic concentration in the test material was 181 ppm.

2.2 Experimental Animals

Young swine were selected for use in these studies because their gastrointestinal physiology is more nearly similar to humans than most other animal models (Weis and LaVelle 1991). All animals were young 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 each study was typically 6-8 more than required by the protocol. These animals were usually purchased at age 4-5 weeks (weaning occurs at age 3 weeks), and they were then held under quarantine for one week to observe their health before beginning exposure to test materials. Any animals which appeared to be in poor health during this quarantine period were excluded. To minimize weight variations between animals and groups, extra animals most different in body weight on day -4 (either heavier or lighter) were also excluded from the study. The remaining animals were assigned to dose groups at random. When exposure began (day zero), the animals were about 5-6 weeks old and weighed an average of about 8-11 kg.

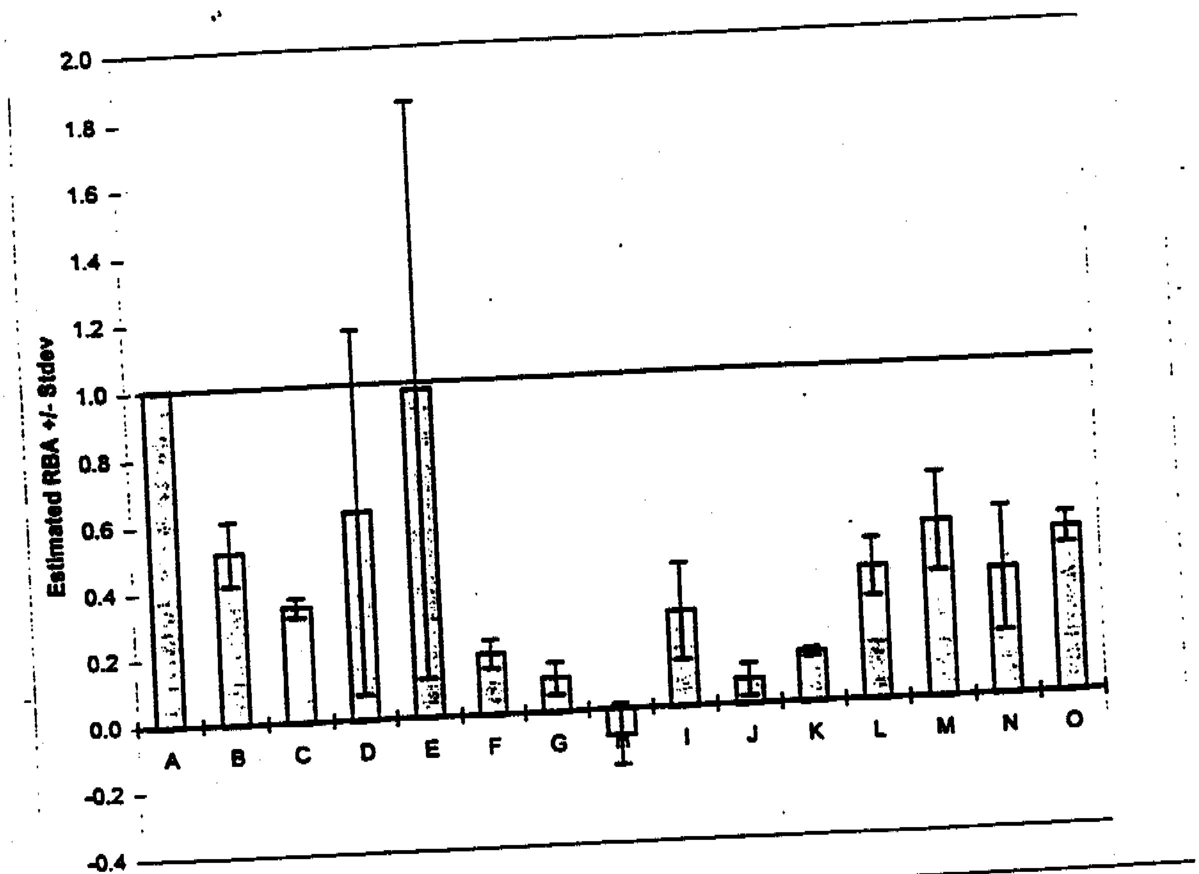
All animals were housed in individual stainless steel cages. Each animal was examined by a certified veterinary clinician (swine specialist) prior to being placed on study, and all animals were examined daily by an attending veterinarian while on study. Blood samples were collected for clinical chemistry and hematological analysis on days -4, 7, and 15 to assist in clinical health assessments. Any animal that became ill and could not be promptly restored to good health by appropriate treatment was promptly removed from the study.

2.3 Diet

Animals provided by the supplier were weaned onto standard pig chow purchased from MFA Inc., Columbia, MO. In order to minimize lead exposure from the diet, the animals were gradually transitioned from the MFA feed to a special low-lead feed (guaranteed less than 0.2 ppm lead, purchased from Zeigler Brothers, Inc., Gardners, PA) over the time interval from day -7 to day -3, and this feed was then 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 5% of the mean body weight of all animals on study. Feed was administered in two equal portions of 2.5% of the mean body weight at each feeding. Feed was provided at 11:00 AM and 5:00 PM daily. Periodic analysis of feed samples during this program indicated the arsenic level was below 0.1 ppm, which corresponds to a dose contribution from food of less than 5 ug/kg-day.

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

FIGURE 3-8 ESTIMATED RBA OF ARSENIC



KEY:

A	NaAs
B	Murray Slag
C	Murray Soil
D	Aspen Berm
E	Aspen Residential
F	Midvale Slag
G	Butte Soil
H	Leadville Residential
I	Leadville FeMnPb Oxide
J	Leadville AV Slag (Test 1)
K	Leadville AV Slag (Test 2)
L	Palmerton Location 2
M	Palmerton Location 4
N	Bingham Creek Channel
O	Clark Fork Tailings

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TABLE 3-1 RBA ESTIMATES FOR ARSENIC IN SOIL AND MINE WASTE

Site	Sample	Arsenic Conc. (ppm)	Arsenic Dose (ug/kg-d)	UEF ± SEM (n)	RBA ± SEM
Murray Smelter	Slag	695	13.4	0.090 ± 0.015 (16)	0.51 ± 0.09
	Soil	310	65.4	0.060 ± 0.004 (19)	0.34 ± 0.03
Aspen/ Smuggler	Berm	67	1.1	0.109 ± 0.089 (16)	0.62 ± 0.55
	Residential	17	1.0	0.172 ± 0.140 (15)	0.98 ± 0.86
Midvale Slag	Slag Composite	591	16.8	0.032 ± 0.007 (19)	0.18 ± 0.04
Butte	Soil Composite	238	6.3	0.017 ± 0.008 (17)	0.10 ± 0.05
California Gulch	Residential Soil	203	6.1	-0.013 ± 0.015 (16)	-0.08 ± 0.09
	FeMnPb Oxide	110	5.7	0.050 ± 0.023 (14)	0.28 ± 0.15
	AV Slag	1050	22.3	0.012 ± 0.008 (17)	0.07 ± 0.05
Palmerton	Location 2	110	7.7	0.069 ± 0.014 (19)	0.39 ± 0.09
	Location 4	134	14.0	0.092 ± 0.024 (19)	0.52 ± 0.15
Bingham Creek	Channel Soil	149	15.8	0.066 ± 0.029 (12)	0.37 ± 0.19

Abbreviations:

UEF = Urinary Excretion Fraction (ug/day excreted per ug/day administered)
SEM = Standard Error of the Mean
n = Number of individual data points used to estimate the UEF
RBA = Relative Bioavailability compared to sodium arsenate administered orally

TABLE 3-2 RELATIVE ARSENIC MASS

Arsenic Phase	AV Slag		Grant Kohrs Tailings		Midvale Slag		Murray Smelter Slag Sample		Murray Smelter Soil sample	
	Total	Lib.	Total	Lib.	Total	Lib.	Total	Lib.	Total	Lib.
As(M) Oxide	5.2	5.2							1.8	1.8
Pb-As(M) Oxide	0.2	0.1								
Pb-As Oxide	84.2	57.8			87.2	64.8	48.8	43.7	86.8	66.2
Pb(M) Oxide	1.8	1.8					0.7	0.6	0.4	0.2
Pb(M) Sulfate	3.3	3.3								
Slag	5.1	5.1	0.1	0.1	11.3	11.3	13.9	13.9	2.4	2.4
Fe-As Sulfate	0.3	0.1	16.7	16.7			9.9	9.9	5.8	5.8
Fe-As Oxide			53.5	53.5	0.2	0.2	26.6	26.6	2.9	2.9
Mn-As Oxide			1.0	1.0						
As Phosphate			15.7	15.4						
Enargite/sulfosalts			13.1	6.9	1.4	1.4				
TOTAL	100	73	100	94	100	78	100	95	100	79
Estimated RBA	15%		49%		18%		63%		37%	

approach to deriving quantitative estimates of phase-specific RBA values is to use multiple linear regression modelling employing the following basic model:

$$RBA = \Sigma\ (f_i \cdot RBA_i)$$

where:

f_i = fraction of total arsenic present in phase "i"
RBA_i = Inherent RBA of phase "i"

However, since there are 11 different phases listed in Table 3-2 but there are only 5 samples available with both speciation data and RBA values, it is evident *a priori* that the phase-specific RBA values cannot be estimated with confidence from the present data set. Indeed, reliable multivariate regression modelling usually requires at least 10 observations (samples) per independent variable (phase). Even if all of the minor phases are ignored and estimates are sought only for the 5 most common phases, none of the resulting coefficients (phase-specific RBAs) are statistically significant. Therefore, it is not yet possible to calculate the RBA of some test material based only on speciation data. However, it is expected that meaningful estimates of phase-specific RBA values may be obtained in the future after additional data become available.

3.6 Arsenic Recovery

As part of the quality assurance steps taken during this investigation, an arsenic mass balance study was performed as part of Pilot Study 2. That is, the amount of arsenic recovered in urine, feces, and various body tissues and fluids was summed and compared to the amount administered. The detailed data are presented in Appendix D, and the results are summarized in Table 3-3.

As seen, fecal excretion of arsenic was clearly elevated in animals exposed to Grant Kohrs tailings, consistent with the conclusion that arsenic is not well absorbed from this test material. However, the mass of arsenic recovered in the feces plus urine did not account for the mass administered for any of the treatment groups. This suggests that arsenic is being retained in the body, but measurements of arsenic levels in tissues were mainly at or below detection limits, and estimated body burdens in these tissues accounted for only a few percent of the administered dose.

TABLE 3-3 ARSENIC MASS BALANCE

Body Fluid or Compartment	Percent Total Dose Recovered (n)	
	NaAs - Oral (50 ug/kg-day)	GK Tailings (50 ug/kg-day)
Urine	17.6% (105)	8.6% (31)
Feces	3.6% (42)	27.5% (42)
Blood	<0.02 (4)	< 0.02 (4)
Bile	0.02% (4)	0.01% (4)
Liver	0.06% (4)	0.04% (4)
Kidney	0.02% (4)	0.02% (4)
Lung	0.03% (2)	–
Muscle	1.8% (1)	–
Skin	0.08% (2)	–
TOTAL	23%	36%

4.0 DISCUSSION

The results of this investigation indicate that young swine may be used to evaluate gastrointestinal absorption of arsenic from different test materials, using urinary arsenic excretion as the measurement endpoint. In addition, these measurements can be performed at the same time as measurements designed to study lead bioavailability.

Most studies of arsenic absorption employ a single dose protocol and measure urinary excretion for 2-3 days. In contrast, this study employed a repeated dosing protocol, with repeated 24-hour urine collections. An advantage of this protocol is that it reflects a more realistic human exposure scenario than does a single dose protocol. Further, multiple measurements can be made from the same animal on different days. In essence, data from different days allow multiple independent estimates of the UEF, and these data can be combined (once steady state has been achieved) to provide a robust estimate of the excretion fraction.

The RBA results for different test materials investigated strongly support the view that arsenic in most soils and mine wastes is not as well absorbed as soluble arsenic. The detailed chemical mechanism accounting for this reduced bioavailability of arsenic in slag is not known, but almost certainly is related to the chemical form of arsenic in the sample. In particular, limited evidence suggests that lead arsenic oxide (one of the more common phases of arsenic in these test materials) may have low bioavailability, but the data are too sparse at present to draw firm conclusions.

Because arsenic in most test materials is absorbed less-extensively than soluble forms of arsenic, use of default toxicity factors for assessing human health risk will lead to an overestimate of hazard. Therefore, measurement and application of site-specific RBA values to adjust the default toxicity factors is expected to increase the accuracy and decrease the uncertainty in human health risk assessments for arsenic.

The basis for the low recovery of arsenic in these studies is not clear. As detailed in Section 2.6, numerous quality assurance checks performed during the study suggest that the problem does not lie at the level of sample preparation or arsenic analysis. Because the basis for the low recovery is not clear, interpreting the significance is also not clear. If the "error" leading to the low recovery is systematic and applies equally in all cases, the RBA values calculated above are expected to be correct. This is because the "error factor" would be the same in the numerator and denominator of the ratio used to calculate RBA, and hence would cancel out. Only if the "error" affects arsenic recovery differently for different treatment groups would the RBA values above be incorrect. Further studies are being performed to investigate the basis for this apparent discrepancy.

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APPENDIX A

DETAILED DATA TABLES FOR PILOT STUDIES 1 AND 2

A-1

DATA SUMMARY - PILOT STUDY 1

Group	Treatment	Dose ug/kg-d	Pig No	Day 2 Excreted ug/d	Day 2 Intake ug/day	Day 5 Excreted ug/d	Day 5 Intake ug/day	Day 8 Excreted ug/d	Day 8 Intake ug/day	Day 11 Excreted ug/d	Day 11 Intake ug/day	Day 14 Excreted ug/d	Day 14 Intake ug/day
4	Control	0	1005	1.7	0.0	2.8	0.0	2.8	0.0	2.6	0.0	1.3	0.0
			1006	1.7	0.0	1.6	0.0	2.6	0.0	2.0	0.0	1.5	0.0
			1022	2.1	0.0	0.9	0.0	1.2	0.0	1.7	0.0	2.2	0.0
			1030	1.1	0.0	0.5	0.0	0.5	0.0	1.5	0.0	1.0	0.0
			Avg	1.7	0.0	1.5	0.0	1.8	0.0	1.9	0.0	1.5	0.0
5	NaAs-Oral	5	1016	1.3	52.8	8.8	58.1	15.4	60.2	17.6	68.8	12.7	76.9
			1021	1.1	52.8	15.1	58.1	17.6	60.2	16.6	68.8	18.0	76.9
			1035	1.6	52.8	8.6	58.1	12.7	60.2	21.5	68.8	8.0	76.9
			1045	0.9	52.8	13.4	58.1	11.6	60.2	17.4	68.8	10.2	76.9
			Avg	1.2	52.8	11.6	58.1	14.3	60.2	18.3	68.8	12.2	76.9
6	NaAs-Oral	20	1001	1.0	230.5	34.6	243.8	54.9	256.5	58.8	277.5	27.4	312.1
			1009	1.1	230.5	39.0	243.8	46.6	256.5	18.6	277.5	45.4	312.1
			1027	1.4	230.5	39.2	243.8	65.1	256.5	55.0	277.5	68.1	312.1
			1028	3.4	230.5	56.7	243.8	83.1	256.5	70.2	277.5	72.3	312.1
			Avg	1.7	230.5	42.4	243.8	62.4	256.5	50.7	277.5	53.3	312.1
7	NaAs-Oral	50	1018	1.7	523.3	88.3	551.3	253.8	612.5	312.0	667.3	177.9	741.5
			1024	0.5	523.3	48.0	551.3	50.7	612.5	59.6	667.3	43.7	741.5
			1029	2.6	523.3	65.6	551.3	98.7	612.5	144.8	667.3	120.5	741.5
			1036	2.1	523.3	166.5	551.3	270.0	612.5	228.9	667.3	273.5	741.5
			Avg	1.7	523.3	89.6	551.3	168.3	612.5	186.6	667.3	153.9	741.5
8	AV Slag	20	1011	3.3	212.4	7.3	237.4	11.5	263.9	12.5	285.0	17.5	317.7
			1013	2.8	212.4	8.5	237.4	17.6	263.9	15.4	285.0	32.7	317.7
			1025	6.1	212.4	11.4	237.4	16.0	263.9	14.4	285.0	6.3	317.7
			1034	10.2	212.4	7.5	237.4	12.5	263.9	10.6	285.0	18.5	317.7
			Avg	5.6	212.4	8.7	237.4	14.4	263.9	13.2	285.0	18.7	317.7
9	AV Slag	50	1002	24.8	575.8	20.6	609.3	17.0	673.8	21.8	737.5	35.9	795.8
			1004	22.5	575.8	16.7	609.3	17.6	673.8	29.4	737.5	39.2	795.8
			1043	19.0	575.8	18.5	609.3	36.1	673.8	30.9	737.5	29.3	795.8
			1046	42.9	575.8	17.7	609.3	53.9	673.8	58.6	737.5	24.6	795.8
			Avg	27.3	575.8	18.1	609.3	31.2	673.8	35.1	737.5	32.2	795.8
10	AV Slag	125	1019	49.4	1311.9	40.7	1418.8	30.7	1550.0	37.8	1685.6	52.6	1894.4
			1023	33.3	1311.9	43.1	1418.8			48.4	1685.6	64.1	1894.4
			1031	28.6	1311.9	45.6	1418.8	41.5	1550.0	57.2	1685.6	43.5	1894.4
			1042	30.7	1311.9	59.1	1418.8	59.0	1550.0	96.3	1685.6		
			Avg	35.5	1311.9	47.1	1418.8	43.7	1550.0	59.9	1685.6	53.4	1894.4

(shaded) Urine sample lost before analysis

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APPENDIX A

DATA SUMMARY - PILOT STUDY 1

pig no.	tag no.	day	group	test material	ug/kg-d	sample number	Q	Conc	Units	Vol (mL)	Mass (ug/d)	Reliable?	Avg (ug/d)	STD (ug/d)
1005	8-910-0287	-2	4	Control	0	II-10-1005 -(-2)-U		2	ug/L	1860	3.7	YES	2.8	0.88
1006	8-910-0277	-2	4	Control	0	II-10-1006 -(-2)-U		2	ug/L	820	1.6	YES		
1022	8-910-0266	-2	4	Control	0	II-10-1022 -(-2)-U		2	ug/L	1360	2.7	YES		
1030	8-910-0257	-2	4	Control	0	II-10-1030 -(-2)-U		3	ug/L	1000	3.0	YES		
1016	8-910-0273	-2	5	NaAs	5	II-10-1016 -(-2)-U	<	1	ug/L	2020	2.0	YES	2.2	0.64
1021	8-910-0289	-2	5	NaAs	5	II-10-1021 -(-2)-U		2	ug/L	1400	2.8	YES		
1035	8-910-0269	-2	5	NaAs	5	II-10-1035 -(-2)-U		1	ug/L	2460	2.5	YES		
1045	8-910-0281	-2	5	NaAs	5	II-10-1045 -(-2)-U		2	ug/L	660	1.3	YES		
21016	8-910-0468	-2	5	NaAs	5	II-10-21016 -(-2)-U		[redacted]	ug/L	2020		YES		
1001	8-910-0285	-2	6	NaAs	20	II-10-1001 -(-2)-U		2	ug/L	1540	3.1	YES	3.3	0.53
1009	8-910-0262	-2	6	NaAs	20	II-10-1009 -(-2)-U		3	ug/L	1360	4.1	YES		
1027	8-910-0280	-2	6	NaAs	20	II-10-1027 -(-2)-U		2	ug/L	1460	2.9	YES		
1028	8-910-0264	-2	6	NaAs	20	II-10-1028 -(-2)-U		2	ug/L	1540	3.1	YES		
1018	8-910-0271	-2	7	NaAs	50	II-10-1018 -(-2)-U		3.3	ug/L	1500	5.0	YES	2.7	1.88
1024	8-910-0274	-2	7	NaAs	50	II-10-1024 -(-2)-U	<	1	ug/L	460	0.5	YES		
1029	8-910-0275	-2	7	NaAs	50	II-10-1029 -(-2)-U	<	1	ug/L	2120	2.1	YES		
1036	8-910-0260	-2	7	NaAs	50	II-10-1036 -(-2)-U		1	ug/L	3180	3.2	YES		
21036	8-910-0469	-2	7	NaAs	50	II-10-21036 -(-2)-U		[redacted]	ug/L	3180		YES		
1011	8-910-0279	-2	8	Soil 1	20	II-10-1011 -(-2)-U		2	ug/L	1200	2.4	YES	3.0	1.14
1013	8-910-0276	-2	8	Soil 1	20	II-10-1013 -(-2)-U	<	1	ug/L	2580	2.6	YES		
1025	8-910-0268	-2	8	Soil 1	20	II-10-1025 -(-2)-U	<	1	ug/L	2440	2.4	YES		
1034	8-910-0259	-2	8	Soil 1	20	II-10-1034 -(-2)-U		3	ug/L	1580	4.7	YES		
1002	8-910-0284	-2	9	Soil 1	50	II-10-1002 -(-2)-U		1	ug/L	3100	3.1	YES	4.8	1.32
1004	8-910-0282	-2	9	Soil 1	50	II-10-1004 -(-2)-U	<	1	ug/L	4500	4.5	YES		
1043	8-910-0265	-2	9	Soil 1	50	II-10-1043 -(-2)-U		2	ug/L	3160	6.3	YES		
1046	8-910-0270	-2	9	Soil 1	50	II-10-1046 -(-2)-U		3	ug/L	1500	4.5	YES		
1019	8-910-0267	-2	10	Soil 1	125	II-10-1019 -(-2)-U		4.9	ug/L	820	4.0	YES	5.1	2.84
1023	8-910-0288	-2	10	Soil 1	125	II-10-1023 -(-2)-U		5.6	ug/L	780	4.3	YES		
1031	8-910-0258	-2	10	Soil 1	125	II-10-1031 -(-2)-U		2	ug/L	1420	2.8	YES		
1042	8-910-0272	-2	10	Soil 1	125	II-10-1042 -(-2)-U	<	1	ug/L	9240	9.2	YES		
1005	8-910-0295	2	4	Control	0	II-10-1005 -(2)-U		3	ug/L	580	1.7	YES	1.7	0.4.
1006	8-910-0296	2	4	Control	0	II-10-1006 -(2)-U		3	ug/L	576	1.7	YES		
1022	8-910-0316	2	4	Control	0	II-10-1022 -(2)-U		3	ug/L	700	2.1	YES		
1030	8-910-0317	2	4	Control	0	II-10-1030 -(2)-U		2	ug/L	540	1.1	YES		
21006	8-910-0459	2	4	Control	0	II-10-21006 -(2)-U		3.8	ug/L	576	2.2	YES		
1016	8-910-0309	2	5	NaAs	5	II-10-1016 -(2)-U		1	ug/L	1340	1.3	YES	1.2	0.32
1021	8-910-0301	2	5	NaAs	5	II-10-1021 -(2)-U	<	1	ug/L	1090	1.1	YES		
1035	8-910-0292	2	5	NaAs	5	II-10-1035 -(2)-U		2	ug/L	810	1.6	YES		
1045	8-910-0298	2	5	NaAs	5	II-10-1045 -(2)-U		3.4	ug/L	260	0.9	YES		
1001	8-910-0322	2	6	NaAs	20	II-10-1001 -(2)-U		2	ug/L	500	1.0	YES	1.7	1.13
1009	8-910-0303	2	6	NaAs	20	II-10-1009 -(2)-U		3	ug/L	360	1.1	YES		
1027	8-910-0312	2	6	NaAs	20	II-10-1027 -(2)-U		2	ug/L	700	1.4	YES		
1028	8-910-0315	2	6	NaAs	20	II-10-1028 -(2)-U		2	ug/L	1700	3.4	YES		
1018	8-910-0320	2	7	NaAs	50	II-10-1018 -(2)-U		1	ug/L	1660	1.7	YES	1.7	0.90
1024	8-910-0313	2	7	NaAs	50	II-10-1024 -(2)-U	<	1	ug/L	500	0.5	YES		
1029	8-910-0293	2	7	NaAs	50	II-10-1029 -(2)-U	<	1	ug/L	2600	2.6	YES		
1036	8-910-0294	2	7	NaAs	50	II-10-1036 -(2)-U	<	1	ug/L	2100	2.1	YES		
1011	8-910-0291	2	8	Soil 1	20	II-10-1011 -(2)-U		3.2	ug/L	1040	3.3	YES	5.6	3.39
1013	8-910-0307	2	8	Soil 1	20	II-10-1013 -(2)-U		1	ug/L	2800	2.8	YES		
1025	8-910-0304	2	8	Soil 1	20	II-10-1025 -(2)-U		3.8	ug/L	1600	6.1	YES		
1034	8-910-0319	2	8	Soil 1	20	II-10-1034 -(2)-U		15	ug/L	680	10.2	YES		

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pig no.	tag no.	day	group	test material	ug/kg-d	sample number	Q	Conc	Units	Vol (mL)	Mass (ug/d)	Reliable?	Avg (ug/d)	STD (ug/d)
21025	8-910-0458	2	8	Soil 1	20	II-10-21025 -(2)-U		5.8	ug/L	1600	9.3	YES		
1002	8-910-0321	2	9	Soil 1	50	II-10-1002 -(2)-U		18	ug/L	1380	24.8	YES	27.3	10.66
1004	8-910-0314	2	9	Soil 1	50	II-10-1004 -(2)-U		23	ug/L	980	22.5	YES		
1043	8-910-0299	2	9	Soil 1	50	II-10-1043 -(2)-U		8.1	ug/L	2340	19.0	YES		
1046	8-910-0311	2	9	Soil 1	50	II-10-1046 -(2)-U		67	ug/L	640	42.9	YES		
21002	8-910-0467	2	9	Soil 1	50	II-10-21002 -(2)-U		17	ug/L	1380	23.5	YES		
1019	8-910-0318	2	10	Soil 1	125	II-10-1019 -(2)-U		130	ug/L	380	49.4	YES	35.5	9.47
1023	8-910-0305	2	10	Soil 1	125	II-10-1023 -(2)-U		34	ug/L	980	33.3	YES		
1031	8-910-0308	2	10	Soil 1	125	II-10-1031 -(2)-U		68	ug/L	420	28.6	YES		
1042	8-910-0310	2	10	Soil 1	125	II-10-1042 -(2)-U		24	ug/L	1280	30.7	YES		
1005	8-910-0355	5	4	Control	0	II-10-1005 -(5)-U		5.4	ug/L	515	2.8	YES	1.5	0.99
1006	8-910-0340	5	4	Control	0	II-10-1006 -(5)-U		2	ug/L	800	1.6	YES		
1022	8-910-0345	5	4	Control	0	II-10-1022 -(5)-U		2	ug/L	460	0.9	YES		
1030	8-910-0342	5	4	Control	0	II-10-1030 -(5)-U	<	1	ug/L	510	0.5	YES		
1016	8-910-0343	5	5	NaAs	5	II-10-1016 -(5)-U		6.7	ug/L	1315	8.8	YES	11.5	3.27
1021	8-910-0344	5	5	NaAs	5	II-10-1021 -(5)-U		15	ug/L	1005	15.1	YES		
1035	8-910-0333	5	5	NaAs	5	II-10-1035 -(5)-U		8.4	ug/L	1025	8.6	YES		
1045	8-910-0347	5	5	NaAs	5	II-10-1045 -(5)-U		28	ug/L	480	13.4	YES		
1001	8-910-0332	5	6	NaAs	20	II-10-1001 -(5)-U		41	ug/L	845	34.6	YES	42.4	9.77
1009	8-910-0351	5	6	NaAs	20	II-10-1009 -(5)-U		60	ug/L	650	39.0	YES		
1027	8-910-0327	5	6	NaAs	20	II-10-1027 -(5)-U		31	ug/L	1265	39.2	YES		
1028	8-910-0350	5	6	NaAs	20	II-10-1028 -(5)-U		27	ug/L	2100	56.7	YES		
21027	8-910-0463	5	6	NaAs	20	II-10-21027 -(5)-U		35	ug/L	1265	44.3	YES		
1018	8-910-0329	5	7	NaAs	50	II-10-1018 -(5)-U		95	ug/L	1045	99.3	YES	99.8	49.47
1024	8-910-0330	5	7	NaAs	50	II-10-1024 -(5)-U		70	ug/L	685	48.0	YES		
1029	8-910-0339	5	7	NaAs	50	II-10-1029 -(5)-U		69	ug/L	1240	85.6	YES		
1036	8-910-0334	5	7	NaAs	50	II-10-1036 -(5)-U		100	ug/L	1665	166.5	YES		
1011	8-910-0323	5	8	Soil 1	20	II-10-1011 -(5)-U		5.4	ug/L	1345	7.3	YES	8.1	1.91
1013	8-910-0335	5	8	Soil 1	20	II-10-1013 -(5)-U		3	ug/L	2830	8.5	YES		
1025	8-910-0338	5	8	Soil 1	20	II-10-1025 -(5)-U		4.5	ug/L	2535	11.4	YES		
1034	8-910-0331	5	8	Soil 1	20	II-10-1034 -(5)-U		5.4	ug/L	1385	7.5	YES		
21013	8-910-0464	5	8	Soil 1	20	II-10-21013 -(5)-U		2	ug/L	2830	5.7	YES		
1002	8-910-0346	5	9	Soil 1	50	II-10-1002 -(5)-U		16	ug/L	1290	20.6	YES	18.1	2.05
1004	8-910-0349	5	9	Soil 1	50	II-10-1004 -(5)-U		15	ug/L	1045	15.7	YES		
1043	8-910-0353	5	9	Soil 1	50	II-10-1043 -(5)-U		12	ug/L	1540	18.5	YES		
1046	8-910-0325	5	9	Soil 1	50	II-10-1046 -(5)-U		26	ug/L	680	17.7	YES		
1019	8-910-0337	5	10	Soil 1	125	II-10-1019 -(5)-U		84	ug/L	485	40.7	YES	47.1	8.24
1023	8-910-0341	5	10	Soil 1	125	II-10-1023 -(5)-U		33	ug/L	1305	43.1	YES		
1031	8-910-0352	5	10	Soil 1	125	II-10-1031 -(5)-U		53	ug/L	860	45.6	YES		
1042	8-910-0324	5	10	Soil 1	125	II-10-1042 -(5)-U		54	ug/L	1095	59.1	YES		
1005	8-910-0361	8	4	Control	0	II-10-1005 -(8)-U		4.9	ug/L	570	2.8	YES	1.8	1.10
1006	8-910-0386	8	4	Control	0	II-10-1006 -(8)-U		3	ug/L	880	2.6	YES		
1022	8-910-0382	8	4	Control	0	II-10-1022 -(8)-U		2	ug/L	600	1.2	YES		
1030	8-910-0365	8	4	Control	0	II-10-1030 -(8)-U		3.6	ug/L	150	0.5	YES		
21006	8-910-0468	8	4	Control	0	II-10-21006 -(8)-U		2	ug/L	880	1.8	YES		
1016	8-910-0356	8	5	NaAs	5	II-10-1016 -(8)-U		8	ug/L	1920	15.4	YES	14.3	2.71
1021	8-910-0384	8	5	NaAs	5	II-10-1021 -(8)-U		11	ug/L	1600	17.6	YES		
1035	8-910-0377	8	5	NaAs	5	II-10-1035 -(8)-U		9.6	ug/L	1320	12.7	YES		
1045	8-910-0362	8	5	NaAs	5	II-10-1045 -(8)-U		10	ug/L	1160	11.6	YES		
1001	8-910-0372	8	6	NaAs	20	II-10-1001 -(8)-U		82	ug/L	670	54.9	YES	62.4	16.70
1009	8-910-0363	8	6	NaAs	20	II-10-1009 -(8)-U		53	ug/L	880	46.6	YES		

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DATA SUMMARY - PILOT STUDY 1

pig no.	tag no.	day	group	test material	ug/kg-d	sample number	Q	Conc	Units	Vol (mL)	Mass (ug/d)	Reliable?	Avg (ug/d)	STD (ug/d)
1027	8-910-0364	8	6	NaAs	20	II-10-1027 -(8)-U		74	ug/L	880	65.1	YES		
1028	8-910-0380	8	6	NaAs	20	II-10-1028 -(8)-U		67	ug/L	1240	83.1	YES		
1018	8-910-0368	8	7	NaAs	50	II-10-1018 -(8)-U		180	ug/L	1410	253.8	YES	168.3	110.04
1024	8-910-0366	8	7	NaAs	50	II-10-1024 -(8)-U		65	ug/L	780	50.7	YES		
1029	8-910-0358	8	7	NaAs	50	II-10-1029 -(8)-U		47	ug/L	2100	98.7	YES		
1036	8-910-0357	8	7	NaAs	50	II-10-1036 -(8)-U		100	ug/L	2700	270.0	YES		
1011	8-910-0371	8	8	Soil 1	20	II-10-1011 -(8)-U		4.5	ug/L	2560	11.5	YES	14.4	2.86
1013	8-910-0374	8	8	Soil 1	20	II-10-1013 -(8)-U		5.2	ug/L	3380	17.6	YES		
1025	8-910-0367	8	8	Soil 1	20	II-10-1025 -(8)-U		5.6	ug/L	2860	16.0	YES		
1034	8-910-0376	8	8	Soil 1	20	II-10-1034 -(8)-U		8.5	ug/L	1470	12.5	YES		
1002	8-910-0379	8	9	Soil 1	50	II-10-1002 -(8)-U		9.9	ug/L	1720	17.0	YES	31.2	17.58
1004	8-910-0373	8	9	Soil 1	50	II-10-1004 -(8)-U		13	ug/L	1350	17.6	YES		
1043	8-910-0367	8	9	Soil 1	50	II-10-1043 -(8)-U		8.5	ug/L	4250	36.1	YES		
1046	8-910-0383	8	9	Soil 1	50	II-10-1046 -(8)-U		140	ug/L	385	53.9	YES		
21002	8-910-0465	8	9	Soil 1	50	II-10-21002 -(8)-U		9.6	ug/L	1720	16.5	YES		
1019	8-910-0359	8	10	Soil 1	125	II-10-1019 -(8)-U		26	ug/L	1180	30.7	YES	43.7	14.29
1023	8-910-0369	8	10	Soil 1	125	II-10-1023 -(8)-U			ug/L	1320		YES		
1031	8-910-0381	8	10	Soil 1	125	II-10-1031 -(8)-U		17	ug/L	2440	41.5	YES		
1042	8-910-0375	8	10	Soil 1	125	II-10-1042 -(8)-U		69	ug/L	855	59.0	YES		
21023	8-910-0472	8	10	Soil 1	125	II-10-21023 -(8)-U			ug/L	1320		YES		
1005	8-910-0407	11	4	Control	0	II-10-1005 -(11)-U		3	ug/L	850	2.6	YES	1.9	0.47
1006	8-910-0390	11	4	Control	0	II-10-1006 -(11)-U		2	ug/L	980	2.0	YES		
1022	8-910-0416	11	4	Control	0	II-10-1022 -(11)-U	<	1	ug/L	1670	1.7	YES		
1030	8-910-0405	11	4	Control	0	II-10-1030 -(11)-U	<	1	ug/L	1460	1.5	YES		
1016	8-910-0402	11	5	NaAs	5	II-10-1016 -(11)-U		5.2	ug/L	3380	17.6	YES	18.3	2.16
1021	8-910-0396	11	5	NaAs	5	II-10-1021 -(11)-U		8.8	ug/L	1890	16.6	YES		
1035	8-910-0420	11	5	NaAs	5	II-10-1035 -(11)-U		7.5	ug/L	2860	21.5	YES		
1045	8-910-0392	11	5	NaAs	5	II-10-1045 -(11)-U		12	ug/L	1450	17.4	YES		
21016	8-910-0457	11	5	NaAs	5	II-10-21016 -(11)-U		6.2	ug/L	3380	21.0	YES		
1001	8-910-0395	11	6	NaAs	20	II-10-1001 -(11)-U		60	ug/L	980	58.8	YES	50.7	22.34
1009	8-910-0389	11	6	NaAs	20	II-10-1009 -(11)-U		16	ug/L	1160	18.6	YES		
1027	8-910-0403	11	6	NaAs	20	II-10-1027 -(11)-U		64	ug/L	860	55.0	YES		
1028	8-910-0409	11	6	NaAs	20	II-10-1028 -(11)-U		36	ug/L	1950	70.2	YES		
1018	8-910-0415	11	7	NaAs	50	II-10-1018 -(11)-U		120	ug/L	2600	312.0	YES	186.6	108.73
1024	8-910-0414	11	7	NaAs	50	II-10-1024 -(11)-U		71	ug/L	840	59.6	YES		
1029	8-910-0411	11	7	NaAs	50	II-10-1029 -(11)-U		57	ug/L	2540	144.8	YES		
1036	8-910-0413	11	7	NaAs	50	II-10-1036 -(11)-U		55	ug/L	4180	229.9	YES		
1011	8-910-0394	11	8	Soil 1	20	II-10-1011 -(11)-U		4.1	ug/L	3050	12.5	YES	13.2	2.12
1013	8-910-0404	11	8	Soil 1	20	II-10-1013 -(11)-U		3	ug/L	5130	15.4	YES		
1025	8-910-0410	11	8	Soil 1	20	II-10-1025 -(11)-U		4.2	ug/L	3420	14.4	YES		
1034	8-910-0421	11	8	Soil 1	20	II-10-1034 -(11)-U		8.4	ug/L	1280	10.8	YES		
21034	8-910-0470	11	8	Soil 1	20	II-10-21034 -(11)-U		8.9	ug/L	1260	11.2	YES		
1002	8-910-0406	11	9	Soil 1	50	II-10-1002 -(11)-U		18	ug/L	1210	21.8	YES	35.1	16.11
1004	8-910-0419	11	9	Soil 1	50	II-10-1004 -(11)-U		21	ug/L	1400	29.4	YES		
1043	8-910-0398	11	9	Soil 1	50	II-10-1043 -(11)-U		5.4	ug/L	5700	30.8	YES		
1046	8-910-0397	11	9	Soil 1	50	II-10-1046 -(11)-U		61	ug/L	960	58.6	YES		
1019	8-910-0393	11	10	Soil 1	125	II-10-1019 -(11)-U		30	ug/L	1260	37.8	YES	59.9	25.50
1023	8-910-0412	11	10	Soil 1	125	II-10-1023 -(11)-U		14	ug/L	3460	48.4	YES		
1031	8-910-0391	11	10	Soil 1	125	II-10-1031 -(11)-U		9.6	ug/L	5960	57.2	YES		
1042	8-910-0400	11	10	Soil 1	125	II-10-1042 -(11)-U		58	ug/L	1660	96.3	YES		
1005	8-910-0438	14	4	Control	0	II-10-1005 -(14)-U		1	ug/L	1320	1.3	YES	1.5	0.51

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DATA SUMMARY - PILOT STUDY 1

pig no.	tag no.	day	group	test material	ug/kg-d	sample number	Q	Conc	Units	Vol (mL)	Mass (ug/d)	Reliable?	Avg (ug/d)	STD (ug/d)
1006	8-910-0430	14	4	Control	0	II-10-1006 -[14]-U		2	ug/L	730	1.5	YES		
1022	8-910-0435	14	4	Control	0	II-10-1022 -[14]-U		3	ug/L	740	2.2	YES		
1030	8-910-0446	14	4	Control	0	II-10-1030 -[14]-U		1	ug/L	1020	1.0	YES		
1016	8-910-0427	14	5	NaAs	5	II-10-1016 -[14]-U		2	ug/L	6335	12.7	YES	12.2	4.30
1021	8-910-0434	14	5	NaAs	5	II-10-1021 -[14]-U		10	ug/L	1800	18.0	YES		
1035	8-910-0426	14	5	NaAs	5	II-10-1035 -[14]-U		7.6	ug/L	1055	8.0	YES		
1045	8-910-0450	14	5	NaAs	5	II-10-1045 -[14]-U		7.8	ug/L	1305	10.2	YES		
1001	8-910-0451	14	6	NaAs	20	II-10-1001 -[14]-U		36	ug/L	760	27.4	YES	53.3	20.93
1009	8-910-0437	14	6	NaAs	20	II-10-1009 -[14]-U		21	ug/L	2160	45.4	YES		
1027	8-910-0432	14	6	NaAs	20	II-10-1027 -[14]-U		74	ug/L	920	68.1	YES		
1028	8-910-0422	14	6	NaAs	20	II-10-1028 -[14]-U		73	ug/L	990	72.3	YES		
21009	8-910-0461	14	6	NaAs	20	II-10-21009 -[14]-U		21	ug/L	2160	45.4	YES		
1018	8-910-0439	14	7	NaAs	50	II-10-1018 -[14]-U		77	ug/L	2310	177.9	YES	153.9	96.86
1024	8-910-0442	14	7	NaAs	50	II-10-1024 -[14]-U		56	ug/L	780	43.7	YES		
1029	8-910-0423	14	7	NaAs	50	II-10-1029 -[14]-U		39	ug/L	3090	120.5	YES		
1036	8-910-0453	14	7	NaAs	50	II-10-1036 -[14]-U		52	ug/L	5260	273.5	YES		
1011	8-910-0444	14	8	Soil 1	20	II-10-1011 -[14]-U		3.9	ug/L	4480	17.5	YES	18.7	10.82
1013	8-910-0440	14	8	Soil 1	20	II-10-1013 -[14]-U		5.6	ug/L	5840	32.7	YES		
1025	8-910-0436	14	8	Soil 1	20	II-10-1025 -[14]-U		2	ug/L	3160	6.3	YES		
1034	8-910-0448	14	8	Soil 1	20	II-10-1034 -[14]-U		14	ug/L	1320	18.5	YES		
21025	8-910-0456	14	8	Soil 1	20	II-10-21025 -[14]-U		2	ug/L	3160	6.3	YES		
1002	8-910-0433	14	9	Soil 1	50	II-10-1002 -[14]-U		26	ug/L	1380	35.9	YES	32.2	6.54
1004	8-910-0425	14	9	Soil 1	50	II-10-1004 -[14]-U		22	ug/L	1780	39.2	YES		
1043	8-910-0454	14	9	Soil 1	50	II-10-1043 -[14]-U		7.7	ug/L	3800	29.3	YES		
1046	8-910-0452	14	9	Soil 1	50	II-10-1046 -[14]-U		30	ug/L	820	24.6	YES		
21004	8-910-0471	14	9	Soil 1	50	II-10-21004 -[14]-U		16	ug/L	1780	28.7	YES		
1019	8-910-0445	14	10	Soil 1	125	II-10-1019 -[14]-U		36	ug/L	1460	52.6	YES	53.4	10.31
1023	8-910-0424	14	10	Soil 1	125	II-10-1023 -[14]-U		18	ug/L	3560	64.1	YES		
1031	8-910-0441	14	10	Soil 1	125	II-10-1031 -[14]-U		15	ug/L	2900	43.5	YES		
1042	8-910-0431	14	10	Soil 1	125	II-10-1042 -[14]-U			ug/L	10000		YES		

missing value due to loss of sample
animal taken off study
duplicate sample

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APPENDIX A
DATA SUMMARY - PILOT STUDY 1

DEPURATION KINETICS (URINE)

pig no.	tag no.	Time (hr)	group	test material	dose	sample number	Q	Conc	Units	Vol (mL)	Mass (ug)	Reliable?	Avg (ug)	Stdev	SEM
1003	8-910-0489	0-4	3	NaAs	50	II-10-1003 -(4A)-U		75	ug/L	500	37.5	YES			
1015	8-910-0491	0-4	3	NaAs	50	II-10-1015 -(4A)-U		230	ug/L	85	19.6	YES	11.7	16.7	7.4
1032	8-910-0481	0-4	3	NaAs	50	II-10-1032 -(4A)-U	<	1	ug/L	660	0.7	YES			
1037	8-910-0492	0-4	3	NaAs	50	II-10-1037 -(4A)-U		2	ug/L	25	0.1	YES			
1038	8-910-0495	0-4	3	NaAs	50	II-10-1038 -(4A)-U		3	ug/L	160	0.5	YES			
1003	8-910-0475	4-8	3	NaAs	50	II-10-1003 -(4B)-U		32	ug/L	90	2.9	YES			
1015	8-910-0493	4-8	3	NaAs	50	II-10-1015 -(4B)-U		86	ug/L	75	6.5	YES	31.1	41.4	18.5
1032	8-910-0477	4-8	3	NaAs	50	II-10-1032 -(4B)-U		250	ug/L	380	95.0	YES			
1037	8-910-0497	4-8	3	NaAs	50	II-10-1037 -(4B)-U		700	ug/L	73	51.1	YES			
1038	8-910-0500	4-8	3	NaAs	50	II-10-1038 -(4B)-U		1	ug/L	150	0.2	YES			
1003	8-910-0487	8-16	3	NaAs	50	II-10-1003 -(8A)-U			ug/L	0					
1015	8-910-0498	8-16	3	NaAs	50	II-10-1015 -(8A)-U		88	ug/L	75	6.6	YES	15.2	12.2	5.4
1032	8-910-0483	8-16	3	NaAs	50	II-10-1032 -(8A)-U		340	ug/L	70	23.8	YES			
1037	8-910-0476	8-16	3	NaAs	50	II-10-1037 -(8A)-U			ug/L	0					
1038	8-910-0484	8-16	3	NaAs	50	II-10-1038 -(8A)-U			ug/L	0					
1003	8-910-0473	16-24	3	NaAs	50	II-10-1003 -(8B)-U		110	ug/L	580	63.8	YES			
1015	8-910-0494	16-24	3	NaAs	50	II-10-1015 -(8B)-U		260	ug/L	265	68.9	YES	33.4	38.1	17.0
1032	8-910-0482	16-24	3	NaAs	50	II-10-1032 -(8B)-U	<	1	ug/L	820	0.8	YES			
1037	8-910-0480	16-24	3	NaAs	50	II-10-1037 -(8B)-U			ug/L	0					
1038	8-910-0502	16-24	3	NaAs	50	II-10-1038 -(8B)-U	<	1	ug/L	85	0.1	YES			
1003	8-910-0479	24-48	3	NaAs	50	II-10-1003 -(24A)-U		10	ug/L	1500	15.0	YES			
1015	8-910-0501	24-48	3	NaAs	50	II-10-1015 -(24A)-U		8.1	ug/L	2275	18.4	YES	57.7	51.5	23.0
1032	8-910-0478	24-48	3	NaAs	50	II-10-1032 -(24A)-U		13	ug/L	2150	28.0	YES			
1037	8-910-0488	24-48	3	NaAs	50	II-10-1037 -(24A)-U		160	ug/L	660	105.6	YES			
1038	8-910-0474	24-48	3	NaAs	50	II-10-1038 -(24A)-U		91	ug/L	1335	121.5	YES			
1003	8-910-0485	48-72	3	NaAs	50	II-10-1003 -(24B)-U		2	ug/L	1650	3.3	YES			
1015	8-910-0490	48-72	3	NaAs	50	II-10-1015 -(24B)-U	<	1	ug/L	3000	3.0	YES	9.3	12.1	5.4
1032	8-910-0499	48-72	3	NaAs	50	II-10-1032 -(24B)-U		2	ug/L	2490	5.0	YES			
1037	8-910-0486	48-72	3	NaAs	50	II-10-1037 -(24B)-U		3	ug/L	1510	4.5	YES			
1038	8-910-0496	48-72	3	NaAs	50	II-10-1038 -(24B)-U		30	ug/L	1030	30.9	YES			

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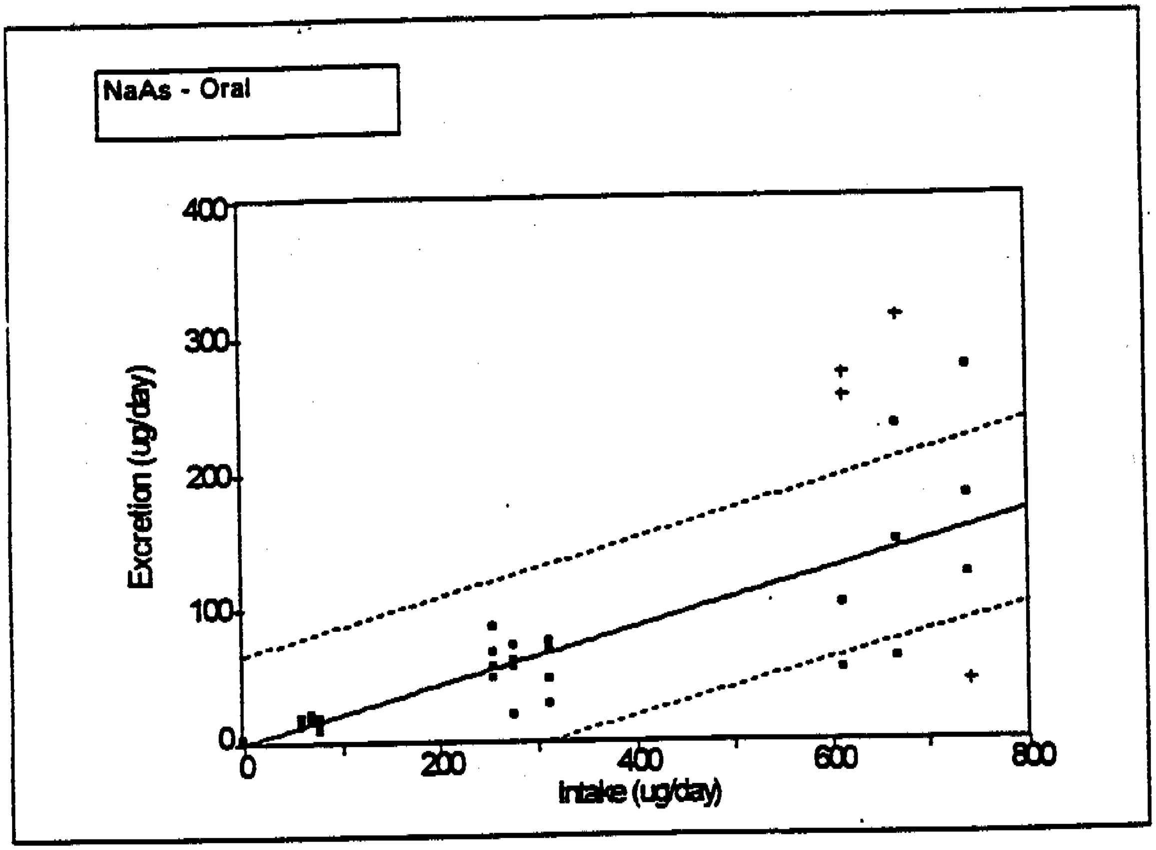
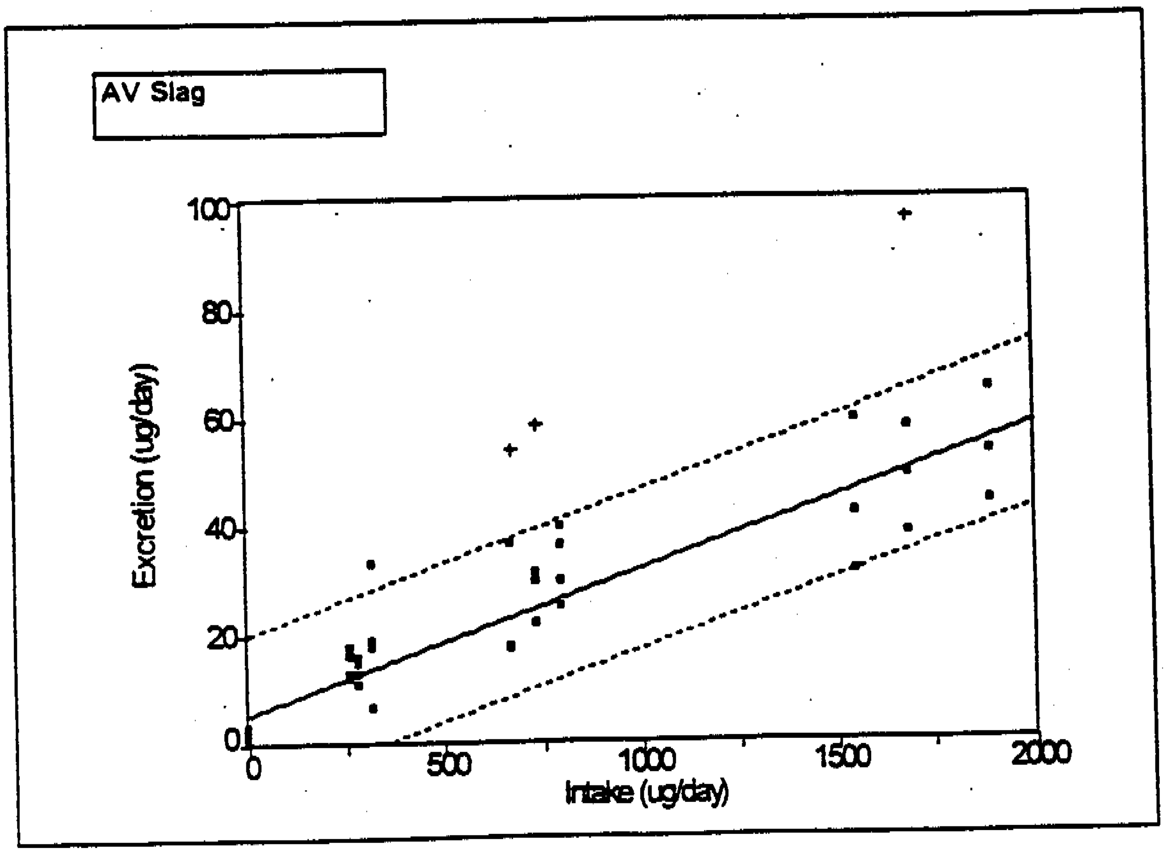
TableCurve 2D FITS

Pilot Study 1

Outliers shown by "+"





APPENDIX A
DATA SUMMARY - PILOT STUDY 2

Group	Treatment	Dose ug/kg-d	Pig No.	Day 5 Intake ug/day	Day 5 Excr. ug/day	Day 8 Intake ug/day	Day 8 Excr. ug/day	Day 11 Intake ug/day	Day 11 Excr. ug/day	Day 14 Intake ug/day	Day 14 Excr. ug/day
1	0	Control	1501	0.0	4.1	0.0	3.0	0.0	2.9	0.0	9.3
			1510	0.0	4.0	0.0	4.0	0.0	2.5	0.0	3.9
			1540	0.0	9.5	0.0	6.3	0.0	2.8	0.0	4.8
4	Gavage	20	1518	253.3	46.1	270.5	63.6	314.0	28.0	346.3	72.7
			1528	253.3	37.3	270.5	89.6	314.0	71.5	346.3	93.8
			1534	253.3	75.0	270.5	35.4	314.0	64.4	346.3	73.9
			1537	253.3	54.7	270.5	65.7	314.0	51.2	346.3	77.0
5	Gavage	50	1506	611.5	92.8	642.5	104.0	740.6	132.0	789.4	130.7
			1517	611.5	118.4	642.5	143.0	740.6	134.4	789.4	149.5
			1519	611.5	132.6	642.5	118.8	740.6	142.8	789.4	lost
			1538	611.5	72.2	642.5	150.0	740.6	340.0	789.4	122.4
6	Oral	20	1502	253.6	53.0	276.3	33.5	316.5	36.5	347.3	111.1
			1521	253.6	43.2	276.3	36.0	316.5	48.0	347.3	55.1
			1523	253.6	24.4	276.3	132.0	316.5	52.0	347.3	57.6
			1539	253.6	51.2	276.3	60.3	316.5	63.8	347.3	68.2
7	Oral	50	1509	652.8	138.0	708.8	132.3	813.8	176.4	879.4	199.4
			1513	652.8	97.2	708.8	132.7	813.8	125.4	879.4	229.6
			1516	652.8	76.4	708.8	73.0	813.8	111.4	879.4	103.0
			1525	652.8	87.4	708.8	lost	813.8	156.0	879.4	176.5
8	Tailings	20	1512	258.9	45.9	275.5	24.7	316.0	60.0	344.3	37.1
			1532	258.9	37.8	275.5	22.7	316.0	21.1	344.3	39.7
			1533	258.9	21.1	275.5	16.8	316.0	27.8	344.3	42.7
			1536	258.9	21.5	275.5	24.4	316.0	33.5	344.3	137.7
9	Tailings	50	1507	698.5	60.8	769.4	108.1	877.5	74.9	990.0	171.0
			1522	698.5	69.1	769.4	51.7	877.5	61.6	990.0	103.8
			1529	698.5	57.6	769.4	70.2	877.5	91.2	990.0	117.5
			1530	698.5	66.1	769.4	82.7	877.5	63.9	990.0	11.0

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Tag number	Group	Day	Treatment	Dose ug/kg-d	Pig No.	Urinary Arsenic Q	Urinary Arsenic C	Urinary Arsenic Units	Urine Vol (mL)	Mass Excreted (ug)	Unreliable
8-915-0121	1	0	Control	0	1501		3.6	ug/L	1920	6.9	
8-915-0122	1	0	Control	0	1510		2	ug/L	2430	4.9	
8-915-0120	1	0	Control	0	1540	<	1	ug/L	3500	3.5	
8-915-0156	1	5	Control	0	1501		3.1	ug/L	1330	4.1	
8-915-0142	1	5	Control	0	1510		2	ug/L	2000	4.0	
8-915-0146	1	5	Control	0	1540		4.3	ug/L	2220	9.5	
8-915-0174	1	8	Control	0	1501		2	ug/L	1500	3.0	
8-915-0197	1	8	Control	0	1510		2	ug/L	1980	4.0	
8-915-0198	1	8	Control	0	1540	<	1	ug/L	6340	6.3	X
8-915-0222	1	11	Control	0	1501		4.1	ug/L	700	2.9	
8-915-0244	1	11	Control	0	1510		7.4	ug/L	340	2.5	
8-915-0221	1	11	Control	0	1540	<	1	ug/L	2820	2.8	
8-915-0284	1	14	Control	0	1501		2	ug/L	4660	9.3	
8-915-0255	1	14	Control	0	1510		2	ug/L	1960	3.9	
8-915-0294	1	14	Control	0	1540	<	1	ug/L	4800	4.8	
8-915-0163	4	5	Sodium Arsenate(Gavage)	20	1518		64	ug/L	720	46.1	
8-915-0133	4	5	Sodium Arsenate(Gavage)	20	1528		23	ug/L	1620	37.3	
8-915-0138	4	5	Sodium Arsenate(Gavage)	20	1534		67	ug/L	1120	75.0	
8-915-0131	4	5	Sodium Arsenate(Gavage)	20	1537		46	ug/L	1190	54.7	
8-915-0175	4	8	Sodium Arsenate(Gavage)	20	1518		37	ug/L	1720	63.6	
8-915-0202	4	8	Sodium Arsenate(Gavage)	20	1528		40	ug/L	2240	89.6	
8-915-0200	4	8	Sodium Arsenate(Gavage)	20	1534		29	ug/L	1220	35.4	
8-915-0188	4	8	Sodium Arsenate(Gavage)	20	1537		31	ug/L	2120	65.7	
8-915-0232	4	11	Sodium Arsenate(Gavage)	20	1518		25	ug/L	1120	28.0	
8-915-0250	4	11	Sodium Arsenate(Gavage)	20	1528		49	ug/L	1460	71.5	
8-915-0239	4	11	Sodium Arsenate(Gavage)	20	1534		140	ug/L	460	64.4	
8-915-0219	4	11	Sodium Arsenate(Gavage)	20	1537		64	ug/L	800	51.2	
8-915-0264	4	14	Sodium Arsenate(Gavage)	20	1518		23	ug/L	3160	72.7	
8-915-0256	4	14	Sodium Arsenate(Gavage)	20	1528		68	ug/L	1380	93.8	
8-915-0282	4	14	Sodium Arsenate(Gavage)	20	1534		56	ug/L	1320	73.9	
8-915-0292	4	14	Sodium Arsenate(Gavage)	20	1537		26	ug/L	2960	77.0	
8-915-0164	5	5	Sodium Arsenate(Gavage)	50	1506		160	ug/L	580	92.8	
8-915-0150	5	5	Sodium Arsenate(Gavage)	50	1517		74	ug/L	1600	118.4	
8-915-0155	5	5	Sodium Arsenate(Gavage)	50	1519		390	ug/L	340	132.6	
8-915-0128	5	5	Sodium Arsenate(Gavage)	50	1538		95	ug/L	760	72.2	
8-915-0205	5	8	Sodium Arsenate(Gavage)	50	1506		200	ug/L	520	104.0	
8-915-0183	5	8	Sodium Arsenate(Gavage)	50	1517		110	ug/L	1300	143.0	
8-915-0208	5	8	Sodium Arsenate(Gavage)	50	1519		220	ug/L	540	118.8	

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DATA SUMMARY - PILOT STUDY 2

Tag number	Group	Day	Treatment	Dose ug/kg-d	Pig No.	Urinary Arsenic Q	C	Units	Urine Vol (mL)	Mass Excreted (ug)	Unreliable
8-915-0170	5	8	Sodium Arsenate(Gavage)	50	1538		250	ug/L	600	150.0	
8-915-0233	5	11	Sodium Arsenate(Gavage)	50	1506		330	ug/L	400	132.0	
8-915-0226	5	11	Sodium Arsenate(Gavage)	50	1517		140	ug/L	960	134.4	
8-915-0224	5	11	Sodium Arsenate(Gavage)	50	1519		340	ug/L	420	142.8	
8-915-0234	5	11	Sodium Arsenate(Gavage)	50	1538		850	ug/L	400	340.0	
8-915-0260	5	14	Sodium Arsenate(Gavage)	50	1506		54	ug/L	2420	130.7	
8-915-0293	5	14	Sodium Arsenate(Gavage)	50	1517		47	ug/L	3180	149.5	
8-915-0258	5	14	Sodium Arsenate(Gavage)	50	1519						
8-915-0296	5	14	Sodium Arsenate(Gavage)	50	1538		180	ug/L	680	122.4	
8-915-0157	6	5	Sodium Arsenate(Oral)	20	1502		53	ug/L	1000	53.0	
8-915-0143	6	5	Sodium Arsenate(Oral)	20	1521		120	ug/L	360	43.2	
8-915-0151	6	5	Sodium Arsenate(Oral)	20	1523		29	ug/L	840	24.4	
8-915-0134	6	5	Sodium Arsenate(Oral)	20	1539		40	ug/L	1280	51.2	
8-915-0165	6	8	Sodium Arsenate(Oral)	20	1502		62	ug/L	540	33.5	
8-915-0210	6	8	Sodium Arsenate(Oral)	20	1521		120	ug/L	300	36.0	
8-915-0201	6	8	Sodium Arsenate(Oral)	20	1523		110	ug/L	1200	132.0	
8-915-0209	6	8	Sodium Arsenate(Oral)	20	1539		29	ug/L	2080	60.3	
8-915-0230	6	11	Sodium Arsenate(Oral)	20	1502		57	ug/L	640	36.5	
8-915-0217	6	11	Sodium Arsenate(Oral)	20	1521		200	ug/L	240	48.0	
8-915-0218	6	11	Sodium Arsenate(Oral)	20	1523		130	ug/L	400	52.0	
8-915-0240	6	11	Sodium Arsenate(Oral)	20	1539		42	ug/L	1520	63.8	
8-915-0272	6	14	Sodium Arsenate(Oral)	20	1502		55	ug/L	2020	111.1	
8-915-0265	6	14	Sodium Arsenate(Oral)	20	1521		95	ug/L	580	55.1	
8-915-0274	6	14	Sodium Arsenate(Oral)	20	1523		49	ug/L	1180	57.8	
8-915-0288	6	14	Sodium Arsenate(Oral)	20	1539		22	ug/L	3100	68.2	
8-915-0140	7	5	Sodium Arsenate(Oral)	50	1509		100	ug/L	1380	138.0	
8-915-0161	7	5	Sodium Arsenate(Oral)	50	1513		60	ug/L	1620	97.2	
8-915-0141	7	5	Sodium Arsenate(Oral)	50	1516		83	ug/L	920	76.4	
8-915-0147	7	5	Sodium Arsenate(Oral)	50	1525		190	ug/L	460	87.4	
8-915-0194	7	8	Sodium Arsenate(Oral)	50	1509		63	ug/L	2100	132.3	
8-915-0169	7	8	Sodium Arsenate(Oral)	50	1513		79	ug/L	1680	132.7	
8-915-0181	7	8	Sodium Arsenate(Oral)	50	1516		22	ug/L	3320	73.0	
8-915-0171	7	8	Sodium Arsenate(Oral)	50	1525				2440		
8-915-0231	7	11	Sodium Arsenate(Oral)	50	1509		180	ug/L	980	176.4	
8-915-0227	7	11	Sodium Arsenate(Oral)	50	1513		110	ug/L	1140	125.4	
8-915-0242	7	11	Sodium Arsenate(Oral)	50	1516		48	ug/L	2320	111.4	
8-915-0238	7	11	Sodium Arsenate(Oral)	50	1525		150	ug/L	1040	156.0	
8-915-0257	7	14	Sodium Arsenate(Oral)	50	1509		36	ug/L	5540	199.4	

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Tag number	Group	Day	Treatment	Dose ug/kg-d	Pig No.	Urinary Arsenic Q	Urinary Arsenic C	Urinary Arsenic Units	Urine Vol (mL)	Mass Excreted (ug)	Unreliable
8-915-0277	7	14	Sodium Arsenate(Oral)	50	1513		280	ug/L	820	229.6	
8-915-0266	7	14	Sodium Arsenate(Oral)	50	1516		19	ug/L	5420	103.0	
8-915-0290	7	14	Sodium Arsenate(Oral)	50	1525		25	ug/L	7060	176.5	
8-915-0130	8	5	Tailings	20	1512		51	ug/L	900	45.9	
8-915-0136	8	5	Tailings	20	1532		35	ug/L	1080	37.8	
8-915-0126	8	5	Tailings	20	1533		16	ug/L	1320	21.1	
8-915-0137	8	5	Tailings	20	1536		37	ug/L	580	21.5	
8-915-0186	8	8	Tailings	20	1512		19	ug/L	1300	24.7	
8-915-0192	8	8	Tailings	20	1532		11	ug/L	2060	22.7	
8-915-0178	8	8	Tailings	20	1533		12	ug/L	1400	16.8	
8-915-0189	8	8	Tailings	20	1536		21	ug/L	1160	24.4	
8-915-0241	8	11	Tailings	20	1512		120	ug/L	500	60.0	
8-915-0237	8	11	Tailings	20	1532		22	ug/L	960	21.1	
8-915-0248	8	11	Tailings	20	1533		12	ug/L	2320	27.8	
8-915-0214	8	11	Tailings	20	1536		54	ug/L	620	33.5	
8-915-0271	8	14	Tailings	20	1512		7	ug/L	5300	37.1	
8-915-0281	8	14	Tailings	20	1532		31	ug/L	1280	39.7	
8-915-0279	8	14	Tailings	20	1533		11	ug/L	3880	42.7	
8-915-0275	8	14	Tailings	20	1536		34	ug/L	4050	137.7	
8-915-0139	9	5	Tailings	50	1507		31	ug/L	1960	60.8	
8-915-0158	9	5	Tailings	50	1522		22	ug/L	3140	69.1	
8-915-0152	9	5	Tailings	50	1529		67	ug/L	860	57.6	
8-915-0154	9	5	Tailings	50	1530		29	ug/L	2280	66.1	
8-915-0187	9	8	Tailings	50	1507		34	ug/L	3180	108.1	
8-915-0182	9	8	Tailings	50	1522		21	ug/L	2460	51.7	
8-915-0184	9	8	Tailings	50	1529		39	ug/L	1800	70.2	
8-915-0172	9	8	Tailings	50	1530		26	ug/L	3180	82.7	
8-915-0220	9	11	Tailings	50	1507		39	ug/L	1920	74.9	
8-915-0213	9	11	Tailings	50	1522		110	ug/L	560	61.6	
8-915-0212	9	11	Tailings	50	1529		120	ug/L	760	91.2	
8-915-0211	9	11	Tailings	50	1530		68	ug/L	940	63.9	
8-915-0286	9	14	Tailings	50	1507		25	ug/L	6840	171.0	
8-915-0280	9	14	Tailings	50	1522		15	ug/L	6920	103.8	
8-915-0273	9	14	Tailings	50	1529		29	ug/L	4050	117.5	
8-915-0287	9	14	Tailings	50	1530		10	ug/L	5100	51.0	

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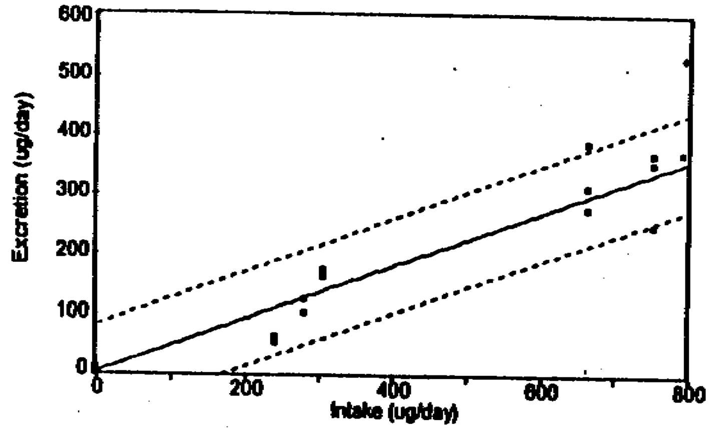
CURVE FITTING IN TABLECURVE 2D
Outliers shown by "+"

IV



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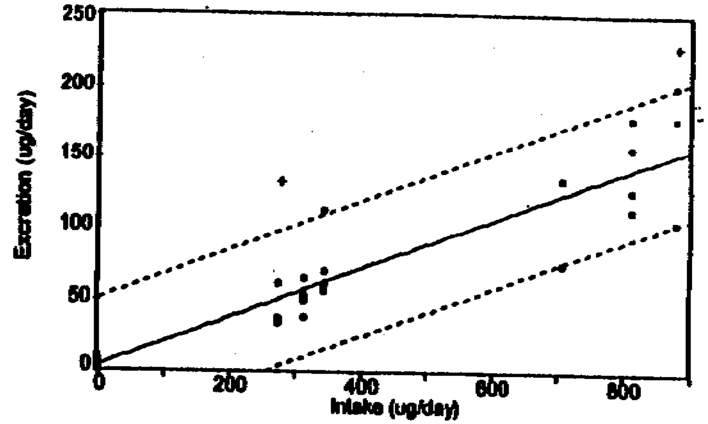

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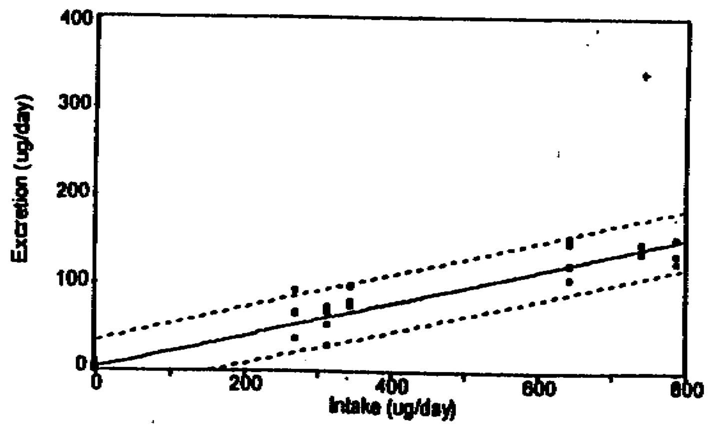
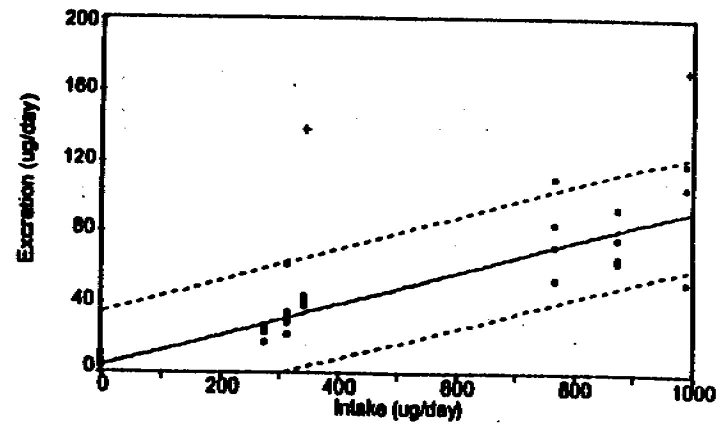


TAILINGS



APPENDIX B

DETAILED DATA TABLES FOR OTHER TEST MATERIALS

URINARY ARSENIC EXCRETION DATA FOR MURRAY SMELTER SLAG SAMPLE

Phase II Experiment 4

Group 3 = Control (PbAc = 225 ug/kg-d)

Group 5 = Murray Slag (Pb = 225 ug/kg-d)

Day	Group	Pig	Intake ug/d	Q	Urine Conc (ug/L)	Urine Volume (mL)	Total Excreted ug/d	Reliable?[a]	Outlier?[b]	Useable Data ug/d
7	3	408	0	<	2.00	4945	9.9			9.9
7	3	410	0		2.00	3215	6.4			6.4
7	3	426	0		2.00	1970	3.9			3.9
7	3	449	0	<	3.00	1510	4.5			4.5
7	3	455	0		3.00	8825	26.5		X	
7	5	420	175.7		12.00	1800	21.6			21.6
7	5	431	175.7		4.00	4380	17.5			17.5
7	5	432	175.7		15.00	6305	94.6		X	
7	5	440	175.7		8.60	2975	25.6			25.6
7	5	446	175.7		4.00	10205	40.8			40.8
14	3	408	0	<	2.00	5860	11.7	No		
14	3	410	0	<	3.00	2920	8.8			8.8
14	3	426	0		4.00	1340	5.4			5.4
14	3	449	0		3.00	1440	4.3			4.3
14	3	455	0		3.00	4070	12.2			12.2
14	5	420	215.5		19.00	1270	24.1			24.1
14	5	431	215.5		10.00	2530	25.3			25.3
14	5	432	215.5		6.00	4330	26.0			26.0
14	5	440	215.5		5.00	4000	20.0			20.0
14	5	446	215.5	<	2.00	7870	15.7	No		

[a] Considered to be unreliable if C <= 2 ug/L and V > 5000 mL. See text for discussion

[b] Considered to be an outlier if value is outside the 95% prediction interval for the best-fit straight line. For control animals, all values above 20 ug/day were judged to be outliers

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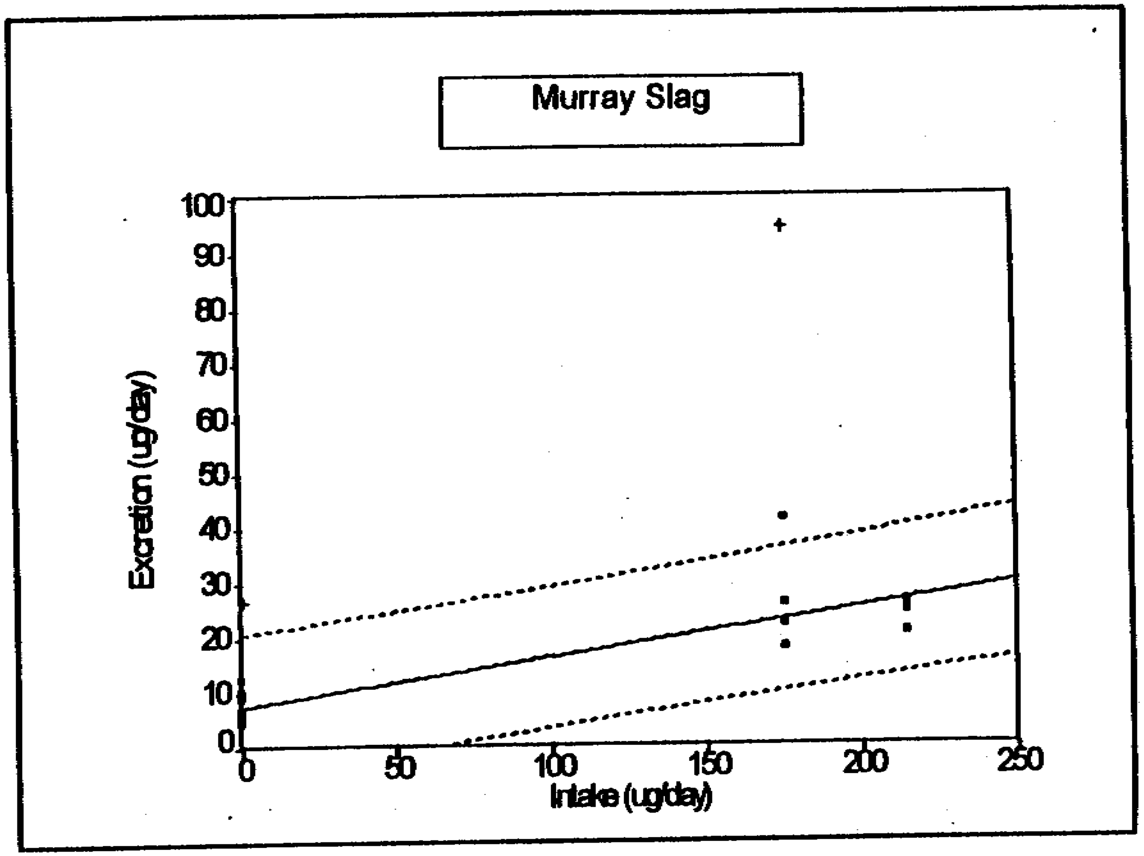
MurraySlag



	Coefficients	Standard Error	t value	Lower 95%	Upper 95%
Intercept	7.23	2.043	3.543	2.856	11.624
Slope	0.090	0.0147	6.112	0.058	0.121

Adj R^2 0.685

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MurraySlag

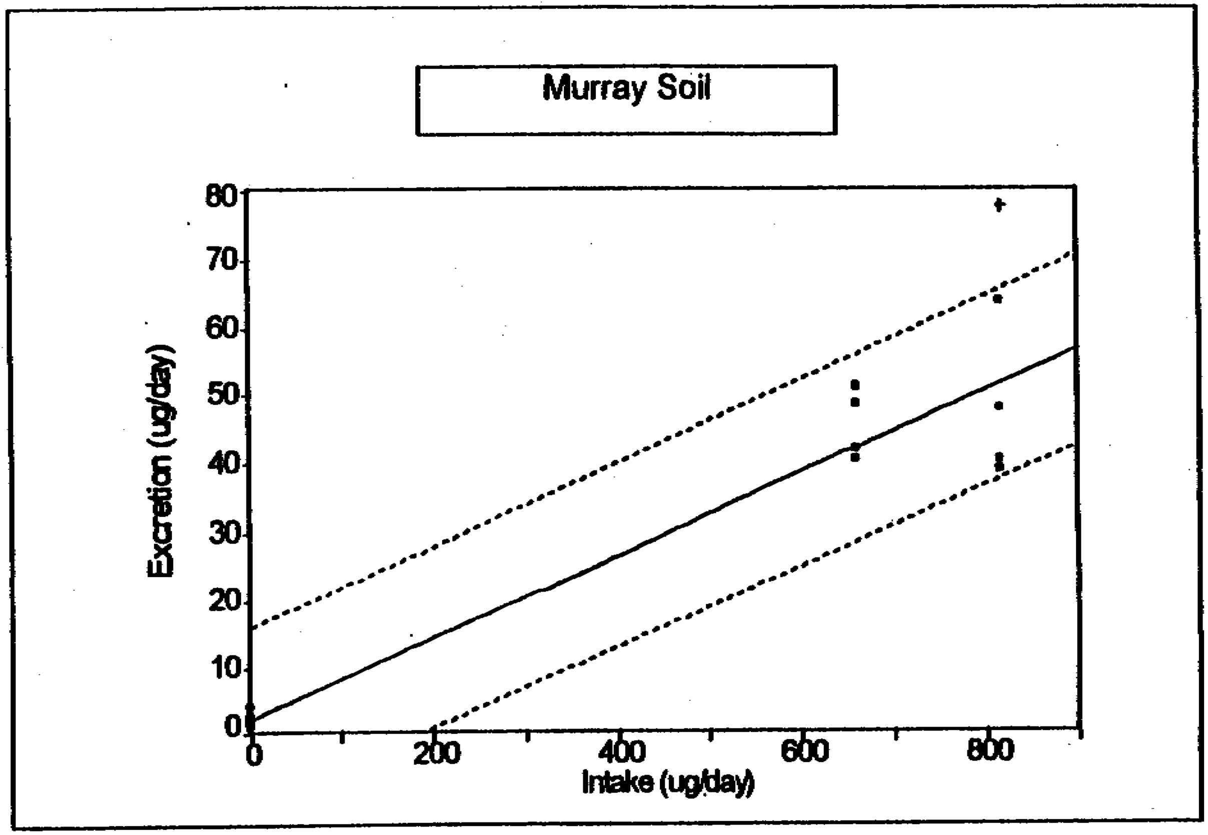
URINARY ARSENIC EXCRETION DATA FOR MURRAY SMELTER SOIL SAMPLE

Phase II Experiment 11
Group 1 = Control (PbAc = 0)
Group 7 = Murray Soil (Pb = 675 ug/kg-d)

Day	Group	Pig	Intake ug/d	Q	Urine Conc (ug/L)	Urine Volume (mL)	Total Excreted ug/d	Reliable?[a]	Outlier?[b]	Useable Data ug/d
7	1	1109	0		2	830	1.7			1.7
7	1	1124	0		2	840	1.7			1.7
7	1	1135	0	<	1	1370	1.4			1.4
7	1	1139	0	<	1	860	0.9			0.9
7	1	1151	0	<	1	1100	1.1			1.1
7	7	1126	659.5		22	2300	50.6			50.6
7	7	1137	659.5		32	1300	41.6			41.6
7	7	1140	659.5		26	1840	47.8			47.8
7	7	1141	659.5		50	1010	50.5			50.5
7	7	1155	659.5		100	400	40.0			40.0
14	1	1109	0		1	1320	1.3			1.3
14	1	1124	0		2	700	1.4			1.4
14	1	1135	0	<	1	2440	2.4			2.4
14	1	1139	0	<	1	1660	1.7			1.7
14	1	1151	0		2	1900	3.8			3.8
14	7	1126	816.5		21	2250	47.3			47.3
14	7	1137	816.5		32	2430	77.8		x	
14	7	1140	816.5		15	2560	38.4			38.4
14	7	1141	816.5		48	1320	63.4			63.4
14	7	1155	816.5		37	1080	40.0			40.0

[a] Considered to be unreliable if C <= 2 ug/L and V > 5000 mL. See text for discussion

[b] Considered to be an outlier if value is outside the 95% prediction interval for the best-fit straight line. For control animals, all values above 20 ug/day were judged to be outliers



	Coefficients	Standard Error	t value	Lower 95%	Upper 95%
Intercept	2.128	1.954	1.089	-1.999	6.256
Slope	0.0604	0.0039	15.6	0.0522	0.0686

Adj R^2 0.927

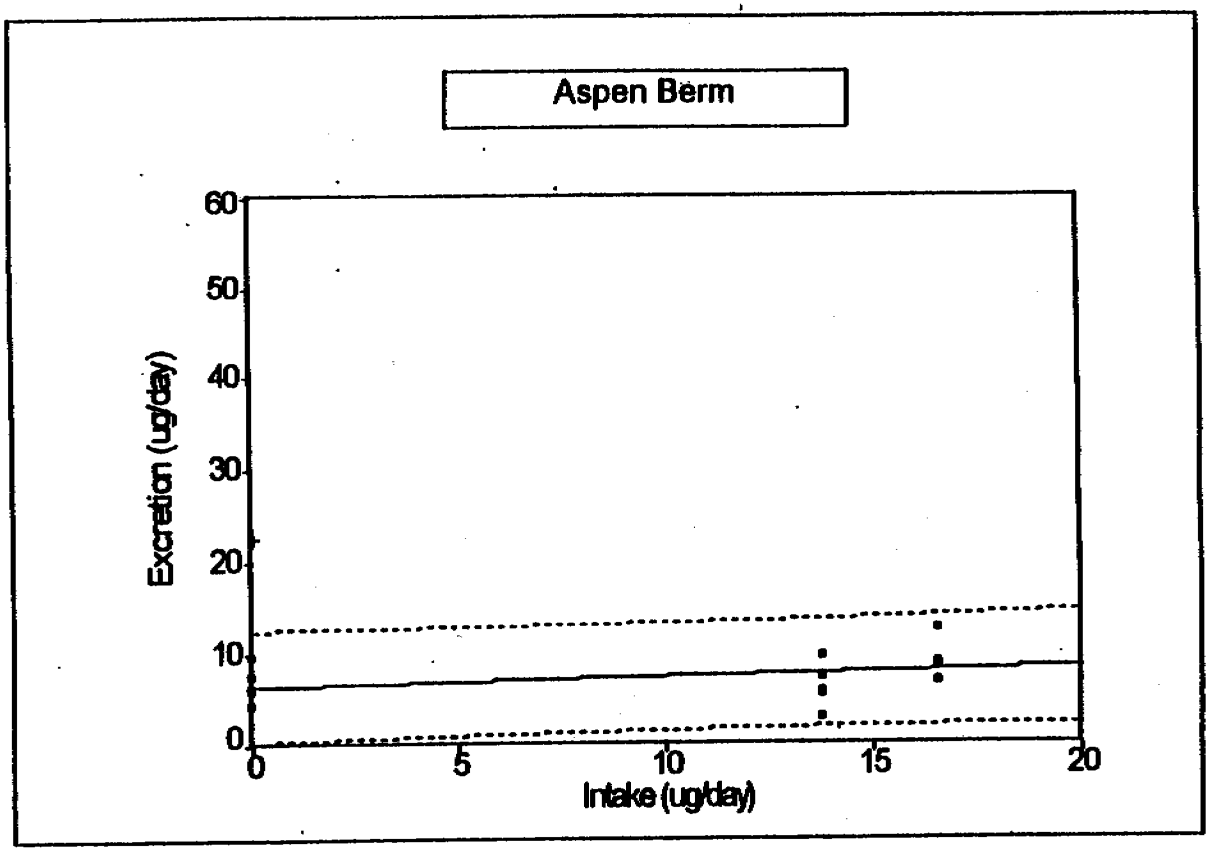
URINARY ARSENIC EXCRETION DATA FOR ASPEN BERM SAMPLE

Phase II Experiment 5
Group 3 = Control (PbAc 225)
Group 5 = Aspen Berm (Pb 225)

Day	Group	Pig	Intake ug/d	Q	Urine Conc (ug/L)	Urine Volume (mL)	Total Excreted ug/d	Reliable?[a]	Outlier?[b]	Useable Data ug/d
7	3	501	0		3	3100	9.3			9.3
7	3	513	0	<	2	11000	22.0	No		
7	3	529	0	<	2	2790	5.6			5.6
7	3	534	0		3	1320	4.0			4.0
7	3	547	0		4	1450	5.8			5.8
7	5	509	13.8		5	1035	5.2			5.2
7	5	512	13.8		3	3110	9.3			9.3
7	5	539	13.8		3	885	2.7			2.7
7	5	540	13.8		3	1795	5.4			5.4
7	5	550	13.8		4	1730	6.9			6.9
14	3	501	0		3	7460	22.4		X	
14	3	513	0	<	2	11500	23.0	No		
14	3	529	0		3	2440	7.3			7.3
14	3	534	0	<	2	5540	11.1	No		
14	3	547	0	<	2	3570	7.1			7.1
14	5	509	16.6		6.4	1330	8.5			8.5
14	5	512	16.6	<	2	3250	6.5			6.5
14	5	539	16.6		3	2810	8.4			8.4
14	5	540	16.6	<	3	4110	12.3			12.3
14	5	550	16.6		3	4120	12.4			12.4

[a] Considered to be unreliable if C <= 2 ug/L and V > 5000 mL. See text for discussion

[b] Considered to be an outlier if value is outside the 95% prediction interval for the best-fit straight line. For control animals, all values above 20 ug/day were judged to be outliers



	Coefficients	Standard Error	t value	Lower 95%	Upper 95%
Intercept	6.253	1.073	5.828	3.95	8.556
Slope	0.109	0.0888	1.232	-0.081	0.3

Adj R^2 0

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Berm

URINARY ARSENIC EXCRETION DATA FOR ASPEN RESIDENTIAL SAMPLE

Phase II Experiment 5

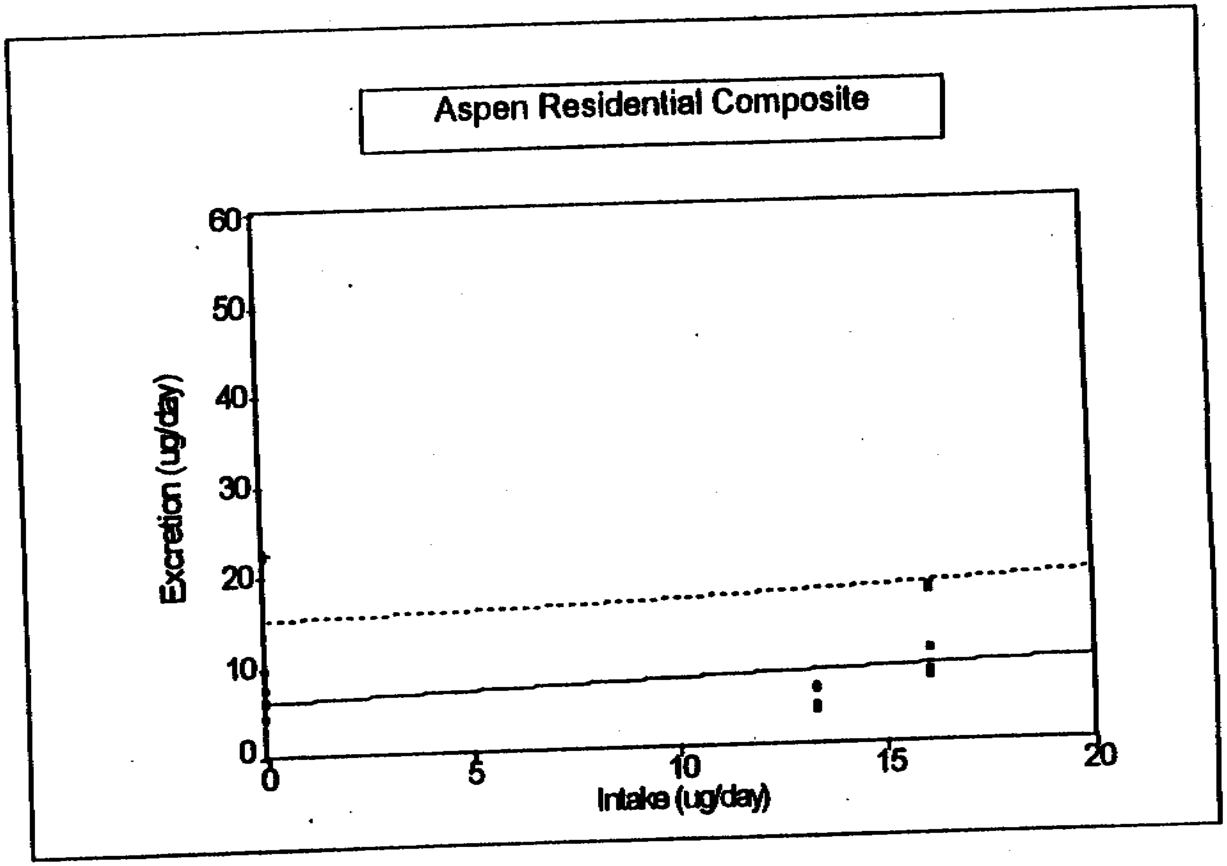
Group 3 = Control (PbAc 225)

Group 8 = Aspen Residential Composite (Pb 225)

Day	Group	Pig	Intake ug/d	Q	Urine Conc (ug/L)	Urine Volume (mL)	Total Excreted ug/d	Reliable?[a]	Outlier?[b]	Useable Data ug/d
7	3	501	0		3	3100	9.3			9.3
7	3	513	0	<	2	11000	22.0	No		
7	3	529	0	<	2	2790	5.6			5.6
7	3	534	0		3	1320	4.0			4.0
7	3	547	0		4	1450	5.8			5.8
7	8	505	13.3		4	1020	4.1			4.1
7	8	506	13.3		2	1830	3.7			3.7
7	8	521	13.3		6	1020	6.1			6.1
7	8	553	13.3		11	540	5.9			5.9
7	8	554	13.3		5	740	3.7			3.7
14	3	501	0		3	7460	22.4		X	
14	3	513	0	<	2	11500	23.0	No		
14	3	529	0		3	2440	7.3			7.3
14	3	534	0	<	2	5540	11.1	No		
14	3	547	0	<	2	3570	7.1			7.1
14	8	505	16.1		6	2855	17.1			17.1
14	8	506	16.1	<	2	8325	16.7	No		
14	8	521	16.1		4	1950	7.8			7.8
14	8	553	16.1		5	2030	10.2			10.2
14	8	554	16.1		3	2350	7.1			7.1

[a] Considered to be unreliable if C <= 2 ug/L and V > 5000 mL. See text for discussion

[b] Considered to be an outlier if value is outside the 95% prediction interval for the best-fit straight line. For control animals, all values above 20 ug/day were judged to be outliers



	Coefficients	Standard Error	t value	Lower 95%	Upper 95%
Intercept	6.006	1.632	3.681	2.504	9.508
Slope	0.1719	0.1397	1.23	-0.128	0.472

Adj R^2 0

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Resid

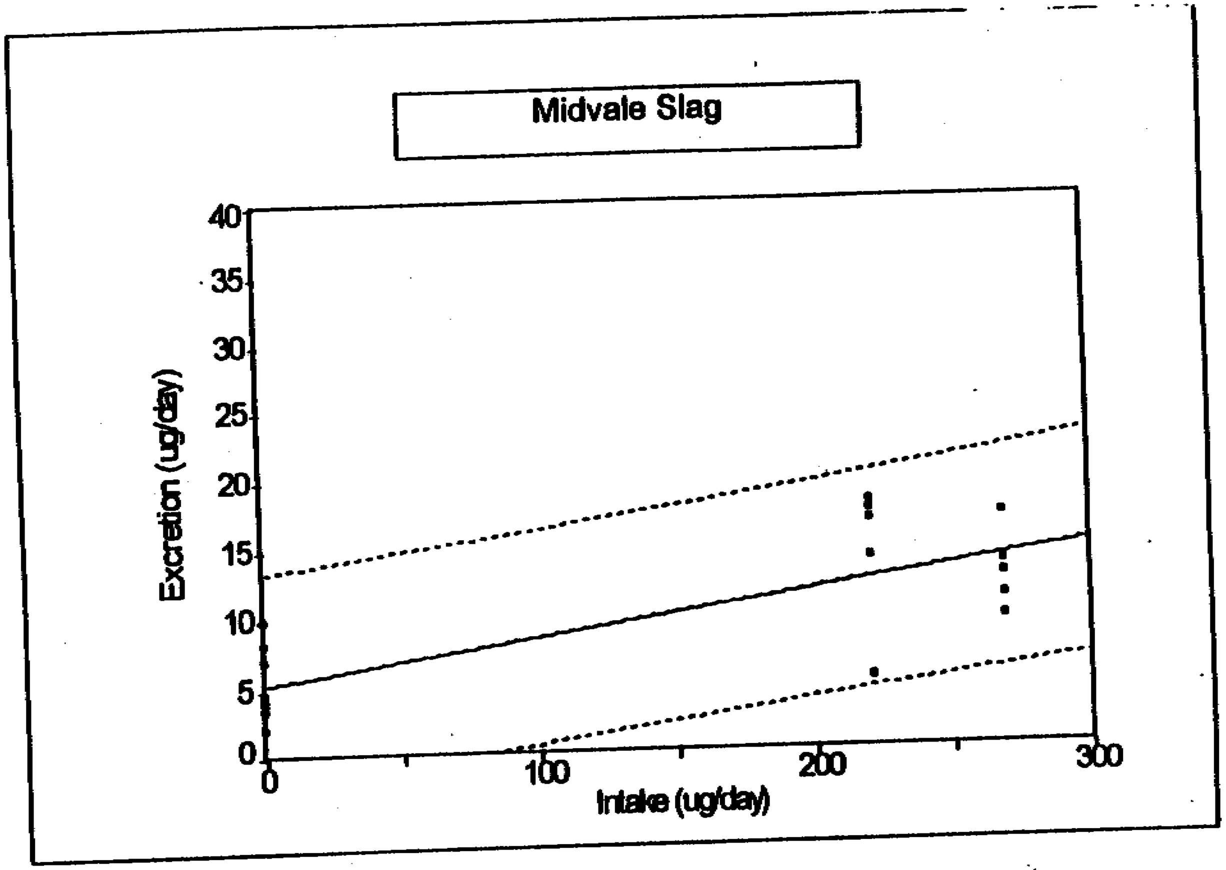
URINARY ARSENIC EXCRETION DATA FOR MIDVALE SLAG SAMPLE

Urinary Arsenic Levels - Experiment 6
Group 3 = Control (PbAc 225)
Group 5 = Midvale Slag (Pb 225 ug/kg)

Day	Group	Pig	Intake ug/d	Q	Urine Conc (ug/L)	Urine Volume (mL)	Total Excreted ug/d	Reliable?[a]	Outlier?[b]	Useable Data ug/d
7	3	616	0	<	2	940	1.9			1.9
7	3	644	0	<	2	1630	3.3			3.3
7	3	651	0	<	2	2090	4.2			4.2
7	3	653	0	<	2	1940	3.9			3.9
7	3	654	0	<	2	6700	13.4	No		
7	5	602	221.3		12	1480	17.8			17.8
7	5	605	221.3		6.4	2665	17.1			17.1
7	5	628	221.3		24	680	16.3			16.3
7	5	640	221.3		5	1000	5.0			5.0
7	5	650	221.3		5	2700	13.5			13.5
14	3	616	0	<	2	4010	8.0			8.0
14	3	644	0	<	2	1960	3.9			3.9
14	3	651	0	<	2	3410	6.8			6.8
14	3	653	0	<	2	1920	3.8			3.8
14	3	654	0	<	2	4870	9.7			9.7
14	5	602	269.1		5	1830	9.2			9.2
14	5	605	269.1		5	2620	13.1			13.1
14	5	628	269.1		9.3	1780	16.6			16.6
14	5	640	269.1		16	760	12.2			12.2
14	5	650	269.1		7	1520	10.6			10.6

[a] Considered to be unreliable if C <= 2 ug/L and V > 5000 mL. See text for discussion

[b] Considered to be an outlier if value is outside the 95% prediction interval for the best-fit straight line.
For control animals, all values above 20 ug/day were judged to be outliers



	Coefficients	Standard Error	t value	Lower 95%	Upper 95%
Intercept	5.229	1.188	4.399	2.718	7.739
Slope	0.0316	0.0066	4.749	0.0175	0.0456

Adj R^2 0.516

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Midvale

URINARY ARSENIC EXCRETION DATA FOR BUTTE SOIL SAMPLE

Urinary Arsenic Levels - Experiment 6

Group 3 = Control (PbAc 225)

Group 8 = Butte Soil (Pb 225 ug/kg)

Day	Group	Pig	Intake ug/d	Q	Urine Conc (ug/L)	Urine Volume (mL)	Total Excreted ug/d	Reliable?[a]	Outlier?[b]	Useable Data ug/d
7	3	616	0	<	2	940	1.9			1.9
7	3	644	0	<	2	1630	3.3			3.3
7	3	651	0	<	2	2090	4.2			4.2
7	3	653	0	<	2	1940	3.9			3.9
7	3	654	0	<	2	6700	13.4	No		
7	8	601	91.4	<	2	6500	13.0	No		
7	8	609	91.4	<	2	3340	6.7			6.7
7	8	618	91.4	<	2	2485	5.0			5.0
7	8	621	91.4	<	2	2770	5.5			5.5
7	8	635	91.4		6.2	930	5.8			5.8
14	3	616	0	<	2	4010	8.0			8.0
14	3	644	0	<	2	1960	3.9			3.9
14	3	651	0	<	2	3410	6.8			6.8
14	3	653	0	<	2	1920	3.8			3.8
14	3	654	0	<	2	4870	9.7		x	
14	8	601	110.4	<	2	4850	9.7			9.7
14	8	609	110.4		2	2710	5.4			5.4
14	8	618	110.4	<	2	2460	4.9			4.9
14	8	621	110.4	<	2	2950	5.9			5.9
14	8	635	110.4	<	2	3460	6.9			6.9

[a] Considered to be unreliable if C <= 2 ug/L and V > 5000 mL. See text for discussion

[b] Considered to be an outlier if value is outside the 95% prediction interval for the best-fit straight line. For control animals, all values above 20 ug/day were judged to be outliers

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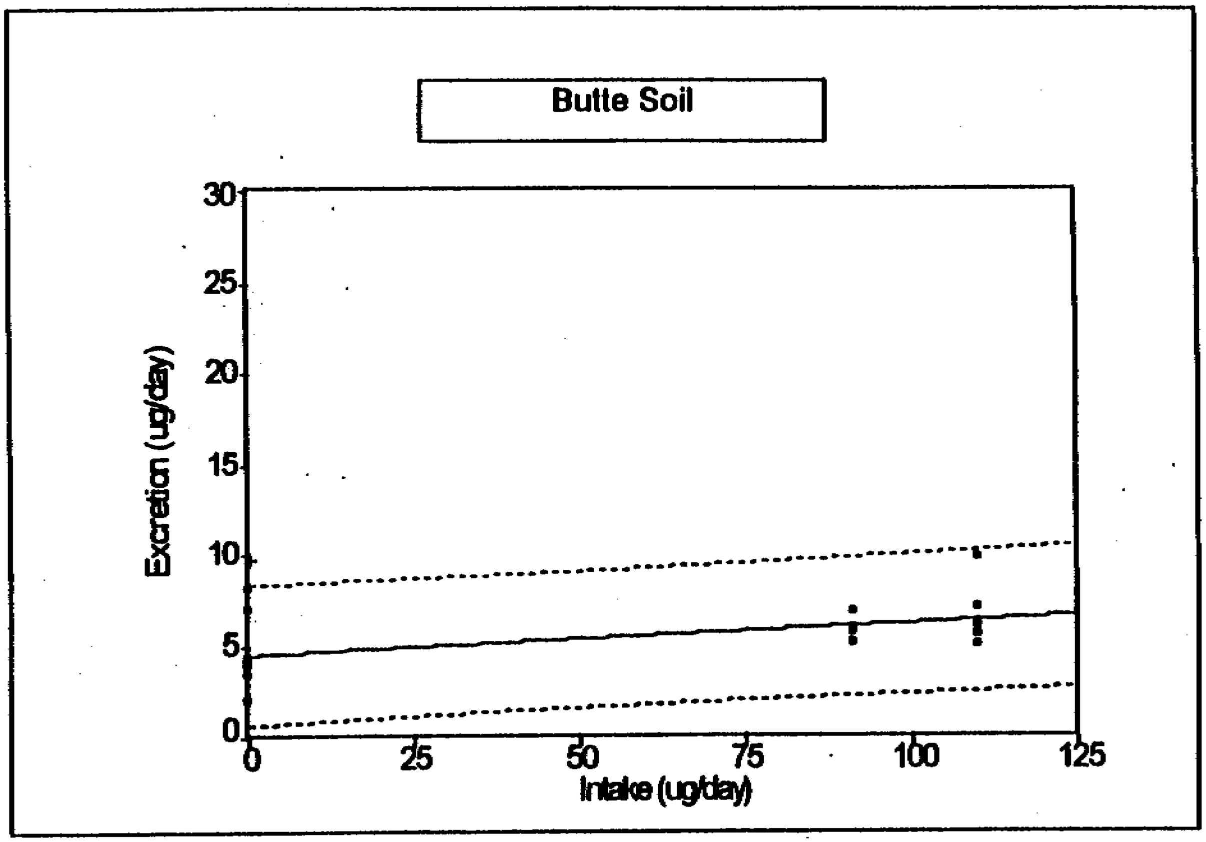
Butte



	Coefficients	Standard Error	t value	Lower 95%	Upper 95%
Intercept	4.449	0.602	7.388	3.169	5.729
Slope	0.017	0.0081	2.155	0.0002	0.0346

Adj R^2 0.127

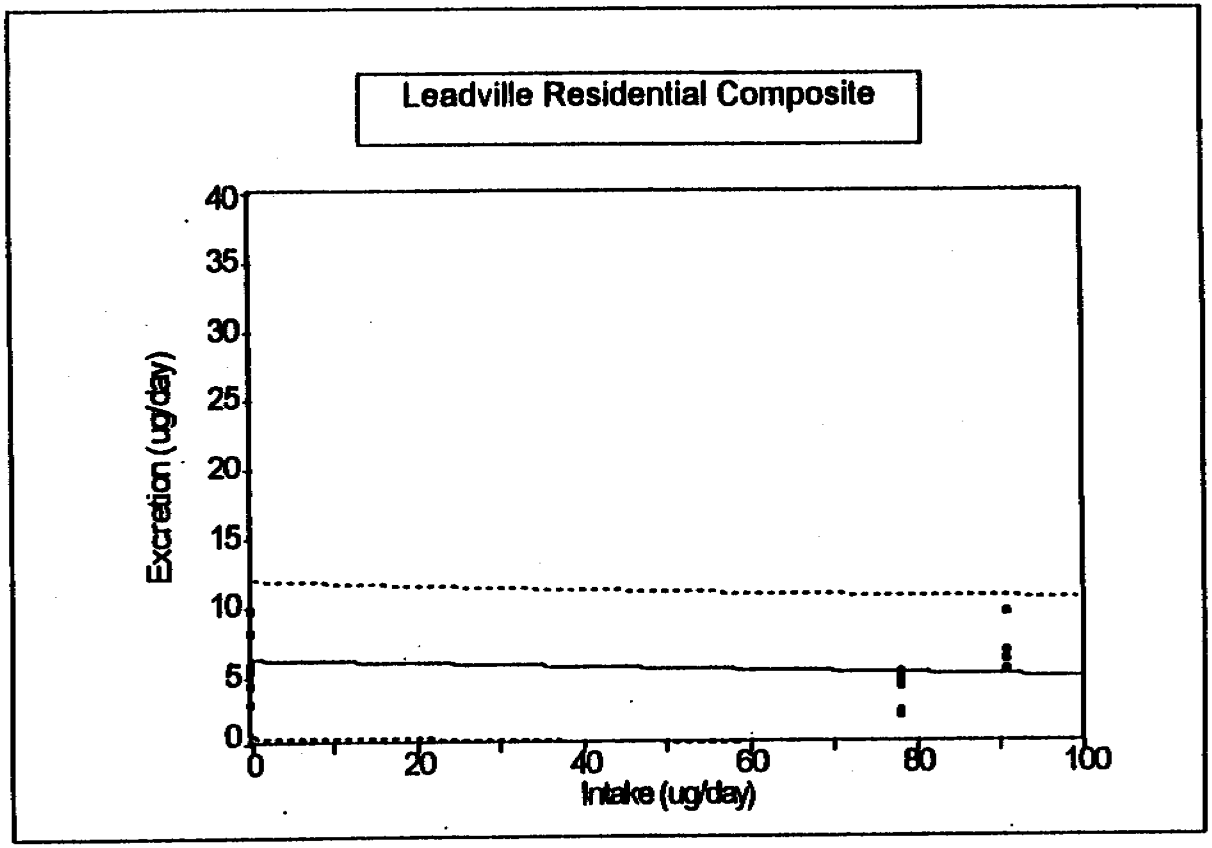
URINARY ARSENIC EXCRETION DATA FOR LEADVILLE RESIDENTIAL COMPOSITE SOIL

Urinary Arsenic Levels - Experiment 7
Group 1 = Control
Group 6 = Leadville Composite (Pb 225)

Day	Group	Pig	Intake ug/d	Q	Urine Conc (ug/L)	Urine Volume (mL)	Total Excreted ug/d	Reliable?[a]	Outlier?[b]	Useable Data ug/d
7	1	706	0	<	2	1360	2.7			2.7
7	1	714	0	<	2	2760	5.5			5.5
7	1	718	0	<	2	2580	5.2			5.2
7	1	735	0	<	2	2000	4.0			4.0
7	1	743	0	<	2	7650	15.3	No		
7	6	717	78.4		3	700	2.1			2.1
7	6	723	78.4	<	2	1960	3.9			3.9
7	6	725	78.4	<	2	2480	5.0			5.0
7	6	732	78.4		3	600	1.8			1.8
7	6	737	78.4		6.5	680	4.4			4.4
14	1	706	0	<	2	4680	9.4			9.4
14	1	714	0	<	2	6010	12.0	No		
14	1	718	0	<	2	8940	17.9	No		
14	1	735	0	<	2	3940	7.9			7.9
14	1	743	0	<	2	4760	9.5			9.5
14	6	717	90.9	<	2	2600	5.2			5.2
14	6	723	90.9	<	2	7560	15.1	No		
14	6	725	90.9	<	2	4600	9.2			9.2
14	6	732	90.9	<	2	2940	5.9			5.9
14	6	737	90.9		4	1640	6.6			6.6

[a] Considered to be unreliable if C <= 2 ug/L and V > 5000 mL. See text for discussion

[b] Considered to be an outlier if value is outside the 95% prediction interval for the best-fit straight line. For control animals, all values above 20 ug/day were judged to be outliers



	Coefficients	Standard Error	t value	Lower 95%	Upper 95%
Intercept	6.146	0.9336	6.583	4.142	8.149
Slope	-0.0134	0.0148	-0.907	-0.045	0.0183

Adj R^2 0

URINARY ARSENIC EXCRETION DATA FOR LEADVILLE IRON-MANGANESE LEAD OXIDE SAMPLE

Urinary Arsenic Levels - Experiment 7

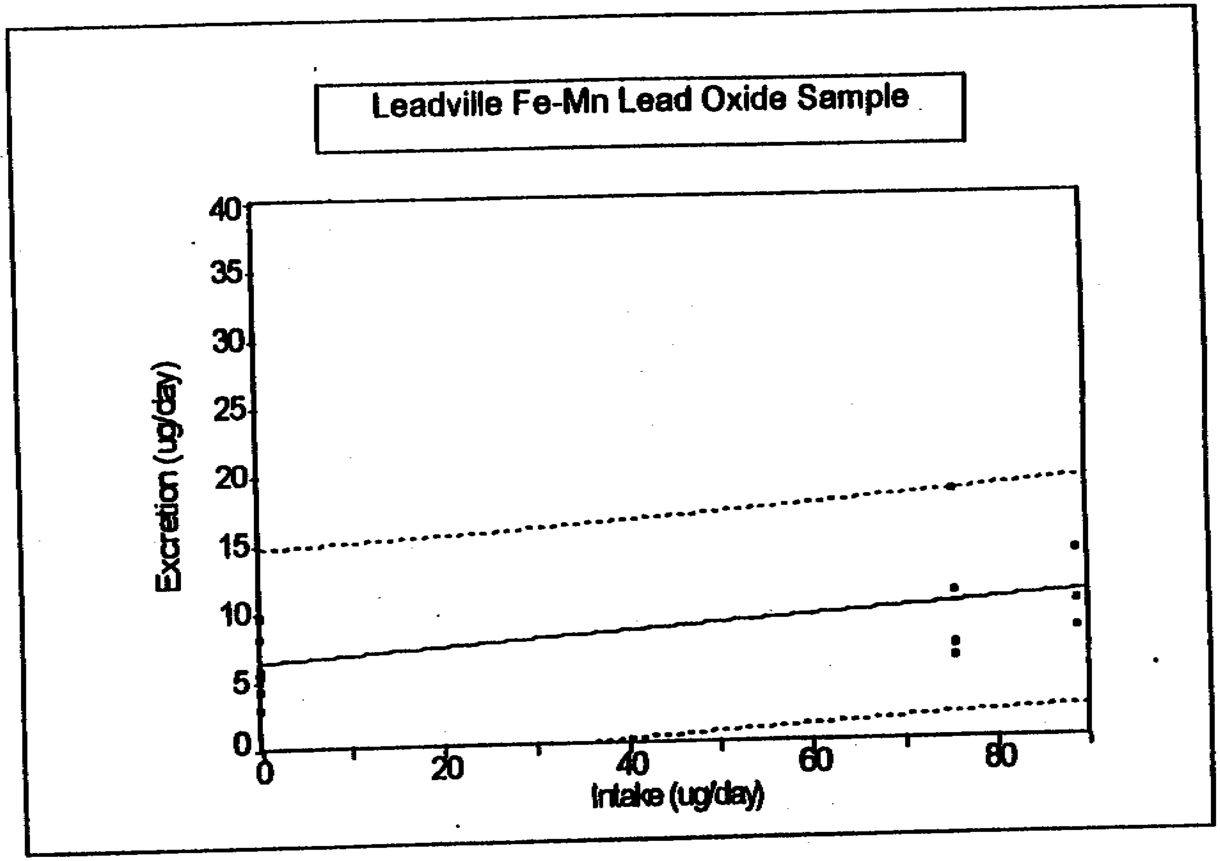
Group 1 = Control

Group 9 = Leadville Fe/Mn PbO (Pb 225)

Day	Group	Pig	Intake ug/d	Q	Urine Conc (ug/L)	Urine Volume (mL)	Total Excreted ug/d	Reliable?[a]	Outlier?[b]	Useable Data ug/d
7	1	706	0	<	2	1360	2.7			2.7
7	1	714	0	<	2	2760	5.5			5.5
7	1	718	0	<	2	2580	5.2			5.2
7	1	735	0	<	2	2000	4.0			4.0
7	1	743	0	<	2	7650	15.3	No		
7	9	719	75.6		5	1180	5.9			5.9
7	9	721	75.6		3	2280	6.8			6.8
7	9	729	75.6		5	3600	18.0			18.0
7	9	744	75.6	<	2	5200	10.4	No		
7	9	745	75.6		4	2680	10.7			10.7
14	1	706	0	<	2	4680	9.4			9.4
14	1	714	0	<	2	6010	12.0	No		
14	1	718	0	<	2	8940	17.9	No		
14	1	735	0	<	2	3940	7.9			7.9
14	1	743	0	<	2	4760	9.5			9.5
14	9	719	88.9		3	3280	9.8			9.8
14	9	721	88.9		3	4520	13.6			13.6
14	9	729	88.9	<	2	7810	15.6	No		
14	9	744	88.9		2	9820	19.6	No		
14	9	745	88.9	<	2	3960	7.9			7.9

[a] Considered to be unreliable if C <= 2 ug/L and V > 5000 mL. See text for discussion

[b] Considered to be an outlier if value is outside the 95% prediction interval for the best-fit straight line. For control animals, all values above 20 ug/day were judged to be outliers



	Coefficients	Standard Error	t value	Lower 95%	Upper 95%
Intercept	6.332	1.332	4.753	3.425	9.239
Slope	0.0497	0.0231	2.152	-0.0007	0.1001

Adj R^2 0.147

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FeMnPbO

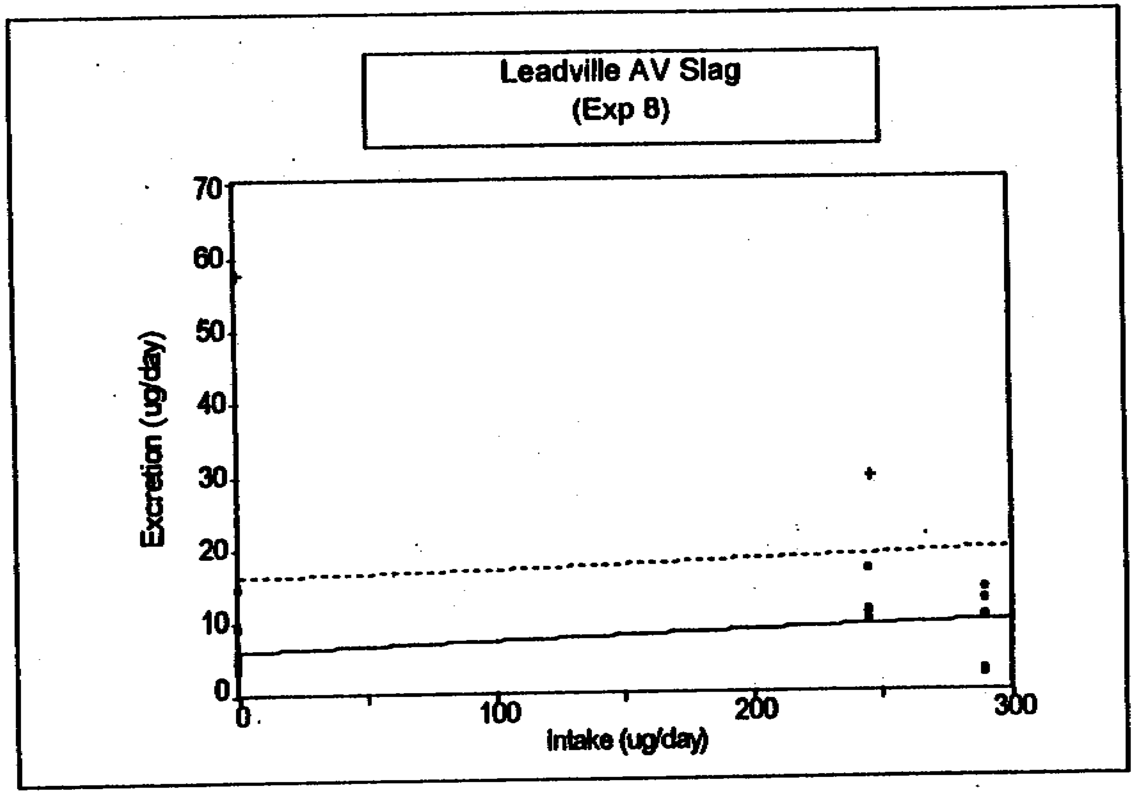
URINARY ARSENIC EXCRETION DATA FOR LEADVILLE AV SLAG SAMPLE

Urinary Arsenic Levels - Experiment 8
Group 5 = Control
Group 10 = Leadville AV Slag (Pb 225)

Day	Group	Pig	Intake ug/d	Q	Urine Conc (ug/L)	Urine Volume (mL)	Total Excreted ug/d	Reliable?[a]	Outlier?[b]	Useable Data ug/d
7	5	809	0		3	1060	3.2			3.2
7	5	830	0	<	2	1600	3.2			3.2
7	5	841	0		2	1480	3.0			3.0
7	5	848	0	<	2	2380	4.8			4.8
7	5	855	0	<	2	4400	8.8			8.8
7	10	811	245.1		7.8	1180	9.2			9.2
7	10	822	245.1		5	3260	16.3			16.3
7	10	824	245.1		14	680	9.5			9.5
7	10	837	245.1		5	2100	10.5			10.5
7	10	856	245.1		6	4880	29.3		x	
14	5	809	0		3	1260	3.8			3.8
14	5	822	0		2	2780	5.6			5.6
14	5	824	0		11	1280	14.1			14.1
14	5	837	0		11	5240	57.6		X	
14	5	855	0	<	2	8640	17.3	No		
14	10	811	290.6		13	920	12.0			12.0
14	10	830	290.6	<	2	4900	9.8			9.8
14	10	841	290.6		2	940	1.9			1.9
14	10	848	290.6	<	2	1300	2.6			2.6
14	10	856	290.6		3	4480	13.4			13.4

[a] Considered to be unreliable if C <= 2 ug/L and V > 5000 mL. See text for discussion

[b] Considered to be an outlier if value is outside the 95% prediction interval for the best-fit straight line.
For control animals, all values above 20 ug/day were judged to be outliers



	Coefficients	Standard Error	t value	Lower 95%	Upper 95%
Intercept	5.977	1.546	3.867	2.692	9.263
Slope	0.0123	0.0078	1.569	-0.004	0.0289

Adj R^2 0.0184

URINARY ARSENIC EXCRETION DATA FOR PALMERTON LOCATION 2 SAMPLE

Urinary Arsenic Levels - Experiment 9
Group 2 = Control
Group 7 = Palmerton Location 2 (Pb 225)

Day	Group	Pig	Intake ug/d	Q	Urine Conc (ug/L)	Urine Volume (mL)	Total Excreted ug/d	Reliable?[a]	Outlier?[b]	Useable Data ug/d
7	2	901	0		7.9	500	4.0			4.0
7	2	902	0		3.3	1320	4.4			4.4
7	2	920	0		2	2240	4.5			4.5
7	2	925	0		3.3	920	3.0			3.0
7	2	928	0		2	1140	2.3			2.3
7	7	906	131.6		4.8	1680	8.1			8.1
7	7	908	131.6		10	700	7.0			7.0
7	7	916	131.6		10	1240	12.4			12.4
7	7	918	131.6		7.3	760	5.5			5.5
7	7	922	131.6		5.2	1250	6.5			6.5
14	2	901	0		5.6	340	1.9			1.9
14	2	902	0		2	1390	2.8			2.8
14	2	920	0		2	1940	3.9			3.9
14	2	925	0		5.5	1160	6.4			6.4
14	2	928	0		2	1720	3.4			3.4
14	7	906	160.1		9	4340	39.1		x	
14	7	908	160.1		12	1480	17.8			17.8
14	7	916	160.1		8.9	1260	11.2			11.2
14	7	918	160.1		19	1280	24.3			24.3
14	7	922	160.1		8	2800	22.4			22.4

[a] Considered to be unreliable if C <= 2 ug/L and V > 5000 mL. See text for discussion

[b] Considered to be an outlier if value is outside the 95% prediction interval for the best-fit straight line.
For control animals, all values above 20 ug/day were judged to be outliers

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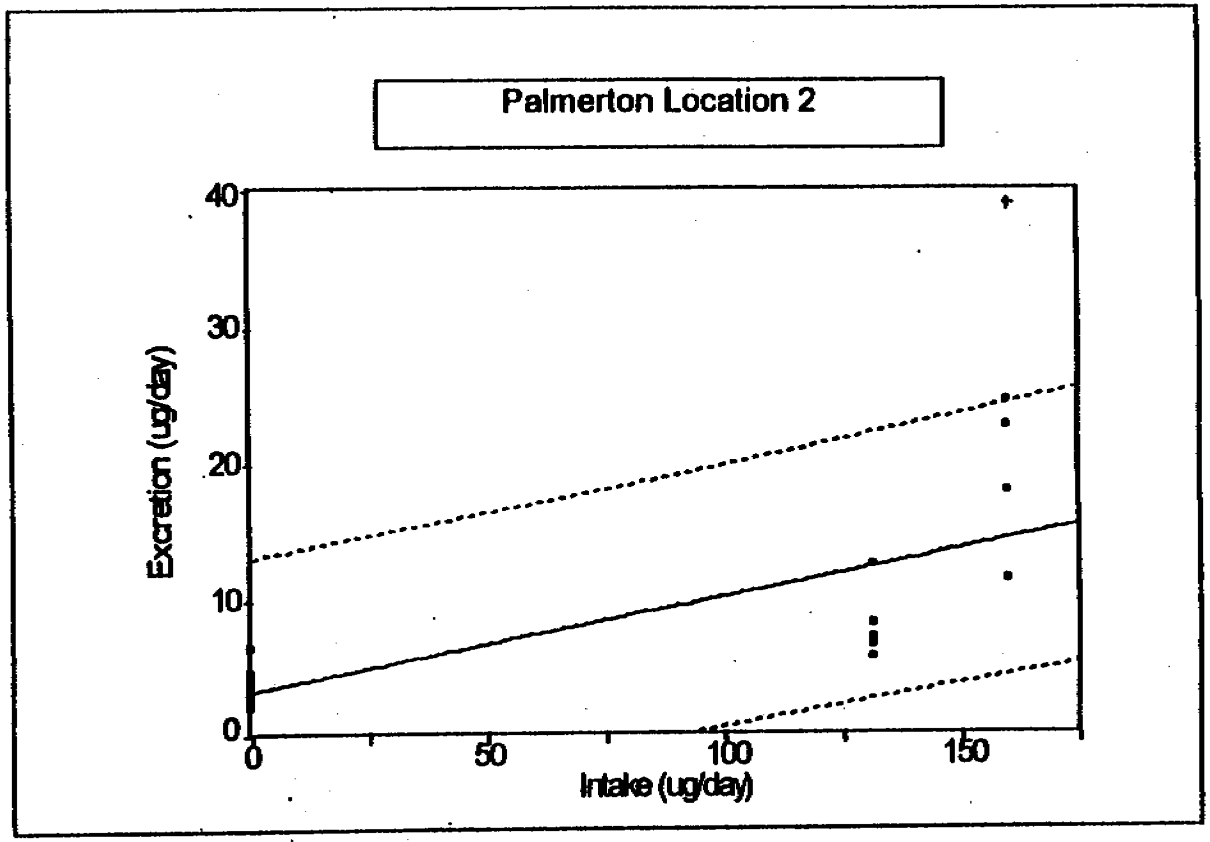
Loc2



	Coefficients	Standard Error	t value	Lower 95%	Upper 95%
Intercept	3.251	1.388	2.341	0.318	6.184
Slope	0.069	0.0139	4.977	0.0399	0.0987

Adj R^2 0.542

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Loc2

URINARY ARSENIC EXCRETION DATA FOR PALMERTON LOCATION 4 SAMPLE

Urinary Arsenic Levels - Experiment 9
Group 2 = Control
Group 10 = Palmerton Location 4 (Pb 225)

Day	Group	Pig	Intake ug/d	Q	Urine Conc (ug/L)	Urine Volume (mL)	Total Excreted ug/d	Reliable?[a]	Outlier?[b]	Useable Data ug/d
7	2	901	0		7.9	500	4.0			4.0
7	2	902	0		3.3	1320	4.4			4.4
7	2	920	0		2	2240	4.5			4.5
7	2	925	0		3.3	920	3.0			3.0
7	2	928	0		2	1140	2.3			2.3
7	10	917	248.0		17	790	13.4			13.4
7	10	921	248.0		7.3	940	6.9			6.9
7	10	939	248.0		2	3840	7.7			7.7
7	10	941	248.0		4	1590	6.4			6.4
7	10	945	248.0		51	480	24.5			24.5
14	2	901	0		5.6	340	1.9			1.9
14	2	902	0		2	1390	2.8			2.8
14	2	920	0		2	1940	3.9			3.9
14	2	925	0		5.5	1160	6.4			6.4
14	2	928	0		2	1720	3.4			3.4
14	10	917	291.7		26	2620	68.1			68.1
14	10	921	291.7		23	2440	56.1			56.1
14	10	939	291.7		6.8	13560	92.2		x	
14	10	941	291.7		6.9	3560	24.6			24.6
14	10	945	291.7		67	400	26.8			26.8

[a] Considered to be unreliable if C <= 2 ug/L and V > 5000 mL. See text for discussion

[b] Considered to be an outlier if value is outside the 95% prediction interval for the best-fit straight line. For control animals, all values above 20 ug/day were judged to be outliers

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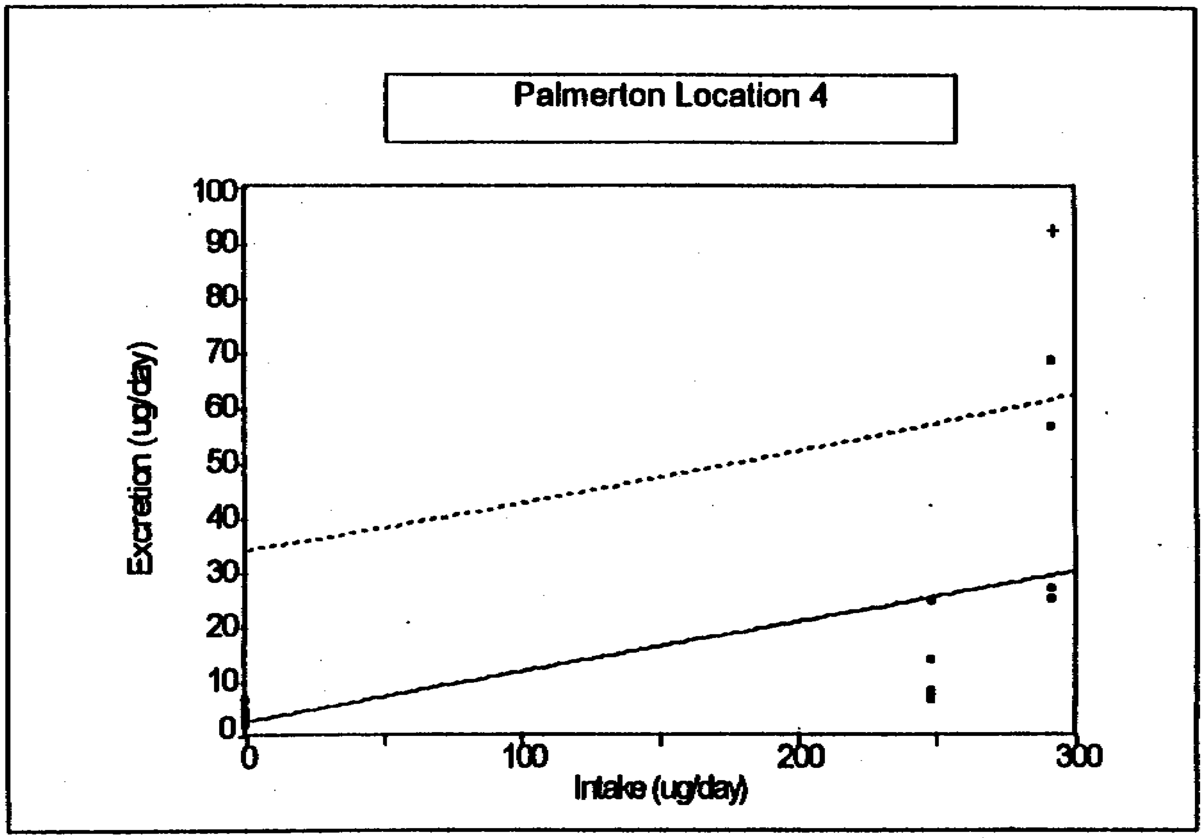
Loc4



	Coefficients	*Standard Error*	*t value*	*Lower 95%*	*Upper 95%*
Intercept	2.627	4.48	0.586	-6.836	12.09
Slope	0.0918	0.024	3.785	0.0406	0.143

Adj R^2 0.389

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URINARY ARSENIC EXCRETION DATA FOR BINGHAM CREEK HIGH LEAD SAMPLE

Urinary Arsenic Levels - Experiment 2

Group 1 = Control

Group 10 = Bingham Creek Channel Soil

Day	Group	Pig	Intake ug/d	Q	Urine Conc (ug/L)	Urine Volume (mL)	Total Excreted ug/d	Reliable?[a]	Outlier?[b]	Useable Data ug/d
7	1	206	0		4	2000	8.0			8.0
7	1	226	0		11	2000	22.0		X	
7	10	205	240.2		13	1340	17.4			17.4
7	10	210	240.2		23	1800	41.4			41.4
7	10	Lost								
7	10	218	240.2		5	4100	20.5			20.5
7	10	255	240.2		3	4040	12.1			12.1
14	1	206	0		4.8	2000	9.6			9.6
14	1	226	0	<	1	2000	2.0			2.0
14	10	205	321.5		8.6	2320	20.0			20.0
14	10	210	321.5		7.6	2540	19.3			19.3
14	10	213	321.5		11	2640	29.0			29.0
14	10	218	321.5		3.3	4160	13.7			13.7
14	10	255	321.5		48	1170	56.2			56.2

[a] Refer to text for outlier decision criteria

[b] Considered to be an outlier if value is outside the 95% prediction interval for the best-fit straight line. For control animals, all values above 20 ug/day were judged to be outliers

[ ] Volume not measured; value is asssumed

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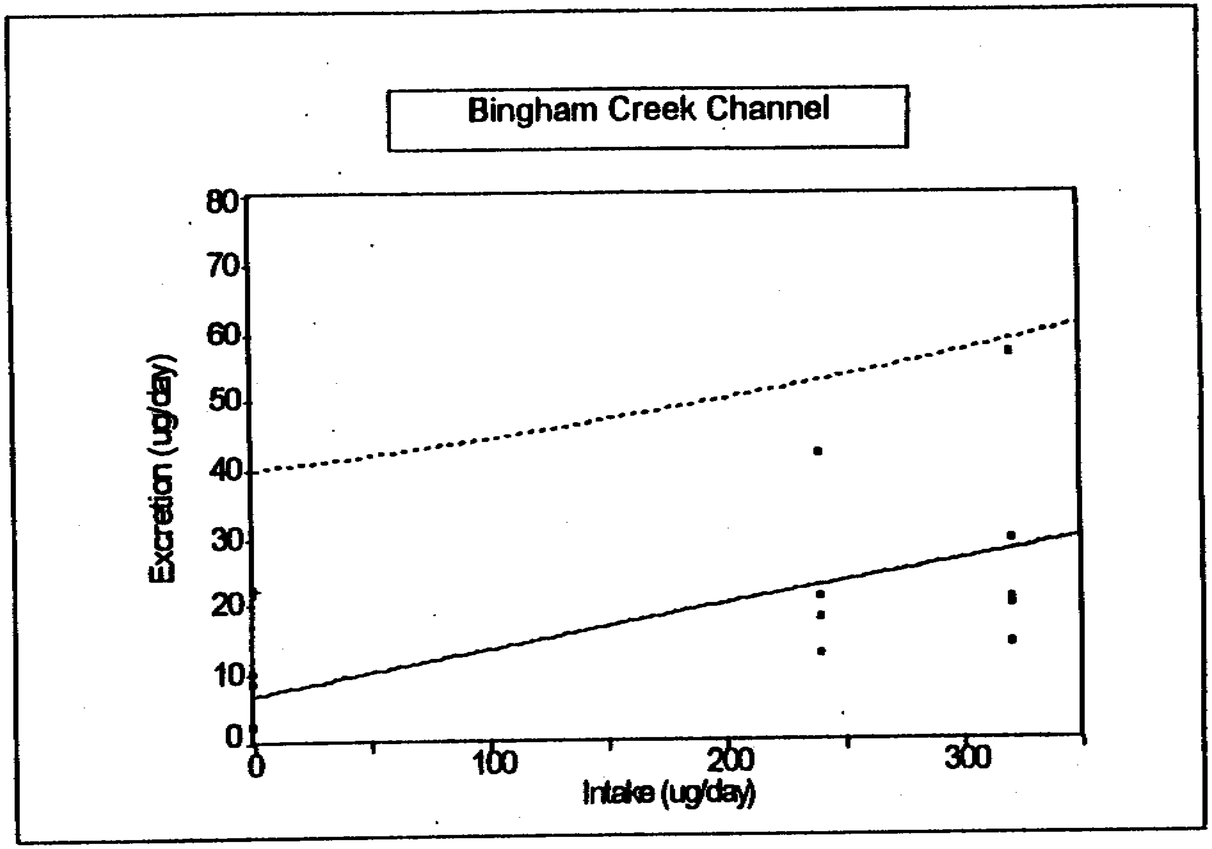
BC



	Coefficients	Standard Error	t value	Lower 95%	Upper 95%
Intercept	6.657	7.239	0.92	-9.512	22.826
Slope	0.0659	0.029	2.274	0.0012	0.1307

Adj R^2 0.194

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BC

APPENDIX C

DETAILED ARSENIC SPECIATION DATA

C-1

ARSENIC SPECIATION DATA
MURRAY SMELTER SITE
SOIL SAMPLE

PHASE	N	Mean Size	LW Frequency			Relative As mass			
			Lib	Inc	Total	Lib	(% Lib)	Inc	Total
Fe-As Sulfate	1	35	0.24%		0.24%	5.80%	7.31%		5.80%
Slag	299	47	97.61%		97.61%	2.41%	3.04%		2.41%
PbMO	6	7	0.18%	0.10%	0.28%	0.24%	0.30%	0.13%	0.37%
PbAsO	44	5	1.24%	0.38%	1.62%	66.20%	83.48%	20.57%	86.77%
Fe-As Oxide	4	8	0.22%		0.22%	2.90%	3.66%		2.90%
AsMO	1	3	0.02%		0.02%	1.75%	2.20%		1.75%
Total	355		99.52%	0.48%	100.00%	79.30%	100.00%	20.70%	100.00%

MUR-SOIL.XLS

ARSENIC SPECIATION DATA
CALIFORNIA GULCH SITE
AV SLAG SAMPLE

Phase	N	Mean Size	LW Frequency			Relative As mass			
			Lib	Inc	Total	Lib	(% Lib)	Inc	Total
AsMO	2	35	0.05%		0.05%	5.20%	7.09%		5.20%
PbAsMO	37	5	0.07%	0.05%	0.12%	0.14%	0.18%	0.09%	0.22%
PbAsO	214	8	0.78%	0.36%	1.14%	57.80%	78.76%	26.35%	84.15%
PbMO	5	94	0.30%		0.30%	1.77%	2.41%		1.77%
PbMS	1	80	0.05%		0.05%	2.82%	3.85%		2.82%
PbMSO4	2	40	0.05%		0.05%	0.51%	0.69%		0.51%
Slag	1206	126	98.16%		98.16%	5.08%	6.92%		5.08%
Fe-As Sulfate	5	37	0.04%	0.08%	0.12%	0.08%	0.10%	0.18%	0.25%
Total	1472		99.51%	0.49%	100.00%	73.39%	100.00%	26.61%	100.00%

ARSENIC SPECIATION DATA
CLARK FORK RIVER OU
GRANT KOHRS TAILINGS/SLICKENS SAMPLE

Phase	N	Mean Size	LW Frequency			Relative As mass			
			Lib	Inc	Total	Lib	(% Lib)	Inc	Total
Fe-As Oxide	45	30	50.95%		53.51%	53.51%	57.15%		53.51%
Mn-As Oxide	7	20	5.20%		1.02%	1.02%	1.09%		1.02%
As Phosphate	20	25	18.06%	0.30%	15.66%	15.41%	16.46%	0.25%	15.66%
Slag	5	57	10.59%		0.10%	0.10%	0.11%		0.10%
Fe-As Sulfate	18	21	13.71%		16.65%	16.65%	17.78%		16.65%
Enargite	3	11	0.63%	0.56%	13.05%	6.93%	7.41%	6.12%	13.05%
Total	98		99.15%	0.85%	100.00%	93.63%	100.00%	6.37%	100.00%

GK-TAIL.XLS

ARSENIC SPECIATION DATA
MIDVALE SLAG SITE
SLAG SAMPLE

PHASE	N	Mean Size	LW Frequency			Relative As Mass			
			Lib	Inc	Total	Lib	(% Lib)	Inc	Total
FeAs Oxide	4	26	0.04%		0.04%	0.15%	0.19%		0.15%
PbAs Oxide	119	16	0.62%	0.21%	0.83%	64.82%	83.51%	22.38%	87.20%
Slag	1721	131	99.09%		99.09%	11.25%	14.49%		11.25%
Sulfosalts	1	50	0.02%		0.02%	1.36%	1.75%		1[illegible]%
FeAsSO4	2	15	0.01%		0.01%	0.04%	0.05%		0.04%
Total	1847		99.79%	0.21%	100.00%	77.62%	100.00%	22.38%	100.00%

MIDVSLAG.XLS

ARSENIC SPECIATION DATA
MURRAY SMELTER SITE
SLAG SAMPLE

Phase	N	Mean Size	LW Frequency			Rel As Mass			
			Lib	Inc	Total	Lib	(% Lib)	Inc	Total
SLAG	1037	17	98.61%		98.61%	13.91%	14.68%		13.91%
PbAsO	39	26	0.28%	0.03%	0.31%	43.69%	46.09%	5.08%	48.77%
Fe-As OXIDE	15	31	0.46%		0.46%	26.64%	28.10%		26.64%
Fe-As Sulfate	2	6	0.14%		0.14%	9.90%	10.44%		9.90%
PbMO	8	18	0.16%	0.03%	0.19%	0.62%	0.65%	0.12%	0.73%
Mn-As Oxide	7	73	0.28%		0.28%	0.04%	0.04%		0.04%
Total	1108		99.94%	0.06%	100.00%	94.80%	100.00%	5.20%	100.00%

MUR-SLAG.XLS

APPENDIX D

DETAILED DATA ON ARSENIC LEVELS IN FECES AND TISSUES PILOT STUDY 2

D-1

FECAL ARSENIC EXCRETION (ug/day) BY ANIMAL - PILOT STUDY 2

Group	Treatment	Dose	Pig	Day 5 Total	Day 5 Dose	Day 5 FEF	Day 8 Total	Day 8 Dose	Day 8 FEF	Day 11 Total	Day 11 Dose	Day 11 FEF	Day 14 Total	Day 14 Dose	Day 14 FEF
1	0	Control	1501	0.8	0.0		3.0	0.0		1.0	0.0		4.0	0.0	
			1510	na	0.0		4.0	0.0		3.0	0.0		4.0	0.0	
			1540	10.0	0.0		4.0	0.0		0.5	0.0		3.0	0.0	
2	IV	20	1504	2.4	238.8	0.01	3.0	241.5	0.01	6.0	281.3	0.02	4.0	306.0	0.01
			1505	2.0	238.8	0.01	3.0	241.5	0.01	Dead			Dead		
			1508	culled			culled			culled			culled		
			1511	5.0	238.8	0.02	8.0	241.5	0.03	4.0	281.3	0.01	1.0	306.0	0.00
			1527	4.0	238.8	0.02	Dead			Dead			Dead		
3	IV	50	1503	6.0	628.3	0.01	8.0	664.4	0.01	6.0	752.5	0.01	3.0	793.8	0.00
			1514	culled			culled			culled			culled		
			1515	3.0	628.3	0.00	10.0	664.4	0.02	11.0	752.5	0.01	na	793.8	
			1531	6.0	628.3	0.01	Dead			Dead			Dead		
			1535	3.7	628.3	0.01	6.0	664.4	0.01	na	752.5		Dead		
4	Gavage	20	1518	14.0	253.3	0.06	28.0	270.5	0.10	10.0	314.0	0.03	5.7	346.3	0.02
			1528	24.0	253.3	0.09	20.0	270.5	0.07	23.0	314.0	0.07	26.0	346.3	0.08
			1534	7.9	253.3	0.03	7.0	270.5	0.03	na	314.0		4.8	346.3	0.01
			1537	13.0	253.3	0.05	10.0	270.5	0.04	13.0	314.0	0.04	4.9	346.3	0.01
5	Gavage	50	1506	19.0	611.5	0.03	12.0	642.5	0.02	26.0	740.6	0.04	12.0	789.4	0.02
			1517	24.0	611.5	0.04	5.6	642.5	0.01	12.0	740.6	0.02	12.0	789.4	0.02
			1519	69.0	611.5	0.11	36.0	642.5	0.06	11.0	740.6	0.01	29.0	789.4	0.04
			1538	4.3	611.5	0.01	11.0	642.5	0.02	na	740.6		240.0	789.4	0.30
6	Oral	20	1502	13.0	253.6	0.05	10.0	276.3	0.04	na	316.5		6.0	347.3	0.02
			1521	8.9	253.6	0.04	8.5	276.3	0.03	36.0	316.5	0.11	10.0	347.3	0.03
			1523	22.0	253.6	0.09	8.5	276.3	0.03	5.8	316.5	0.02	15.0	347.3	0.04
			1539	9.0	253.6	0.04	15.0	276.3	0.05	16.0	316.5	0.05	5.0	347.3	0.01
7	Oral	50	1509	29.0	652.8	0.04	15.0	708.8	0.02	25.0	813.8	0.03	na	879.4	
			1513	33.0	652.8	0.05	23.0	708.8	0.03	29.0	813.8	0.04	29.0	879.4	0.03
			1516	46.0	652.8	0.07	96.0	708.8	0.14	30.0	813.8	0.04	6.0	879.4	0.01
			1525	49.0	652.8	0.08	63.0	708.8	0.09	15.0	813.8	0.02	10.0	879.4	0.01
8	Tailings	20	1512	110.0	258.9	0.42	16.0	275.5	0.06	34.0	316.0	0.11	16.0	344.3	0.05
			1532	55.0	258.9	0.21	120.0	275.5	0.44	130.0	316.0	0.41	130.0	344.3	0.38
			1533	69.0	258.9	0.27	81.0	275.5	0.29	68.0	316.0	0.22	240.0	344.3	0.70
			1536	na	258.9		130.0	275.5	0.47	220.0	316.0	0.70	77.0	344.3	0.22
9	Tailings	50	1507	330.0	698.5	0.47	610.0	769.4	0.79	300.0	877.5	0.34	310.0	990.0	0.31
			1522	150.0	698.5	0.21	320.0	769.4	0.42	370.0	877.5	0.42	330.0	990.0	0.33
			1529	18.0	698.5	0.03	83.0	769.4	0.11	210.0	877.5	0.24	120.0	990.0	0.12
			1530	49.0	698.5	0.07	220.0	769.4	0.29	na	877.5		140.0	990.0	0.14

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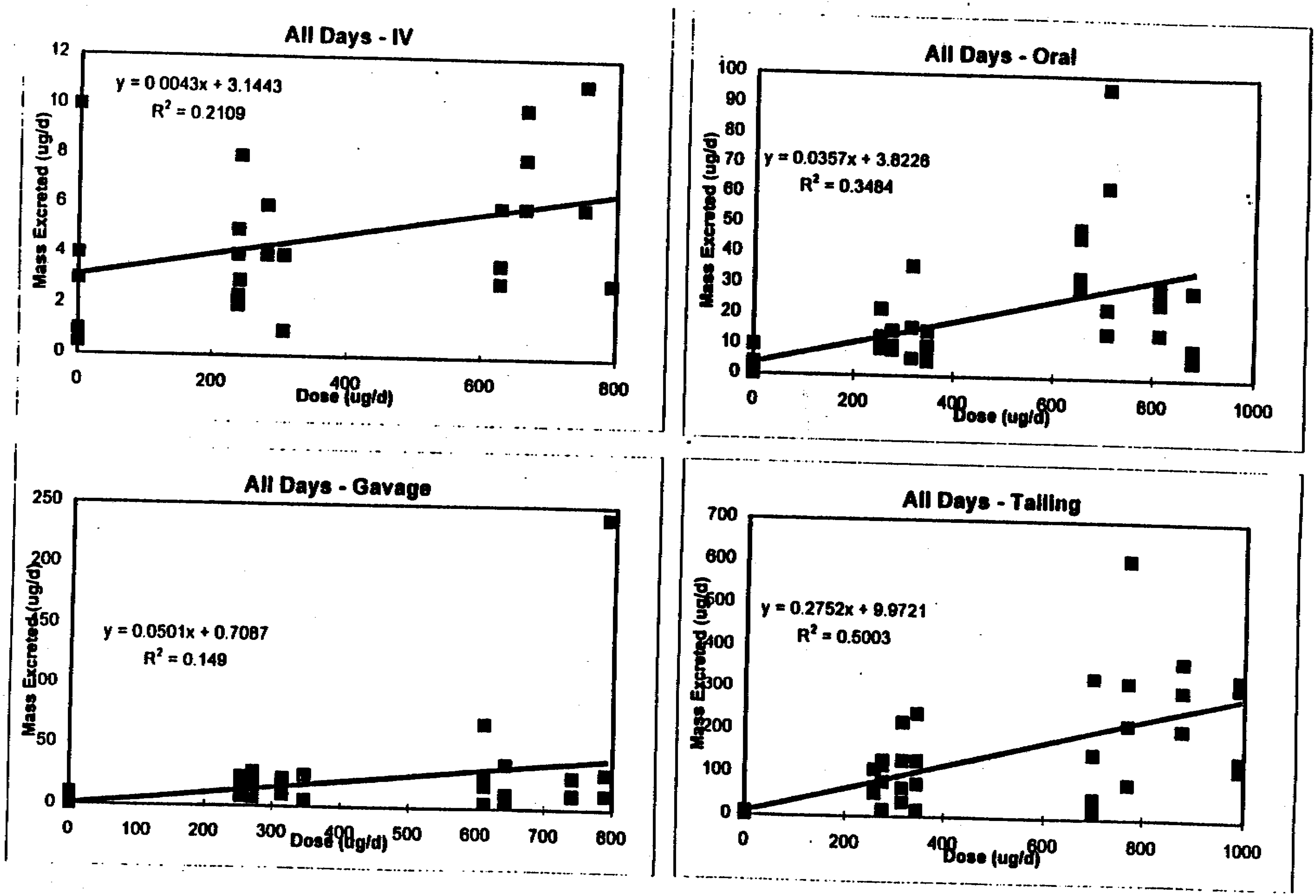
FIGURE C-1 ESTIMATION OF FECAL EXCRETION FRACTION -- PILOT STUDY 2



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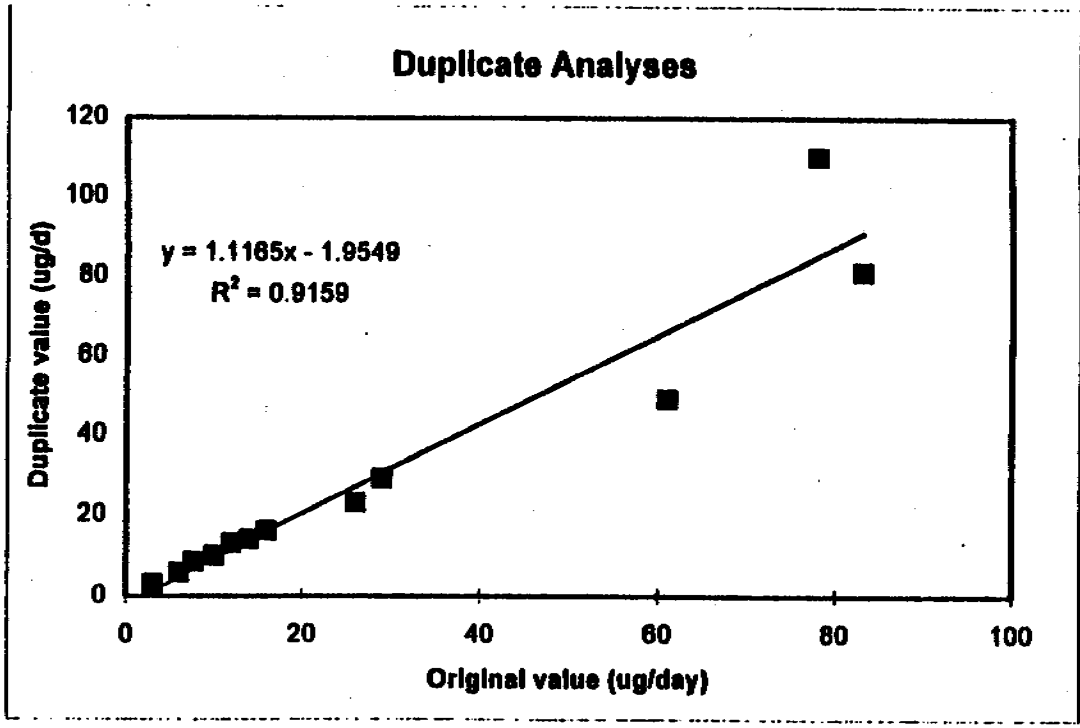
ANALYTICAL QUALITY ASSURANCE DATA
Fecal Data -- Pilot Study 2



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Phase II Experiment 15 Terminal Organ Weights

Group	Pig ID	Lungs(g)	Liver(g)	Kidney(g)	Bile(ml)	Catheter length (cm)
1	1501	362.48	505.7	115.56	25	
1	1510	197.22	478.03	104.97	20.5	
1	1540	210.05	423.91	98.58	19	
2	1504	178.5	531.5	94.1	5	17.2
2	1511	252.9	550.1	100.9	19	16.6
3	1503	323.5	463.9	106.2	8	17.5
3	1515	227.7	500.2	102.7	17	16.2
4	1518	214.15	484.72	103.76	11	
4	1528	234.18	519.85	99.67	4.5	
4	1534	202.81	478.28	110.91	13	
4	1537	209.31	454.67	117.16	14	
5	1506	197.72	506.35	115.05	17	
5	1517	419.6	426.6	106.6	42	
5	1519	381.55	475.67	103.26	27.5	
5	1538	161.4	404.5	112.4	8	
6	1502	244.14	617.7	108.39	8	
6	1521	248.6	480.3	114.5	6	
6	1523	199.98	448.7	96.5	17	
6	1539	226.4	493.2	118.4	40	
7	1509	211.89	619.8	111.8	19	
7	1513	193.68	516.95	108.1	8.5	
7	1516	203.4	352.59	85.5	18	
7	1525	230.3	531.2	121.6	23	
8	1512	283.4	527.9	114.5	16	
8	1532	241.9	588.1	125.6	23	
8	1533	196.7	482.9	111.5	24	
8	1536	185.9	342.1	85.4	20	
9	1507	239.1	521.8	158.5	35	
9	1522	266.3	584.5	155.6	30	
9	1529	267.1	529.2	139.8	13	
9	1530	253.6	530.1	149.5	18	

OBSERVED	Lungs(g)	Liver(g)	Kidney(g)	Bile(ml)
AVERAGES	241	496	113	18

ESTIMATED	[illegible]	Skin(g)	Muscle(g)
VALUES	[illegible]	750	10000

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Appendix D

Mean Body Weights

Animal Ear tag	Mean BW (0-14)
1501	14.6
1502	14.4
1503	12.2
1504	11.4
1505	11.6
1506	14.3
1507	16.8
1508	–
1509	14.7
1510	13.8
1511	13.4
1512	13.7
1513	13.9
1514	–
1515	13.6
1516	13.6
1517	13.7
1518	13.8
1519	13.5
1521	14.0
1522	16.3
1523	14.3
1525	15.2
1527	10.9
1528	13.4
1529	15.4
1530	15.2
1531	12.4
1532	15.3
1533	14.3
1534	14.0
1535	12.6
1536	13.1
1537	14.6
1538	11.0
1539	13.9
1540	14.4

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SUMMARY OF ARSENIC MEASUREMENTS IN BILE
PHASE II, STUDY 15

EPA TAG	LET ID	MATRIX	C (ng/g)	Q	Adj (ng/g)	Total (ug)	Pig ID	Test Material	Dose ug/kg-d	Mean BW kg	Total Dose ug-d	% Total/day In Bile
8-915-0558	L97020382	Bile	5	u	2.5	0.05	1537	Sodium Arsenate(Gavage)	20	14.6	293	0.02
8-915-0559	L97020383	Bile	10		10	0.18	1513	Sodium Arsenate(Oral)	50	13.9	693	0.03
8-915-0560	L97020384	Bile	10		10	0.18	1518	Sodium Arsenate(Oral)	50	13.6	678	0.03
8-915-0561	L97020385	Bile	10		10	0.18	1533	Clark Fork	20	14.3	285	0.06
8-915-0563	L97020386	Bile	7		7	0.13	1519	Sodium Arsenate(Gavage)	50	13.5	673	0.02
8-915-0564	L97020387	Bile	5	u	2.5	0.05	1510	Control	5	13.8	69	0.07
8-915-0565	L97020388	Bile	10		10	0.18	21530	Clark Fork	50	14.4	719	0.03
8-915-0566	L97020389	Bile	4	u	2	0.04	1501	Control	5	14.6	73	0.05
8-915-0567	L97020391	Bile	5	u	2.5	0.05	1534	Sodium Arsenate(Gavage)	20	14.0	280	0.02
8-915-0568	L97020392	Bile	5	u	2.5	0.05	1523	Sodium Arsenate(Oral)	20	14.3	286	0.02
8-915-0569	L97020393	Bile	5	u	2.5	0.05	1509	Sodium Arsenate(Oral)	50	14.7	737	0.01
8-915-0570	L97020394	Bile	5		5	0.09	1525	Sodium Arsenate(Oral)	50	15.2	758	0.01
8-915-0572	L97020395	Bile	5	u	2.5	0.05	1540	Control	5	14.4	72	0.06
8-915-0573	L97020396	Bile	7		7	0.13	1528	Sodium Arsenate(Gavage)	20	13.4	267	0.05
8-915-0574	L97020397	Bile	6		6	0.11	1507	Clark Fork	50	16.8	842	0.01
8-915-0576	L97020398	Bile	4	u	2	0.04	1517	Sodium Arsenate(Gavage)	50	13.7	686	0.01
8-915-0578	L97020399	Bile	5	u	2.5	0.05	21502	Sodium Arsenate(Oral)	20	14.4	288	0.02
8-915-0579	L97020401	Bile	10		10	0.18	1538	Sodium Arsenate(Gavage)	50	11.0	549	0.03
8-915-0581	L97020402	Bile	5	u	2.5	0.05	1532	Clark Fork	20	15.3	307	0.01
8-915-0583	L97020403	Bile	6		6	0.11	1539	Sodium Arsenate(Oral)	20	13.9	278	0.04
8-915-0584	L97020404	Bile	5	u	2.5	0.05	1502	Sodium Arsenate(Oral)	20	14.4	287	0.02
8-915-0585	L97020405	Bile	6		6	0.11	1522	Clark Fork	50	16.3	816	0.01
8-915-0587	L97020406	Bile	23		23	0.42	1536	Clark Fork	20	13.1	261	0.16
8-915-0588	L97020407	Bile	14		14	0.26	1512	Clark Fork	20	13.7	274	0.09
8-915-0589	L97020408	Bile	5	u	2.5	0.05	1518	Sodium Arsenate(Gavage)	20	13.8	276	0.02
8-915-0590	L97020409	Bile	5	u	2.5	0.05	1506	Sodium Arsenate(Gavage)	50	14.3	717	0.01
8-915-0591	L97020410	Bile	4	u	2	0.04	1521	Sodium Arsenate(Oral)	20	14.0	280	0.01
8-915-0592	L97020411	Bile	6		6	0.11	1529	Clark Fork	50	15.4	769	0.01
8-915-0594	L97020412	Bile	10		10	0.18	1530	Clark Fork	50	15.2	758	0.02
8-915-0596	L97020413	Bile	10		10	0.18	21512	Clark Fork	20	14.4	288	0.06
8-915-0571	L97020415	Bile	4	u	2	0.04	1511	Sodium Arsenate(IV)	20	13.4	268	0.01
8-915-0580	L97020416	Bile	5	u	2.5	0.05	1515	Sodium Arsenate(IV)	50	13.6	678	0.01
8-915-0593	L97020417	Bile	4	u	2	0.04	1503	Sodium Arsenate(IV)	50	12.2	609	0.01
8-915-0597	L97020418	Bile	5	u	2.5	0.05	1504	Sodium Arsenate(IV)	20	11.4	227	0.02

SUMMARY OF ARSENIC MEASUREMENTS IN KIDNEY
PHASE II, STUDY 15

EPA TAG	LET ID	MATRIX	C (ng/g)	Q	Adj (ng/g)	Total (ug)	Pig ID	Test Material	Dose ug/kg-d	Mean BW kg	Total Dose ug	% Total in Kidney
8-915-0396	L97020422	Kidney	20	u	10	1.13	1532	Clark Fork	20	15.3	4596	0.02
8-915-0397	L97020423	Kidney	30		30	3.38	1506	Sodium Arsenate(Gavage)	50	14.3	10759	0.03
8-915-0398	L97020424	Kidney	20	u	10	1.13	1540	Control	5	14.4	1079	0.10
8-915-0399	L97020425	Kidney	20		20	2.26	1513	Sodium Arsenate(Oral)	50	13.9	10389	0.02
8-915-0400	L97020426	Kidney	20	u	10	1.13	1517	Sodium Arsenate(Gavage)	50	13.7	10296	0.01
8-915-0401	L97020427	Kidney	20	u	10	1.13	1507	Clark Fork	50	16.8	12835	0.01
8-915-0403	L97020428	Kidney	20	u	10	1.13	1539	Sodium Arsenate(Oral)	20	13.9	4176	0.03
8-915-0404	L97020429	Kidney	20		20	2.26	1536	Clark Fork	20	13.1	3917	0.06
8-915-0405	L97020431	Kidney	30	u	15	1.69	1518	Sodium Arsenate(Gavage)	20	13.8	4138	0.04
8-915-0406	L97020432	Kidney	20	u	10	1.13	21513	Sodium Arsenate(Oral)	50	14.4	10785	0.01
8-915-0407	L97020433	Kidney	20	u	10	1.13	1510	Control	5	13.8	1037	0.11
8-915-0408	L97020434	Kidney	20	u	10	1.13	1523	Sodium Arsenate(Oral)	20	14.3	4288	0.03
8-915-0410	L97020435	Kidney	20	u	10	1.13	21533	Clark Fork	20	14.4	4314	0.03
8-915-0411	L97020436	Kidney	20	u	10	1.13	1521	Sodium Arsenate(Oral)	20	14.0	4196	0.03
8-915-0412	L97020437	Kidney	20	u	10	1.13	1533	Clark Fork	20	14.3	4275	0.03
8-915-0413	L97020438	Kidney	30		30	3.38	21528	Sodium Arsenate(Gavage)	20	14.4	4314	0.08
8-915-0414	L97020439	Kidney	30		30	3.38	1516	Sodium Arsenate(Oral)	50	13.6	10173	0.03
8-915-0416	L97020441	Kidney	30		30	3.38	1525	Sodium Arsenate(Oral)	50	15.2	11365	0.03
8-915-0417	L97020442	Kidney	30	u	15	1.69	1528	Sodium Arsenate(Gavage)	20	13.4	4006	0.04
8-915-0420	L97020443	Kidney	20	u	10	1.13	1537	Sodium Arsenate(Gavage)	20	14.6	4390	0.03
8-915-0422	L97020444	Kidney	20	u	10	1.13	1501	Control	5	14.6	1094	0.10
8-915-0423	L97020445	Kidney	30	u	15	1.69	1509	Sodium Arsenate(Oral)	50	14.7	11056	0.02
8-915-0426	L97020446	Kidney	20		20	2.26	1529	Clark Fork	50	15.4	11535	0.02
8-915-0427	L97020447	Kidney	20		20	2.26	1519	Sodium Arsenate(Gavage)	50	13.5	10101	0.02
8-915-0428	L97020448	Kidney	20	u	10	1.13	1534	Sodium Arsenate(Gavage)	20	14.0	4193	0.03
8-915-0429	L97020449	Kidney	30		30	3.38	1530	Clark Fork	50	15.2	11368	0.03
8-915-0430	L97020450	Kidney	20	u	10	1.13	1512	Clark Fork	20	13.7	4109	0.03
8-915-0432	L97020451	Kidney	20		20	2.26	1502	Sodium Arsenate(Oral)	20	14.4	4305	0.05
8-915-0433	L97020452	Kidney	30		30	3.38	1538	Sodium Arsenate(Gavage)	50	11.0	8230	0.04
8-915-0434	L97020453	Kidney	20		20	2.26	1522	Clark Fork	50	16.3	12244	0.02
8-915-0394	L97020455	Kidney	20	u	10	1.13	1511	Sodium Arsenate(IV)	20	13.4	4017	0.03
8-915-0409	L97020456	Kidney	20		20	2.26	1515	Sodium Arsenate(IV)	50	13.6	10164	0.02
8-915-0415	L97020457	Kidney	20	u	10	1.13	21508	Sodium Arsenate(IV)	20	14.4	4314	0.03
8-915-0418	L97020458	Kidney	20	u	10	1.13	1504	Sodium Arsenate(IV)	20	11.4	3406	0.03
8-915-0431	L97020459	Kidney	20	u	10	1.13	1503	Sodium Arsenate(IV)	50	12.2	9136	0.01

SUMMARY OF ARSENIC MEASUREMENTS IN LIVER
PHASE II, STUDY 15

EPA TAG	LET ID	MATRIX	C (ng/g)	Q	Adj (ng/g)	Total (ug)	Pig ID	Test Material	Dose ug/kg-d	Mean BW kg	Total Dose ug	% Total in Liver
8-915-0356	L97020463	Liver	20	u	10	4.96	21539	Sodium Arsenate(Oral)	20	14.4	4314	0.11
8-915-0357	L97020464	Liver	20	u	10	4.96	1537	Sodium Arsenate(Gavage)	20	14.6	4390	0.11
8-915-0359	L97020465	Liver	30		30	14.88	1510	Control	5	13.8	1037	1.43
8-915-0360	L97020466	Liver	20	u	10	4.96	1507	Clark Fork	50	16.8	12635	0.04
8-915-0361	L97020467	Liver	30	u	15	7.44	1525	Sodium Arsenate(Oral)	50	15.2	11365	0.07
8-915-0362	L97020468	Liver	20	u	10	4.96	1513	Sodium Arsenate(Oral)	50	13.9	10389	0.05
8-915-0363	L97020469	Liver	20	u	10	4.96	1534	Sodium Arsenate(Gavage)	20	14.0	4193	0.12
8-915-0364	L97020471	Liver	20	u	10	4.96	1521	Sodium Arsenate(Oral)	20	14.0	4196	0.12
8-915-0366	L97020472	Liver	30	u	15	7.44	1512	Clark Fork	20	13.7	4109	0.18
8-915-0367	L97020473	Liver	20	u	10	4.96	21517	Sodium Arsenate(Gavage)	50	14.4	10785	0.05
8-915-0368	L97020474	Liver	20	u	10	4.96	1528	Sodium Arsenate(Gavage)	20	13.4	4006	0.12
8-915-0369	L97020475	Liver	20	u	10	4.96	1530	Clark Fork	50	15.2	11368	0.04
8-915-0370	L97020476	Liver	20	u	10	4.96	1509	Sodium Arsenate(Oral)	50	14.7	11058	0.04
8-915-0371	L97020477	Liver	20	u	10	4.96	1522	Clark Fork	50	16.3	12244	0.04
8-915-0373	L97020478	Liver	20	u	10	4.96	1523	Sodium Arsenate(Oral)	20	14.3	4286	0.12
8-915-0374	L97020479	Liver	40		40	19.83	1538	Sodium Arsenate(Gavage)	50	11.0	8230	0.24
8-915-0375	L97020480	Liver	20	u	10	4.96	1529	Clark Fork	50	15.4	11535	0.04
8-915-0376	L97020482	Liver	20	u	10	4.96	1533	Clark Fork	20	14.3	4275	0.12
8-915-0379	L97020483	Liver	20	u	10	4.96	21501	Control	5	14.4	1079	0.46
8-915-0380	L97020484	Liver	20	u	10	4.96	1539	Sodium Arsenate(Oral)	20	13.9	4176	0.12
8-915-0383	L97020485	Liver	20	u	10	4.96	1519	Sodium Arsenate(Gavage)	50	13.5	10101	0.05
8-915-0384	L97020486	Liver	20	u	10	4.96	1502	Sodium Arsenate(Oral)	20	14.4	4305	0.12
8-915-0385	L97020487	Liver	96		96	47.60	1506	Sodium Arsenate(Gavage)	50	14.3	10759	0.44
8-915-0386	L97020488	Liver	30		30	14.88	1532	Clark Fork	20	15.3	4598	0.32
8-915-0387	L97020489	Liver	20	u	10	4.96	1517	Sodium Arsenate(Gavage)	50	13.7	10296	0.05
8-915-0388	L97020490	Liver	20	u	10	4.96	1501	Control	5	14.6	1094	0.45
8-915-0389	L97020491	Liver	30	u	15	7.44	1536	Clark Fork	20	13.1	3917	0.19
8-915-0390	L97020492	Liver	30		30	14.88	1518	Sodium Arsenate(Gavage)	20	13.8	4138	0.36
8-915-0391	L97020493	Liver	20	u	10	4.96	1540	Control	5	14.4	1079	0.46
8-915-0392	L97020494	Liver	30	u	15	7.44	1516	Sodium Arsenate(Oral)	50	13.6	10173	0.07
8-915-0377	L97020496	Liver	30		30	14.88	1503	Sodium Arsenate(IV)	50	12.2	9136	0.16
8-915-0378	L97020497	Liver	30		30	14.88	1511	Sodium Arsenate(IV)	20	13.4	4017	0.37
8-915-0381	L97020498	Liver	20	u	10	4.96	1504	Sodium Arsenate(IV)	20	11.4	3406	0.15
8-915-0382	L97020499	Liver	20	u	10	4.96	1515	Sodium Arsenate(IV)	50	13.6	10164	0.05
8-915-0393	L97020500	Liver	20	u	10	4.96	21508	Sodium Arsenate(IV)	20	14.4	4314	0.11

SUMMARY OF ARSENIC MEASUREMENTS IN SKIN, MUSCLE, LUNG
PHASE II, STUDY 15

EPA TAG	LET ID	MATRIX	C (ng/g)	Q	Adj (ng/g)	Total (ug)	Pig ID	Test Material	Dose ug/kg-d	Mean BW kg	Total Dose ug	% Total In Tissue
8-915-0498	L97030104	Skin	20		20	15	1509	Sodium Arsenate(Oral)	50	14.7	11056	0.14
8-915-0504	L97030105	Skin	10	u	5	3.75	1525	Sodium Arsenate(Oral)	50	15.2	11365	0.03
8-915-0511	L97030106	Skin	140		140	105	1503	Sodium Arsenate(IV)	50	12.2	9136	1.15
8-915-0476	L97030107	Skin	20		20	15	1515	Sodium Arsenate(IV)	50	13.6	10164	0.15
8-915-0545	L97030108	Muscle	20		20	200	1509	Sodium Arsenate(Oral)	50	14.7	11056	1.81
8-915-0532	L97030109	Muscle	20		20	200	1532	Clark Fork	20	15.3	4598	4.35
8-915-0522	L97030110	Muscle	20		20	200	1503	Sodium Arsenate(IV)	50	12.2	9136	2.19
8-915-0537	L97030111	Muscle	20		20	200	1515	Sodium Arsenate(IV)	50	13.6	10164	1.97
8-915-0471	L97030112	Lung	20		20	4.82	1509	Sodium Arsenate(Oral)	50	14.7	11056	0.04
8-915-0473	L97030113	Lung	10	u	5	1.20	1525	Sodium Arsenate(Oral)	50	15.2	11365	0.01
8-915-0468	L97030114	Lung	10	u	5	1.20	1503	Sodium Arsenate(IV)	50	12.2	9136	0.01
8-915-0461	L97030115	Lung	10	u	5	1.20	1515	Sodium Arsenate(IV)	50	13.6	10164	0.01

SUMMARY OF ARSENIC MEASUREMENTS IN SKIN, MUSCLE, LUNG
PHASE II, STUDY 15

EPA TAG	LET ID	MATRIX	C (ng/g)	Q	Adj (ng/g)	Total (ug)	Pig ID	Test Material	Dose ug/kg-d	Mean BW kg	Total Dose ug	% Total in Tissue
8-915-0498	L97030104	Skin	20		20	15	1509	Sodium Arsenate(Oral)	50	14.7	11056	0.14
8-915-0504	L97030105	Skin	10	u	5	3.75	1525	Sodium Arsenate(Oral)	50	15.2	11365	0.03
8-915-0511	L97030106	Skin	140		140	105	1503	Sodium Arsenate(IV)	50	12.2	9136	1.15
8-915-0476	L97030107	Skin	20		20	15	1515	Sodium Arsenate(IV)	50	13.6	10164	0.15
8-915-0545	L97030108	Muscle	20		20	200	1509	Sodium Arsenate(Oral)	50	14.7	11056	1.81
8-915-0532	L97030109	Muscle	20		20	200	1532	Clark Fork	20	15.3	4598	4.35
8-915-0522	L97030110	Muscle	20		20	200	1503	Sodium Arsenate(IV)	50	12.2	9136	2.19
8-915-0537	L97030111	Muscle	20		20	200	1515	Sodium Arsenate(IV)	50	13.6	10164	1.97
8-915-0471	L97030112	Lung	20		20	4.82	1509	Sodium Arsenate(Oral)	50	14.7	11056	0.04
8-915-0473	L97030113	Lung	10	u	5	1.20	1525	Sodium Arsenate(Oral)	50	15.2	11365	0.01
8-915-0468	L97030114	Lung	10	u	5	1.20	1503	Sodium Arsenate(IV)	50	12.2	9136	0.01
8-915-0461	L97030115	Lung	10	u	5	1.20	1515	Sodium Arsenate(IV)	50	13.6	10164	0.01

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