

BIOTRANSPORT OF TRANSURANIUM RADIONUCLIDES
IN DAIRY ANIMALS: A Data Summary

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IN DAIRY ANIMALS: A Data Summary

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INTRODUCTION

Because of the long physical and biological half lives of many of the transuranium radionuclides, because of their relatively high toxicity and because of their increasing worldwide inventory and distribution, it is imperative that their potential hazard to humans be assessed. To this end, in recent years, the Environmental Monitoring Systems Laboratory at Las Vegas, Nevada (EMSL-LV) has carried out a series of studies on the biological transport of plutonium, americium, neptunium, and curium in lactating dairy cattle and goats. Ruminants in general and cattle in particular form one of the more important links in the human food chain. Milk and milk products constitute a significant portion of the human diet, especially for children. In addition, beef, which also forms an important fraction of the diet in the United States, is in part derived from culled dairy animals.

This summary consists of a compilation of detailed data from a series of previously published studies. It has been prepared to present the data from all of these studies in a single source to be used by regulatory agencies in their transport modeling and hazard assessment activities. Selected source materials for the data presented in this document have been published either in the Proceedings of the Nevada Applied Ecology Group (NAEG) or as EMSL-LV publications and are listed in the References section. The references listed there have been categorized as "Data Base References" and "Body Weight and Tissue Weight References."

METHODS AND MATERIALS

Most of the studies covered in this report were conducted at an experimental farm in Area 15 of the Nevada Test Site. Pertinent experimental parameters for individual animals are summarized in Table 1, and each animal is referenced to the appropriate appendix table(s) where results for the individual animals are presented. The radionuclide content of tissue or biological product for each animal is expressed as a percentage of the administered dose per gram of tissue or product.

Oral doses were placed in gelatin capsules containing either cellulose fiber or starch as absorbants and were administered to the animal by means of a balling gun. Intravenous doses were made up to approximately 5 ml in volume and were administered by jugular venipuncture. No adjustments of intravenous or oral dose were made for individual variations in animal weight.

Prior to beginning each experiment, animals were placed in metabolism stalls. Daily milk, urine, and fecal samples, as well as frequent blood

TABLE 1. BACKGROUND INFORMATION ON THE DAIRY ANIMALS DOSED WITH EITHER PLUTONIUM (P), AMERICIUM (A), CURIUM (C), OR NEPTUNIUM (N)

Animal Number	Approx. Weight (kg)	Nuclide Dose	Sacrifice Time Post-Treatment (days)	Average Daily Output During Experiment (kg)			Table No. in Appendix B
				Milk	Urine	Feces	
cow 45	625	Single oral dose 3 mCi citrate-buffered plutonium-238 nitrate	--	19.7	17.2	23.8	B-6
cow 87	652	Single oral dose 3 mCi citrate-buffered plutonium-238 nitrate	93	24.7	21.4	26.7	B-7
cow 128	686	Single oral dose 3 mCi citrate-buffered plutonium-238 nitrate	--	21.5	15.7	22.3	B-4
cow 39	677	Single oral dose 3 mCi citrate-buffered plutonium-238 nitrate	93	16.1	14.1	18.5	B-5, B-7
goat 2P	42.7	Single intravenous dose 50 μ Ci citrate-buffered plutonium-238 nitrate	30	2.4	2.9	0.8	B-1, B-2, B-3
cow 117	658	Chronic oral dose 1 mCi/day, 19 days, plutonium-238 dioxide	73	25.8	23.9	24.3	B-8, B-12
cow 122	658	Chronic oral dose 1 mCi/cay, 19 days, plutonium-238 dioxide	42	27.0	22.0	23.9	B-9, B-12
cow 134	807	Chronic oral dose 1 mCi/day, 19 days, plutonium-238 dioxide	73	14.5	24.1	26.9	B-10, B-12
cow 185	547	Chronic oral dose 1 mCi/day, 19 days, plutonium-238 nitrate	42	16.0	16.0	17.3	B-11, B-12
cow 119	843	Single intravenous dose 16.0 mCi citrate-buffered plutonium-238 nitrate	6	14.3	14.0	11.9	B-13, B-17
cow 179	764	Single intravenous dose 16.3 mCi citrate-buffered plutonium-238 nitrate	6	18.3	24.2	20.6	B-14, B-17

(continued)

TABLE 1. (Continued)

Animal Number	Approx. Weight (kg)	Nuclide Dose	Sacrifice Time Post-Treatment (days)	Average Daily Output During Experiment (kg)			Table No. in Appendix B
				Milk	Urine	Feces	
cow 123	863	Single intravenous dose 17.5 mCi citrate-buffered plutonium-238 nitrate	13	15.9	15.5	18.0	B-15, B-17
cow 128	736	Single intravenous dose 16.6 mCi citrate-buffered plutonium-238 nitrate	13	16.9	25.9	25.9	B-16, B-17
cow 256	596	Single oral dose 39.6 mCi curium-243 chloride	7	8.7	7.6	10.7	B-25, B-27
cow 344	736	Single intravenous dose 1.12 mCi citrate-buffered curium-243 chloride	7	12.7	17.8	20.2	B-26, B-27
goat 1C	37.5	Single oral dose 200 μ Ci curium-243 chloride	7	1.3	1.0	0.8	B-18, B-24
goat 2C	35.5	Single oral dose 200 μ Ci curium-243 chloride	7	1.2	0.9	0.7	B-19, B-24
goat 3C	49.5	Single oral dose 200 μ Ci curium-243 chloride	7	1.5	1.3	0.8	B-20, B-24
goat 4C	52.0	Single intravenous dose 20.8 μ Ci citrate-buffered curium-243 chloride	7	1.5	1.4	0.9	B-21, B-24
goat 5C	39.0	Single intravenous dose 20.8 μ Ci citrate-buffered curium-243 chloride	7	0.9	0.8	0.3	B-22, B-24
goat 6C	33.0	Single intravenous dose 20.8 μ Ci citrate-buffered curium-243 chloride	7	1.1	1.0	0.6	B-23, B-24
cow 269	568	Single oral dose 41.7 mCi americium-241 chloride	8	9.4	11.2	20.6	B-35, B-37

(continued)

TABLE 1. (Continued)

Animal Number	Approx. Weight (kg)	Nuclide Dose	Sacrifice Time Post-Treatment (days)	Average Daily Output During Experiment (kg)			Table No. in Appendix B
				Milk	Urine	Feces	
cow 281	582	Single oral dose 41.7 mCi americium-241 chloride	8	15.1	11.7	14.5	B-36, B-37
cow 184	677	Single intravenous dose 0.96 mCi citrate-buffered americium-241 chloride	9	20.3	20.3	30.3	B-34, B-37
cow 280	518	Single intravenous dose 0.96 mCi citrate-buffered americium-241 chloride	9	9.8	10.1	14.0	B-33, B-37
goat 1A	29.5	Single oral dose 1.91 mCi americium-241 nitrate	8	1.5	1.4	0.6	B-28, B-32
goat 2A	40.5	Single oral dose 1.91 mCi americium-241 nitrate	8	1.6	1.9	0.9	B-29, B-32
goat 4A	30.9	Single intravenous dose 41.7 µCi citrate-buffered americium-241 nitrate	8	2.6	3.4	1.4	B-30, B-32
goat 5A	40.5	Single intravenous dose 41.7 µCi citrate-buffered americium-241 nitrate	8	1.9	1.5	0.8	B-31, B-32
goat 1N	40.2	Single oral dose 318.5 µCi neptunium-234 chloride	5	0.9	1.5	0.9	B-38, B-41
goat 2N	47.8	Single oral dose 425.7 µCi neptunium-234 chloride	5	0.9	2.2	0.7	B-39, B-41
goat 3N	52.8	Single intravenous dose 86.2 µCi citrate-buffered neptunium-234 chloride	5	2.1	1.8	1.2	B-40, B-41
cow 351	555	Single oral dose 1.73 mCi ²³⁹ Pu oxide 1.62 mCi ²³⁹ Pu oxide in same particles	7	18.8	27.4	34.3	B-42, B-43, B-46

(continued)

TABLE 1. (Continued)

Animal Number	Approx. Weight (kg)	Nuclide Dose	Sacrifice Time Post-Treatment (days)	Average Daily Output During Experiment (kg)			Table No. in Appendix B
				Milk	Urine	Feces	
cow 349	627	Single oral dose 2.30 mCi ^{239}Pu oxide 2.16 mCi ^{239}Pu oxide in same particles	7	14.3	25.8	29.0	B-42, B-44 B-46
cow 352	636	Single oral dose 43.3 mCi ^{239}Pu oxide 1.38 mCi ^{239}Pu oxide in same particles	7	14.3	26.1	33.9	B-42, B-45 B-46

samples, were taken beginning at least 1 day prior to dosing and continuing throughout the experimental period. Each cow was catheterized with an indwelling inflatable urinary catheter, and the urine was collected through a polyethylene tube that drained into a 20-liter plastic bottle. A polyethylene-lined pan placed under the metal grid at the rear of each stall facilitated collection of feces. Milk was collected with individual bucket milkers twice daily. Blood samples were taken by jugular venipuncture. All urine, milk and fecal collections were weighed and, for some of the studies, morning and evening collections were combined into a single 24-hour composite for each animal. Composites were mixed by shaking thoroughly in plastic containers. Weighed subsamples were then taken from each composite and placed in individual containers with formaldehyde added as a preservative. Large fecal collections were mixed in a 30-quart Hobart food mixer.

The goats were maintained under conditions similar to those of the cows but in small, elevated metabolism stalls that permitted ready access for hand milking. Urine was collected by catheter, and fecal pellets were collected in a tray. Occasionally, the pellets had to be ground in an electric meat grinder to homogenize or mix the daily fecal collections.

Cows and goats were sacrificed by an intravenous euthanasia solution. Each animal was weighed at time of sacrifice and partially exsanguinated before tissue samples were collected. Organs and tissues were removed from the animals within 60 minutes of sacrifice. Extraneous adipose tissue or muscle was trimmed from the samples, formaldehyde was added as a preservative, and each sample was sealed in an appropriate container. Total weights were taken on most organs so that the percentage of the administered dose retained by a specific tissue or organ could be calculated. When this was not practical, for example, in the case of muscle, bone, or blood, total nuclide content was based on extrapolated organ weights using the respective

percentage of body weight reported by Davis et al. (1975), Smith and Baldwin (1974), and Mathews et al. (1975). Nuclide concentrations in the various bone samples were averaged in order to estimate retention in bone. However, specific data for individual bone types are reported wherever they are available.

Appropriate spiked standards for feces, milk, urine, plasma, blood cells, distilled water, and either agar or animal tissue were prepared for each study. The amount of added nuclide was based on the calculated range (percentage of dose per gram) expected to be observed in samples of milk, urine, etc., throughout the project. The analytical procedures used during each of these studies have been presented in the previously referenced Nevada Applied Ecology Group reports. Plutonium and americium samples were quantified using a phoswich detector, which consists of a thin NaI scintillator backed by a thick CsI scintillator used in an anticoincidence mode in order to reduce background. Selected curium, neptunium, and americium samples were assayed using NaI(Tl) detectors in either a solid or well-type configuration. After assaying the samples by direct counting, radiochemical analyses were performed on: (1) a portion of the spiked standard samples and on selected split samples (for quality assurance purposes), (2) sets of samples that demonstrated considerable between-animal or within-animal variability, and (3) samples that contained nuclide concentrations in the fCi/g range, publications as listed in the references. The information contained in this data base has been derived from 35 lactating dairy animals, (20 cows and 15 goats) that had been administered plutonium, americium, neptunium, or curium. Certain minor differences between values reported here and those reported in the original NAEG publications will be evident. These minor changes have been made in order to present the data in a comparative format. For example, in this summary the nuclide concentrations in milk, urine, and feces have all been based on 24-hour collection intervals, slightly altering those peaking times and concentrations that had originally been based on 12-hour collection intervals.

Specific areas summarized in this report include: (1) transport of the nuclides across the gut, (2) the fraction of the nuclide transported to milk expressed as a percentage of the administered dose, (3) plasma clearance rates, (4) urinary and fecal excretion characteristics, and (5) tissue deposition patterns. In addition, this summary also presents data on nuclide concentrations in milk, urine, feces, blood plasma, and tissues for individual animals. The Appendix is divided into two parts: Appendix A contains summary and comparative tables relating the above information to the four transuranium radionuclides; Appendix B contains data from individual animals used in preparation of the comparative tables shown in Appendix A. Appendix B tables are cross indexed with individual animal parameters shown in Table 1, which gives each animal number, nuclide dosing specifics, and the daily output of milk, urine, and feces from each animal.

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APPENDIX A

This Appendix consists of 25 summary and comparative tables relative to the uptake and transport of neptunium, plutonium, americium, and curium in milk, blood, urine, and feces. These tables also report tissue concentrations of the four transuranium radionuclides. Values reported in Appendix A are generally mean values for each nuclide obtained from one or more studies.

TABLE A-1. NUMBERS OF LACTATING ANIMALS AND TIMES AT WHICH THEY WERE SLAUGHTERED FOLLOWING A SINGLE ACUTE RADIONUCLIDE DOSE

Nuclide	Number of Animals				Approximate		Sacrifice Time	
	Oral Dose		Intravenous Dose		Oral Dose		Intravenous Dose	
	Cow	Goat	Cow	Goat	Cow	Goat	Cow	Goat
^{238}Pu	4	**	4	1	3 mo	**	1 w	1 mo
^{243}Cm	1	3	1	3	1 w	1 w	1 w	1 w
^{241}Am	2	2	2	2	1 w	1 w	1 w	1 w
^{234}Np	**	2	**	1	**	1 w	**	1 w
$^{238}, ^{239}\text{Pu}$	3	**	**	**	1 w	**	**	**

** No single oral plutonium doses were given to dairy goats; no oral or intravenous neptunium doses were given to dairy cows; and oral doses of mixed plutonium-238 and plutonium-239 were given to dairy cows.

TABLE A-2. GROSS ESTIMATE OF NUCLIDE UPTAKE IN DAIRY ANIMALS FOLLOWING ORAL DOSES OF EITHER PLUTONIUM-238, AMERICIUM-241, CURIUM-243, OR NEPTUNIUM-234*

Animal	Nuclide	% of Oral Dose Absorbed
Cows	citrate-buffered plutonium nitrate	2.5×10^{-2}
	plutonium dioxide	3.0×10^{-3}
	americium chloride	1.4×10^{-2}
	curium chloride	2.0×10^{-2}
Goats	americium nitrate	1.4×10^{-2}
	curium chloride	6.0×10^{-3}
	citrate-buffered neptunium chloride	4.8×10^{-1}

* Mean approximation of gastrointestinal absorption composed of (1) total nuclide transport to milk and urine, (2) recovered activity estimate for animal carcass, and (3) the extrapolated amount of absorbed nuclide return to the digestive tract

TABLE A-3. NUCLIDE RETENTION IN THE SKELETON OF DAIRY COWS FOLLOWING EITHER ORAL OR INTRAVENOUS DOSES OF PLUTONIUM-238, AMERICIUM-241, OR CURIUM-243 (Values expressed as a percentage of the administered dose*)

Nuclide	Animal Number	Sacrifice Time (days)	Extrapolated** % of Dose Retained in Skeleton	Bones Used for Percentage Calculation	Extrapolated*** % of Dose in Bone Based Only on Femur Concentration
Plutonium nitrate (single oral dose)	Cow 39	93	6.4×10^{-3}	Femur, rib, vertebra	1.4×10^{-3}
	Cow 87	93	1.1×10^{-2}	Femur, rib, vertebra	3.4×10^{-3}
Americium chloride (single oral dose)	Cow 269	8	5.3×10^{-3}	Femur, rib, vertebra	4.3×10^{-3}
	Cow 281	8	6.0×10^{-3}	Femur, rib, vertebra	4.1×10^{-3}
Curium chloride (single oral dose)	Cow 256	7	1.1×10^{-2}	Femur, sternum	6.8×10^{-3}
Plutonium dioxide (multiple oral dose)	Cow 122	42	1.3×10^{-3}	Femur, rib, vertebra	2.2×10^{-4}
	Cow 185	42	2.0×10^{-3}	Femur, rib, vertebra	2.4×10^{-4}
	Cow 117	73	1.6×10^{-3}	Femur, rib, vertebra	4.9×10^{-4}
	Cow 134	73	1.9×10^{-3}	Femur, rib, vertebra	6.5×10^{-4}
Plutonium nitrate (single I.V. dose)	Cow 119	6	57.3	Femur, sternum	8.1
	Cow 179	6	53.2	Femur, sternum	5.3
	Cow 123	13	40.9	Femur, sternum	10.3
	Cow 128	13	36.1	Femur, sternum	7.8
Americium chloride (single I.V. dose)	Cow 184	9	44.5	Femur, rib, sternum, vertebra	43.4
	Cow 280	9	56.4	Femur, rib, sternum, vertebra	40.6
Curium chloride (single I.V. dose)	Cow 344	7	58.6	Femur, Sternum	43.6

* Percentage of dose retained in bone

$$\frac{(\text{average nuclide concentration in bone})(17\% \text{ of empty body weight})}{(\text{administered dose})} \times 100$$

** Values used for average nuclide concentration in bone based on indicated bone samples

*** Values used for average nuclide concentration in bone based on femur samples only

(These extrapolations are not considered to be an accurate representation of skeletal retention but are presented for comparative purposes. Femur samples were the only bone collections common to all treatment groups.)

TABLE A-4. COMPARISON OF PLUTONIUM-238, AMERICIUM-241, AND CURIUM-243 RETENTION IN DAIRY COW TISSUES APPROXIMATELY 1 WEEK AFTER THE ANIMALS HAD RECEIVED SINGLE INTRAVENOUS NUCLIDE INJECTIONS (Values expressed as mean percentage of the dose* per gram of tissue)

Tissue	Plutonium	Americium	Curium
Diaphysis	2.6×10^{-5}	3.1×10^{-4}	3.4×10^{-4}
Epiphysis	8.3×10^{-5}	6.1×10^{-4}	4.2×10^{-4}
Sternum	8.3×10^{-4}	6.8×10^{-4}	6.4×10^{-4}
Liver	2.5×10^{-3}	3.8×10^{-3}	2.5×10^{-3}
Kidney	3.0×10^{-4}	1.2×10^{-3}	9.9×10^{-4}
Lung	4.4×10^{-4}	2.6×10^{-4}	2.2×10^{-4}
Spleen	2.0×10^{-4}	2.7×10^{-4}	2.9×10^{-4}
Thyroid	3.4×10^{-4}	7.1×10^{-5}	1.0×10^{-4}
Muscle	2.6×10^{-5}	1.9×10^{-5}	9.4×10^{-6}
Mammary	3.2×10^{-4}	4.8×10^{-4}	2.4×10^{-4}
Heart	9.6×10^{-5}	2.9×10^{-4}	2.1×10^{-4}

* Citrate-buffered doses of either plutonium nitrate, americium nitrate, or curium chloride

TABLE A-5. COMPARISON OF PLUTONIUM-238, AMERICIUM-241, AND CURIUM-243 RETENTION IN DAIRY COWS FOLLOWING ORAL NUCLIDE DOSES (Values expressed as mean percentage of the dose per gram of tissue)

Tissue or Organ	Plutonium Nitrate (93 d)*	Plutonium Dioxide (42 d)*	Plutonium Dioxide (73 d)*	Americium Nitrate (8 d)*	Curium Chloride (7 d)*
Liver	2.7×10^{-7}	5.3×10^{-8}	5.8×10^{-8}	4.3×10^{-7}	6.6×10^{-7}
Femur	2.3×10^{-8}	2.5×10^{-9}	5.0×10^{-9}	4.7×10^{-8}	7.4×10^{-8}
Sternum	-	-	-	8.7×10^{-8}	1.6×10^{-7}
Vertebra	9.0×10^{-8}	2.7×10^{-8}	2.6×10^{-8}	7.3×10^{-8}	
Rib	1.3×10^{-7}	2.4×10^{-8}	1.5×10^{-8}	4.5×10^{-8}	-
Kidney	9.9×10^{-9}	4.7×10^{-9}	4.9×10^{-9}	1.5×10^{-7}	3.1×10^{-7}
Lung	1.2×10^{-8}	3.9×10^{-9}	3.2×10^{-9}	5.2×10^{-8}	6.9×10^{-8}
Muscle	4.2×10^{-9}	3.3×10^{-10}	3.5×10^{-10}	3.6×10^{-9}	3.8×10^{-9}
Spleen	2.4×10^{-8}	8.4×10^{-9}	6.9×10^{-9}	3.3×10^{-8}	5.8×10^{-8}
Heart	1.8×10^{-8}	1.8×10^{-9}	1.0×10^{-9}	7.3×10^{-9}	8.0×10^{-8}

* Sacrifice time in days after dosing

TABLE A-6. COMPARISON OF PLUTONIUM-238, AMERICIUM-241, AND CURIUM-243, RETENTION IN ORGANS OF DAIRY COWS (Values expressed as mean percentage of dose retained per organ)

Tissue or Organ	Oral Nuclide Dose					Intravenous Nuclide Dose			
	Plutonium Nitrate (93 d)*	Plutonium Dioxide (42 d)*	Plutonium Dioxide (73 d)*	Americium Chloride (8 d)*	Curium Chloride (7 d)*	Plutonium Nitrate (6 d)*	Plutonium Nitrate (13 d)*	Americium Chloride (9 d)*	Curium Chloride (7 d)*
Liver	1.8×10^{-3}	5.3×10^{-4}	6.2×10^{-4}	4.1×10^{-3}	6.9×10^{-3}	32.5	33.2	40.8	29.1
Bone	8.7×10^{-3}	1.7×10^{-3}	1.8×10^{-3}	5.7×10^{-3}	1.1×10^{-2}	55.3	38.5	50.5	58.6
Kidney	2.2×10^{-3}	7.5×10^{-6}	9.6×10^{-6}	3.8×10^{-4}	5.2×10^{-4}	8.2×10^{-1}	1.0	2.4	3.0
Lung	7.4×10^{-5}	2.3×10^{-5}	2.0×10^{-5}	2.8×10^{-4}	3.3×10^{-4}	2.8	2.9	1.7	1.4
Muscle	1.3×10^{-3}	2.3×10^{-3}	1.2×10^{-4}	9.6×10^{-4}	1.0×10^{-3}	9.5	3.5	5.4	3.2
Spleen	2.4×10^{-5}	7.7×10^{-6}	7.3×10^{-6}	7.8×10^{-5}	1.1×10^{-4}	2.8×10^{-1}	2.4×10^{-1}	7.0×10^{-1}	7.5×10^{-1}
Heart	5.9×10^{-5}	2.4×10^{-6}	3.7×10^{-6}	2.6×10^{-4}	2.5×10^{-4}	3.1×10^{-1}	1.9×10^{-1}	9.6×10^{-1}	7.5×10^{-1}

* Sacrifice time in days after dosing

TABLE A-7. COMPARISON OF PLUTONIUM-238, AMERICIUM-241, CURIUM-243, AND NEPTUNIUM-234 RETENTION IN DAIRY GOATS (Values expressed as mean percentage of dose retained per organ)

Tissue or Organ	Oral Dose			Intravenous Dose			
	Americium Nitrate (8 d)*	Curium Chloride (7 d)*	Neptunium Chloride (5 d)*	Plutonium Nitrate (30 d)*	Americium Nitrate (8 d)*	Curium Chloride (7 d)*	Neptunium Chloride (5 d)*
Liver	5.4×10^{-3}	1.7×10^{-3}	1.4×10^{-2}	24.6	47.4	37.2	6.6
Bone	1.7×10^{-3}	3.1×10^{-3}	7.3×10^{-3}	**	12.7	18.7	28.0
Kidney	1.5×10^{-4}	1.1×10^{-4}	6.3×10^{-3}	**	9.0×10^{-1}	1.6	9.0×10^{-1}
Lung	1.0×10^{-4}	8.7×10^{-5}	4.0×10^{-4}	7.3×10^{-2}	5.0×10^{-1}	7.3×10^{-1}	2.1×10^{-1}
Muscle	6.7×10^{-4}	2.3×10^{-4}	1.1×10^{-2}	1.3	4.4	4.9	9.3×10^{-1}
Spleen	8.0×10^{-6}	1.8×10^{-5}	5.0×10^{-4}	3.1×10^{-2}	4.0×10^{-1}	8.8×10^{-2}	5.4×10^{-2}
Heart	1.9×10^{-5}	1.9×10^{-4}	2.8×10^{-5}	3.4×10^{-2}	1.8×10^{-1}	3.1×10^{-1}	5.2×10^{-2}

* Sacrifice time in days after dosing

** Limited data available

TABLE A-8. TRANSPORT OF PLUTONIUM-238 TO BOVINE MILK, URINE, AND FECES
FOLLOWING ORAL PLUTONIUM DIOXIDE DOSES OF 1 mCi PER ANIMAL PER DAY
FOR 19 CONSECUTIVE DAYS

Sample	Peak Concentration (% daily dose per g)	Time of Peak Concentration (dosing day)	Total Nuclide Transport* (% of total dose)
Cow 117:			
Milk	3.9×10^{-9}	10	3.3×10^{-5}
Urine	1.8×10^{-8}	15	2.1×10^{-4}
Feces	6.3×10^{-3}	10	>100
Cow 122:			
Milk	8.9×10^{-10}	5	9.0×10^{-6}
Urine	1.4×10^{-8}	3	1.9×10^{-4}
Feces	7.8×10^{-3}	5	>100
Cow 134:			
Milk	2.0×10^{-9}	11	1.4×10^{-5}
Urine	1.2×10^{-8}	10 and 14	1.9×10^{-4}
Feces	6.9×10^{-3}	14	>100
Cow 185:			
Milk	5.1×10^{-9}	11	3.0×10^{-5}
Urine	1.8×10^{-8}	14	2.0×10^{-4}
Feces	8.0×10^{-3}	6 and 12	>100

* Total nuclide transport for dosing period (19 days) and for first 7 days after last dose was administered (Note: Plutonium excretion in feces should approach 100 percent of dose following nuclide ingestion. Calculations for the four cows exceed 100 percent due to inaccuracies associated with fecal determinations.)

TABLE A-9. COMPARISON OF AMERICIUM-241, CURIUM-243, AND NEPTUNIUM-234 RETENTION IN DAIRY GOATS
(Values expressed as a mean percentage of the dose per gram of tissue)

Tissue or Organ	Oral Dose			Intravenous Dose		
	Americium Nitrate (8 d)*	Curium Chloride (7 d)*	Neptunium Chloride (5 d)*	Americium Nitrate (8 d)*	Curium Chloride (7 d)*	Neptunium Chloride (5 d)*
Liver	8.0×10^{-6}	1.9×10^{-6}	1.5×10^{-5}	5.7×10^{-2}	4.2×10^{-2}	5.1×10^{-3}
Diaphysis	8.5×10^{-7}	6.7×10^{-7}	1.5×10^{-6}	3.6×10^{-3}	7.4×10^{-3}	5.2×10^{-3}
Epiphysis	1.0×10^{-6}	8.3×10^{-7}	1.7×10^{-6}	6.3×10^{-3}	6.4×10^{-3}	5.9×10^{-3}
Sternum	1.0×10^{-6}	1.9×10^{-6}	5.4×10^{-6}	5.4×10^{-3}	8.1×10^{-3}	6.6×10^{-3}
Vertebra	5.5×10^{-7}	---	---	4.7×10^{-3}	---	---
Rib	8.5×10^{-7}	---	4.6×10^{-6}	6.8×10^{-3}	---	1.1×10^{-2}
Kidney	1.2×10^{-6}	6.3×10^{-7}	4.3×10^{-5}	7.0×10^{-3}	1.1×10^{-2}	4.6×10^{-3}
Lung	1.2×10^{-7}	1.4×10^{-7}	7.9×10^{-7}	1.1×10^{-3}	1.3×10^{-3}	2.6×10^{-4}
Muscle	4.4×10^{-8}	1.1×10^{-8}	4.8×10^{-7}	2.9×10^{-4}	2.7×10^{-4}	3.3×10^{-5}
Thyroid	8.1×10^{-8}	---	3.6×10^{-5}	3.8×10^{-3}	1.7×10^{-3}	1.3×10^{-4}
Spleen	6.4×10^{-8}	1.2×10^{-7}	1.7×10^{-5}	2.9×10^{-3}	9.5×10^{-4}	2.4×10^{-4}
Mammary	4.4×10^{-7}	2.5×10^{-7}	1.3×10^{-6}	2.5×10^{-3}	3.3×10^{-3}	1.4×10^{-5}
Adrenals	7.4×10^{-8}	---	2.1×10^{-6}	4.5×10^{-4}	9.0×10^{-4}	5.1×10^{-4}
Lymph Nodes	3.0×10^{-7}	---	6.5×10^{-6}	1.9×10^{-3}	---	2.0×10^{-4}
Heart	1.2×10^{-7}	2.5×10^{-7}	1.5×10^{-6}	1.1×10^{-3}	1.6×10^{-3}	1.8×10^{-4}
Gonads	3.9×10^{-8}	---	---	4.7×10^{-3}	1.5×10^{-3}	---

* Sacrifice time in days after dosing

TABLE A-10. COMPARISON OF PLUTONIUM-238, AMERICIUM-241, AND CURIUM-243 TRANSPORT TO FECES IN DAIRY COWS FOLLOWING SINGLE ORAL NUCLIDE DOSES (Values expressed as mean percentage of the dose*)

Time After Dosing	% of Dose per Collection			% of Dose per Gram of Feces		
	Plutonium	Americium	Curium	Plutonium	Americium	Curium
24 h	23.9	5.8	4.4	8.8×10^{-4}	3.9×10^{-4}	1.4×10^{-3}
48 h	33.4	9.6	16.3	1.3×10^{-3}	2.0×10^{-3}	3.8×10^{-3}
72 h	10.4	31.0	32.6	3.6×10^{-4}	2.3×10^{-3}	3.1×10^{-3}
96 h	3.7	20.5	27.4	1.3×10^{-4}	1.0×10^{-3}	1.7×10^{-3}
Total**	71.4	66.9	80.7	-	-	-

* Citrate-buffered doses of plutonium nitrate or unbuffered doses of either americium nitrate or curium chloride

** Mean summation for the 96-hour period

TABLE A-11. COMPARISON OF PLUTONIUM-238, AMERICIUM-241, AND CURIUM-243 TRANSPORT TO FECES IN DAIRY COWS FOLLOWING SINGLE INTRAVENOUS NUCLIDE INJECTIONS (Values expressed as mean percentage of the dose*)

Time After Dosing	% of Dose per Collection			% of Dose per Gram of Feces		
	Plutonium	Americium	Curium	Plutonium	Americium	Curium
24 h	2.7×10^{-1}	1.1	3.7×10^{-1}	1.7×10^{-5}	5.5×10^{-5}	2.0×10^{-5}
48 h	6.1×10^{-1}	4.5×10^{-1}	3.2×10^{-1}	3.1×10^{-5}	2.5×10^{-5}	1.8×10^{-5}
72 h	5.1×10^{-1}	3.0×10^{-1}	3.0×10^{-1}	2.9×10^{-5}	1.5×10^{-5}	1.5×10^{-5}
96 h	4.2×10^{-1}	2.0×10^{-1}	2.1×10^{-1}	2.5×10^{-5}	1.1×10^{-5}	9.6×10^{-6}
120 h	3.9×10^{-1}	1.5×10^{-1}	1.4×10^{-1}	3.3×10^{-5}	8.2×10^{-6}	6.6×10^{-6}
144 h	3.4×10^{-1}	1.5×10^{-1}	9.8×10^{-2}	1.7×10^{-5}	7.2×10^{-6}	4.7×10^{-6}
Total**	2.5	2.4	1.4	---	---	---

* Citrate-buffered doses of either plutonium nitrate, americium nitrate or curium chloride

** Mean summation for the 144-hour period

TABLE A-12. COMPARISON OF AMERICIUM-241, CURIUM-243, AND NEPTUNIUM-234
TRANSPORT TO FECES IN DAIRY GOATS FOLLOWING SINGLE ORAL NUCLIDE DOSES
(Values expressed as mean percentage of the dose*)

Approximate Time After Dosing**	% of Dose per Collection			% of Dose per Gram of Feces		
	Americium	Curium	Neptunium	Americium	Curium	Neptunium
24 h	20.4	13.8	35.2	2.0×10^{-2}	2.6×10^{-2}	3.1×10^{-2}
48 h	48.1	84.0	34.5	5.5×10^{-2}	1.0×10^{-1}	4.9×10^{-2}
72 h	14.3	10.1	10.0	1.6×10^{-2}	1.8×10^{-2}	1.1×10^{-2}
96 h	2.4	1.2	2.1	3.1×10^{-3}	1.5×10^{-3}	2.5×10^{-3}
Total***	85.2	109.1	81.8	---	---	---

* Citrate-buffered doses of neptunium chloride and unbuffered doses of either americium nitrate or curium chloride

** Neptunium values based on 29 h, 53 h, 77 h and 101 h collection intervals

*** Total nuclide transport as of approximately 96 h post-treatment. The calculation for curium excretion exceeds 100 percent due to inaccuracies associated with fecal determinations.

TABLE A-13. COMPARISON OF PLUTONIUM-238, AMERICIUM-241, CURIUM-243, AND NEPTUNIUM-234 TRANSPORT
TO FECES IN DAIRY GOATS FOLLOWING SINGLE INTRAVENOUS NUCLIDE DOSES
(Values expressed as mean percentage of the dose*)

Approximate Time After Dosing**	Plutonium	% of Dose per Collection			Plutonium	% of Dose per Gram of Feces		
		Americium	Curium	Neptunium		Americium	Curium	Neptunium
24 h	9.6×10^{-1}	3.5×10^{-1}	7.3×10^{-2}	4.5×10^{-3}	5.1×10^{-4}	2.5×10^{-4}	2.4×10^{-4}	3.4×10^{-5}
48 h	6.3×10^{-1}	5.8×10^{-1}	6.9×10^{-1}	2.6×10^{-3}	4.4×10^{-4}	3.7×10^{-4}	1.6×10^{-3}	2.1×10^{-6}
72 h	5.4×10^{-1}	3.4×10^{-1}	5.5×10^{-1}	2.7×10^{-3}	3.8×10^{-4}	2.6×10^{-4}	1.6×10^{-3}	1.5×10^{-6}
96 h	4.0×10^{-1}	2.9×10^{-1}	9.3×10^{-1}	1.2×10^{-3}	4.6×10^{-4}	2.4×10^{-4}	1.5×10^{-3}	1.1×10^{-6}
Total***	2.5	1.6	2.2	1.1×10^{-2}	---	-	---	---

* Citrate-buffered doses of plutonium nitrate, americium nitrate, curium chloride and neptunium chloride

** Neptunium values based on 29 h, 53 h, 77 h, and 101 h collection intervals

*** Total nuclide transport as of approximately 96 h post-treatment

TABLE A-14. COMPARISON OF PLUTONIUM-238, AMERICIUM-241, AND CURIUM-243 TRANSPORT TO MILK IN DAIRY COWS FOLLOWING SINGLE ORAL NUCLIDE DOSES (Values expressed as a mean percentage of the dose*)

Time After Dosing**	% of Dose per Collection			% of Dose per Gram of Milk		
	Plutonium	Americium	Curium	Plutonium	Americium	Curium
24 h	7.5×10^{-5}	9.1×10^{-5}	2.3×10^{-5}	3.1×10^{-9}	8.6×10^{-9}	5.0×10^{-9}
48 h	4.3×10^{-5}	9.4×10^{-5}	1.3×10^{-4}	1.9×10^{-9}	8.9×10^{-9}	2.1×10^{-8}
72 h	1.5×10^{-5}	9.4×10^{-5}	1.4×10^{-4}	7.2×10^{-10}	8.0×10^{-9}	1.6×10^{-8}
96 h	1.0×10^{-5}	7.4×10^{-5}	7.4×10^{-5}	4.8×10^{-10}	6.1×10^{-9}	7.7×10^{-9}
Total**	1.4×10^{-4}	3.5×10^{-4}	3.7×10^{-4}	---	---	---

* Citrate-buffered doses of plutonium nitrate or unbuffered doses of either americium nitrate or curium chloride

** Mean summation for the 96-hour period

TABLE A-15. COMPARISON OF PLUTONIUM-238, AMERICIUM-241 AND CURIUM-243 TRANSPORT TO MILK IN DAIRY COWS FOLLOWING SINGLE INTRAVENOUS NUCLIDE INJECTIONS (Values expressed as a mean percentage of the dose*)

Time After Dosing**	% of Dose per Collection			% of Dose per Gram of Milk		
	Plutonium	Americium	Curium	Plutonium	Americium	Curium
24 h	4.5×10^{-1}	1.4	9.0×10^{-1}	2.8×10^{-5}	1.4×10^{-4}	6.5×10^{-5}
48 h	4.3×10^{-1}	4.7×10^{-1}	4.3×10^{-1}	2.5×10^{-5}	4.0×10^{-5}	3.5×10^{-5}
72 h	2.7×10^{-1}	2.8×10^{-1}	3.3×10^{-1}	1.6×10^{-5}	2.5×10^{-5}	2.4×10^{-5}
96 h	1.9×10^{-1}	2.3×10^{-1}	1.8×10^{-1}	1.2×10^{-5}	1.7×10^{-5}	1.4×10^{-5}
120 h	1.4×10^{-1}	1.7×10^{-1}	8.9×10^{-2}	9.8×10^{-6}	1.3×10^{-5}	7.3×10^{-6}
144 h	1.3×10^{-1}	1.1×10^{-1}	5.8×10^{-2}	7.4×10^{-6}	9.3×10^{-6}	5.1×10^{-6}
Total**	1.6	2.7	2.0	---	---	---

*Citrate-buffered doses of either plutonium nitrate, americium nitrate or curium chloride

**Mean summation for the 144-hour period

TABLE A-16. COMPARISON OF AMERICIUM-241, CURIUM-243, AND NEPTUNIUM-234
TRANSPORT TO MILK IN DAIRY GOATS FOLLOWING SINGLE ORAL NUCLIDE DOSES
(Values expressed as mean percentage the dose*)

Approximate Time After Dosing**	% of Dose per Collection			% of Dose per Gram of Milk		
	Americium	Curium	Neptunium	Americium	Curium	Neptunium
24 h	1.8×10^{-4}	2.2×10^{-5}	4.0×10^{-3}	9.6×10^{-8}	1.3×10^{-8}	2.6×10^{-6}
48 h	3.8×10^{-3}	5.1×10^{-5}	4.6×10^{-3}	1.7×10^{-6}	2.3×10^{-8}	4.3×10^{-6}
72 h	1.9×10^{-4}	1.7×10^{-4}	1.2×10^{-3}	1.1×10^{-7}	1.3×10^{-7}	1.2×10^{-6}
96 h	6.9×10^{-5}	8.7×10^{-6}	3.1×10^{-4}	4.5×10^{-8}	5.5×10^{-9}	4.5×10^{-7}
Total***	4.2×10^{-3}	2.5×10^{-4}	1.0×10^{-2}	-	-	-

* Citrate-buffered doses of neptunium chloride and unbuffered doses of either americium nitrate or curium chloride

** Neptunium values based on 29-h, 53-h, 77-h and 101-h collection intervals

*** Total nuclide transport as of approximately 96 h post-treatment

TABLE A-17. COMPARISON OF PLUTONIUM-238, AMERICIUM-241, CURIUM-243, AND NEPTUNIUM-234
TRANSPORT TO MILK IN DAIRY GOATS FOLLOWING SINGLE INTRAVENOUS NUCLIDE DOSES
(Values expressed as mean percentage of the dose*)

Approximate Time After Dosing**	% of Dose per Collection				% of Dose per Gram of Milk			
	Plutonium	Americium	Curium	Neptunium	Plutonium	Americium	Curium	Neptunium
24 h	4.8×10^{-1}	1.5	1.3	1.6×10^{-1}	1.8×10^{-4}	5.3×10^{-4}	1.0×10^{-3}	5.3×10^{-5}
48 h	1.3×10^{-1}	2.0×10^{-1}	3.3×10^{-1}	3.8×10^{-2}	5.0×10^{-5}	7.2×10^{-5}	2.9×10^{-4}	1.8×10^{-5}
72 h	5.4×10^{-2}	1.1×10^{-1}	1.9×10^{-1}	2.9×10^{-2}	2.1×10^{-5}	4.4×10^{-5}	1.8×10^{-4}	1.2×10^{-5}
96 h	5.4×10^{-2}	7.2×10^{-2}	1.7×10^{-1}	1.1×10^{-2}	2.1×10^{-5}	3.4×10^{-5}	1.1×10^{-4}	5.5×10^{-6}
Total***	1.2×10^{-1}	1.9	2.0	2.4×10^{-1}	-	-	-	-

* Citrate-buffered doses of plutonium nitrate, americium nitrate, curium chloride and neptunium chloride

** Neptunium values based on 29-h, 53-h, 77-h and 101-h collection intervals

*** Total nuclide transport as of approximately 96 h post-treatment

TABLE A-18. COMPARISON OF PLUTONIUM-238, AMERICIUM-241 AND CURIUM-243 TRANSPORT TO URINE IN DAIRY COWS FOLLOWING SINGLE ORAL NUCLIDE DOSES (Values expressed as mean percentage of the dose*)

Time After Dosing**	% of Dose per Collection			% of Dose per Gram of Urine		
	Plutonium	Americium	Curium	Plutonium	Americium	Curium
24 h	1.3×10^{-4}	9.7×10^{-5}	2.3×10^{-4}	4.5×10^{-9}	9.3×10^{-9}	5.0×10^{-8}
48 h	5.5×10^{-5}	2.8×10^{-4}	7.1×10^{-4}	3.2×10^{-9}	4.3×10^{-8}	1.3×10^{-7}
72 h	2.5×10^{-5}	2.7×10^{-4}	3.9×10^{-4}	1.2×10^{-9}	2.4×10^{-8}	6.3×10^{-8}
96 h	2.0×10^{-5}	1.8×10^{-4}	2.8×10^{-4}	1.3×10^{-9}	1.4×10^{-8}	3.5×10^{-8}
Total**	2.3×10^{-4}	8.3×10^{-4}	1.6×10^{-3}	-	-	-

* Citrate-buffered doses of plutonium nitrate or unbuffered doses of either americium nitrate or curium chloride

** Mean summation for the 96-hour period

TABLE A-19. COMPARISON OF PLUTONIUM-238, AMERICIUM-241 AND CURIUM-243 TRANSPORT TO URINE IN DAIRY COWS FOLLOWING SINGLE INTRAVENOUS NUCLIDE INJECTIONS (Values expressed as mean percentage of the dose*)

Time After Dosing**	% of Dose per Collection			% of Dose per Gram of Urine		
	Plutonium	Americium	Curium	Plutonium	Americium	Curium
24 h	9.9×10^{-1}	3.2	4.9	6.6×10^{-5}	2.3×10^{-4}	2.7×10^{-4}
48 h	4.8×10^{-1}	8.9×10^{-1}	9.6×10^{-1}	3.2×10^{-5}	5.8×10^{-5}	5.8×10^{-5}
72 h	3.9×10^{-1}	5.4×10^{-1}	8.6×10^{-1}	2.4×10^{-5}	4.0×10^{-5}	5.8×10^{-5}
96 h	2.8×10^{-1}	3.3×10^{-1}	6.5×10^{-1}	1.5×10^{-5}	2.4×10^{-5}	3.7×10^{-5}
120 h	2.4×10^{-1}	2.9×10^{-1}	4.6×10^{-1}	1.0×10^{-5}	1.9×10^{-5}	2.3×10^{-5}
144 h	1.9×10^{-1}	2.0×10^{-1}	3.5×10^{-1}	9.8×10^{-6}	1.6×10^{-5}	1.7×10^{-5}
Total**	2.6	5.5	8.2	-	-	-

* Citrate-buffered doses of either plutonium nitrate, americium nitrate or curium chloride

** Mean summation for the 144-hour period

TABLE A-20. COMPARISON OF AMERICIUM-241, CURIUM-243, AND NEPTUNIUM-234 TRANSPORT TO URINE IN DAIRY GOATS FOLLOWING SINGLE ORAL NUCLIDE DOSES
(Values expressed as mean percentage of the dose*)

Approximate Time After Dosing**	% of Dose per Collection			% of Dose per Gram of Urine		
	Americium	Curium	Neptunium	Americium	Curium	Neptunium
24 h	2.8×10^{-4}	1.8×10^{-4}	1.9×10^{-1}	2.7×10^{-7}	1.5×10^{-7}	1.2×10^{-4}
48 h	3.9×10^{-4}	7.0×10^{-5}	2.1×10^{-1}	1.8×10^{-7}	6.7×10^{-8}	1.3×10^{-4}
72 h	1.9×10^{-4}	2.1×10^{-5}	2.2×10^{-2}	1.1×10^{-7}	3.1×10^{-8}	8.6×10^{-6}
96 h	1.1×10^{-4}	1.8×10^{-5}	5.8×10^{-3}	8.5×10^{-8}	1.7×10^{-8}	4.6×10^{-6}
Total***	9.7×10^{-4}	2.9×10^{-4}	4.3×10^{-1}	-	-	-

* Citrate-buffered doses of neptunium chloride and unbuffered doses of either americium nitrate or curium chloride

** Neptunium values based on 29 h, 53 h, 77 h and 101 h collection intervals

*** Total nuclide transport as of approximately 96 h post treatment

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TABLE A-21. COMPARISON OF PLUTONIUM-238, AMERICIUM-241, CURIUM-243, AND NEPTUNIUM-234 TRANSPORT TO URINE IN DAIRY GOATS FOLLOWING SINGLE INTRAVENOUS NUCLIDE DOSES
(Values expressed as mean percentage of the dose*)

Approximate Time After Dosing**	Plutonium	% of Dose per Collection			% of Dose per Gram of Urine			
		Americium	Curium	Neptunium	Plutonium	Americium	Curium	Neptunium
24 h	1.5	2.7	3.1	2.3	6.9×10^{-4}	1.5×10^{-3}	3.4×10^{-3}	1.2×10^{-3}
48 h	1.1×10^{-1}	6.6×10^{-1}	3.9×10^{-1}	1.4	3.2×10^{-5}	1.9×10^{-4}	5.0×10^{-4}	6.0×10^{-4}
72 h	1.1×10^{-1}	3.0×10^{-1}	3.0×10^{-1}	7.4×10^{-1}	2.6×10^{-5}	1.1×10^{-4}	3.6×10^{-4}	3.1×10^{-4}
96 h	3.6×10^{-2}	2.1×10^{-1}	2.9×10^{-1}	3.7×10^{-1}	1.5×10^{-5}	1.2×10^{-4}	2.8×10^{-4}	1.7×10^{-4}
Total***	1.8	3.9	4.3	4.8	-	-	-	-

* Citrate-buffered doses of plutonium nitrate, americium nitrate, curium chloride and neptunium chloride

** Neptunium values based on 29 h, 53 h, 77 h and 101 h collection intervals

*** Total nuclide transport as of approximately 96 h post-treatment

TABLE A-22. COMPARISON OF AMERICIUM-241 AND NEPTUNIUM-234 TRANSPORT TO BLOOD PLASMA IN DAIRY GOATS FOLLOWING SINGLE ORAL NUCLIDE DOSES (Values expressed as mean percentage of the dose)

Approximate Time After Dosing**	% of Dose per Total Body Plasma*		% of Dose per Gram of Plasma	
	Americium	Neptunium	Americium	Neptunium
24 h	1.4×10^{-4}	1.5×10^{-2}	6.6×10^{-8}	6.1×10^{-6}
48 h	6.0×10^{-5}	1.1×10^{-2}	2.8×10^{-8}	4.7×10^{-6}
72 h	3.6×10^{-5}	5.4×10^{-3}	1.7×10^{-8}	2.2×10^{-6}
96 h	2.0×10^{-5}	4.1×10^{-3}	9.9×10^{-9}	1.7×10^{-6}

* Extrapolated values

** Neptunium values based on 29-h, 53-h, 77-h and 101-h collection intervals

TABLE A-23. COMPARISON OF PLUTONIUM-238, AMERICIUM-241, AND CURIUM-243 TRANSPORT TO BLOOD PLASMA IN DAIRY COWS FOLLOWING SINGLE ORAL NUCLIDE DOSES (Values expressed as mean percentage of the dose)

Time After Dosing**	% of Dose per Total Body Plasma*			% of Dose per Gram of Plasma		
	Plutonium	Americium	Curium	Plutonium**	Americium	Curium
24 h	1.4×10^{-3}	2.3×10^{-4}	4.2×10^{-4}	4.3×10^{-8}	7.8×10^{-9}	1.5×10^{-8}
48 h	1.1×10^{-3}	2.7×10^{-4}	3.7×10^{-4}	3.5×10^{-8}	9.3×10^{-9}	1.3×10^{-8}
72 h	6.4×10^{-4}	1.3×10^{-4}	1.5×10^{-4}	2.0×10^{-8}	4.5×10^{-9}	5.3×10^{-9}
96 h	7.4×10^{-4}	1.1×10^{-4}	7.8×10^{-5}	2.4×10^{-8}	3.9×10^{-9}	2.7×10^{-9}

* Extrapolated values

** Plutonium concentrations determined on blood serum

TABLE A-24. COMPARISON OF AMERICIUM-241, CURIUM-243 AND NEPTUNIUM-234 RETENTION IN BLOOD PLASMA OF DAIRY GOATS FOLLOWING SINGLE INTRAVENOUS NUCLIDE DOSES
(Values expressed as mean percentage of the dose)

Approximate Time After Dosing**	% of Dose per Total Body Plasma*			% of Dose per Gram of Plasma		
	Americium	Curium	Neptunium	Americium	Curium	Neptunium
24 h	2.8×10^{-1}	4.5×10^{-1}	9.8×10^{-1}	1.1×10^{-4}	1.9×10^{-4}	3.3×10^{-4}
48 h	1.7×10^{-1}	3.2×10^{-1}	2.7×10^{-1}	7.0×10^{-5}	1.3×10^{-4}	9.1×10^{-5}
72 h	1.1×10^{-1}	2.3×10^{-1}	1.8×10^{-1}	5.0×10^{-5}	9.8×10^{-5}	6.1×10^{-5}
96 h	6.6×10^{-2}	6.1×10^{-2}	1.2×10^{-1}	2.9×10^{-5}	2.4×10^{-5}	4.2×10^{-5}

* Extrapolated values

** Neptunium values based on 29-h, 53-h, 77-h and 101-h collection intervals

TABLE A-25. COMPARISON OF AMERICIUM-241 AND CURIUM-243 RETENTION IN BLOOD PLASMA OF DAIRY COWS FOLLOWING SINGLE INTRAVENOUS NUCLIDE DOSES (Values expressed as mean percentage of the dose)

Approximate Time After Dosing**	% of Dose per Total Body Plasma*		% of Dose per Gram of Plasma	
	Americium	Curium	Americium	Curium
24 h	1.2	9.6×10^{-1}	4.1×10^{-5}	2.7×10^{-5}
48 h	5.1×10^{-1}	7.4×10^{-1}	1.7×10^{-5}	2.1×10^{-5}
72 h	3.2×10^{-1}	5.1×10^{-1}	1.1×10^{-5}	1.5×10^{-5}
96 h	2.0×10^{-1}	2.2×10^{-1}	6.7×10^{-6}	6.2×10^{-6}

* Extrapolated values

APPENDIX B

Appendix B consists of 46 tables of data from individual animals. These data were used to prepare the comparative tables included in Appendix A. The tables in Appendix B are cross indexed with individual animal parameters shown in Table 1 of the text. Table 1 gives the animal number, describes the radionuclide dose administered, and reports the daily output of milk, urine, and feces from each animal.

TABLE B-1. PLUTONIUM-238 DOSE RECOVERED FROM GOAT 2P AFTER AN
INTRAVENOUS DOSE OF CITRATE-BUFFERED PLUTONIUM NITRATE

Time After Dosing (h)	Blood Plasma* (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
24	-	1.8×10^{-4}	6.9×10^{-4}	5.1×10^{-4}
48	-	5.0×10^{-5}	3.2×10^{-5}	4.4×10^{-4}
72	-	2.1×10^{-5}	2.6×10^{-5}	3.8×10^{-4}
96	-	2.1×10^{-5}	1.5×10^{-5}	4.6×10^{-4}
120	5.3×10^{-4}	1.5×10^{-5}	1.8×10^{-5}	4.1×10^{-4}
144	3.7×10^{-4}	9.2×10^{-6}	1.0×10^{-5}	3.1×10^{-4}
168	2.3×10^{-4}	7.2×10^{-6}	1.8×10^{-5}	3.6×10^{-4}
192	2.3×10^{-4}	5.6×10^{-6}	1.7×10^{-5}	2.2×10^{-4}
216	1.5×10^{-4}	3.8×10^{-6}	6.2×10^{-6}	2.9×10^{-4}
240	1.6×10^{-4}	3.6×10^{-6}	7.0×10^{-6}	3.0×10^{-4}
264	1.4×10^{-4}	2.8×10^{-6}	8.6×10^{-6}	3.5×10^{-4}
288	1.1×10^{-4}	2.6×10^{-6}	4.0×10^{-6}	1.8×10^{-4}
312	1.1×10^{-4}	2.4×10^{-6}	1.0×10^{-6}	2.2×10^{-4}
336	1.0×10^{-4}	2.6×10^{-6}	8.6×10^{-6}	2.6×10^{-4}
360	5.8×10^{-5}	2.2×10^{-6}	7.4×10^{-6}	3.7×10^{-4}
384	6.8×10^{-5}	1.8×10^{-6}	3.2×10^{-6}	3.0×10^{-4}
408	8.0×10^{-5}	1.8×10^{-6}	8.0×10^{-6}	2.5×10^{-4}
432	9.6×10^{-5}	1.8×10^{-6}	3.6×10^{-6}	4.4×10^{-4}

* Limited data for initial post-injection period.

TABLE B-2. INTRAVENOUS PLUTONIUM-238 DOSE RETAINED IN TISSUE
OF DAIRY GOAT 2P

Tissue	Pu-238 Retained (%/g)
Bone (femur)	2.3×10^{-4}
Liver	2.9×10^{-2}
Spleen	2.9×10^{-4}
Lung	1.9×10^{-4}
Heart	1.7×10^{-4}
Gonads	1.1×10^{-3}
Thyroid	8.0×10^{-4}
Muscle	6.5×10^{-5}

TABLE B-3. PLUTONIUM-238 DOSE RECOVERED FROM GOAT 2P AFTER AN
INTRAVENOUS DOSE OF CITRATE-BUFFERED PLUTONIUM NITRATE

Time After Dosing (h)	Blood Serum (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
24	5.7×10^{-8}	5.0×10^{-9}	3.9×10^{-9}	7.3×10^{-5}
48	3.7×10^{-8}	2.8×10^{-9}	3.4×10^{-9}	1.6×10^{-3}
72	3.7×10^{-8}	5.9×10^{-10}	7.2×10^{-10}	2.0×10^{-3}
96	3.1×10^{-8}	3.2×10^{-10}	5.1×10^{-10}	1.1×10^{-3}

TABLE B-4. PLUTONIUM-238 DOSE RECOVERED IN COW 128 AFTER AN
ORAL DOSE OF CITRATE-BUFFERED PLUTONIUM NITRATE

Time After Dosing (h)	Blood Serum (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
24	6.0×10^{-8}	4.2×10^{-9}	7.4×10^{-9}	4.6×10^{-4}
48	4.7×10^{-8}	2.6×10^{-9}	4.7×10^{-9}	2.5×10^{-3}
72	3.3×10^{-9}	1.4×10^{-9}	2.5×10^{-9}	1.9×10^{-3}
96	2.7×10^{-8}	7.1×10^{-10}	2.0×10^{-9}	1.1×10^{-3}

TABLE B-5. PLUTONIUM-238 DOSE RECOVERED FROM COW 39 AFTER AN
ORAL DOSE OF CITRATE-BUFFERED PLUTONIUM NITRATE

Time After Dosing (h)	Blood Serum (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
24	3.2×10^{-8}	1.3×10^{-9}	2.8×10^{-9}	5.0×10^{-5}
48	3.0×10^{-8}	9.4×10^{-10}	3.2×10^{-9}	1.6×10^{-3}
72	2.5×10^{-8}	5.6×10^{-10}	1.0×10^{-9}	1.3×10^{-3}
96	1.8×10^{-8}	4.1×10^{-10}	-	7.1×10^{-4}

TABLE B-6. PLUTONIUM-238 DOSE RECOVERED FROM COW 45 AFTER AN ORAL DOSE OF CITRATE-BUFFERED PLUTONIUM NITRATE

Time After Dosing (h)	Blood Serum (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
24	2.4×10^{-8}	1.9×10^{-9}	3.7×10^{-9}	3.3×10^{-5}
48	2.4×10^{-8}	1.2×10^{-9}	1.5×10^{-9}	1.8×10^{-3}
72	1.6×10^{-8}	4.0×10^{-10}	7.0×10^{-10}	1.3×10^{-3}
96	1.9×10^{-8}	-	-	3.7×10^{-4}

TABLE B-7. PLUTONIUM-238 RECOVERED IN TWO DAIRY COWS 93 DAYS AFTER AN ORAL DOSE OF CITRATE-BUFFERED PLUTONIUM NITRATE

Tissue	Cow 39 (%/g)	Cow 87 (%/g)
Liver	1.7×10^{-7}	3.7×10^{-7}
Femur	1.3×10^{-8}	3.3×10^{-8}
Rib	3.0×10^{-8}	2.2×10^{-7}
Vertebra	1.3×10^{-7}	5.0×10^{-8}
Kidney	6.7×10^{-9}	1.3×10^{-8}
Spleen	1.3×10^{-8}	3.0×10^{-8}
Muscle	1.7×10^{-9}	6.7×10^{-9}
Lung	1.0×10^{-8}	1.3×10^{-8}
Heart	3.0×10^{-8}	6.7×10^{-9}
Rumen	1.7×10^{-8}	3.0×10^{-8}
Abomasum	3.3×10^{-9}	3.3×10^{-9}
Duodenum	1.7×10^{-7}	2.0×10^{-7}
Small intestine	2.7×10^{-7}	1.7×10^{-7}

TABLE B-8. DAILY PLUTONIUM-238 DOSE RECOVERED FROM DAIRY COW 117 FED
1 mCi OF PLUTONIUM DIOXIDE PER DAY FOR 19 CONSECUTIVE DAYS

Dosing Day*	Blood Serum (%/g)	Milk** (%/g)	Urine (%/g)	Feces (%/g)
1	-	-	-	-
2	2.0×10^{-8}	-	1.5×10^{-9}	9.6×10^{-4}
3	4.5×10^{-8}	-	8.0×10^{-9}	3.7×10^{-3}
4	8.3×10^{-8}	2.3×10^{-9}	2.6×10^{-9}	4.4×10^{-3}
5	5.4×10^{-8}	6.3×10^{-10}	3.2×10^{-9}	5.1×10^{-3}
6	6.3×10^{-8}	-	4.3×10^{-9}	5.7×10^{-3}
7	6.4×10^{-8}	-	4.8×10^{-9}	5.5×10^{-3}
8	5.5×10^{-8}	-	4.8×10^{-9}	5.5×10^{-3}
9	6.0×10^{-8}	1.3×10^{-9}	7.6×10^{-9}	5.6×10^{-3}
10	7.0×10^{-8}	3.9×10^{-9}	1.2×10^{-8}	6.3×10^{-3}
11	6.5×10^{-8}	1.9×10^{-9}	9.4×10^{-9}	5.9×10^{-3}
12	3.3×10^{-8}	9.6×10^{-10}	1.0×10^{-8}	5.2×10^{-3}
13	6.4×10^{-8}	2.0×10^{-9}	1.0×10^{-8}	5.7×10^{-3}
14	8.4×10^{-8}	1.4×10^{-9}	1.2×10^{-8}	5.6×10^{-3}
15	7.7×10^{-8}	1.8×10^{-9}	1.8×10^{-8}	4.6×10^{-3}
16	7.7×10^{-8}	3.4×10^{-9}	1.4×10^{-8}	4.9×10^{-3}
17	7.8×10^{-8}	9.4×10^{-10}	9.6×10^{-9}	4.4×10^{-3}
18	6.7×10^{-8}	1.4×10^{-9}	1.0×10^{-8}	3.7×10^{-3}
19	9.6×10^{-8}	1.6×10^{-9}	7.7×10^{-9}	5.2×10^{-3}
(1)	8.0×10^{-8}	3.7×10^{-10}	5.0×10^{-9}	4.6×10^{-3}
(2)	7.0×10^{-8}	-	2.7×10^{-9}	2.2×10^{-3}
(3)	5.6×10^{-8}	-	1.9×10^{-9}	4.9×10^{-4}
(4)	5.6×10^{-8}	-	2.3×10^{-9}	1.1×10^{-4}
(5)	5.8×10^{-8}	-	2.3×10^{-9}	3.0×10^{-5}
(6)	3.0×10^{-8}	-	3.1×10^{-9}	2.0×10^{-5}
(7)	3.9×10^{-8}	-	1.9×10^{-9}	3.9×10^{-6}

*All doses given at approximately 1600 hours on day indicated.
Days shown in parentheses are the first 7 days after the last
plutonium dioxide dose was given.

**Limited data available.

TABLE B-9. DAILY PLUTONIUM-238 DOSE RECOVERED FROM DAIRY COW 122 FED 1 mCi OF PLUTONIUM DIOXIDE PER DAY FOR 19 CONSECUTIVE DAYS

Dosing Day*	Blood Serum (%/g)	Milk** (%/g)	Urine (%/g)	Feces (%/g)
1	-	-	-	-
2	2.6×10^{-8}	-	6.5×10^{-9}	2.1×10^{-3}
3	6.8×10^{-8}	4.3×10^{-11}	1.4×10^{-8}	4.3×10^{-3}
4	5.7×10^{-8}	5.0×10^{-10}	7.6×10^{-9}	5.7×10^{-3}
5	8.2×10^{-8}	8.9×10^{-10}	9.2×10^{-9}	1.8×10^{-3}
6	7.5×10^{-8}	-	7.7×10^{-9}	6.5×10^{-3}
7	7.1×10^{-8}	-	8.0×10^{-9}	5.7×10^{-3}
8	5.1×10^{-8}	-	6.8×10^{-9}	5.5×10^{-3}
9	6.0×10^{-8}	3.1×10^{-10}	1.1×10^{-8}	6.2×10^{-3}
10	5.5×10^{-8}	5.4×10^{-10}	6.5×10^{-9}	7.2×10^{-3}
11	5.6×10^{-8}	7.5×10^{-10}	7.5×10^{-9}	5.4×10^{-3}
12	7.4×10^{-8}	3.7×10^{-10}	6.0×10^{-9}	5.3×10^{-3}
13	5.8×10^{-8}	1.8×10^{-10}	1.0×10^{-8}	5.2×10^{-3}
14	6.7×10^{-8}	1.5×10^{-10}	9.4×10^{-9}	5.1×10^{-3}
15	8.8×10^{-8}	7.9×10^{-10}	8.9×10^{-9}	4.8×10^{-3}
16	8.0×10^{-8}	1.4×10^{-10}	6.3×10^{-9}	5.1×10^{-3}
17	6.4×10^{-8}	1.8×10^{-10}	5.7×10^{-9}	3.7×10^{-3}
18	6.8×10^{-8}	3.3×10^{-10}	6.0×10^{-9}	3.3×10^{-3}
19	5.0×10^{-8}	3.6×10^{-10}	7.3×10^{-9}	4.8×10^{-3}
(1)	5.7×10^{-8}	2.9×10^{-10}	5.4×10^{-9}	3.4×10^{-3}
(2)	3.8×10^{-8}	9.6×10^{-11}	4.0×10^{-9}	2.2×10^{-3}
(3)	3.6×10^{-8}	-	1.8×10^{-9}	4.2×10^{-4}
(4)	3.6×10^{-8}	-	4.3×10^{-9}	7.0×10^{-5}
(5)	4.1×10^{-8}	-	3.1×10^{-9}	2.0×10^{-5}
(6)	3.2×10^{-8}	-	3.0×10^{-9}	4.8×10^{-6}
(7)	1.8×10^{-8}	-	3.1×10^{-9}	4.8×10^{-6}

*All doses given at approximately 1600 hours on day indicated.
Days shown in parentheses are the first 7 days after the last plutonium dioxide dose was given.

**Limited data available.

TABLE B-10. DAILY PLUTONIUM-238 DOSE RECOVERED FROM DAIRY COW 134 FED
1 mCi OF PLUTONIUM DIOXIDE PER DAY FOR 19 CONSECUTIVE DAYS

Dosing Day*	Blood Serum (%/g)	Milk** (%/g)	Urine (%/g)	Feces (%/g)
1	-	-	-	
2	2.5×10^{-8}	1.7×10^{-10}	3.3×10^{-9}	1.5×10^{-3}
3	5.3×10^{-8}	3.3×10^{-10}	8.5×10^{-9}	4.5×10^{-3}
4	7.7×10^{-8}	1.7×10^{-9}	4.4×10^{-9}	5.2×10^{-3}
5	8.3×10^{-8}	-	4.3×10^{-9}	5.0×10^{-3}
6	9.3×10^{-8}	-	7.3×10^{-9}	5.0×10^{-3}
7	9.0×10^{-8}	-	7.6×10^{-9}	5.2×10^{-3}
8	8.1×10^{-8}	-	3.4×10^{-9}	5.2×10^{-3}
9	1.1×10^{-7}	1.2×10^{-9}	9.8×10^{-9}	5.7×10^{-3}
10	1.1×10^{-7}	5.4×10^{-10}	1.2×10^{-8}	6.2×10^{-3}
11	8.8×10^{-8}	2.0×10^{-9}	1.1×10^{-8}	5.8×10^{-3}
12	9.8×10^{-8}	1.2×10^{-9}	7.5×10^{-9}	5.6×10^{-3}
13	8.5×10^{-8}	4.0×10^{-10}	1.1×10^{-8}	5.1×10^{-3}
14	9.5×10^{-8}	8.1×10^{-10}	1.2×10^{-8}	6.9×10^{-3}
15	8.7×10^{-8}	8.6×10^{-10}	9.8×10^{-9}	5.7×10^{-3}
16	9.0×10^{-8}	1.3×10^{-9}	1.1×10^{-8}	5.1×10^{-3}
17	7.5×10^{-8}	1.8×10^{-9}	8.1×10^{-9}	4.1×10^{-3}
18	8.5×10^{-8}	1.4×10^{-9}	7.3×10^{-9}	3.9×10^{-3}
19	8.7×10^{-8}	1.1×10^{-9}	6.5×10^{-9}	4.8×10^{-3}
(1)	8.0×10^{-8}	6.7×10^{-10}	3.1×10^{-9}	2.3×10^{-3}
(2)	7.5×10^{-8}	1.6×10^{-9}	2.1×10^{-9}	1.5×10^{-3}
(3)	6.1×10^{-8}	-	2.6×10^{-9}	2.2×10^{-4}
(4)	5.3×10^{-8}	-	2.6×10^{-9}	4.0×10^{-5}
(5)	6.5×10^{-8}	-	3.7×10^{-9}	1.0×10^{-5}
(6)	5.3×10^{-8}	-	1.3×10^{-9}	2.9×10^{-6}
(7)	3.9×10^{-8}	-	1.4×10^{-9}	2.9×10^{-6}

*All doses given at approximately 1600 hours on day indicated.
Days shown in parentheses are the first 7 days after the last
plutonium dioxide dose was given.

**Limited data available.

TABLE B-11. DAILY PLUTONIUM-238 DOSE RECOVERED FOR DAIRY COW 185
 FED 1 mCi OF PLUTONIUM DIOXIDE PER DAY FOR 19 CONSECUTIVE DAYS

Dosing Day*	Blood Serum (%/g)	Milk** (%/g)	Urine (%/g)	Feces (%/g)
1	-	-	-	-
2	2.4×10^{-8}	1.9×10^{-10}	3.8×10^{-9}	1.8×10^{-3}
3	5.1×10^{-8}	7.1×10^{-10}	1.4×10^{-8}	6.5×10^{-3}
4	6.0×10^{-8}	5.2×10^{-10}	5.1×10^{-9}	5.9×10^{-3}
5	8.2×10^{-8}	-	3.8×10^{-9}	5.2×10^{-3}
6	8.2×10^{-8}	-	5.8×10^{-9}	8.0×10^{-3}
7	9.8×10^{-8}	-	7.9×10^{-9}	6.9×10^{-3}
8	5.8×10^{-8}	-	1.1×10^{-8}	7.3×10^{-3}
9	9.1×10^{-8}	1.1×10^{-9}	1.6×10^{-8}	7.5×10^{-3}
10	-	3.4×10^{-9}	1.2×10^{-8}	6.2×10^{-3}
11	8.6×10^{-8}	5.1×10^{-9}	1.6×10^{-8}	7.9×10^{-3}
12	9.0×10^{-8}	1.4×10^{-9}	1.4×10^{-8}	8.0×10^{-3}
13	1.1×10^{-7}	3.7×10^{-9}	1.2×10^{-8}	6.8×10^{-3}
14	1.3×10^{-7}	1.5×10^{-9}	1.8×10^{-8}	6.3×10^{-3}
15	7.6×10^{-8}	3.2×10^{-9}	1.6×10^{-8}	7.4×10^{-3}
16	-	1.6×10^{-9}	1.5×10^{-8}	7.4×10^{-3}
17	6.7×10^{-8}	2.6×10^{-9}	1.4×10^{-8}	4.8×10^{-3}
18	8.4×10^{-8}	1.8×10^{-9}	9.5×10^{-9}	5.6×10^{-3}
19	6.6×10^{-8}	1.3×10^{-9}	1.0×10^{-8}	6.1×10^{-3}
(1)	1.3×10^{-8}	3.1×10^{-9}	9.7×10^{-9}	5.5×10^{-3}
(2)	7.7×10^{-8}	3.5×10^{-9}	5.2×10^{-9}	3.6×10^{-3}
(3)	7.5×10^{-8}	-	5.1×10^{-9}	8.2×10^{-4}
(4)	6.4×10^{-8}	-	4.9×10^{-9}	2.4×10^{-4}
(5)	5.8×10^{-8}	-	5.1×10^{-9}	6.1×10^{-5}
(6)	4.6×10^{-8}	-	4.3×10^{-9}	2.4×10^{-5}
(7)	7.3×10^{-8}	-	1.8×10^{-9}	5.7×10^{-6}

* All doses given at approximately 1600 hours on day indicated.
 Days shown in parentheses are the first 7 days after the last
 plutonium dioxide dose was given.

**Limited data available.

TABLE B-12. PLUTONIUM-238 DOSE RECOVERED FROM DAIRY COWS FED
1 mCi OF PLUTONIUM DIOXIDE PER DAY FOR 19 CONSECUTIVE DAYS

Tissue	42 Day Sacrifice*		73 Day Sacrifice*	
	Cow 122 (%/g)	Cow 185 (%/g)	Cow 117 (%/g)	Cow 134 (%/g)
Femur	2.2×10^{-9}	2.8×10^{-9}	4.7×10^{-9}	5.2×10^{-9}
Rib	1.3×10^{-8}	3.4×10^{-8}	1.2×10^{-8}	1.8×10^{-8}
Vertebra	2.1×10^{-8}	3.3×10^{-8}	2.9×10^{-8}	2.2×10^{-8}
Liver	5.3×10^{-8}	5.3×10^{-8}	5.8×10^{-8}	5.8×10^{-8}
Kidney	4.0×10^{-9}	5.3×10^{-9}	6.3×10^{-7}	3.4×10^{-9}
Spleen	4.8×10^{-9}	1.2×10^{-8}	5.8×10^{-9}	7.9×10^{-9}
Heart	-	1.8×10^{-9}	1.2×10^{-9}	8.4×10^{-10}
Lung	3.6×10^{-9}	4.2×10^{-9}	3.3×10^{-9}	3.1×10^{-9}
Muscle	-	3.3×10^{-10}	3.5×10^{-10}	3.4×10^{-10}

*Forty-two days and 73 days after final dose was given.

TABLE B-13. PLUTONIUM-238 RECOVERED FROM DAIRY COW 119 AFTER AN
INTRAVENOUS DOSE OF CITRATE-BUFFERED PLUTONIUM NITRATE

Time After Dosing (h)	Blood Plasma (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
24	2.0×10^{-3}	3.6×10^{-5}	9.9×10^{-5}	2.3×10^{-5}
48	1.3×10^{-3}	4.0×10^{-5}	6.1×10^{-5}	3.9×10^{-5}
72	9.1×10^{-4}	2.4×10^{-5}	4.5×10^{-5}	4.3×10^{-5}
96	5.3×10^{-4}	1.6×10^{-5}	2.6×10^{-5}	1.9×10^{-5}
120	5.1×10^{-4}	1.3×10^{-5}	1.4×10^{-5}	1.5×10^{-5}

TABLE B-14. PLUTONIUM-238 DOSE RECOVERED FROM DAIRY COW 179 AFTER AN INTRAVENOUS DOSE OF CITRATE-BUFFERED PLUTONIUM NITRATE

Time After Dosing (h)	Blood Plasma (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
24	1.6×10^{-3}	2.8×10^{-5}	5.7×10^{-5}	1.5×10^{-5}
48	9.7×10^{-4}	2.5×10^{-5}	1.9×10^{-5}	4.1×10^{-5}
72	6.9×10^{-4}	1.6×10^{-5}	1.3×10^{-5}	3.3×10^{-5}
96	3.9×10^{-4}	1.4×10^{-5}	7.9×10^{-6}	4.3×10^{-5}
120	3.6×10^{-4}	1.1×10^{-5}	5.5×10^{-6}	6.6×10^{-5}

TABLE B-15. PLUTONIUM-238 DOSE RECOVERED FROM DAIRY COW 123 AFTER AN INTRAVENOUS DOSE OF CITRATE-BUFFERED PLUTONIUM NITRATE

Time After Dosing (h)	Blood Plasma (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
24	1.5×10^{-3}	2.0×10^{-5}	6.2×10^{-5}	9.5×10^{-6}
48	8.9×10^{-4}	1.7×10^{-5}	2.8×10^{-5}	2.5×10^{-5}
72	6.0×10^{-4}	1.3×10^{-5}	2.2×10^{-5}	2.6×10^{-5}
96	4.7×10^{-4}	9.7×10^{-6}	1.6×10^{-5}	2.1×10^{-5}
120	3.2×10^{-4}	8.5×10^{-6}	1.4×10^{-5}	1.5×10^{-5}

TABLE B-16. PLUTONIUM-238 DOSE RECOVERED FROM DAIRY COW 128 AFTER AN INTRAVENOUS DOSE OF CITRATE-BUFFERED PLUTONIUM NITRATE

Time After Dosing (h)	Blood Plasma (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
24	1.7×10^{-3}	2.8×10^{-5}	4.7×10^{-5}	1.9×10^{-5}
48	1.2×10^{-3}	2.0×10^{-5}	2.2×10^{-5}	2.0×10^{-5}
72	7.7×10^{-4}	1.1×10^{-5}	1.4×10^{-5}	1.5×10^{-5}
96	7.5×10^{-4}	8.0×10^{-6}	1.0×10^{-5}	1.8×10^{-5}
120	4.0×10^{-4}	7.0×10^{-6}	8.1×10^{-6}	1.4×10^{-5}

TABLE B-17. PLUTONIUM-238 DOSE RECOVERED FROM DAIRY COWS ADMINISTERED AN INTRAVENOUS INJECTION OF CITRATE-BUFFERED PLUTONIUM NITRATE

Tissue	Sacrificed 1 Week After Injection		Sacrificed 2 Weeks After Injection	
	Cow 119 (%/g)	Cow 179 (%/g)	Cow 123 (%/g)	Cow 128 (%/g)
Diaphysis	3.3×10^{-5}	1.8×10^{-5}	5.0×10^{-5}	5.0×10^{-5}
Epiphysis	9.4×10^{-5}	7.1×10^{-5}	1.1×10^{-4}	9.3×10^{-5}
Sternum	8.1×10^{-4}	8.5×10^{-4}	5.7×10^{-4}	5.9×10^{-4}
Liver	2.3×10^{-3}	2.7×10^{-3}	2.6×10^{-3}	2.3×10^{-3}
Kidney	2.9×10^{-4}	3.0×10^{-4}	4.0×10^{-4}	2.7×10^{-4}
Lung	5.3×10^{-4}	3.5×10^{-4}	3.0×10^{-4}	3.1×10^{-4}
Muscle	1.6×10^{-5}	3.7×10^{-5}	1.1×10^{-5}	9.0×10^{-6}
Spleen	1.7×10^{-4}	2.2×10^{-4}	2.6×10^{-4}	1.4×10^{-4}
Heart	9.2×10^{-5}	1.0×10^{-4}	5.4×10^{-5}	6.1×10^{-5}
Thyroid	2.5×10^{-4}	4.3×10^{-4}	5.9×10^{-5}	7.9×10^{-5}
Mammary gland	3.5×10^{-4}	2.9×10^{-4}	2.4×10^{-4}	1.2×10^{-4}

TABLE B-18. CURIUM-243 DOSE RECOVERED FROM DAIRY GOAT 1C AFTER AN ORAL DOSE OF CURIUM CHLORIDE

Time After Dosing (h)	Blood Plasma (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
8	1.4×10^{-8}	4.7×10^{-9}	7.7×10^{-8}	-
24	-	2.7×10^{-8}	1.6×10^{-7}	3.2×10^{-2}
48	-	1.6×10^{-8}	3.6×10^{-8}	7.9×10^{-2}
72	-	3.7×10^{-7}	1.6×10^{-8}	9.3×10^{-3}
96	-	6.0×10^{-9}	8.2×10^{-9}	7.8×10^{-4}
120	-	8.7×10^{-9}	1.1×10^{-9}	1.4×10^{-4}
144	-	1.4×10^{-8}	1.6×10^{-9}	3.8×10^{-5}
Sacrifice	5.5×10^{-9}	-	-	-

TABLE B-19. CURIUM-243 DOSE RECOVERED FROM DAIRY GOAT 2C AFTER AN ORAL DOSE OF CURIUM CHLORIDE

Time After Dosing (h)	Blood Plasma (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
8	1.7×10^{-8}	2.1×10^{-9}	4.0×10^{-8}	-
24	-	1.5×10^{-8}	2.3×10^{-7}	3.5×10^{-2}
48	-	1.3×10^{-8}	7.9×10^{-8}	1.1×10^{-1}
72	-	9.9×10^{-9}	4.4×10^{-8}	1.2×10^{-2}
96	-	6.1×10^{-9}	2.4×10^{-8}	1.4×10^{-3}
120	-	4.0×10^{-9}	1.9×10^{-8}	1.3×10^{-4}
144	-	4.5×10^{-9}	1.7×10^{-8}	1.3×10^{-5}
Sacrifice	4.9×10^{-9}	-	-	-

TABLE B-20. CURIUM-243 DOSE RECOVERED FROM DAIRY GOAT 3C AFTER AN ORAL DOSE OF CURIUM CHLORIDE

Time After Dosing (h)	Blood Plasma (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
8	1.6×10^{-8}	1.4×10^{-9}	2.2×10^{-8}	-
24	-	1.5×10^{-8}	2.4×10^{-7}	1.2×10^{-2}
48	-	4.1×10^{-8}	8.8×10^{-8}	1.2×10^{-1}
72	-	1.2×10^{-8}	3.2×10^{-8}	3.4×10^{-2}
96	-	4.2×10^{-9}	1.9×10^{-8}	2.2×10^{-3}
120	-	2.6×10^{-9}	1.1×10^{-8}	1.2×10^{-4}
144	-	3.1×10^{-9}	1.1×10^{-8}	1.1×10^{-5}
Sacrifice	3.3×10^{-9}	-	-	-

TABLE B-21. CURIUM-243 DOSE RECOVERED FROM DAIRY GOAT 4C AFTER AN INTRAVENOUS DOSE OF CURIUM CHLORIDE

Time After Dosing (h)	Blood Plasma (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
8	6.7×10^{-4}	1.5×10^{-3}	7.5×10^{-3}	4.3×10^{-5}
24	1.5×10^{-4}	3.9×10^{-4}	1.4×10^{-4}	7.2×10^{-5}
48	1.1×10^{-4}	1.4×10^{-4}	4.7×10^{-4}	1.6×10^{-3}
72	7.7×10^{-5}	9.1×10^{-5}	3.7×10^{-4}	1.5×10^{-3}
96	3.4×10^{-5}	5.8×10^{-5}	3.5×10^{-4}	1.9×10^{-3}
120	4.8×10^{-5}	4.3×10^{-5}	2.6×10^{-4}	1.5×10^{-3}
144	2.9×10^{-5}	3.4×10^{-5}	1.7×10^{-4}	1.2×10^{-3}

TABLE B-22. CURIUM-243 DOSE RECOVERED FROM DAIRY GOAT 5C AFTER AN INTRAVENOUS DOSE OF CURIUM CHLORIDE

Time After Dosing (h)	Blood Plasma (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
8	4.5×10^{-4}	1.4×10^{-3}	5.1×10^{-3}	3.9×10^{-5}
24	1.8×10^{-4}	9.5×10^{-4}	6.9×10^{-4}	3.5×10^{-4}
48	1.4×10^{-4}	5.0×10^{-4}	5.3×10^{-4}	1.6×10^{-3}
72	1.2×10^{-4}	3.1×10^{-4}	3.3×10^{-4}	2.3×10^{-3}
96	2.4×10^{-5}	1.9×10^{-4}	2.4×10^{-4}	1.8×10^{-3}
120	9.6×10^{-6}	1.5×10^{-4}	2.2×10^{-4}	2.6×10^{-3}
144	5.3×10^{-5}	9.1×10^{-5}	1.2×10^{-4}	3.2×10^{-3}

TABLE B-23. CURIUM-243 DOSE RECOVERED FROM DAIRY GOAT 6C AFTER AN INTRAVENOUS DOSE OF CURIUM CHLORIDE

Time After Dosing (h)	Blood Plasma (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
8	2.9×10^{-4}	1.9×10^{-3}	8.1×10^{-3}	4.3×10^{-5}
24	2.5×10^{-4}	5.0×10^{-4}	3.1×10^{-3}	4.9×10^{-4}
48	1.5×10^{-4}	2.3×10^{-4}	5.1×10^{-4}	1.6×10^{-3}
72	1.0×10^{-4}	1.4×10^{-4}	3.8×10^{-4}	8.9×10^{-4}
96	1.4×10^{-5}	8.2×10^{-5}	2.7×10^{-4}	9.1×10^{-4}
120	1.4×10^{-5}	6.3×10^{-5}	2.0×10^{-4}	1.1×10^{-3}
144	3.4×10^{-5}	4.3×10^{-5}	1.6×10^{-4}	7.2×10^{-4}

TABLE B-24. CURIUM-243 DOSE RETAINED IN CAPRINE TISSUE

Tissue	Sacrificed 7 Days After Single Oral Dose of Curium Chloride			Sacrificed 7 Days After Single I.V. Dose of Citrate-Buffered Curium Chloride		
	Goat 1C	Goat 2C	Goat 3C	Goat 4C	Goat 5C	Goat 6C
Diaphysis	2.4×10^{-10}	1.0×10^{-6}	1.0×10^{-6}	5.3×10^{-3}	3.8×10^{-3}	1.3×10^{-2}
Epiphysis	1.0×10^{-7}	1.4×10^{-6}	1.0×10^{-6}	5.0×10^{-3}	4.5×10^{-3}	9.7×10^{-3}
Sternum	4.6×10^{-6}	5.0×10^{-7}	5.0×10^{-7}	5.7×10^{-3}	9.0×10^{-3}	9.7×10^{-3}
Liver	6.7×10^{-7}	2.5×10^{-6}	2.5×10^{-6}	3.0×10^{-2}	4.6×10^{-2}	5.1×10^{-2}
Kidney	4.0×10^{-7}	5.0×10^{-7}	1.0×10^{-6}	7.3×10^{-2}	1.1×10^{-2}	1.4×10^{-2}
Lung	-	2.4×10^{-7}	3.7×10^{-8}	9.1×10^{-4}	1.5×10^{-3}	1.5×10^{-3}
Muscle	8.7×10^{-9}	6.9×10^{-9}	1.8×10^{-8}	1.6×10^{-4}	4.3×10^{-4}	2.0×10^{-4}
Spleen	2.0×10^{-7}	-	4.3×10^{-8}	7.2×10^{-5}	9.0×10^{-4}	1.9×10^{-3}
Heart	1.5×10^{-7}	3.0×10^{-7}	3.0×10^{-7}	1.0×10^{-3}	2.6×10^{-3}	1.2×10^{-3}
Thyroid	-	-	-	1.2×10^{-3}	2.2×10^{-3}	1.7×10^{-3}
Adrenal	-	-	-	1.5×10^{-4}	1.6×10^{-3}	1.0×10^{-3}
Mammary gland	2.5×10^{-7}	2.0×10^{-7}	-	4.4×10^{-3}	3.2×10^{-3}	2.4×10^{-3}
Gonads	-	-	-	8.0×10^{-4}	1.9×10^{-3}	1.7×10^{-3}

TABLE B-25. CURIUM-243 DOSE RECOVERED FROM DAIRY COW 256
AFTER AN ORAL DOSE OF CURIUM CHLORIDE

Time After Dosing (h)	Blood Plasma (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
8	1.0×10^{-8}	7.3×10^{-10}	7.5×10^{-9}	-
24	1.5×10^{-8}	7.8×10^{-9}	6.8×10^{-8}	1.6×10^{-3}
48	1.3×10^{-8}	2.1×10^{-8}	1.3×10^{-7}	3.8×10^{-3}
72	5.3×10^{-9}	1.6×10^{-8}	6.3×10^{-8}	3.1×10^{-3}
96	2.7×10^{-9}	7.7×10^{-9}	3.5×10^{-8}	1.7×10^{-3}
120	1.5×10^{-9}	4.7×10^{-9}	1.9×10^{-8}	6.1×10^{-4}
144	1.3×10^{-9}	3.0×10^{-9}	1.3×10^{-8}	2.5×10^{-7}

TABLE B-26. CURIUM-243 DOSE RECOVERED FROM DAIRY COW 344
AFTER AN INTRAVENOUS DOSE OF CURIUM CHLORIDE

Time After Dosing (h)	Blood Plasma (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
8	2.6×10^{-5}	7.5×10^{-5}	8.3×10^{-4}	2.3×10^{-6}
24	2.7×10^{-5}	5.7×10^{-5}	1.2×10^{-4}	2.3×10^{-5}
48	2.1×10^{-5}	3.5×10^{-5}	5.8×10^{-5}	1.8×10^{-5}
72	1.5×10^{-5}	2.4×10^{-5}	5.8×10^{-5}	1.5×10^{-5}
96	6.2×10^{-6}	1.4×10^{-5}	3.7×10^{-5}	9.6×10^{-6}
120	4.0×10^{-6}	7.3×10^{-6}	2.3×10^{-5}	6.6×10^{-6}
144	2.8×10^{-6}	5.1×10^{-6}	1.7×10^{-5}	4.7×10^{-6}

TABLE B-27. CURIUM-243 DOSE RETAINED IN BOVINE TISSUE

Tissue	Sacrificed 7 Days After Single Oral Dose of Curium Chloride	Sacrificed 7 Days After Single I.V. Dose of Citrate-Buffered Curium Chloride
	Cow 256 (%/)	Cow 344 (%/)
Diaphysis	6.8×10^{-8}	3.4×10^{-4}
Epiphysis	8.0×10^{-8}	4.2×10^{-4}
Sternum	1.6×10^{-7}	6.4×10^{-4}
Liver	6.6×10^{-7}	2.5×10^{-3}
Kidney	3.1×10^{-7}	9.9×10^{-4}
Lung	6.9×10^{-8}	2.2×10^{-4}
Muscle	3.8×10^{-9}	9.4×10^{-6}
Spleen	5.8×10^{-8}	2.9×10^{-4}
Heart	8.0×10^{-8}	2.1×10^{-4}
Thyroid	2.7×10^{-8}	1.0×10^{-4}
Adrenal	3.1×10^{-8}	2.5×10^{-4}
Mammary gland	1.1×10^{-7}	2.4×10^{-4}
Gonads	5.0×10^{-8}	1.4×10^{-4}

TABLE B-28. AMERICIUM-241 DOSE RECOVERED FROM DAIRY
GOAT 1A AFTER AN ORAL DOSE OF AMERICIUM NITRATE

Time After Dosing (h)	Blood Plasma (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
8	5.8×10^{-8}	3.8×10^{-9}	8.5×10^{-9}	5.2×10^{-7}
24	1.2×10^{-7}	1.1×10^{-7}	6.3×10^{-7}	4.9×10^{-3}
48	4.7×10^{-8}	7.1×10^{-8}	2.6×10^{-7}	7.4×10^{-2}
72	2.7×10^{-8}	1.1×10^{-7}	1.7×10^{-7}	2.0×10^{-2}
96	1.4×10^{-8}	2.3×10^{-8}	1.3×10^{-7}	3.4×10^{-3}
120	1.4×10^{-8}	3.9×10^{-8}	7.8×10^{-8}	7.6×10^{-4}
144	9.3×10^{-9}	1.7×10^{-8}	5.9×10^{-8}	2.5×10^{-4}
168	7.0×10^{-9}	2.0×10^{-8}	4.5×10^{-8}	8.1×10^{-5}

TABLE B-29. AMERICIUM-241 DOSE RECOVERED FROM DAIRY
GOAT 2A AFTER AN ORAL DOSE OF AMERICIUM NITRATE

Time After Dosing (h)	Blood Plasma (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
8	1.4×10^{-8}	2.8×10^{-9}	6.4×10^{-8}	7.3×10^{-9}
24	1.2×10^{-8}	2.0×10^{-7}	1.7×10^{-7}	5.2×10^{-2}
48	8.5×10^{-9}	3.4×10^{-6}	9.3×10^{-8}	3.6×10^{-2}
72	6.7×10^{-9}	1.1×10^{-7}	4.5×10^{-8}	1.3×10^{-2}
96	5.8×10^{-9}	6.6×10^{-8}	3.9×10^{-8}	2.7×10^{-3}
120	5.1×10^{-9}	2.6×10^{-8}	2.9×10^{-8}	5.2×10^{-4}
144	4.1×10^{-9}	2.1×10^{-8}	3.3×10^{-8}	1.3×10^{-4}
168	4.1×10^{-9}	1.8×10^{-7}	2.0×10^{-8}	6.0×10^{-5}

TABLE B-30. AMERICIUM-241 DOSE RECOVERED FROM DAIRY
GOAT 4A AFTER AN INTRAVENOUS DOSE OF AMERICIUM NITRATE

Time After Dosing (h)	Blood Plasma (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
8	2.8×10^{-4}	1.0×10^{-3}	2.9×10^{-3}	1.0×10^{-4}
24	1.2×10^{-4}	1.6×10^{-4}	4.2×10^{-4}	3.8×10^{-4}
48	1.2×10^{-5}	6.6×10^{-5}	1.5×10^{-4}	4.6×10^{-4}
72	5.3×10^{-5}	4.1×10^{-5}	7.5×10^{-5}	2.7×10^{-4}
96	2.6×10^{-5}	3.1×10^{-5}	1.0×10^{-4}	2.2×10^{-4}
120	2.1×10^{-5}	3.6×10^{-5}	9.9×10^{-5}	2.1×10^{-4}
144	2.9×10^{-5}	2.5×10^{-5}	4.6×10^{-5}	1.8×10^{-4}
168	2.2×10^{-5}	2.1×10^{-5}	4.3×10^{-5}	2.0×10^{-4}

TABLE B-31. AMERICIUM-241 DOSE RECOVERED FROM DAIRY
GOAT 5A AFTER AN INTRAVENOUS DOSE OF AMERICIUM NITRATE

Time After Dosing (h)	Blood Plasma (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
8	2.4×10^{-4}	1.2×10^{-3}	3.7×10^{-3}	1.1×10^{-5}
24	1.1×10^{-4}	2.1×10^{-4}	6.8×10^{-4}	3.2×10^{-4}
48	6.8×10^{-5}	7.8×10^{-5}	2.3×10^{-4}	2.9×10^{-4}
72	4.7×10^{-5}	4.7×10^{-5}	1.4×10^{-4}	2.5×10^{-4}
96	3.3×10^{-5}	3.8×10^{-5}	1.3×10^{-4}	2.5×10^{-4}
120	2.1×10^{-5}	3.9×10^{-5}	1.1×10^{-4}	3.5×10^{-4}
144	2.3×10^{-5}	3.3×10^{-5}	7.6×10^{-5}	3.3×10^{-4}
168	1.4×10^{-5}	3.8×10^{-5}	8.7×10^{-5}	3.4×10^{-4}

TABLE B-32. AMERICIUM-241 DOSE RETAINED IN CAPRINE TISSUE

Tissue	Sacrificed 8 Days After Single Oral Dose of Americium Nitrate		Sacrificed 8 Days After Single I.V. Dose of Citrate-Buffered Americium Nitrate	
	Goat 1A (%/g)	Goat 2A (%/g)	Goat 4A (%/g)	Goat 5A (%/g)
Diaphysis	1.4×10^{-6}	3.5×10^{-7}	3.0×10^{-3}	4.1×10^{-3}
Epiphysis	1.7×10^{-6}	3.7×10^{-7}	5.1×10^{-3}	7.5×10^{-3}
Sternum	1.7×10^{-6}	3.5×10^{-7}	4.7×10^{-3}	6.1×10^{-3}
Vertebra	8.1×10^{-7}	2.9×10^{-7}	4.0×10^{-3}	5.3×10^{-3}
Rib	1.4×10^{-6}	2.7×10^{-7}	6.1×10^{-3}	7.5×10^{-3}
Liver	1.4×10^{-5}	1.8×10^{-6}	5.5×10^{-2}	5.8×10^{-2}
Kidney	2.1×10^{-6}	4.1×10^{-7}	8.2×10^{-3}	5.8×10^{-3}
Lung	2.0×10^{-7}	4.1×10^{-8}	1.5×10^{-3}	6.6×10^{-4}
Spleen	1.1×10^{-7}	2.4×10^{-8}	5.6×10^{-3}	3.0×10^{-4}
Thyroid	1.0×10^{-7}	5.9×10^{-8}	7.1×10^{-3}	4.7×10^{-4}
Muscle	5.7×10^{-8}	3.0×10^{-8}	4.1×10^{-4}	1.6×10^{-4}
Gonads	-	3.9×10^{-8}	8.7×10^{-3}	7.3×10^{-4}
Heart	2.1×10^{-7}	3.0×10^{-8}	1.6×10^{-3}	5.5×10^{-4}
Mammary gland	7.5×10^{-7}	1.2×10^{-7}	2.1×10^{-3}	2.9×10^{-3}
Lymph nodes	3.0×10^{-7}	-	1.4×10^{-3}	2.5×10^{-3}
Adrenals	7.4×10^{-8}	-	4.9×10^{-4}	4.1×10^{-4}

TABLE B-33. AMERICIUM-241 DOSE RECOVERED FROM DAIRY COW 280
AFTER AN INTRAVENOUS DOSE OF AMERICIUM CHLORIDE

Time After Dosing (h)	Blood Plasma (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
8	1.6×10^{-4}	-	4.3×10^{-4}	1.6×10^{-4}
12	4.0×10^{-5}	2.3×10^{-4}	1.5×10^{-4}	5.1×10^{-5}
24	5.3×10^{-5}	1.9×10^{-4}	1.3×10^{-4}	4.2×10^{-5}
48	2.1×10^{-5}	6.4×10^{-5}	7.6×10^{-5}	4.1×10^{-5}
72	1.3×10^{-5}	4.1×10^{-5}	5.2×10^{-5}	2.3×10^{-5}
96	7.4×10^{-6}	2.9×10^{-5}	3.0×10^{-5}	1.8×10^{-5}
120	1.1×10^{-5}	2.2×10^{-5}	2.3×10^{-5}	1.3×10^{-5}
144	1.1×10^{-5}	1.6×10^{-5}	2.0×10^{-5}	1.1×10^{-5}
168	8.1×10^{-6}	1.5×10^{-5}	-	8.3×10^{-6}

TABLE B-34. AMERICIUM-241 DOSE RECOVERED FROM DAIRY COW 184
AFTER AN INTRAVENOUS DOSE OF AMERICIUM CHLORIDE

Time After Dosing (h)	Blood Plasma (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
8	8.1×10^{-5}	-	6.5×10^{-4}	2.5×10^{-5}
12	7.8×10^{-5}	7.9×10^{-5}	1.7×10^{-4}	2.2×10^{-5}
24	2.8×10^{-5}	6.4×10^{-5}	6.1×10^{-5}	2.0×10^{-5}
48	1.4×10^{-5}	1.5×10^{-5}	4.0×10^{-5}	8.4×10^{-6}
72	8.5×10^{-6}	8.3×10^{-6}	2.8×10^{-5}	6.5×10^{-6}
96	6.0×10^{-6}	5.6×10^{-6}	1.7×10^{-5}	4.4×10^{-6}
120	4.1×10^{-6}	4.3×10^{-6}	1.4×10^{-5}	3.1×10^{-6}
144	3.4×10^{-6}	3.1×10^{-6}	1.2×10^{-5}	3.7×10^{-6}
168	2.6×10^{-6}	2.6×10^{-6}	-	4.5×10^{-6}

TABLE B-35. AMERICIUM-241 DOSE RECOVERED FROM DAIRY COW 269
AFTER AN ORAL DOSE OF AMERICIUM CHLORIDE

Time After Dosing (h)	Blood Plasma (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
8	1.7×10^{-9}	-	3.0×10^{-9}	9.5×10^{-6}
12	7.1×10^{-9}	2.0×10^{-8}	1.8×10^{-8}	1.2×10^{-3}
24	1.1×10^{-8}	2.6×10^{-9}	3.1×10^{-8}	2.2×10^{-3}
48	1.3×10^{-8}	1.2×10^{-8}	6.7×10^{-8}	2.8×10^{-3}
72	4.1×10^{-9}	8.4×10^{-9}	2.6×10^{-8}	1.8×10^{-3}
96	9.3×10^{-10}	6.5×10^{-9}	1.5×10^{-8}	5.4×10^{-5}
120	1.6×10^{-9}	2.6×10^{-9}	8.0×10^{-9}	1.2×10^{-4}
144	8.5×10^{-10}	1.5×10^{-9}	5.6×10^{-9}	2.5×10^{-5}
168	9.0×10^{-10}	1.6×10^{-9}	4.6×10^{-9}	8.1×10^{-6}

TABLE B-36. AMERICIUM-241 DOSE RECOVERED FROM DAIRY COW 281
AFTER AN ORAL DOSE OF AMERICIUM CHLORIDE

Time After Dosing (h)	Blood Plasma (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
8	4.9×10^{-10}	-	1.1×10^{-9}	6.5×10^{-9}
12	3.8×10^{-9}	2.1×10^{-9}	6.1×10^{-9}	6.5×10^{-7}
24	4.7×10^{-9}	1.2×10^{-9}	9.8×10^{-9}	1.7×10^{-4}
48	5.9×10^{-9}	6.1×10^{-9}	2.0×10^{-8}	1.2×10^{-3}
72	5.0×10^{-9}	7.6×10^{-9}	2.1×10^{-8}	2.8×10^{-3}
96	6.9×10^{-9}	5.7×10^{-9}	1.4×10^{-8}	2.0×10^{-3}
120	1.2×10^{-8}	4.0×10^{-9}	1.1×10^{-8}	1.1×10^{-3}
144	6.1×10^{-10}	2.6×10^{-9}	4.9×10^{-9}	4.6×10^{-4}
168	7.7×10^{-10}	1.4×10^{-9}	3.8×10^{-9}	1.4×10^{-4}

TABLE B-37. AMERICIUM-241 DOSE RETAINED IN BOVINE TISSUE

Tissue	Sacrificed 8 Days After Single Oral Dose of Americium Chloride		Sacrificed 9 Days After Single I.V. Dose of Citrate-Buffered Americium Chloride	
	Cow 281	Cow 269	Cow 184	Cow 280
	(%/g)	(%/g)	(%/g)	(%/g)
Diaphysis	2.8×10^{-8}	4.1×10^{-8}	2.5×10^{-4}	3.6×10^{-4}
Epiphysis	6.0×10^{-8}	5.5×10^{-8}	5.7×10^{-4}	6.4×10^{-4}
Sternum	1.1×10^{-7}	6.5×10^{-8}	5.7×10^{-4}	7.9×10^{-4}
Vertebra	6.9×10^{-8}	7.8×10^{-8}	4.3×10^{-4}	8.8×10^{-4}
Rib	4.3×10^{-8}	4.7×10^{-8}	2.6×10^{-4}	6.2×10^{-4}
Liver	4.4×10^{-7}	4.2×10^{-7}	4.7×10^{-3}	3.0×10^{-3}
Kidney	1.7×10^{-7}	1.4×10^{-7}	7.3×10^{-4}	1.6×10^{-3}
Lung	7.3×10^{-8}	3.0×10^{-8}	1.8×10^{-4}	3.5×10^{-4}
Spleen	4.0×10^{-8}	2.6×10^{-8}	2.4×10^{-4}	3.0×10^{-4}
Thyroid	1.7×10^{-8}	7.6×10^{-9}	5.4×10^{-5}	8.7×10^{-5}
Gonads	2.2×10^{-8}	2.6×10^{-8}	1.3×10^{-4}	2.2×10^{-4}
Muscle	4.2×10^{-9}	3.1×10^{-9}	2.1×10^{-5}	1.8×10^{-5}
Heart	1.1×10^{-7}	4.0×10^{-8}	1.7×10^{-4}	4.0×10^{-4}
Lymph nodes	3.0×10^{-8}	2.5×10^{-8}	1.4×10^{-4}	3.8×10^{-4}
Mammary gland	5.4×10^{-8}	3.1×10^{-8}	2.5×10^{-4}	7.1×10^{-4}
Plasma	6.1×10^{-10}	7.3×10^{-10}	1.4×10^{-6}	2.7×10^{-6}

TABLE B-38. NEPTUNIUM-234 DOSE RECOVERED FROM GOAT 1N AFTER
AN ORAL DOSE OF NEPTUNIUM CHLORIDE

Time After Dosing (h)	Blood Plasma (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
29	6.3×10^{-6}	2.9×10^{-6}	1.5×10^{-4}	2.7×10^{-2}
53	5.6×10^{-6}	5.9×10^{-6}	2.0×10^{-4}	4.4×10^{-2}
77	2.0×10^{-6}	1.2×10^{-6}	8.2×10^{-6}	8.4×10^{-3}
101	1.6×10^{-6}	6.5×10^{-7}	6.8×10^{-6}	1.9×10^{-3}

TABLE B-39. NEPTUNIUM-234 DOSE RECOVERED FROM GOAT 2N AFTER AN ORAL DOSE OF NEPTUNIUM CHLORIDE

Time After Dosing (h)	Blood Plasma (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
29	5.8×10^{-6}	2.3×10^{-6}	8.2×10^{-5}	3.5×10^{-2}
53	3.8×10^{-6}	2.6×10^{-6}	5.4×10^{-5}	5.3×10^{-2}
77	2.3×10^{-6}	1.2×10^{-6}	9.0×10^{-6}	1.4×10^{-2}
101	1.8×10^{-6}	2.4×10^{-7}	2.5×10^{-6}	3.1×10^{-3}

TABLE B-40. NEPTUNIUM-234 DOSE RECOVERED FROM GOAT 3N AFTER AN INTRAVENOUS DOSE OF CITRATE-BUFFERED NEPTUNIUM CHLORIDE

Time After Dosing (h)	Blood Plasma (%/g)	Milk (%/g)	Urine (%/g)	Feces (%/g)
29	3.3×10^{-4}	5.3×10^{-5}	1.2×10^{-3}	3.4×10^{-5}
53	9.1×10^{-5}	1.8×10^{-5}	6.0×10^{-4}	2.1×10^{-6}
77	6.1×10^{-5}	1.2×10^{-5}	3.1×10^{-4}	1.5×10^{-6}
101	4.2×10^{-5}	5.5×10^{-6}	1.7×10^{-4}	1.1×10^{-6}

TABLE B-41. NEPTUNIUM-234 DOSE RETAINED IN CAPRINE TISSUE

Tissue	Sacrificed 5 Days After Single Oral Dose of Citrate-Buffered Neptunium Chloride		Sacrificed 5 Days After Single I.V. Dose of Citrate-Buffered Neptunium Chloride
	Goat 1N (%/g)	Goat 2N (%/g)	Goat 3N (%/g)
Bone	3.3×10^{-6}	4.8×10^{-7}	7.3×10^{-3}
Liver	1.5×10^{-5}	1.4×10^{-5}	5.1×10^{-3}
Kidney	3.9×10^{-5}	4.7×10^{-5}	4.6×10^{-3}
Spleen	4.1×10^{-7}	3.4×10^{-5}	2.4×10^{-4}
Lung	1.4×10^{-6}	2.2×10^{-7}	2.6×10^{-4}
Heart	2.8×10^{-6}	1.8×10^{-7}	1.8×10^{-4}
Lymph nodes	1.3×10^{-5}	$<1.0 \times 10^{-8}$	2.0×10^{-4}
Mammary gland	1.3×10^{-6}	1.3×10^{-6}	1.4×10^{-5}
Adrenals	4.1×10^{-6}	$<1.0 \times 10^{-8}$	5.1×10^{-4}
Thyroid	7.3×10^{-5}	$<1.0 \times 10^{-8}$	1.3×10^{-4}
Muscle	6.5×10^{-7}	3.0×10^{-7}	3.3×10^{-5}

TABLE B-42. BACKGROUND INFORMATION ON DAIRY COWS GIVEN A SINGLE ORAL DOSE OF MIXED ^{238}Pu AND ^{239}Pu DIOXIDES

Animal No.	Dose, mCi		Activity Ratio ¹ in Dose	Mass Ratio ¹ in Dose	Animal Dose Day	Weight, Kg Sacrifice Day	Average Daily Output, Kg Per Day				Days Lactating ³
	^{238}Pu	^{239}Pu					Milk Previous to Study ²	During Study	Urine During Study	Feces During Study	
351	1.73	1.62	1.07	0.0034	553	510	25	19	27	34	86
349	2.30	2.16	1.06	0.0034	626	599	17	14	26	29	136
352	43.3	1.38	31.4	0.100	635	594	19	14	26	34	125
346	Control		-	-	628	556	22	22	19	25	32

¹Ratios used hereafter in the series of tables on this study are the activity ratios normalized to indicate differences in metabolism; a ratio of unity indicates the activity ratio in a sample was the same as that in the ^{238}Pu and ^{239}Pu dose administered. Ratios are always ^{238}Pu , ^{239}Pu .

²During week of August 18, 1977.

³As of November 14, 1977 (Dose Day). All cows in second lactation.

TABLE B-43. PLUTONIUM-238 AND PLUTONIUM-239 RECOVERED FROM COW 351
AFTER A SINGLE ORAL DOSE OF MIXED PLUTONIUM OXIDES*

Time After Dosing (h)	^{238}Pu (% x 10^{-10} /g)	Serum ^{239}Pu (% x 10^{-10} /g)	Ratio**	^{238}Pu (% x 10^{-10} /g)	Milk ^{239}Pu (% x 10^{-10} /g)	Ratio**	^{238}Pu (% x 10^{-10} /g)	Urine ^{239}Pu (% x 10^{-10} /g)	Ratio**
24	0.68	0.76	0.90	-	-	-	-	-	-
48	1.6	1.0	1.6	6.4	5.2	1.2	ND	ND	-
72	-	-	-	5.0	4.2	1.2	-	-	-
96	0.47	0.38	1.2	2.4	1.9	1.3	0.38	0.24	1.6
120	-	-	-	2.3	1.8	1.2	-	-	-
144	0.65	0.54	1.2	1.3	1.0	1.3	0.22	0.10	2.2
Sac	0.30	1.0	.30	-	-	-	-	-	-

* 1.73 mCi plutonium-238 and 1.62 mCi plutonium-239; the two isotopes were homogeneously mixed within the same plutonium oxide particles, the mass median diameter of the particles was approximately 1.5 micrometer.

** Ratio normalized to indicate differences in metabolism; a ratio of unity indicates no difference. The data have not been corrected for normal background levels in samples.

ND Not detectable.

TABLE B-44. PLUTONIUM-238 AND PLUTONIUM-239 RECOVERED FROM COW 349
AFTER A SINGLE ORAL DOSE OF MIXED PLUTONIUM OXIDES*

Time After Dosing (h)	Serum		Ratio**	Milk		Ratio**	Urine		Ratio**
	^{238}Pu (% x 10^{-10} /g)	^{239}Pu (% x 10^{-10} /g)		^{238}Pu (% x 10^{-10} /g)	^{239}Pu (% x 10^{-10} /g)		^{238}Pu (% x 10^{-10} /g)	^{239}Pu (% x 10^{-10} /g)	
24	5.0	1.0	4.9	-	-	-	-	-	-
48	6.4	1.2	5.2	3.1	2.8	1.1	1.3	0.27	4.8
72	-	-	-	1.8	6.6	0.27	-	-	-
96	4.3	0.83	5.1	1.4	1.6	0.88	1.3	0.26	5.0
120	-	-	-	2.0	2.0	1.0	-	-	-
144	2.8	0.43	6.7	0.35	0.38	0.91	0.84	0.13	6.5
Sac	1.0	1.20	5.1	-	-	-	-	-	-

* 2.30 mCi plutonium-238 and 2.16 mCi plutonium-239; the two isotopes were not homogeneously mixed within the same plutonium oxide particles, the mass median diameter of the ^{238}Pu particles was approximately 1.5 micrometer and of the ^{239}Pu particles was approximately 1.0 micrometer.

**Ratio normalized to indicate differences in metabolism; a ratio of unity indicates no difference. The data have not been corrected for normal background levels in samples.

TABLE B-45. PLUTONIUM-238 AND PLUTONIUM-239 RECOVERED FROM COW 352
AFTER A SINGLE ORAL DOSE OF MIXED PLUTONIUM OXIDES*

Time After Dosing (h)	Serum		Ratio**	Milk		Ratio**	Urine		Ratio**
	^{238}Pu (% x $10^{-10}/\text{g}$)	^{239}Pu (% x $10^{-10}/\text{g}$)		^{238}Pu (% x $10^{-10}/\text{g}$)	^{239}Pu (% x $10^{-10}/\text{g}$)		^{238}Pu (% x $10^{-10}/\text{g}$)	^{239}Pu (% x $10^{-10}/\text{g}$)	
24	2.8	2.7	1.0	-	-	-	-	-	-
48	8.6	11.0	0.78	0.67	1.1	0.61	0.34	1.6	0.21
72	-	-	-	0.34	0.46	0.74	-	-	-
96	1.5	2.0	0.75	0.35	0.44	0.79	0.13	0.35	0.37
120	-	-	-	0.23	0.38	0.60	-	-	-
144	1.1	1.3	0.85	0.20	0.25	0.81	0.07	<0.22	<.32
Sac	0.68	0.66	1.0	-	-	-	-	-	-

* 43.3 mCi plutonium-238 and 1.38 mCi plutonium-239; the two isotopes were not homogeneously mixed within the same plutonium oxide particles, the mass median diameter of the particles was approximately 1.5 micrometer.

** Ratio normalized to indicate differences in metabolism; a ratio of unity indicates no difference. The data have not been corrected for normal plutonium background levels in samples.

TABLE B-46. PLUTONIUM-238 AND PLUTONIUM-239 RECOVERED FROM COWS 7
DAYS AFTER A SINGLE ORAL DOSE OF PLUTONIUM OXIDES

Tissue (h)	Cow 351			Cow 349			Cow 352		
	$\frac{^{238}\text{Pu}}{(\% \times 10^{-10}/\text{g})}$	$\frac{^{239}\text{Pu}}{(\% \times 10^{-10}/\text{g})}$	Ratio*	$\frac{^{238}\text{Pu}}{(\% \times 10^{-10}/\text{g})}$	$\frac{^{239}\text{Pu}}{(\% \times 10^{-10}/\text{g})}$	Ratio*	$\frac{^{238}\text{Pu}}{(\% \times 10^{-10}/\text{g})}$	$\frac{^{239}\text{Pu}}{(\% \times 10^{-10}/\text{g})}$	Ratio*
Liver	6.3	6.3	1.0	13.	3.5	3.8	6.0	8.0	0.75
Spleen	6.1	5.7	1.1	6.6	3.9	1.7	7.4	14.	0.52
Bile	3.1	0.59	5.3	1.1	0.34	3.3	0.16	0.61	0.26
Kidney	3.6	2.9	1.2	0.59	0.22	2.7	1.0	1.6	0.63
Lung	5.4	1.9	2.8	35.	4.6	7.6	1.9	5.3	0.36
Heart	0.67	0.16	4.2	4.4	0.38	11.	0.18	0.44	0.42
Gonads	39.	1.5	25.	2.5	2.2	1.1	0.79	1.3	0.60
Lymph nodes	34.	12.	2.9	-	-	-	-	-	-
Mammary	3.5	2.5	1.4	12.	25.	0.47	1.9	5.3	0.37
Adrenal	45.	14.	3.2	13.	35.	0.37	2.7	8.5	0.32
Muscle	10.	11.	1.0	6.9	7.8	0.89	26.	32.	0.83
Plasma	0.30	1.0	0.30	1.0	0.20	5.0	0.68	0.66	1.0
Femur	-	-	-	-	-	-	-	-	-
Epiphysis	11.	3.1	3.7	13.	2.9	4.4	2.9	5.6	0.52
Diaphysis	6.1	>0.4	>15.	6.2	9.4	0.66	4.0	3.7	0.11
Sternum	12.	4.4	2.7	2.2	9.4	2.3	5.0	9.2	0.55

* Activity ratio normalized to indicate differences in metabolism; a ratio of unity indicates no difference. Data are not corrected for normal background plutonium levels in tissues.

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