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Monitoring Systems Research and Development Division
Environmental Monitoring and Support Laboratory - Las Vegas
U.S. ENVIRONMENTAL PROTECTION AGENCY
Las Vegas, NV 89114

January 1976

This study performed under a Memorandum
of Understanding No. AT(26-1)-539
for the
U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

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by
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Effective June 29, 1975, the National Environmental Research Center-Las Vegas (NERC-LV) was designated the Environmental Monitoring and Support Laboratory-Las Vegas (EMSL-LV). This Laboratory is one of three Environmental Monitoring and Support Laboratories of the Office of Monitoring and Technical Support in the U.S. Environmental Protection Agency's Office of Research and Development.

ABSTRACT

During 1972, cattle from three different herds on and around the Nevada Test Site were sampled to determine the tissue burdens of plutonium and uranium. The only other isotopes detected in tissues were ^{90}Sr, ^{131}I, ^{137}Cs, and ^{3}H, although ^{95}Zr, ^{103}Ru, ^{140}Ba, and ^{141}Ce were frequently found in rumen contents. The herds sampled were: (1) a control herd from Searchlight, Nevada; (2) a herd from Area 18, the Nevada Test Site; and (3) a herd grazing in the Operation Roller Coaster Area of the Tonopah Test Range, where four chemical detonations involving plutonium were conducted in 1963.

The ^{90}Sr content of bone ash was similar to that measured in other ruminants sampled in past years. The thyroids of cattle sacrificed in May 1972 contained ^{131}I ranging from 2 to 76 pCi/g which was attributed to fallout from a nuclear test conducted on the Chinese mainland on March 8, 1972. Elevated tritium levels were found in the blood of selected cattle from the Roller Coaster herd which were maintained in the feedlot on the Nevada Test Site near the Sedan crater, the site of a nuclear test conducted in 1962.

The uranium content of the tissues sampled was relatively consistent among the three herds; however, the geometric mean ^{239}Pu was about 20 times higher in femurs from the Roller Coaster cattle than in femurs from the Searchlight cattle. On the other hand, this ratio was much lower in edible tissues. The hypothetical maximum bone dose from plutonium and uranium for a man, accrued while ingesting 250 g/day for 50 years, was calculated to be about 10 mrem from beef muscle and 19 mrem from beef liver. The yearly dose-rate values after the postulated 50-year ingestion period are less than 1% of the yearly guide of 500 mrem per year.

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INTRODUCTION

The biological studies working group of the Plutonium Studies Planning Group of the U.S. Atomic Energy Commission met at the National Environmental Research Center, Las Vegas, Nevada (NERC-LV)* on January 7, 1971, for the purpose of developing an applied experimental plan to support current and anticipated radiological safety needs of the testing program at the Nevada Test Site (NTS). Of particular concern to this group were the environmental effects of the actinides, especially the isotopes of plutonium. In order to assess the impact of an actual plutonium release into the ecosystem, studies are planned in which beef cattle, goats, and fistulated steers will live and graze over an area of known plutonium contamination.

Preparation for these studies included the collection of baseline data on plutonium levels in tissues from beef animals that lived their entire lives in the Reno, Nevada, area exposed to no radiation other than natural background radiation and worldwide fallout. Through the cooperation of the University of Nevada, Reno, selected tissues were collected as the source of baseline data from six beef animals as they were being processed through the abattoir.

Meanwhile, in February of 1972, three beef animals that grazed over the Tonopah Test Range (TTR) were purchased, sacrificed, necropsied, and sampled as part of the routine surveillance activities of the Animal Investigation Program of NERC-LV. These animals were from a commercial herd of approximately 300 to 500 animals that graze the TTR area the year round. An additional 2,000 animals graze in the area during the late fall, winter, and early spring months. Each year suitable animals

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*Effective January 19, 1975, the U.S. Atomic Energy Commission was designated the U.S. Energy Research and Development Administration. Effective June 29, 1975, the National Environmental Research Center-Las Vegas (NERC-LV) was designated the Environmental Monitoring and Support Laboratory-Las Vegas.

are removed and sold to feedlot operators and eventually enter the retail meat market.

Analysis of selected tissues from two of these animals indicated the presence of elevated levels of plutonium when compared to the baseline data from the Reno samples. The plutonium levels in these animals were thought to have resulted from grazing on areas contaminated during the events of Operation Roller Coaster, which was a joint United States and United Kingdom experiment to determine the plutonium hazards from non-nuclear accidents with plutonium-bearing weapons. Four chemical detonations involved such weapons. The events in this series and their dates were:

Double Track	May 15, 1963
Clean Slate I	May 25, 1963
Clean Slate II	May 31, 1963
Clean Slate III	June 9, 1963

Double Track and Clean Slate I and II released detectable levels of plutonium to off-site areas.[1]

When plutonium data from these animals were presented to the Ad Hoc Plutonium Committee, Nevada Applied Ecology Group of the U.S. Atomic Energy Commission Nevada Operations Office (NV/AEC) it was recommended that additional studies be initiated to develop more complete data concerning plutonium levels in cattle grazing on and near the Roller Coaster sites. Therefore, an experimental plan was developed which included the collection of a number of cattle samples from the TTR herd, from a control herd grazing a similar, but uncontaminated, range and from the NTS herd. The approximate grazing locations of these herds are shown on the map (Figure 1).

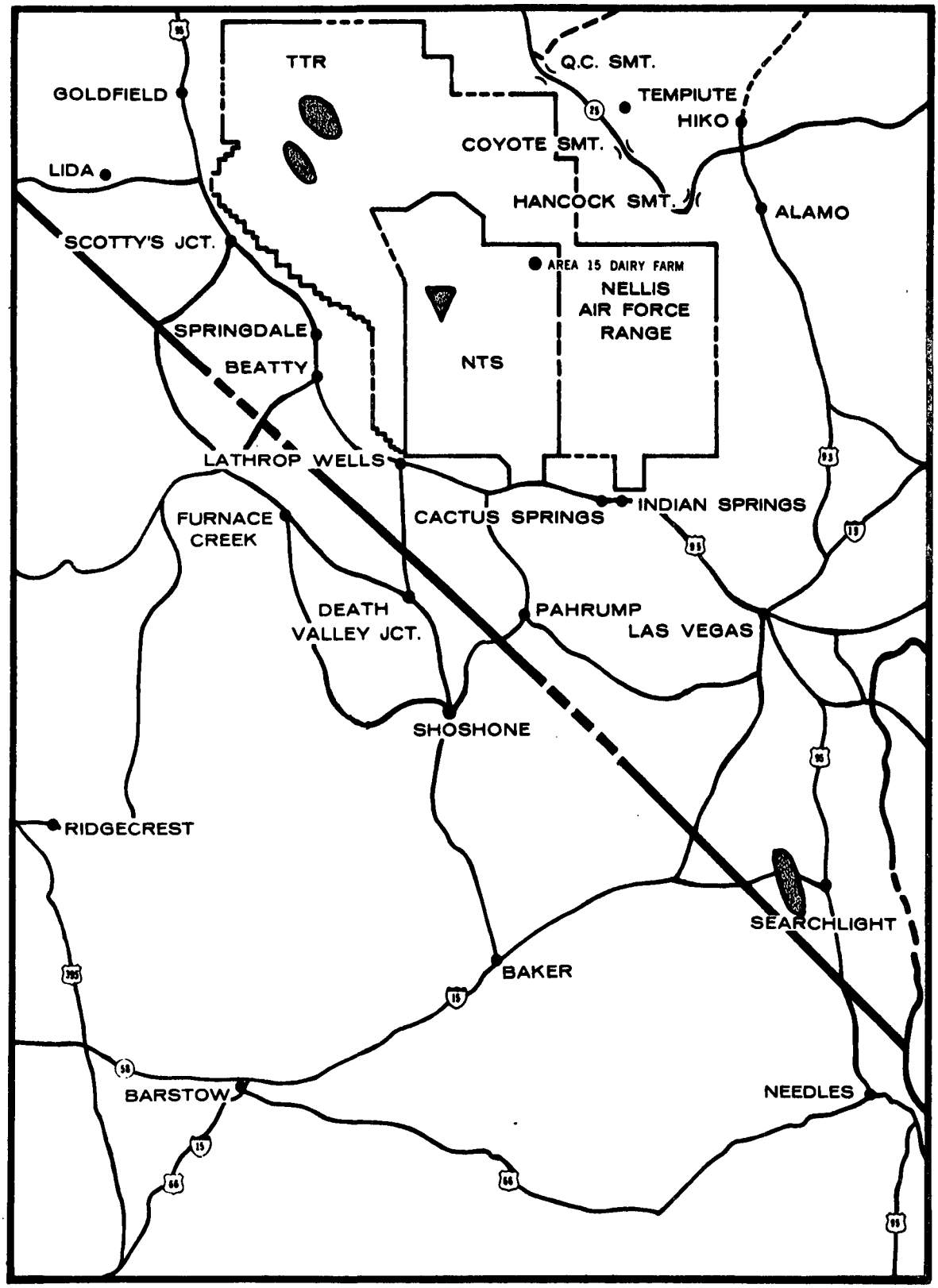

Figure 1. Approximate Grazing Locations of NTS, Roller Coaster, and Searchlight Cattle.

PROCEDURES

The study was designed to sample both mature and young beef animals from each of the three herds mentioned previously. The vital statistics of all study animals are presented in Table 1. After capture on the range, all animals were transported to the NTS abattoir for sacrifice, necropsy, and sampling. Unless otherwise noted, sacrificed cattle received no supplemental feed between capture and sacrifice. Sacrifice usually occurred within 24 hours of capture. Occasionally, because of testing activities, this period was extended to 48 hours. For identification purposes, the cattle from the TTR herd are hereinafter designated as Roller Coaster Cattle.

For the feedlot group, five young cattle from the Roller Coaster area were maintained in a feedlot at Area 15, NTS, from July 1 to October 19, 1972. They were then transported to the NTS facility for sacrifice, necropsy, and sampling.

All animals were sacrificed by firing a .243 caliber bullet into the brain. Immediately after death and exsanguination, each animal was necropsied and gross pathological conditions noted. The adrenals, eyes, heart, kidneys, liver, lungs, muscle, spleen, thyroid, and gonads of of each animal were sampled and prepared for histopathological evaluation. Tissues collected for radioanalysis included rumen contents, reticulum sediment, liver, lungs, tracheo-bronchial lymph nodes, muscle, thyroid, blood or urine, kidneys, fetus (if present), and bone (femur, ribs, and/or vertebrae), though not all analyses were performed on all tissues. Also, sufficient rumen contents were collected for botanical analysis.

Soil samples were collected from the Searchlight range. Sample locations (Appendix IV-11) were selected from undisturbed areas within the cattle grazing areas. The sampling method was that used by the Terrestrial Monitoring Branch of NERC-LV.[2] Each soil sample consisted of ten composited soil cores that were selected from an area of not less

Table 1. Vital Statistics of Study Cattle

Nevada Test Site Cattle

Cow No.	Date of Collection	Age	Location	Remarks
1	5/10/72	1 yr	Area 18, NTS	Hereford steer. Spent entire life in Area 18, NTS.
2	5/10/72	8 yrs	"	Hereford cow. Spent entire life in Area 18, NTS.
3	5/10/72	4 yrs	"	Hereford steer. Spent entire life in Area 18, NTS except for 3 months at Area 15 when on a tritium study.
4	5/10/72	1 yr	"	Hereford steer. Spent entire life in Area 18, NTS.
5	5/10/72	1 yr	"	Hereford steer. Spent entire life in Area 18, NTS.
6	5/10/72	14 yrs	Area 15, NTS	Holstein cow. Numerous radioiodine experiments, including Palanquin. Three-month-old fetus. Never grazed on range.
7	5/10/72	11½ yrs	"	Holstein cow. Cystic ovaries, not responsive to treatment Never grazed on range.

Roller Coaster Site Cattle

Cow No.	Date of Collection	Age	Location	Remarks
4	5/23/72	7 yrs	Tonopah Test Range	Hereford cow. Spent entire life on TTR. Caught NE of Antelope Springs on May 20, 1972.
5	5/23/72	1 yr	"	Brahma bull. Spent entire life on TTR. Caught SE of Antelope Springs on May 21, 1972.
6	5/23/72	2½ yrs	"	Hereford cow. Spent entire life on TTR. Caught at Able Gate on May 20, 1972.
7	5/23/72	2½ yrs	"	Angus cow. Spent entire life on TTR. Caught S end of Antelope Lake on May 21, 1972.
8	5/23/72	1 yr	"	Shorthorn steer. Spent entire life on TTR. Caught S end of Antelope Lake on May 21, 1972.

Table 1. Vital Statistics of Study Cattle (contd)

Roller Coaster Site Cattle

Cow No.	Date of Collection	Age	Location	Remarks
9	5/31/72	1 yr	Tonopah Test Range	Charolais steer. Spent entire life on TTR. Caught at Able Gate
10	5/31/72	1½ yrs	"	Hereford steer. Spent entire life on TTR. Caught at Able Gate.
11	5/31/72	1 yr	"	Hereford heifer. Spent entire life on TTR. Caught at Able Gate.
12	5/31/72	14+ yrs	"	Hereford cow. Spent entire life on TTR. Caught at Able Gate. Eight months pregnant.
12F	5/31/72	8 mo. fetus	"	Eight-month-old fetus of cow 12.
13	6/6/72	14+ yrs	"	Angus cow. Spent entire life on TTR. Caught at Able Gate.

Searchlight Cattle

Cow No.	Date of Collection	Age	Location	Remarks
1	6/13/72	8+ yrs	5 miles W of Searchlight, NV	Hereford cow. Lived three years at Searchlight; orginally from Sells, AZ. Contained 2½-month-old fetus.
2	6/13/72	1 yr	"	Hereford heifer. Spent entire life at Searchlight, NV. For last two months had received supplemental alfalfa hay while on range.
3	6/14/72	1 yr	"	Hereford heifer. Spent entire life at Searchlight, NV. For last two months had received supplemental alfalfa hay while on range.
4	6/14/72	8+ yrs	"	Hereford cow. Lived past three years at Searchlight; originally from Sells, AZ.
5	6/14/72	8+ yrs	"	Hereford cow. Lived past three years at Searchlight; originally from Sells, AZ. Uterus contained 2-month-old fetus.

Table 1. Vital Statistics of Study Cattle (contd)

Searchlight Cattle

Cow No.	Date of Collection	Age	Location	Remarks
6	6/14/72	8+ yrs	Five miles W of Searchlight, NV	Hereford cow. Lived past three years at Searchlight; orginally from Sells, AZ. Uterus contained 4-month-old fetus.
7	6/14/72	8+ yrs	"	Hereford cow. Lived past three years at Searchlight; originally from Sells, AZ. Uterus contained 2-month-old fetus.
8	6/14/72	1 yr	"	Hereford heifer. Spent entire life at Searchlight, NV. For last two months had received supplemental alfalfa hay while on range.
9	6/14/72	1 - 2 yrs	"	Hereford steer. Spent entire life at Searchlight, NV. For last two months had received supplemental alfalfa hay while on range.
10	6/14/72	1 yr	"	Hereford heifer. Spent entire life at Searchlight, NV. For last two months had received supplemental alfalfa hay while on range.

Table 1. Vital Statistics of Study Cattle (contd)

Roller Coaster Feedlot Cattle

Animal No.	Date of Collection	Age Years	Location	Remarks
14	10/19/72	1-1/2	Area 15, NTS 5/23/72-10/19/72	Hereford steer. Spent entire life on TTR except for period in feedlot at Area 15. Weight gain from 346 lbs to 617 lbs.
15	10/19/72	1-1/2	"	Hereford-Angus crossbred heifer. Spent entire life on TTR except for period in feedlot at Area 15. Weight gain from 425 lbs to 690 lbs.
16	10/19/72	2	Area 15, NTS 6/20/72-10/19/72	Hereford-Angus crossbred heifer. Spent entire life on TTR except for period in feedlot at Area 15. Weight gain from 676 lbs to 840 lbs.
17	10/19/72	1	"	Hereford-Angus crossbred heifer. Spent entire life on TTR except for period in feedlot at Area 15. Weight gain from 383 lbs to 573 lbs.
18	10/19/72	1-1/2	"	Hereford steer. Spent entire life on TTR except for period in feedlot at Area 15. Weight gain from 621 lbs to 837 lbs.
19	10/19/72	1/2	Area 15, NTS 5/14/72-10/19/72	Holstein steer. Born and raised at Area 15, NTS. Placed in feedlot on 1 July 72 to serve as a control. Final weight 465 lbs.

than 10 yards in diameter. The dimensions of each individual core were 10 cm by 10 cm in an area 5 cm deep. Therefore, the surface area of the total sample was 1,000 cm^2. Samples of feed and water consumed by the feedlot cattle were also collected for analysis.

Sample Analysis

All samples were analyzed by the Technical Support Laboratory of the NERC-LV. Replicate samples were not analyzed; however, plutonium analytical procedures described below as applied to soil analysis have been cross-calibrated with other laboratories. Plutonium-236 is used as a tracer and yield percentages are determined to indicate recovery. All data are reported at the 95% confidence level and are corrected to time of collection. The minimum detectable activity (MDA) for each radionuclide is listed in Appendix VII.

The soft tissues and rumen contents were prepared for gamma analysis by grinding and placing in 1,000-ml polyethylene Marinelli beakers. Those of smaller volume; i.e., thyroid, kidneys, etc., were prepared for analysis by macerating in a blender and suspending in an agar solution in a 400-ml container. The samples were counted for 100 minutes on a 4-inch by 4-inch NaI(Tl) crystal connected to 200 channels of a 400-channel pulse-height analyzer calibrated at 10 keV/channel.

Soft tissues and bone samples submitted for strontium, plutonium, and uranium analyses were prepared by a multi-stage ashing process. Initially the samples were oven dried at 105°C for 16 to 72 hours. The temperature was raised at intervals over an 8- to 48-hour period of time to a temperature of 480°C and ashed for 16 hours or more to produce an ash with the least possible amount of carbon (grey-black stage). At this point, in order to prevent fusion of the sample to the container, ashing was completed by nitric acid digestion. The radionuclide content of the sample is reported in pCi per kg of wet weight and pCi per g of ash; however, because of the variation in percent ash obtained with this procedure, it is recommended that the pCi/kg wet weight data be used when comparing data among tissues.

The plutonium was analyzed by alpha spectrometry.[3, 4, 5] The uranium analysis (unpublished) consisted of the dissolution of the tissue ash, separation by ion exchange, electroplating, and counting by alpha spectrometry. Other radionuclide analytical procedures used at NERC-LV were described previously.[5]

Tissue and lesion samples collected for histopathologic examination were first fixed in a 10% formalin solution. They were then prepared as 5-μm sections with hematoxylin and eosin stain and submitted to a pathologist for interpretation.

A 200- to 300-g sample of rumen content was collected for botanical analysis. These samples were frozen until analyzed. Samples were prepared by washing and screening a random aliquot, which was then examined under a binocular microscope. Individual species of browse, forbs, and grasses were identified by procedures described elsewhere.[6] After the species in the sample were identified, a visual estimate was made of the fraction of each species in the sample.

RESULTS

All of the results of radionuclide analysis are tabulated in the appendices to this report. Where ± values are included, they are the two-sigma counting errors. The median values as well as the range are also indicated for each tissue in each experimental group. In order, the appendices represent the following experimental groups of cattle:

A. Baseline group (Reno cattle) - Appendix I
B. Initial Roller Coaster group (TTR cattle) - Appendix II
C. Roller Coaster group (10 additional from TTR) - Appendix III
D. Control group (from Searchlight, Nevada) - Appendix IV
E. NTS group (five from Area 18, two dairy cows) - Appendix V
F. Feedlot group (five TTR cattle in Area 15 corrals for 4 to 5 months) - Appendix VI

The rumen contents collected from range animals contained the greatest variety of gamma-emitting radionuclides, with ^{95}Zr, ^{103}Ru, ^{140}Ba, and ^{141}Ce frequently detected. The levels in the rumen contents from cattle at all three range sites were similar. Of these radionuclides, only ^{137}Cs was detected in the muscle. Zirconium-95 was detected in the lungs of the NTS cattle. Lungs collected from animals grazing other sites were not analyzed by gamma spectroscopy, as the entire lung was ashed for actinide analysis.

The thyroids of all seven NTS cattle contained detectable levels of ^{131}I ranging from 2 to 21 pCi/g. All the thyroids, including that from a fetus, collected from Roller Coaster site cattle also contained ^{131}I ranging from 3.7 to 76 pCi/g. Only three of the thyroids collected from the Searchlight cattle, sacrificed several weeks after the NTS and Roller Coaster groups, contained detectable levels of ^{131}I. All of these elevated ^{131}I levels are attributed to a nuclear detonation conducted on March 8, 1972, by the People's Republic of China.[7]

Tritium levels detected in the blood of the range animals were at background levels except for one steer from the NTS beef herd (2,100 ± 240 pCi/l). However, this animal was utilized in an experiment

designed to determine the biological half-life of tritium in cattle and was injected intravenously with 50 mCi of HTO on March 8, 1971 (unpublished data). Blood from the two NTS dairy cows and the Roller Coaster feedlot cattle contained elevated levels of tritium. The Area 15 corrals where these animals were maintained (4 to 5 months for the feedlot animals, 8 years for the dairy cattle) are located within 2 miles of the Sedan crater, the site of a 1962 nuclear detonation, which was the probable source of their tritium exposure.

Detectable levels of ^{89}Sr in the bones of the study animals were infrequently reported. The ^{90}Sr levels in the femurs collected from animals of all four groups were very consistent, as the median values for the groups ranged from 3.0 to 5.1 pCi/g of ash. These values are consistent with those reported for other ruminants (cattle, deer, and desert bighorn sheep) of this area sampled during the past few years.[8, 9, 10, 11]

Rumen content samples for botanical analysis were not collected from the NTS cattle or from non-grazing animals (Roller Coaster feedlot animals). The generic makeup of the vegetation in the rumen contents from the Roller Coaster and Searchlight cattle was approximately the same, with grass species providing the majority of the diet on both ranges.

The botanical composition of the diet of the cattle ranging the Roller Coaster sites was as follows: forbs ranged from a trace to 2% with a median of 1%, shrubs ranged from a trace to 3% with a median of 1%, and the grasses ranged from 95% to over 99% with a median of 98%.

The forb percentage of the diet of the Searchlight cattle ranged from a trace to 4% with a median of 1%, shrubs provided a trace to 7% with a median of 2%, and grass species in the ingesta ranged from 89% to over 99% with a median of 97%.

Necropsies of the sacrificed animals revealed only incidental lesions. The necropsy protocols for each animal are on file at NERC-LV. The pathologist, Dr. W. C. Ward, of the Washington State University,

who conducted the microscopic examination of selected tissues concluded, "The lesions found in this group of animals are not significantly different from what one would expect to find in a normal population of the same age group." He also made the following general comments:

Heart - Sarcocysts were seen frequently. A lymphocytic infiltrate was seen in a few hearts and may be related to sarcocysts.

Ovary - Most of the ovaries appeared normal and active. A few cystic lesions were seen.

Kidney - The mononuclear infiltrates seen frequently in these kidneys are also commonly seen in other animals with the same frequency. The significance of their presence is unknown.

DISCUSSION

Possible reasons for discrepancies among the experimental animals, with regard to tritium concentration in blood and ^{131}I concentration in thyroid, were mentioned previously under the "Results" section. The variations in actinide concentrations result from several factors acting in concert. A reasonable hypothesis is that plutonium in worldwide fallout would consist of fairly small particulates which would be relatively uniformly deposited, thus minimizing sampling variation in environmental samples. However, the contamination on TTR, and probably on NTS Area 18, may consist of larger particulates which would cause larger variations in such samples. Therefore, the range of values found in the rumen content and reticulum sediment samples as reported in the Appendices is not unexpected.

In addition to the physical nature of the deposit and the expected biological variation, there may be a variation with age of the animal. When the concentration of plutonium in bone is plotted as a function of age for each experimental group, there is some indication of increasing concentration with increasing age. This hypothesis was tested statistically by the Mana-Whitney U-test with the result being a probability of between 95 and 99% that the concentration did increase with age. The data were too few to derive any explicit information on the type of buildup or the effective half-life.

One of the first considerations for manipulation of data is the form in which the data should be expressed so that comparison among experimental groups may be made. The median values, as shown in the tabulated data in the Appendices, are useful for some purposes and are easy to calculate. However, the mean value is more useful statistically. As with much biological data, the actinide concentrations in cattle appear to be distributed log-normally, so the log-normal means were calculated for each sample group and are displayed in Table 2. For this purpose, it was assumed that the variation with age was minor compared to other

variations. Furthermore, all "less than" values in the Appendices were divided by two for calculating these means.

A concise graphical depiction of the data from this project is shown in Figures 2 and 3. The log-normal mean and range for similar samples from each experimental group are shown so that visual comparison can be made.

The log-normal mean data from Table 2 can be used to draw some useful conclusions from the experiment. For example, the data are internally consistent since the $^{234}U/^{238}U$ ratios are close to 1.07 (pCi of ^{234}U to pCi of ^{238}U) which is the natural ratio, and the $^{238}U/^{235}U$ ratio is near 22, which is also the natural value. Of the tissues examined, the Pu/U ratio was generally highest in the liver, a finding that is consistent with other data indicating that the liver stores plutonium.[12] Both the lung and tracheo-bronchial lymph node data suggest that plutonium inhalation is higher for the NTS herd than for the Roller Coaster cattle. The higher uranium concentration and lower plutonium concentration in the dairy cows, compared to the rest of the NTS group, suggest different exposures and, therefore, two different populations from which the samples were drawn.

The suitability of the Searchlight herd as a baseline group is confirmed by the soil data shown in Appendix IV. The mean ^{239}Pu activity is 0.009 pCi/g soil which averages out to a ^{239}Pu deposition in that area of 0.61 mCi/km^2. The average deposition of plutonium in the U. S. of 1.7 mCi/km^2 is about 3 times that found in the Searchlight area. However, the ^{239}Pu concentration in femur was about 1.7 times and in the liver about 2.2 times that found in the Reno cattle in 1971. On the average, human bone contains about 1/3 times and human liver about 7 times the plutonium concentrations found in the Searchlight cattle. Some of the published baseline data on plutonium and uranium are shown in Table 3.

In Table 3, the average U.S. soil is reported as containing 0.76 μg of uranium per gram of soil (0.27 pCi of ^{234}U per gram), which is about

Table 2. Log-Normal Mean Actinide Concentrations in Cattle in pCi per kg Tissue

Group	Kidney	Rib	Femur	Vertebra	Liver	Lung	TBLN**	Muscle	Rumen Content	Reticulum Sediment
					Plutonium-238					
S(10)*		0.04	0.049		0.023	0.028	0.68	0.013	0.046	1.26
N(5)			0.048		0.076	0.16	0.53	0.061	0.43	
D(2)			0.10		0.14	0.18	0.53	0.035	0.16	
RC(10)		0.12	0.25		0.078	0.038	0.84	0.03	0.063	0.68
F(5)		0.27	0.28	0.18	0.27	0.043	0.45	0.015	0.062	2.0
C(1)		0.17	0.12	0.085	0.041	0.031	0.24	0.012	0.21	7.0
					Plutonium-239					
S		0.12	0.21		0.12	0.107	0.42	0.023	0.33	1.6
N			0.41		0.44	1.2	4.4	0.10	4.3	
D			0.28		0.66	1.06	16	0.18	6.3	
RC		1.8	4.02		0.83	0.43	2.3	0.044	0.79	1.3
F		5.4	4.6	5.8	4.5	0.29	0.49	0.174	1.3	11.2
C		0.11	0.38	0.34	0.32	0.042	0.18	0.012	3.6	134
R			0.12		0.054	0.027	1.32			
					Uranium-234					
S		0.47	0.72		0.064	0.17			1.90	260
N	0.46		0.38		0.19	0.28			1.7	
D	1.3		1.2		0.14	0.39			16	
RC	0.16	0.17	0.39		0.085	0.20			2.81	18
F		2.9	1.85	1.3	0.25	0.22	3.95	0.19	10.2	3,100
C		4.9	1.9	1.7	0.22	3.7	3.2	0.010	18	25,000

Table 2. Log-Normal Mean Actinide Concentrations in Cattle in pCi per kg Tissue (contd)

Group	Kidney	Rib	Femur	Vertebra	Liver	Lung	TBLN**	Muscle	Rumen Content	Reticulum Sediment
					Uranium-235					
S		0.021	0.030		0.0073	0.017			0.052	11
N	0.015		0.014		0.013	0.013			0.065	
D	0.055		0.04		0.01	0.019			0.52	
RC	0.014	0.008	0.015		0.015	0.019			0.11	0.88
F		0.098	0.055	0.065	0.014	0.008	0.28	0.028	0.34	95
C		0.18	0.094	0.085	0.012	0.40	0.18	0.010	0.60	1,100
					Uranium-238					
S		0.53	0.63		0.054	0.153			1.86	250
N	0.42		0.34		0.14	0.25			1.5	
D	1.2		0.78		0.88	0.35			13	
RC	0.12	0.14	0.28		0.058	0.14			2.52	16
F		2.7	1.7	1.2	0.22	0.20	3.6	0.176	9.5	2,900
C		4.6	1.7	1.6	0.19	3.5	2.9	0.01	15	24,000

*( ) indicates number of animals.
**Tracheo-bronchial lymph nodes.
A blank space indicates no analysis.
S = Searchlight herd
N = NTS
D = Dairy cows
RC = Roller Coaster
F = Feedlot
C = Control calf
R = Reno

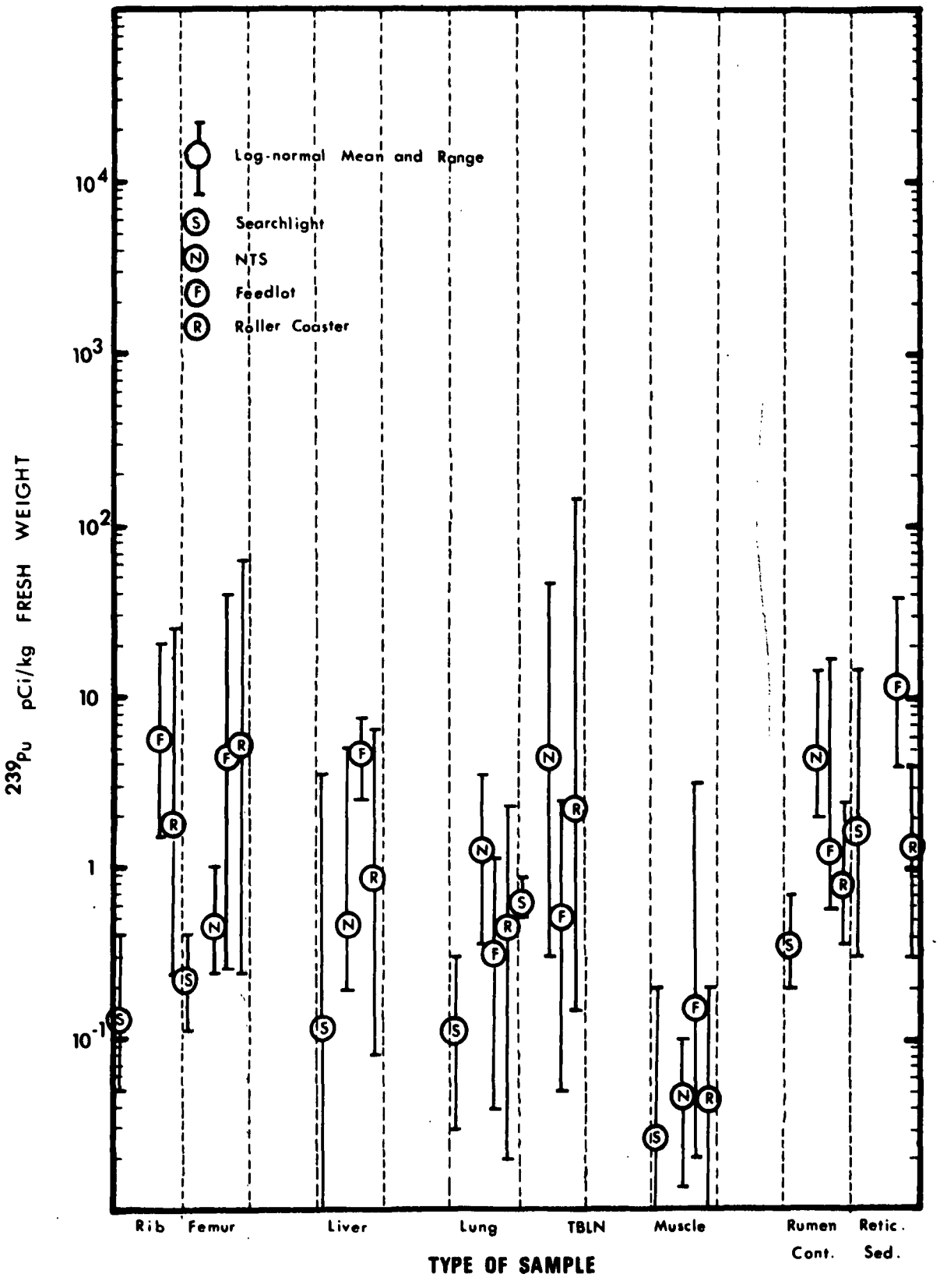

Figure 2. Log-Normal Mean and Range of ^{239}Pu in Cattle Tissue.

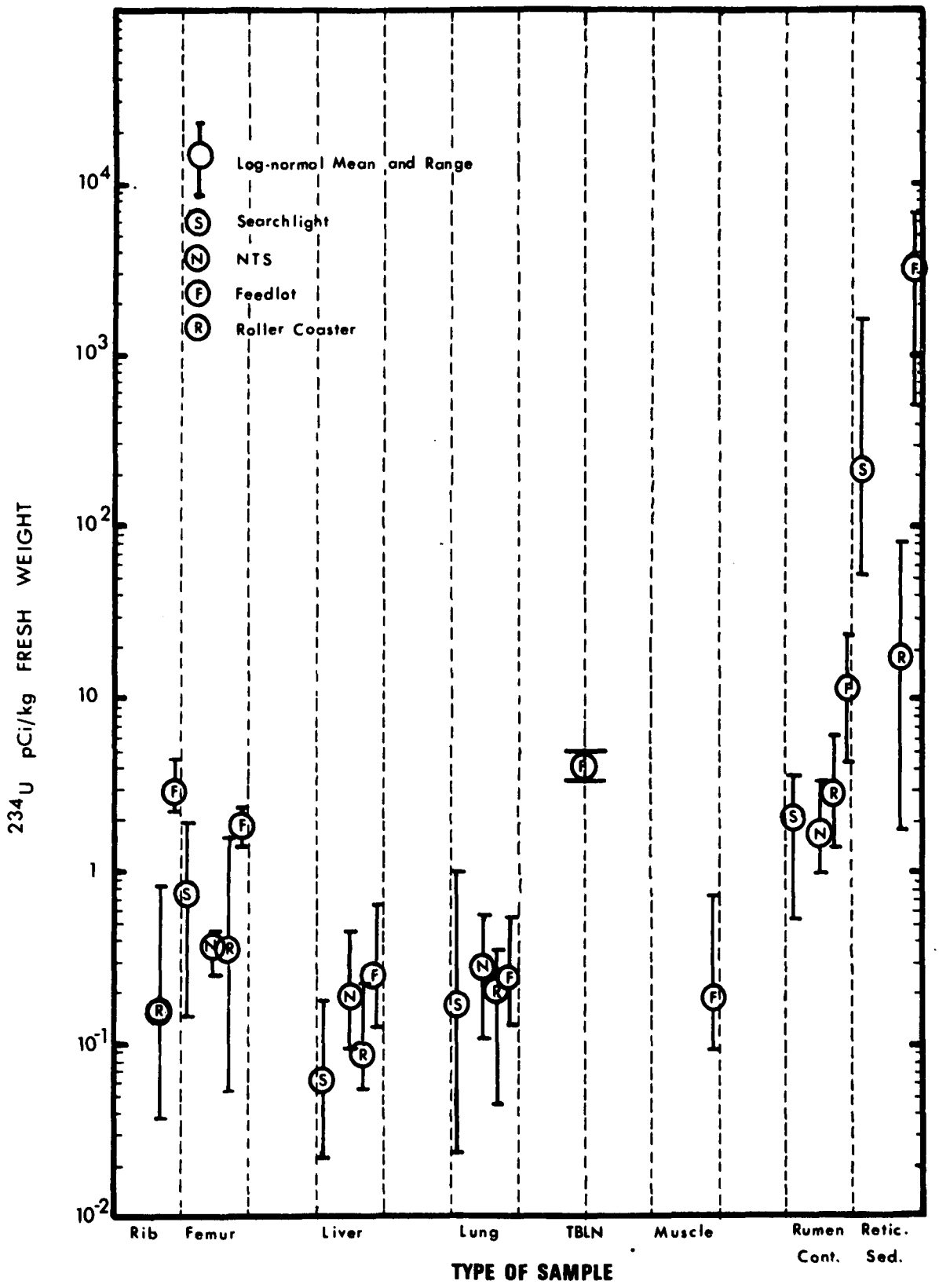

Figure 3. Log-Normal Mean and Range of ^{234}U in Cattle Tissue.

1/4 the concentration measured in Searchlight. Human bone samples, though, contain about 3 times the concentration of ^{234}U as those of the Searchlight cattle.

The ratio of ^{239}Pu to ^{238}Pu is reported as between 5 and 25 for air filter samples and between 3 and 27 for soil samples. The data in Table 4, for cattle samples, indicate that this ratio ranges from <1 to about 40. This range may occur because most of the ^{238}Pu values were less than the minimum detectable activity (MDA) which may have distorted the $^{239/238}Pu$ ratio.

The data on fetal tissue concentration from the Searchlight and Roller Coaster groups suggest that both uranium and plutonium pass the placental barrier. The data, though, are too few or are inappropriate for determining transfer coefficients with any degree of confidence.

The data from the feedlot group suggest an increased plutonium concentration in those animals as compared to the other samples from the TTR herd. Since the two dairy cows in the NTS group lived at the Area 15 farm for several years, yet contained less plutonium in bone, the increase in the feedlot group must be attributed to their previous exposure on the TTR. This anomaly is therefore considered as due to sampling error. If this experiment were to be repeated, it would be desirable to collect a new group of cattle from TTR, remove sufficient samples of coccygeal vertebrae for analysis, then sample the same tissue again after prolonged feedlot maintenance to measure individual changes in plutonium concentration.

Some clue to the physical form of plutonium in the environment may be gained by examining the tissue distribution in the various groups. Work with mice and dogs[12] indicates that polymeric plutonium deposits chiefly in liver, spleen, and lungs with much less in the skeleton. The concentration of the monomeric form, however, was about equal in liver and skeleton. Those data indicate that the Searchlight and NTS cattle ingested mostly monomeric plutonium while the dairy cows ingested mostly the polymeric form. The other groups had higher concentrations in bone than in liver.

Table 3. Selected Data on Actinides in the Biosphere

Sample Type	Unit	^{239}Pu	$^{239}Pu/^{238}Pu$	^{234}U	^{238}U	Remarks
Human Bone	pCi/kg	0.04[b]		2.1[a]	1.95[a]	
		0.12[c]				
" "	"	0.27[d]				
" "	"	1.5				For 6 of 50 cases--others negative
" "	"	0.07[e]				
Human Liver	"	0.78[b]				
" "	"	0.63[c]				
" "	"	0.43[d]				For 6 of 50 cases
" "	"	0.70[e]				
Soil	pCi/g	0.01[f]	3.3[f]	0.27[a]	0.25[a]	
"	mCi/km^2	1.5 [g]				Derby, CO (1965)
"	"	1.7 [h]	27[h]			Average of 13 sites in continental U. S.
Precipitation	"	0.5 [i]				Total for 1953 to 1962
Air	---		25[b]			
"	---		5 [j]			

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Table 4. Actinide Activity Ratios in Ci/Ci from Log-Normal Means

Group	Kidney	Rib	Femur	Vertebra	Liver	Lung	TBLN*	Muscle	Rumen Con.	Ret. Sed.
					$^{234}U:^{238}U$					
S(10)**		1.11	1.14		1.18	1.11			1.02	1.04
N(5)	1.09		1.12		1.36	1.12			1.13	
D(2)	1.08		1.54		1.56	1.11			1.23	
RC(10)	1.33	1.21	1.21		1.46	1.28			1.12	1.12
F(5)		1.07	1.06	1.08	1.14	1.10	1.10	1.08	1.05	1.07
C(1)		1.07	1.12	1.06	1.16	1.06	1.10	1.00	1.20	1.04
					$^{239}Pu:^{238}Pu$					
S		3.0	4.3		4.3	3.6	0.61	1.8	7.2	1.1
N			8.5		5.8	7.5	8.3	1.6	10	
D			2.8		4.7	5.9	30	5.1	39	
RC		15.0	1.6		11	8.7	2.7	1.4	12	1.9
F		20.0	16.4	32	17	6.7	1.1	11	21	5.5
C		0.65	3.2	4.0	7.8	1.4	0.75	1.0	17	19
					$^{239}Pu:^{234}U$					
S		0.2	0.29		1.6	0.6			0.17	0.005
N			1.1		2.3	4.3			2.5	
D			0.23		4.7	2.7			0.39	
RC		11	1.2		9.8	1.8			0.28	0.07
F		1.9	2.6	4.5	18	1.3	0.12	0.84	0.13	0.004
C		0.02	0.2	0.2	1.4	0.01	0.06	1.2	0.2	0.005
					$^{234}U:^{235}U$					
S		28	24		8.8	10			37	24
N	31		27		15	22			26	
D	24		30		14	21			31	
RC	11	21	23		5.7	9.5			26	20
F		30	33	20	18	28	14	6.8	30	33
C		27	20	20	18	9.2	18	1.0	30	23

*Tracheo-bronchial lymph nodes.
**( ) indicates number of animals. A blank space indicates no analysis.
S = Searchlight herd
N = Nevada Test Site
D = Dairy cows
RC = Roller Coaster
F = Feedlot
C = Control calf

The actinide concentrations in the three animals from the TTR sampled in February (Appendix II) were similar to the concentrations found in the ten Roller Coaster animals discussed herein. Not only are the concentration ranges similar, but also when the mean value of ^{239}Pu for all 13 animals is calculated it results in 3.86 pCi/kg for the femur compared to the 4.08 pCi/kg for the ten samples shown in Table 2. Likewise, the ^{234}U is 0.51 compared to 0.39 in Table 2. These data would have been combined except that the same tissue types were not collected in both sampling efforts.

An earlier collection of cattle samples was made from the same area in August 1967. In that experiment, six animals were sampled and the results reported.[13] The plutonium concentrations were much higher in the 1967 collection; e.g. 580 pCi/kg fresh femur vs. 4 pCi/kg reported herein. The other tissues sampled (lung, muscle, tracheo-bronchial lymph nodes, and rumen contents) were also higher by one to two orders of magnitude, only the liver samples yielded a mean value similar to that in Table 2 (0.99 vs. 0.83). However, the analytical procedure used in 1967 was relatively non-specific so that other alpha-emitters may have been detected and then reported as plutonium. That procedure involved solution of the tissue ash, liquid/liquid extraction, and liquid scintillation counting.

Doubts about the analytical procedure preclude any meaningful comparison between the 1967 study and the study reported herein.

The comparatively high levels of uranium detected in rumen contents and reticulum sediment in the cattle maintained in the Area 15 feed lot (five Roller Coaster animals and a control Holstein calf) appear to be related to the uranium content of the fattening concentrate fed them (see Appendix VI-11). It is thought that the source of the uranium in this concentrate was defluorinated phosphate rock (DPR) which is commonly used as a source of phosphorus in feed supplements. A study by Habashi[14] indicates that a beef animal fed a daily ration of 0.5 kg DPR would receive approximately 20 times the permissible intake of uranium.[14]

ESTIMATES OF DOSE TO HUMANS

Table 5 presents dose estimates for the edible bovine tissues containing the highest concentrations of the actinides. These hypothetical bone doses are for continuous intake of 250 grams per day of the indicated tissue:

a. The dose commitment resulting from continuous intake for a year. The dose commitment represents the dose for a 50-year period after intake. For plutonium this is the same as the yearly dose rate after ingestion for 50 years.

b. The cumulative dose accrued during an ingestion period of 50 years.

The dose calculations are based on the data and techniques in ICRP-10[15] with some supplemental data from ICRP-2[16] and Stehn.[17] The data used in the calculations, along with the calculated dose factors, are given in Table 6.

The dose factors in Table 6 are based on several time periods of integration. It is assumed that once plutonium is deposited in the bone the quantity is only reduced by radioactive decay. The integration factors for plutonium are based on the integral of $e^{-\lambda t}dt$ from zero to 50 years, where λ is the radioactive decay constant (λ = 0.693/half-life).

The dose parameters are based on the standard ICRP equation:[16]

$$\text{rem} = \mu\text{Ci-days} \times f \times 51.2 \times \frac{\text{Effective Energy (MeV)}}{\text{Organ Mass (g)}}$$

where

51.2 is the units conversion factor for energy and time in units of rem-disintegration-g/μCi-day-MeV,

Effective Energy is taken from Table 6,[15, 16]

Organ mass of bone is 7,000 grams,[15, 16]

μCi-days x f is the integral of ingested activity times its residence time in the bone, and

f is the fraction of activity transmitted to the bone.

Table 5. Hypothetical Human Bone Dose from Actinides in Beef Tissue.
(Based on consumption of 250 g/day of beef sample)

Sample with Maximum Concentration	Measured pCi/kg	Postulated Intake pCi/day	Hypothetical Bone Dose: mrem per year after ingestion for 50 years	mrem in 50 years after ingestion for 1 year	mrem accrued during 50 years of ingestion
		Plutonium-238			
Feedlot #18 - Liver	1.2	0.3	0.08	0.08	2.2
Dairy Cow #7 - Muscle	<1.2	<0.3	<0.08	<0.08	<2.2
		Plutonium-239			
Feedlot #17 - Liver	7.6	1.9	0.60	0.60	15
Feedlot #18 - Muscle	3.0	0.75	0.24	0.24	5.9
		Uranium-234, -235, & -238 Based on Conc. of Uranium-234*			
Feedlot #16 - Liver	0.62	0.16	0.06	0.006	1.9
Feedlot #15 - Muscle	0.72	0.18	0.07	0.007	2.2
Dairy Cow #7 - Kidney	1.6	0.40	0.15	0.01	4.9
			Total Dose		
Liver			0.7	0.7	19
Muscle			0.4	0.3	10

*The uranium doses are based on the maximum measured uranium-234 concentrations and the associated theortical concentrations of uranium-235 and-238.

Table 6. Parameters for Human Dose Calculations from ICRP

Nuclide	Effective Energy (MeV)(14)	Fraction ingestion to bone(14)	1-y integral for intake or dose (pCi/day x day) or (days)	50-y integral for intake or dose (pCi/day x day) or (days)	50-y double integral for dose during 50-y uptake (pCi/day x days^2)	Bone Dose Parameters mrem per time: pCi/day intake		
						mrem/y after ingestion for 50 y	mrem in 50 y after ingestion for 1 y	mrem accrued during 50-y ingestion
^{238}Pu	280	2.4×10^{-5}	363	15,000	1.46×10^{8}	0.27	0.27	7.2
^{239}Pu	270	2.4×10^{-5}	365	18,250	1.67×10^{8}	0.32	0.32	7.9
^{234}U	240	1.1×10^{-3}	36.2	268	3.25×10^{6}	0.19	0.019	6.3
^{235}U	230	1.1×10^{-3}	36.2	268	3.25×10^{6}	0.18	0.018	6.0
^{238}U	220	1.1×10^{-3}	36.2	268	3.25×10^{6}	0.17	0.017	5.8
Total U Based on ^{234}U		1.1×10^{-3}	36.2	268	3.25×10^{6}	0.37	0.036	12

Table 7. Comparison of Mass and Radiation Units for Uranium Isotopes

Isotope	Ci/g of Isotope	% of Natural U	Ci/g of Natural U	Rem to bone in 50 yrs per g of natural U ingested
^{234}U	6.17×10^{-3}	0.0055	33.9×10^{-8}	0.176
^{235}U	2.14×10^{-6}	0.72	1.54×10^{-8}	0.008
^{238}U	3.33×10^{-7}	99.28	33.1×10^{-8}	0.156

The time integration factors for uranium are based on a power function retention of $t^{-0.5}$ (t in days) integrated between 1 day and 1 or 50 years.[16] The dose parameters were calculated using the same equation as that used for plutonium.

The chemical toxicity of uranium is such that it is normally more limiting than the radioactive dose and the critical organ is the kidney. However, the radiological dose in Table 5 has been included for comparison with plutonium. Table 7 indicates comparisons between mass and radiation units for uranium. The ICRP standard for occupational exposure is 75 mg/day which for the general population is reduced to an average intake of less than 7.5 mg/day.[15] The maximum observed concentrations in the bovine tissues are less than about 1/1,000 of this value.

The total maximum yearly dose rate (sum of doses from Table 5) after eating 250 grams of muscle daily for 50 years would be about 0.4 mrem from the plutonium and uranium content. For liver, this dose would be about 0.7 mrem. These values are less than 1% of the yearly radiation protection guides (500 mrem/y) of the National Council on Radiation Protection and Measurements (NCRP).[19] The total doses accrued during a 50-year ingestion period are 10 mrem from muscle and 19 mrem from liver. These 50-year values are less than 10% of the yearly NCRP guide or about one-tenth percent of the yearly guide for 50 years (500 mrem/y x 50 y = 25,000 mrem).[19]

SUMMARY

During 1972, animals from three beef herds on and around the NTS were extensively sampled to determine tissue burdens of plutonium and uranium. The herds represented animals grazing range contaminated by worldwide fallout (Searchlight herd), animals grazing range contaminated by U.S. atmospheric nuclear detonations (NTS herd), and animals grazing range contaminated by unfissioned nuclear material (TTR herd). Selected animals from the latter herd were also maintained in a feedlot on the NTS for four months prior to sampling.

In addition to the actinide analysis, tissues were analyzed for the presence of gamma-emitting radionuclides, tritium, and strontium. Iodine-131 detected in the thyroids of animals sacrificed during May was attributed to a nuclear detonation conducted in March by the People's Republic of China. Cesium-137 was the only gamma-emitting fission product radionuclide detected in edible tissues. Tritium levels were elevated only in animals that had previously participated in a tritium study or that were maintained in Area 15 of the NTS which is in close proximity to the Sedan crater. The strontium levels detected in the bones from all three herds were consistent (median values ranged from 3 to 5.1 pCi/g of ash) and of the same magnitude reported for animals from this area during the last few years.[8, 9, 10, 11]

Necropsies of the sacrificed animals revealed only incidental gross lesions. No significant lesions attributable to radiation damage were found during microscopic examinations.

Based on geometric mean values, ratios of ^{234}U, ^{235}U, and ^{238}U levels found in tissues from all four study groups were consistent with the natural ratios. Of the tissues examined, the Pu/U ratio was generally highest in the liver. The plutonium levels in bone were highest in the femur, with lower levels in the ribs. For the younger animals (feedlot

and the control calf), the actinide levels were higher in rib than in either femur or vertebrae samples. Both the lung and tracheo-bronchial lymph node data suggest that plutonium inhalation was higher for the NTS herd than for the TTR cattle. The rumen content and reticulum sediment data suggest that the contamination of the range of Area 18 of the NTS and of the Roller Coaster sites on the TTR consisted of larger particles unevenly distributed compared to the relatively uniform deposition from worldwide fallout on the Searchlight Range. The data also suggest that the actinide concentrations in bone increased with age. Fetal tissue concentrations of the actinides indicate that passage through the placental barrier occurs.

The data from the feedlot group were rather contradictory in that some tissue levels of plutonium apparently increased during the four months the animals were off the contaminated range. It is thought that this observation was the result of a sampling or analytical error as tissue concentration in dairy cows maintained for several years on the same forage and at the same location were of lower magnitude. This error could be avoided in future studies, if bone samples from each animal are obtained surgically before initiation of the study.

Using the maximum concentrations of the actinides measured in beef tissue, the hypothetical bone dose to man from eating 250 grams of either liver or muscle daily for 50 years is less than 0.2% of the pertinent NCRP[19] radiation protection guides for the general population. The majority of the postulated dose is due to the plutonium isotopes.

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Animal No.	LUNGS		T-B LYMPH NODES*		LIVER		BONE				Remarks
	^{239}Pu fCi/g ash fCi/kg**	^{239}Pu fCi/g ash fCi/kg**	^{238}Pu fCi/g ash fCi/kg**	^{239}Pu fCi/g ash fCi/kg**	^{238}Pu fCi/g ash fCi/kg**	^{239}Pu fCi/g ash fCi/kg**	^{89}Sr pCi/g ash pCi/kg**	^{90}Sr pCi/g ash pCi/kg**	^{238}Pu fCi/g ash fCi/kg**	^{239}Pu fCi/g ash fCi/kg**	
1	<1.5 <9.9	3 ± 1.5 20 ± 10	<3 <200	<60 <4000	<3.1 <20	1.5 ± 1.5 10 ± 10	<1.1 <290	2.7 ± 0.81 700 ± 210	<0.27 <70	<0.12 <31	Mature Hereford cow
2	<2 <20	1 ± 1 10 ± 10	<110 <7200	<31 <2000	<3.2 <30	5.3 ± 3.2 50 ± 30	1.2 ± 1.1 430 ± 400	1.5 ± 0.78 540 ± 280	<0.25 <90	0.19 ± 0.17 68 ± 61	Four-year-old Hereford cow
3	<4.5 <50	4.5 ± 2.7 50 ± 30	<68 <5000	<41 <3000	<3.5 <40	7.8 ± 3.5 90 ± 40	<2.1 <820	11 ± 1.5 4300 ± 590	<0.26 <100	0.77 ± 0.26 300 ± 100	Six-year-old Hereford cow
4	4 ± 2 40 ± 20	4 ± 2 40 ± 20	<61 <2000	<27 <890	<6.2 <81	9.2 ± 4.6 120 ± 60	<2.5 <850	14 ± 1.8 4800 ± 610	<0.29 <99	0.5 ± 0.21 170 ± 70	Mature Hereford cow
5	<4.4 <40	3.3 ± 3.3 30 ± 30	<130 <9200	56 ± 56 4000 ± 4000	<3.4 <30	9.2 ± 3.4 80 ± 30	<2.1 <710	9.4 ± 1.5 3200 ± 510	<0.26 <88	0.62 ± 0.24 210 ± 80	Mature Hereford cow
6	<2.9 <20	4.3 ± 1.4 30 ± 10	<140 <7800	<36 <2000	<2.9 <20	8.6 ± 2.9 60 ± 20	<1.8 <650	7.8 ± 1.3 2800 ± 470	<0.28 <100	0.83 ± 0.28 300 ± 100	Four-year-old Hereford cow
MEDIAN	<3.95 <30	3.65 30	<89 <6100	<38.5 <2500	<3.3 <30	8.2 70	<1.95 <680	8.6 3000	<0.265 <95	0.56 190	
RANGE	<1.5-<4.5 <9.9-<50	1-4.5 10-50	<3-<140 <200-<9200	<27-56 <890-4000	<2.9-<6.2 <20-<81	1.5-9.2 10-120	<1.1-<2.5 <290-<850	1.5-14.0 540-4800	<0.25-<0.29 <70-<100	<0.12-0.83 <31-300	

* Tracheo-bronchial Lymph Nodes
** Wet weight

APPENDIX I. Plutonium and Strontium Concentrations in Tissues from Cattle - Reno, Nevada - January 1971

Tissue	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	^{89}Sr pCi/g ash pCi/kg*	^{90}Sr pCi/g ash pCi/kg*	Ca mg/g	% Ash	Wet wt (kg)	Ash wt (g)
Femur	<2	32 ± 5	5.7 ± 4.8	<3	4.8 ± 4.3	<2	8 ± 2	370	23	0.44	103
	<470	7500 ± 1000	1300 ± 1100	<690	1100 ± 1000	<460	1900 ± 350				
Liver	<20	200 ± 40	<60	<40	<40	NA	NA	NA	3.1	1.28	40
	<620	6200 ± 1000	<1900	<1300	<1300						
Lung	30 ± 30	40 ± 20	<40	<40	<40	NA	NA	NA	3.1	0.90	28
	930 ± 930	1200 ± 600	<1200	<1200	<1200						
Muscle	<40	<20	<60	<40	<40	NA	NA	NA	2.0	1.99	39
	<780	<390	<1200	<780	<780						

NA = Not analyzed
* Wet weight

APPENDIX II-1. Actinide and Strontium Concentrations in Tissues from a One-Year-Old Charolais Heifer - Roller Coaster Site - February 1972

Tissue	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	^{89}Sr pCi/g ash pCi/kg*	^{90}Sr pCi/g ash pCi/kg*	Ca mg/g	% Ash	Wet wt (kg)	Ash wt (g)
Femur	<3 <700	1 ± 1 240 ± 240	6 ± 3 1400 ± 700	3 ± 2 700 ± 400	5 ± 3 1200 ± 700	<2 <470	4 ± 1 930 ± 230	370	23	0.63	147
Liver	<20 <600	10 ± 10 280 ± 280	<40 <1000	<40 <1000	<40 <1000	NA	NA	NA	2.8	1.98	55
Lung	<20 <660	10 ± 10 330 ± 330	<60 <2000	<30 <1000	<60 <2000	NA	NA	NA	3.3	0.60	20
Muscle	<30 <400	<10 <200	≤50 <740	<50 <740	<50 <740	NA	NA	NA	1.5	2.49	37
Fetus	<3 <66	<1 <22	NA	NA	NA	<1 <22	2 ± 1 44 ± 22	210	2.2	0.81	18

NA = Not analyzed

* Wet weight

APPENDIX II-2. Actinide and Strontium Concentrations in Tissues from a Two-Year-Old Angus Crossbred Cow - Roller Coaster Site - February 1972

Tissue	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	^{89}Sr pCi/g ash pCi/kg*	^{90}Sr pCi/g ash pCi/kg*	Ca mg/g	% Ash	Wet wt (kg)	Ash wt (g)
Femur	<3 <580	110 ± 10 22000 ± 2000	17 ± 5 3300 ± 1000	2 ± 2 390 ± 390	12 ± 4 2300 ± 800	<3 <580	9 ± 2 1800 ± 390	360	19.5	0.92	179
Liver	<20 <610	550 ± 70 17000 ± 2000	<40 <1200	<40 <1200	<40 <1200	NA	NA	NA	3.0	2.11	64
Lung	<20 <620	110 ± 30 3400 ± 900	<70 <2200	<40 <1000	<60 <1900	NA	NA	NA	3.1	1.74	54
Muscle	<20 <270	20 ± 20 270 ± 270	32 ± 22 430 ± 300	24 ± 19 320 ± 250	32 ± 22 430 ± 300	NA	NA	NA	1.3	1.88	25
Tracheo-Bronchial Lymph Nodes	200 ± 100 6700 ± 3300	6100 ± 500 200000 ± 16000	400 ± 200 13000 ± 6600	<30 <1000	400 ±200 13000 ± 6600	NA	NA	NA	3.3	0.03	1
Fetus Muscle	<40 <1200	<20 <590	<30 <880	<20 <590	<30 <880	NA	NA	NA	2.9	0.34	10
Fetus Bone	<3 <190	7 ± 2 430 ± 120	7 ± 3 430 ± 190	2 ± 2 120 ± 120	5 ± 3 310 ± 190	<2 <120	4 ± 1 250 ± 62	310	6.2	0.39	24

NA = Not analyzed

* Wet weight

APPENDIX II-3. Actinide and Strontium Concentrations in Tissues from a Seventeen-Year-Old Hereford Cow - Roller Coaster Site - February 1972

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	% Ash	Wet wt (kg)	Ash wt (g)
4	3 ± 3 30 ± 30	34 ± 7 340 ± 70	22 ± 3.7 220 ± 40	0.91 ± 0.75 9.1 ± 7.5	22 ± 3.6 220 ± 40	1.0	2.59	26
5	<7 <73	100 ± 20 1000 ± 200	21 ± 3.5 220 ± 40	5.2 ± 1.7 54 ± 20	15 ± 3 160 ± 30	1.04	1.54	16
6	<4 <49	60 ± 10 730 ± 120	16 ± 3.1 200 ± 40	4.5 ± 1.6 55 ± 20	11 ± 2.4 130 ± 30	1.22	1.88	23
7	<30 <380	80 ± 60 1000 ± 760	15 ± 2.9 190 ± 40	1.2 ± 0.84 15 ± 10	12 ± 2.5 150 ± 30	1.26	1.11	14
8	4 ± 3 78 ± 59	11 ± 4 210 ± 78	13 ± 2.8 250 ± 50	1.2 ± 0.88 23 ± 17	10 ± 2.5 200 ± 50	1.95	1.74	34
9	<4 <42	15 ± 6 160 ± 63	11 ± 2 120 ± 21	0.71 ± 0.57 7.5 ± 6	10 ± 2 100 ± 21	1.05	1.62	17
10	<20 <260	40 ± 20 520 ± 200	15 ± 3 200 ± 40	2.5 ± 1.2 33 ± 16	13 ± 3 170 ± 40	1.30	1.84	24
11	<3 <30	4 ± 2 40 ± 20	12 ± 3 120 ± 30	<0.7 <7	10 ± 3 100 ± 30	1.0	1.30	13
12	6 ± 5 65 ± 54	210 ± 20 2300 ± 220	26 ± 4 280 ± 44	1.3 ± 0.9 14 ± 10	19 ± 3 210 ± 33	1.09	3.39	37
12 Fetus	<4 <39	2 ± 2 19 ± 19	4.8 ± 2.1 47 ± 20	<0.6 <5.8	2.9 ± 1.4 28 ± 14	0.97	0.70	6.8
13	<3 <32	48 ± 5 510 ± 53	34 ± 4.7 360 ± 50	4 ± 1.5 42 ± 16	33 ± 4.7 350 ± 50	1.06	2.83	30.0
MEDIAN	<4 <39	40 510	15 200	1.2 15	12 160	1.06		
RANGE	<3-<30 <26-<380	2-210 19-2300	4,8-34 47-360	<0.6-5.2 <5.8-55	2.9-33 28-350	0.97-1.95		

* Wet weight

APPENDIX III-1. Actinide Concentrations in Lungs from Roller Coaster Cattle - May 1972

Animal No.	^{238}Pu fCi/g ash	^{238}Pu fCi/kg*	^{239}Pu fCi/g ash	^{239}Pu fCi/kg*	% Ash	Wet wt (kg)	Ash wt (g)
4	100 ± 100	760 ± 760	90 ± 70	680 ± 530	0.76	0.025	0.19
5	<200	<2000	200 ± 100	2000 ± 1000	1.0	0.013	0.13
6	<80	<750	140 ± 60	1300 ± 600	0.94	0.033	0.31
7	<200	<2000	400 ± 100	4000 ± 1000	1.00	0.016	0.16
8	<100	<790	<40	<320	0.79	0.033	0.26
9	<100	<950	70 ± 70	660 ± 660	0.95	0.020	0.19
10	<50	<930	<20	<370	1.86	0.028	0.52
11	<80	<1300	<40	<660	1.65	0.017	0.28
12	<200	<2700	9700 ± 900	130000 ± 10000	1.33	0.015	0.20
13	400 ± 200	7900 ± 4000	4700 ± 400	94000 ± 9000	2.0	0.01	0.20
MEDIAN	<100	<1125	115	1090	1.0		
RANGE	<50-400	750-7900	<20-9700	<320-130000	0.76-2		

* Wet weight

APPENDIX III-2. Actinide Concentrations in Tracheo-Bronchial Lymph Nodes from Roller Coaster Cattle - May 1972

Animal No.	^{238}Pu fCi/g ash	^{238}Pu fCi/kg*	^{239}Pu fCi/g ash	^{239}Pu fCi/kg*	% Ash	Wet wt (kg)	Ash wt (g)
4	<3	<46	2 ± 2	31 ± 20	1.53	19.30	296
5	<2	<24	2 ± 1	24 ± 12	1.19	19.18	229
6	<2	<45	3 ± 2	68 ± 45	2.26	4.69	106
7	<3	<30	2 ± 2	20 ± 20	1.0	3.49	35
8	<3	<33	1 ± 1	10 ± 10	1.11	4.49	50
9	<2	<32	<1	<16	1.59	3.77	60
10	<20	<240	20 ± 10	240 ± 120	1.21	4.48	54
11	<3	<78	3 ± 2	78 ± 50	2.61	3.26	85
12	<3	<60	2 ± 2	40 ± 40	2.02	4.81	97
12 Fetus	<3	<100	<0.9	<31	3.44	2.70	93
13	<6	<210	7 ± 7	250 ± 250	3.53	3.37	119
MEDIAN	<3	<46	2	28	1.59		
RANGE	<2-<20	<24-<240	<0.9-20	10-250	1-3.53		

* Wet weight

APPENDIX III-3. Actinide Concentrations in Muscle from Roller Coaster Cattle - May 1972

Animal No.	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	% Ash	Wet weight (kg)	Ash weight (g)
4	26 ± 14 230 ± 120	<6 <50	19 ± 11 170 ± 100	0.88	0.46	4
5	25 ± 14 190 ± 100	<6 <46	25 ± 14 190 ± 100	0.77	0.518	4
6	8.6 ± 7.6 96 ± 86	<5 <56	8.6 ± 7.6 96 ± 86	1.11	0.45	5
7	16 ± 4.4 190 ± 50	<0.8 <9.5	12 ± 3.5 140 ± 40	1.19	0.42	5
8	19 ± 12 190 ± 120	<6 <59	12 ± 9 120 ± 100	0.98	0.41	4
9	8.5 ± 2.6 130 ± 40	<0.7 <11	7.2 ± 2.6 110 ± 40	1.53	0.457	7
10	8.4 ± 3.3 150 ± 60	<1 <18	6.1 ± 2.8 110 ± 50	1.80	0.445	8
11	12 ± 4.2 140 ± 50	4 ± 2 47 ± 20	9.2 ± 4.2 110 ± 50	1.18	0.422	5
12	8.7 ± 3.5 100 ± 40	<2 <23	6 ± 3.5 70 ± 40	1.15	0.434	5
12 Fetus	24 ± 7 200 ± 60	<4 <33	16 ± 7 130 ± 60	0.83	0.242	2
13	17 ± 4 180 ± 44	<0.9 <10	13 ± 4 140 ± 40	1.09	0.46	5
MEDIAN	16 180	<4 <33	12 120	1.11		
RANGE	8.4-26 96-230	0.7-<6 <9.5-<59	6.1-25 70-190	0.77- 1.80		

* Wet weight

APPENDIX III-4. Actinide Concentrations in Kidneys from Roller Coaster Cattle - May 1972

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	% Ash	Wet wt (kg)	Ash wt (g)
4	<3 <84	3 ± 2 84 ± 56	5 ± 2.1 140 ± 60	0.82 ± 0.82 23 ± 23	1.8 ± 1.1 51 ± 30	2.81	3.2	90
5		SAMPLE			LOST			
6	3 ± 3 130 ± 130	110 ± 10 4600 ± 400	5.3 ± 1.9 220 ± 80	<0.7 <30	3.9 ± 1.9 160 ± 80	4.22	1.8	76
7	<3 <80	55 ± 7 1400 ± 190	2.2 ± 1.2 59 ± 31	0.88 ± 0.73 24 ± 20	1.5 ± 0.9 40 ± 24	2.67	2.02	54
8	<20 <910	90 ± 50 4100 ± 2000	2.6 ± 1.5 120 ± 70	1.5 ± 1.1 68 ± 50	2 ± 1.1 90 ± 50	4.55	1.10	50
9	10 ± 10 190 ± 190	100 ± 40 1900 ± 700	3.7 ± 1.7 70 ± 32	1.1 ± 0.85 21 ± 16	2.5 ± 1.5 47 ± 28	1.89	1.27	24
10	<3 <39	10 ± 3 130 ± 40	4.9 ± 1.6 63 ± 21	<0.54 <7	4.2 ± 1.6 54 ± 20	1.29	2.32	30
11	<3 <47	19 ± 4 300 ± 60	4.8 ± 2 75 ± 32	1.1 ± 1 17 ± 15	4 ± 1.9 63 ± 30	1.57	1.15	18
12	9 ± 6 120 ± 80	450 ± 30 6200 ± 500	3.8 ± 1.7 53 ± 24	<0.58 <8	2.5 ± 1.5 35 ± 21	1.39	3.03	42
12 Fetus	<30 <410	10 ± 10 140 ± 140	5.7 ± 5.7 78 ± 78	<0.8 <11	5.7 ± 5.7 78 ± 78	1.37	0.51	7
13	<30 <80	670 ± 80 1900 ± 200	21 ± 16 58 ± 43	<8 <22	15 ± 13 42 ± 37	0.277	3.77	10.5
MEDIAN	<6 <102.5	54.5 1100	4.85 72.5	0.85 23	3.2 52.5	1.73		
RANGE	<3-<20 <39-<910	3-670 84-6200	2.2-21 53-220	<0.54-<8 <7-68	1.5-15 35-160	0.277-4.55		

* Wet weight

APPENDIX III-5. Actinide Concentrations in Liver from Roller Coaster Cattle - May 1972

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	% Ash	Wet wt (kg)	Ash wt (g)
4	10 ± 4 180 ± 60	42 ± 5 740 ± 88	150 ± 10 2600 ± 180	7 ± 2 120 ± 35	140 ± 10 2400 ± 180	1.75	4.57	80
5	3 ± 3 45 ± 45	24 ± 4 360 ± 60	170 ± 10 2500 ± 150	8.9 ± 2.8 130 ± 40	130 ± 10 1900 ± 150	1.49	2.69	40
6	<9 <180	30 ± 20 600 ± 400	100 ± 15 2000 ± 300	3.2 ± 2.4 64 ± 48	100 ± 15 2000 ± 300	2.01	3.28	66
7	<7 <170	27 ± 9 670 ± 220	56 ± 8 1400 ± 200	2.4 ± 2 59 ± 50	56 ± 8 1400 ± 200	2.48	2.10	52
8	<10 <140	50 ± 20 680 ± 270	100 ± 15 1400 ± 200	4.7 ± 2.6 64 ± 35	96 ± 15 1300 ± 200	1.35	2.96	40
9	<5 <89	80 ± 10 1400 ± 180	340 ± 22 6100 ± 400	12 ± 3.9 210 ± 70	260 ± 17 4600 ± 300	1.79	3.30	59
10	<5 <88	140 ± 20 2400 ± 350	310 ± 17 5400 ± 300	8.6 ± 3.4 150 ± 60	260 ± 17 4600 ± 300	1.75	3.31	58
11	<5 <84	26 ± 8 440 ± 140	130 ± 12 2200 ± 200	4.7 ± 2.4 79 ± 40	130 ± 12 2200 ± 200	1.69	3.38	57
12	<6 <110	60 ± 10 1100 ± 180	200 ± 17 3600 ± 300	9 ± 3.4 160 ± 60	190 ± 17 3400 ± 300	1.78	2.81	50
13	<5 <100	34 ± 8 780 ± 180	200 ± 18 4600 ± 400	10 ± 3.5 230 ± 80	170 ± 13 3900 ± 300	2.28	4.38	100
MEDIAN	<5.5 <105	38 710	160 2550	7.8 125	135 2300	1.765		
RANGE	3-10 45-180	24-140 360-2400	56-340 1400-6100	2.4-12 59-230	56-260 1300-4600	1.35- 2.48		

* Wet weight

APPENDIX III-6. Actinide Concentrations in Rumen Contents from Roller Coaster Cattle - May 1972

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	% Ash	Wet wt (kg)	Ash wt (g)
4	30 ± 30 2800 ± 2800	20 ± 20 1800 ± 1800	400 ± 50 37000 ± 4600	50 ± 30 4600 ± 2400	340 ± 50 31000 ± 4400	9.23	0.26	24
5	<40 <4700	30 ± 20 3500 ± 2300	300 ± 50 35000 ± 5900	<10 <1200	240 ± 50 28000 ± 6000	11.76	0.034	4
6	<30 <200	50 ± 20 330 ± 100	270 ± 40 1800 ± 200	20 ± 10 130 ± 70	260 ± 40 1700 ± 200	0.67	0.30	2
7	<30 <2500	20 ± 10 1700 ± 800	830 ± 70 70000 ± 6000	40 ± 20 3400 ± 1700	760 ± 70 64000 ± 5700	8.42	0.19	16
8	<20 <600	110 ± 30 3300 ± 900	350 ± 40 11000 ± 1200	20 ± 10 610 ± 300	340 ± 40 10000 ± 1200	3.04	0.23	7
9		NOT			COLLECTED			
10	<30 <630	20 ± 10 420 ± 210	440 ± 50 9200 ± 1100	20 ± 10 420 ± 210	400 ± 50 8400 ± 1100	2.09	0.43	9
11	30 ± 30 820 ± 820	20 ± 10 540 ± 270	260 ± 26 7100 ± 710	13 ± 6 350 ± 170	240 ± 30 6500 ± 820	2.73	0.33	9
12	<30 <3300	30 ± 20 3300 ± 2200	730 ± 70 81000 ± 7200	30 ± 10 3300 ± 1100	720 ± 60 80000 ± 6600	11.06	0.47	52
13	<20 <590	30 ± 20 890 ± 600	700 ± 67 21000 ± 2000	30 ± 14 890 ± 400	660 ± 64 20000 ± 1900	2.97	0.64	19
MEDIAN	<30 820	30 1700	400 21000	20 890	340 20000	3.04		
RANGE	<20-<40 <200-<4700	20-110 330-3500	260-830 1800-81000	<10-50 130-4600	240-760 1700-80000	0.67- 11.76		

* Wet weight

APPENDIX III-7. Actinide Concentrations in Reticulum Sediment from Roller Coaster Cattle - May 1972

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	^{89}Sr pCi/g ash pCi/kg*	^{90}Sr pCi/g ash pCi/kg*	% Ash	Ca mg/g	Wet wt (kg)	Ash wt (g)
4	<0.5 <90	10 ± 2 2000 ± 400	1.8 ± 0.56 360 ± 110	<0.1 <20	1.4 ± 0.48 280 ± 100	<2 <400	4 ± 1 810 ± 200	20.3	380	1.42	288
5	0.8 ± 0.8 200 ± 200	4 ± 1 1000 ± 260	0.92 ± 0.35 240 ± 90	<0.06 <16	0.64 ± 0.32 170 ± 80	<3 <780	7 ± 1 1800 ± 260	26	390	1.36	353
6	<0.8 <200	24 ± 3 7000 ± 880	2.2 ± 0.54 650 ± 200	0.23 ± 0.16 70 ± 50	1.8 ± 0.48 500 ± 140	<2.8 <820	5.1 ± 0.6 1500 ± 180	29.4	310	0.86	253
7	2 ± 1 470 ± 230	10 ± 2 2400 ± 500	1.8 ± 0.54 430 ± 130	<0.08 <20	1.5 ± 0.5 360 ± 120	<2.5 <590	3.6 ± 0.6 850 ± 140	23.7	310	0.90	213
8	1.1 ± 0.9 220 ± 180	6 ± 1 1200 ± 300	1.1 ± 0.43 220 ± 90	<0.1 <20	0.95 ± 0.4 190 ± 80	<3 <610	5.5 ± 0.6 1100 ± 130	20.4	300	1.39	283
9	5 ± 0.6 1400 ± 200	220 ± 10 62000 ± 3000	0.57 ± 0.16 160 ± 40	<0.02 <6	0.49 ± 0.15 140 ± 40	<3 <840	6 ± 1 1700 ± 280	28.1	370	0.48	135
10	1 ± 0.5 240 ± 120	0.9 ± 0.4 220 ± 90	1.9 ± 0.3 460 ± 80	0.14 ± 0.08 30 ± 20	1.7 ± 0.3 410 ± 70	<3 <730	4 ± 1 970 ± 240	24.4	370	0.78	190

* Wet weight

APPENDIX III-8. Actinide and Strontium Concentrations in Femurs from Roller Coaster Cattle - May 1972

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	^{89}Sr pCi/g ash pCi/kg*	^{90}Sr pCi/g ash pCi/kg*	% Ash	Ca mg/g	Wet wt (kg)	Ash wt (g)
11	<0.6 <140	18 ± 2 4300 ± 480	0.76 ± 0.34 180 ± 80	<0.08 <20	0.6 ± 0.34 140 ± 80	<2.5 <600	4.8 ± 0.6 1200 ± 140	24	310	1	240
12	3 ± 1 790 ± 260	180 ± 20 47000 ± 5300	0.84 ± 0.31 220 ± 80	<0.06 <16	0.76 ± 0.31 200 ± 80	7.6 ± 3.3 2000 ± 880	8.1 ± 0.8 2100 ± 200	26.3	310	0.92	242
12F	4 ± 2 350 ± 170	18 ± 4 1600 ± 350	0.59 ± 0.26 52 ± 23	<0.1 <9	0.53 ± 0.23 47 ± 21	<1.4 <120	<0.5 <44	8.8	340	1.09	96
13	<0.6 <180	34 ± 3 10000 ± 910	5.1 ± 0.89 1500 ± 270	0.4 ± 0.24 120 ± 70	4.3 ± 0.83 1300 ± 250	<5.4 <1600	6.5 ± 1.5 2000 ± 440	30.3	350	1.13	342
MEDIAN	1 220	18 2400	1.1 240	<0.1 <20	0.95 200	<3 <730	5.1 1200	24.4	340		
RANGE	<0.5-5 <90-1400	0.9-220 220-62000	0.57-5.1 52-1500	<0.02-0.4 <6-120	0.49-4.3 47-1300	<1.4-7.6 <120-2000	<0.5-8.1 <42-2100	8.8-30.3	310-390		

* Wet weight

APPENDIX III-8. Actinide and Strontium Concentrations in Femurs from Roller Coaster Cattle - May 1972 (contd)

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	^{89}Sr pCi/g ash pCi/kg*	^{90}Sr pCi/g ash pCi/kg*	% Ash	Ca mg/g	Wet wt (kg)	Ash wt (g)
4	0.6 ± 0.4 110 ± 76	12 ± 1 2300 ± 190	1.2 ± 0.3 230 ± 50	<0.04 <8	1.1 ± 0.3 210 ± 59	<2 <380	2 ± 1 380 ± 190	19.0	360	1.47	280
5	<0.3 <55	3.3 ± 0.6 600 ± 100	0.34 ± 0.13 62 ± 25	<0.04 <7	0.24 ± 0.11 44 ± 21	5 ± 3 920 ± 540	5 ± 1 920 ± 180	18.4	390	1.16	213
6	1.3 ± 0.4 290 ± 90	37 ± 3 8400 ± 600	0.33 ± 0.14 75 ± 31	<0.05 <10	0.22 ± 0.11 50 ± 26	<2 <450	5 ± 1 1100 ± 230	22.6	360	1.52	344
7	0.6 ± 0.4 150 ± 100	10 ± 1 2600 ± 260	3.1 ± 0.4 800 ± 110	0.12 ± 0.08 30 ± 20	2.7 ± 0.4 700 ± 100	<3 <770	4 ± 1 1000 ± 260	25.8	360	0.76	196
8	<0.4 <61	5.2 ± 0.8 800 ± 100	1.3 ± 0.3 200 ± 45	<0.05 <7.6	1.2 ± 0.3 180 ± 45	5 ± 3 760 ± 460	4 ± 1 600 ± 150	15.2	320	1.11	169
9	0.3 ± 0.3 54 ± 54	3.6 ± 0.7 650 ± 120	0.45 ± 0.16 81 ± 30	<0.05 <9	0.36 ± 0.15 65 ± 26	<3 <540	4 ± 1 720 ± 180	18.0	350	0.90	162
10	1.2 ± 0.4 180 ± 60	1.4 ± 0.4 210 ± 60	0.72 ± 0.21 110 ± 30	0.06 ± 0.06 9.1 ± 9.1	0.58 ± 0.18 88 ± 30	2 ± 2 300 ± 300	4 ± 1 610 ± 150	15.3	350	0.95	145
11	<2 <200	4 ± 3 480 ± 360	0.71 ± 0.33 86 ± 40	<0.2 <20	0.59 ± 0.33 71 ± 40	<2.7 <330	3.5 ± 1 420 ± 120	12.1	340	0.96	116

* Wet weight

APPENDIX III-9. Actinide and Strontium Concentrations in Ribs from Roller Coaster Cattle - May 1972

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	^{89}Sr pCi/g ash pCi/kg*	^{90}Sr pCi/g ash pCi/kg*	% Ash	Ca mg/g	Wet wt (kg)	Ash wt (g)
12	2 ± 2 380 ± 380	130 ± 20 25000 ± 3800	1.4 ± 0.47 260 ± 90	<0.09 <17	1.2 ± 0.47 230 ± 90	4.9 ± 3 930 ± 570	6.6 ± 0.7 1200 ± 140	18.9	310	1.48	280
12 Fetus	9 ± 2 440 ± 96	370 ± 20 18000 ± 960	0.76 ± 0.39 37 ± 19	<0.1 <4.8	0.66 ± 0.37 32 ± 18	<3 <140	3 ± 1 140 ± 50	4.8	310	0.62	30
13	1.9 ± 0.8 360 ± 150	47 ± 4 8900 ± 760	3.5 ± 0.64 660 ± 120	0.17 ± 0.14 32 ± 27	3.4 ± 0.64 640 ± 120	<2.3 <440	4.5 ± 0.6 850 ± 120	19.0	300	1.24	235
MEDIAN	1.2 180	10 2300	0.76 110	<0.06 9.1	0.66 88	<3 <450	4 720	18.4	350		
RANGE	<0.3-9 <50-440	1.4-370 210-25000	0.33-3.5 37-800	<0.04-<0.2 <4.8-32	0.22-3.4 32-700	<2-5 <140-930	2-6.6 140-1200	4.8- 25.8	300- 390		

* Wet weight

APPENDIX III-9. Actinide and Strontium Concentrations in Ribs from Roller Coaster Cattle - May 1972 (contd)

Animal No.	Rumen Contents K g/g ^{95}Zr ^{103}Ru pCi/g ^{141}Ce pCi/g	Liver K g/g	Thyroid ^{131}I pCi/g	Kidney K g/g	Muscle K g/g ^{137}Cs pCi/g	Blood ^{3}H pCi/l
4	0.0014 0.64 0.27 0.49	0.0026	3.7	0.0021	0.0039 <MDA	<210
5	0.002 0.36 0.19 0.28	0.0031	20.0	0.002	0.0032 0.04	<210
6	0.0017 0.70 0.25 0.47	NA	76.0	0.0025	0.0032 <MDA	670±210
7	0.0024 2.7 0.74 1.5	0.0031	44.0	0.0016	NA	<210
8	0.0013 0.43 0.20 0.32	0.0034	15.0	0.0019	NA	290±210
9	0.0017 0.13 <MDA 0.36	0.003	37.0	0.0015	NA	490±210
10	0.0021 0.17 <MDA <MDA	0.003	42.0	0.0019	NA	340±210

APPENDIX III-10. Other Radionuclides Measured in Tissues from Roller Coaster Cattle - May 1972*

Animal No.	Rumen Contents K g/g ^{95}Zr pCi/g ^{103}Ru pCi/g ^{141}Ce pCi/g	Liver K g/g	Thyroid ^{131}I pCi/g	Kidney K g/g	Muscle K g/g ^{137}Cs pCi/g	Blood ^{3}H pCi/l
11	0.0016 0.10 0.31 <MDA	0.0028	63.0	0.0015	0.0036 0.04	580±210
12	0.0017 0.18 0.21 0.51	NA	45.0	0.001	0.0038 0.03	600±210
12F	Not collected	NA	13.0	0.002	NA	NA
13	0.0018 0.57 0.38 0.54	NA	21.0	0.0017	0.0024 <MDA	540±210
MEDIAN	0.0017 0.395 0.26 0.48	0.003	37.0	0.0019	0.0034 0.035	415
RANGE	0.0013-0.0024 0.10-2.7 0.19-0.74 0.28-1.5	0.0026-0.0034	3.7-76.0	0.001- 0.0025	0.0024-0.0039 0.03-0.04	<210-670

*Wet weight
<MDA = Less than minimum detectable activity
NA = Not analyzed

APPENDIX III-10. Other Radionuclides Measured in Tissues from Roller Coaster Cattle - May 1972* (contd)

Animal No.	^{238}Pu fCi/g ash	^{238}Pu fCi/kg*	^{239}Pu fCi/g ash	^{239}Pu fCi/kg*	% Ash	Wet wt (kg)	Ash wt (g)
1	<100	<870	<60	<520	0.87	0.023	0.20
2	400 ± 100	3200 ± 1000	100 ± 100	790 ± 790	0.79	0.019	0.15
3	<100	<1100	<60	<700	1.10	0.02	0.22
4	<200	<1900	70 ± 70	670 ± 670	0.95	0.022	0.21
5	<100	<1300	<60	<780	1.30	0.02	0.26
6	<100	<1000	<50	<500	1.0	0.019	0.19
7	<60	<760	<40	<500	1.26	0.034	0.43
8	<80	<980	70 ± 50	860 ± 600	1.23	0.035	0.43
9	<100	<1100	<80	<900	1.12	0.016	0.18
10	<100	<1800	<40	<710	1.78	0.014	0.25
MEDIAN	<100	<1100	<60	<705	1.11		
RANGE	<60 - 400	<760 - 3200	<40 - 100	<500 - 860	0.79-1.78		

* Wet weight

APPENDIX IV-1. Actinide Concentrations in Lungs from Searchlight Cattle - June 1972

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	% Ash	Wet wt (kg)	Ash wt (g)
1	<9 <110	20 ± 10 250 ± 200	18 ± 3.2 220 ± 40	2.3 ± 1 28 ± 13	17 ± 3.2 210 ± 40	1.24	2.18	27
2	<5 <140	<4 <120	9 ± 3.5 260 ± 100	<0.7 <20	8 ± 3.1 230 ± 90	2.89	0.90	26
3	<4 <60	2 ± 2 30 ± 30	7.3 ± 2.4 110 ± 36	1.2 ± 1 18 ± 15	5.8 ± 2.2 88 ± 33	1.51	1.06	16
4	<4 <73	9 ± 5 160 ± 90	19 ± 4.4 340 ± 80	1.1 ± 1.1 20 ± 20	18 ± 4.4 330 ± 80	1.81	2.15	39
5	<5 <63	20 ± 7 250 ± 80	21 ± 4.8 260 ± 60	1.7 ± 1.1 21 ± 14	19 ± 4.8 240 ± 60	1.26	1.98	25
6	<2 <21	6 ± 3 63 ± 30	2.1 ± 1.2 22 ± 12	<0.4 <4.2	2.1 ± 1.2 22 ± 12	1.04	1.63	17
7	<4 <48	11 ± 5 130 ± 60	15 ± 5 180 ± 60	<0.4 <4.8	14 ± 5 170 ± 60	1.21	2.48	30
8	<4 <46	20 ± 10 230 ± 120	86 ± 26 1000 ± 300	52 ± 17 600 ± 200	69 ± 17 800 ± 200	1.16	1.12	13
9	<2 <18	3 ± 2 27 ± 18	9.6 ± 2.3 86 ± 21	1.2 ± 0.89 11 ± 8	8.8 ± 2.3 79 ± 21	0.90	1.11	10
10	<5 <82	7 ± 4 110 ± 60	7.4 ± 2.5 120 ± 40	1.6 ± 1.3 26 ± 21	5.5 ± 2.5 90 ± 40	1.63	0.92	15
MEDIAN	<4 <61.5	8 125	12.3 200	1.2 20	11.4 190	1.25		
RANGE	<2-<9 <18-<140	2-20 27-250	2.1-86 22-1000	<0.4-52 <4.2-600	2.1-69 22-800	0.9-2.89		

* Wet weight

APPENDIX IV-2. Actinide Concentrations in Tracheo-Bronchial Lymph Nodes from Searchlight Cattle - June 1972

Animal No.	^{238}Pu fCi/g ash	^{238}Pu fCi/kg*	^{239}Pu fCi/g ash	^{239}Pu fCi/kg*	% Ash	Wet wt (kg)	Ash wt (g)
1	<3	<20	2 ± 2	14 ± 14	0.7	17.5	122
1 Fetus	<3	<50	<1	<17	1.74	0.46	8
2	<5	<52	14 ± 8	150 ± 80	1.05	11.45	120
3	<2	<42	1 ± 1	<21	2.13	7.69	164
4	<2	<16	1 ± 1	7.8 ± 7.8	0.78	7.08	55
5	<2	<17	1 ± 1	8.4 ± 8.4	0.84	5.21	44
5 Fetus	<7	<190	8 ± 6	220 ± 170	2.73	0.11	3
6	<4	<24	<4	<24	0.61	6.24	38
6 Fetus	<2	<49	1 ± 1	25 ± 25	2.46	1.79	44
7	<3	<30	3 ± 2	30 ± 20	1.01	6.44	65
7 Fetus	<4	<92	<2	<46	2.31	0.26	6
8	<2	<10	12 ± 4	70 ± 20	0.59	4.41	26
9	<2	<17	2 ± 2	17 ± 17	0.85	3.64	31
10	<3	<15	3 ± 2	15 ± 9.8	0.49	7.13	35
MEDIAN	<3	<27	<2	<22.5	0.93		
RANGE	<2-<7	<10-<190	<1-14	<7.8-220	0.49-2.73		

* Wet weight

APPENDIX IV-3. Actinide Concentrations in Muscle from Searchlight Cattle - June 1972

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	% Ash	Wet wt (kg)	Ash wt (g)
1	<4 <74	5 ± 4 93 ± 70	7.5 ± 2.5 140 ± 50	<0.5 <9.3	7 ± 2.5 130 ± 50	1.86	2.04	38
2	<8 <70	<7 <62	5.2 ± 2.5 46 ± 22	<1 <8.8	4.4 ± 2.4 39 ± 21	0.88	1.25	11
3	<7 <75	10 ± 9 110 ± 100	9.2 ± 3.3 99 ± 36	1.6 ± 1.4 17 ± 15	7.3 ± 3.1 79 ± 33	1.08	1.39	15
4	<8 <45	<4 <20	5.7 ± 2.5 32 ± 14	<1 <5.6	4.6 ± 2.3 26 ± 13	0.56	3.54	20
5	<10 <56	20 ± 10 100 ± 60	5.6 ± 2.5 32 ± 14	<0.7 <4	5.1 ± 2.1 29 ± 12	0.57	3.51	20
6	<3 <30	340 ± 20 3400 ± 200	7 ± 2.1 70 ± 20	1.5 ± 0.9 15 ± 9	4.6 ± 1.7 47 ± 17	1.01	1.48	15
7	<2 <24	8 ± 3 100 ± 40	4.2 ± 1.7 51 ± 21	1.1 ± 0.98 13 ± 12	3.2 ± 1.5 39 ± 18	1.22	2.21	27
8	<4 <16	5 ± 3 20 ± 10	5.4 ± 3 21 ± 12	<1 <4	4.3 ± 3 17 ± 12	0.40	1.73	7
9	<20 <160	40 ± 10 300 ± 100	22 ± 11 180 ± 96	<2 <16	21 ± 11 170 ± 90	0.82	1.10	9
10	<10 <230	9 ± 7 210 ± 160	6 ± 3 140 ± 70	3 ± 2 70 ± 47	6 ± 3 140 ± 69	2.33	1.2	28
MEDIAN	<7.5 <63	8.5 100	5.8 60.5	1 12.15	4.85 43	1.045		
RANGE	<2-<20 <16-<230	<4-340 <20-3400	4.2-22 21-180	<0.5-3 <4-70	3.2-21 17-170	0.40-2.33		

* Wet weight

APPENDIX IV-4. Actinide Concentrations in Liver from Searchlight Cattle - June 1972

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	% ash	Wet wt (kg)	Ash wt (g)
1	<4 <60	18 ± 6 280 ± 90	190 ± 13 2900 ± 200	7.8 ± 2.6 120 ± 40	180 ± 13 2800 ± 200	1.54	4.16	64
2	<7 <100	30 ± 10 450 ± 200	120 ± 14 1800 ± 200	3 ± 2.2 45 ± 33	110 ± 14 1650 ± 200	1.51	4.11	62
3	<10 <160	30 ± 20 490 ± 300	100 ± 12 1700 ± 200	5.4 ± 3 89 ± 50	96 ± 12 1600 ± 200	1.66	4.04	67
4	<4 <63	19 ± 7 300 ± 100	33 ± 3.8 520 ± 60	0.38 ± 0.38 6 ± 6	32 ± 3.8 510 ± 60	1.59	3.46	55
5	<4 <66	12 ± 5 200 ± 90	220 ± 18 3600 ± 300	7.3 ± 3.4 120 ± 60	210 ± 18 3500 ± 300	1.65	3.63	60
6	<9 <180	30 ± 20 600 ± 400	100 ± 15 2000 ± 300	3.2 ± 2.4 64 ± 48	100 ± 15 2000 ± 300	2.01	3.28	66
7	<4 <62	14 ± 6 200 ± 100	120 ± 13 1900 ± 200	<1 <15	120 ± 13 1900 ± 200	1.57	3.56	56
8	<10 <100	50 ± 20 670 ± 300	100 ± 15 1400 ± 200	4.7 ± 2.6 63 ± 35	96 ± 15 1300 ± 200	1.35	2.96	40
9	<5 <100	10 ± 7 220 ± 150	150 ± 14 3300 ± 300	8.3 ± 3.7 180 ± 80	140 ± 14 3000 ± 300	2.18	3.90	85
10	<6 <89	18 ± 8 270 ± 100	170 ± 20 2500 ± 300	5.3 ± 2.7 79 ± 40	170 ± 20 2500 ± 300	1.50	3.07	46
MEDIAN	<5.5 <94.5	18.5 290	100 1950	5 71.5	115 1950	1.58		
RANGE	<4-<10 <60-<180	10-50 200-670	33-190 520-3600	0.38-8.3 6-180	32-210 510-3500	1.35- 2.18		

* Wet weight

APPENDIX IV-5. Actinide Concentrations in Rumen Contents from Searchlight Cattle - June 1972

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	% Ash	Wet wt (kg)	Ash wt (g)
1	<20 <4300	20 ± 10 4300 ± 2200	2100 ± 120 460000 ± 27000	120 ± 30 26000 ± 6600	2000 ± 120 430000 ± 26000	21.7	0.12	26
2	<20 <1500	10 ± 10 760 ± 760	2800 ± 200 210000 ± 15000	87 ± 26 6700 ± 2000	2600 ± 100 200000 ± 7600	7.6	0.17	13
3	<20 <950	10 ± 10 480 ± 480	1100 ± 100 52000 ± 48000	45 ± 15 2100 ± 800	1100 ± 100 52000 ± 48000	4.76	0.21	10
4	<20 <3300	20 ± 20 3300 ± 3300	2000 ± 100 330000 ± 17000	89 ± 23 15000 ± 3800	1800 ± 100 300000 ± 17000	16.7	0.12	20
5	<30 <4000	10 ± 10 1400 ± 1400	2500 ± 100 340000 ± 14000	91 ± 24 12000 ± 3300	2400 ± 100 330000 ± 14000	13.7	0.124	17
6	<30 <3800	20 ± 10 2500 ± 1200	5100 ± 180 640000 ± 22000	190 ± 34 24000 ± 4300	5200 ± 180 650000 ± 22000	12.5	0.12	15
7	<20 <9800	30 ± 20 15000 ± 9800	3400 ± 100 1700000 ± 49000	130 ± 30 64000 ± 14000	3300 ± 100 1600000 ± 49000	49.0	0.055	27
8	<20 <920	10 ± 10 460 ± 460	2000 ± 100 92000 ± 4600	88 ± 30 4100 ± 1300	2000 ± 100 92000 ± 4600	4.6	0.13	6
9	<20 <1600	10 ± 10 780 ± 780	2100 ± 130 160000 ± 10000	100 ± 29 7800 ± 2200	2000 ± 130 160000 ± 10000	7.8	0.115	9
10	<20 <2400	<10 <1200	1400 ± 100 160000 ± 12000	49 ± 20 5800 ± 2400	1400 ± 100 160000 ± 12000	11.8	0.17	20
MEDIAN	<20 <2850	10 1300	2100 270000	90 9900	2000 250000	12.15		
RANGE	<20-<30 <920-<9800	<10-30 460-15000	1100-5100 52000-1700000	45-190 2100-64000	1100-5200 52000-1600000	4.6-49		

* Wet weight

APPENDIX IV-6. Actinide Concentrations in Reticulum Sediment from Searchlight Cattle - June 1972

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	^{89}Sr pCi/g ash pCi/kg*	^{90}Sr pCi/g ash pCi/kg*	% Ash	Ca mg/g	Wet wt (kg)	Ash wt (g)
1	<0.5 <100	0.9 ± 0.5 180 ± 100	9.5 ± 1 1900 ± 200	0.45 ± 0.05 90 ± 10	8 ± 1 1600 ± 200	<8 <1600	5 ± 1 1000 ± 290	20.11	370	1.77	356
2	<0.6 <100	0.7 ± 0.4 130 ± 70	2.3 ± 0.58 440 ± 110	<0.1 <19	2.1 ± 0.58 400 ± 110	<4 <760	2.8 ± 1 530 ± 180	19.05	340	1.05	200
3	<0.5 <150	1.1 ± 0.4 330 ± 100	3.3 ± 0.6 990 ± 180	0.25 ± 0.17 75 ± 50	3.2 ± 0.6 960 ± 180	<6 <1800	6 ± 1 1800 ± 400	30	370	1.01	303
4	<0.5 <50	2.6 ± 0.6 280 ± 70	8.6 ± 1 920 ± 110	0.36 ± 0.21 38 ± 22	7.3 ± 0.9 780 ± 100	<4 <430	2 ± 0.9 210 ± 100	10.7	360	0.86	92
5	<0.4 <100	0.4 ± 0.3 100 ± 80	5.1 ± 0.78 1300 ± 200	0.24 ± 0.2 60 ± 50	4.8 ± 0.78 1200 ± 200	<6 <1500	5 ± 1 1300 ± 330	25.29	370	0.85	215
6	<0.6 <100	1 ± 0.5 230 ± 110	2 ± 0.61 460 ± 140	<0.2 <46	1.7 ± 0.57 390 ± 130	<6 <1400	3 ± 1 690 ± 250	22.92	380	0.72	165

* Wet weight

APPENDIX IV-7. Actinide and Strontium Concentrations in Femurs from Searchlight Cattle - June 1972

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	^{89}Sr pCi/g ash pCi/kg*	^{90}Sr pCi/g ash pCi/kg*	% Ash	Ca mg/g	Wet wt (kg)	Ash wt (g)
7	<0.4 <100	1.3 ± 0.5 380 ± 100	1.5 ± 0.52 440 ± 150	<0.1 <29	1.3 ± 0.48 380 ± 140	<5 <1500	4 ± 1 1200 ± 360	29.16	370	0.95	277
8	<0.5 <120	0.8 ± 0.4 190 ± 90	5 ± 0.83 1200 ± 200	0.25 ± 0.21 60 ± 50	4.6 ± 0.83 1100 ± 200	<5 <1200	3 ± 1 720 ± 260	24.1	360	0.83	200
9	<0.5 <100	1.9 ± 0.6 390 ± 100	5.3 ± 0.97 1100 ± 200	0.39 ± 0.22 80 ± 46	4.8 ± 0.97 990 ± 200	<5 <1000	3 ± 1 620 ± 190	20.62	330	0.97	200
10	<0.5 <86	0.7 ± 0.4 120 ± 80	0.81 ± 0.29 140 ± 50	<0.03 <5	0.63 ± 0.29 110 ± 50	<5 <870	3 ± 1 520 ± 170	17.38	360	1.49	259
MEDIAN	<0.5 <100	0.95 220	4.2 955	0.24 53	3.9 870	<5 <1300	3 705	21.77	365		
RANGE	<0.4-<0.6 <50-<150	0.4-2.6 100-390	0.81-9.5 140-1900	<0.03-0.45 <5-90	0.63-8 110-1600	<4-<8 <430-<1800	2-6 210-1800	10.7-30	330-380		

* Wet weight

APPENDIX IV-7. Actinide and Strontium Concentrations in Femurs from Searchlight Cattle - June 1972 (contd)

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	^{89}Sr pCi/g ash pCi/kg*	^{90}Sr pCi/g ash pCi/kg*	% Ash	Ca mg/g	Wet wt (kg)	Ash wt (g)
1	<0.4 <75	1 ± 0.4 190 ± 80	10 ± 1.6 1900 ± 300	0.31 ± 0.21 58 ± 40	9.5 ± 1.1 1800 ± 200	<5 <950	3.4 ± 1 640 ± 230	19.0	370	1.92	364
2	<0.5 <78	0.5 ± 0.3 78 ± 50	2.3 ± 0.51 360 ± 80	2.3 ± 0.16 38 ± 26	1.8 ± 0.44 280 ± 70	<5 <790	2 ± 1 320 ± 160	15.8	360	0.57	90
3	<0.6 <110	0.3 ± 0.3 56 ± 56	0.49 ± 0.16 92 ± 30	<0.05 <9	0.44 ± 0.16 82 ± 30	<5 <940	1 ± 1 190 ± 190	18.7	360	0.77	144
4	<0.5 <120	1.8 ± 0.5 420 ± 100	2.7 ± 0.55 630 ± 130	0.24 ± 0.18 56 ± 41	2.1 ± 0.51 490 ± 120	<6.4 <1500	3.8 ± 1.4 890 ± 330	23.4	360	1.05	246
5	<0.4 <52	1.1 ± 0.5 140 ± 70	3.8 ± 0.76 500 ± 100	<0.2 <26	3.8 ± 0.76 500 ± 100	<6 <790	4 ± 1 520 ± 170	13.1	360	1.28	168
6	<0.4 <69	0.8 ± 0.5 140 ± 80	2.9 ± 0.58 500 ± 100	0.24 ± 0.2 41 ± 34	2.3 ± 0.58 400 ± 100	<6 <1000	3 ± 1 520 ± 170	17.3	380	0.78	135

* Wet weight

APPENDIX IV-8. Actinide and Strontium Concentrations in Ribs from Searchlight Cattle - June 1972

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	^{89}Sr pCi/g ash pCi/kg*	^{90}Sr pCi/g ash pCi/kg*	% Ash	Ca mg/g	Wet wt (kg)	Ash wt (g)
7	<0.4 <49	2.1 ± 0.6 260 ± 70	2.7 ± 0.64 340 ± 80	0.21 ± 0.17 26 ± 21	2.4 ± 0.64 300 ± 80	<10 <1200	3.4 ± 0.9 420 ± 110	12.4	360	1.56	194
8	<0.6 <130	0.4 ± 0.3 87 ± 70	3.2 ± 0.73 700 ± 160	<0.1 <21	3.1 ± 0.73 680 ± 160	<4 <870	3 ± 0.9 650 ± 200	21.8	360	0.72	157
9	<0.5 <100	0.5 ± 0.3 100 ± 70	6.3 ± 0.97 1300 ± 200	0.21 ± 0.15 43 ± 31	5.8 ± 0.97 1200 ± 200	<4 <820	2 ± 0.9 410 ± 200	20.6	360	0.79	163
10	<0.4 <66	0.3 ± 0.3 50 ± 50	1.1 ± 0.36 180 ± 60	<0.03 <5	1 ± 0.36 170 ± 60	<6 <1000	2 ± 1 330 ± 170	16.7	360	0.88	147
MEDIAN	<0.45 <76.5	0.65 120	2.8 500	0.2 32	2.7 455	<5.5 <945	3 470	18.0	360		
RANGE	<0.4-<0.6 <49-<130	0.3-2.1 50-420	0.49-10 92-1900	<0.03-0.34 <5-58	1-9.5 82-1800	<4-<10 <790-<1500	1-4 190-890	12.4-23.4	360-380		

* Wet weight

APPENDIX IV-8. Actinide and Strontium Concentrations in Ribs from Searchlight Cattle - June 1972 (contd)

Animal No.	Rumen Contents K g/g ^{95}Zr pCi/g ^{103}Ru pCi/g ^{141}Ce pCi/g	Liver K g/g	Thyroid ^{131}I pCi/g	Kidney K g/g	Muscle K g/g ^{137}Cs pCi/g	Blood ^{3}H pCi/l
1	0.0016 0.23 0.18 0.22	0.002	2.8	0.0021	0.003 0.02	<200
2	0.0013 0.21 0.19 0.23	0.0035	<MDA	0.0031	NA	230±200
3	0.0013 0.18 0.56 0.18	0.0035	<MDA	0.0019	0.0031 <MDA	390±200
4	0.0017 0.28 0.19 0.23	0.0027	2.8	0.0019	0.0037 0.05	340±200
5	0.0012 0.09 0.11 0.13	0.0032	3.2	0.0021	NA	460±220
6	0.0012 0.19 0.17 0.24	0.003	<MDA	0.0018	0.0033 0.03	530±210
7	0.0011 0.16 0.09 0.15	0.0023	<MDA	0.0023	0.0036 <MDA	350±230

APPENDIX IV-9. Other Radionuclides Measured in Tissues from Searchlight

Animal No.	Rumen Contents K g/g ^{95}Zr ^{103}Ru ^{141}Ce	Liver K g/g	Thyroid ^{131}I pCi/g	Kidney K g/g	Muscle K g/g ^{137}Cs pCi/g	Blood ^{3}H pCi/l
8	0.0013 0.04 0.09 0.13	0.0031	<MDA	0.0019	0.003 <MDA	730±230
9	0.0013 0.14 0.02 0.24	0.0033	<MDA	0.0045	0.0035 <MDA	260±230
10	0.0014 0.09 0.16 0.15	0.0031	<MDA	0.0020	0.0026 <MDA	620±230
MEDIAN	0.0013 0.20 0.165 0.19	0.0031	2.8	0.00205	0.0032 0.03	370
RANGE	0.0011-0.0017 0.04-0.28 0.02-0.56 0.13-0.24	0.002- 0.0035	2.8- 3.2	0.0018- 0.0045	0.0026-0.0037 0.02-0.05	<200-730

*Wet weight
<MDA = Less than minimum detectable activity
NA = Not analyzed

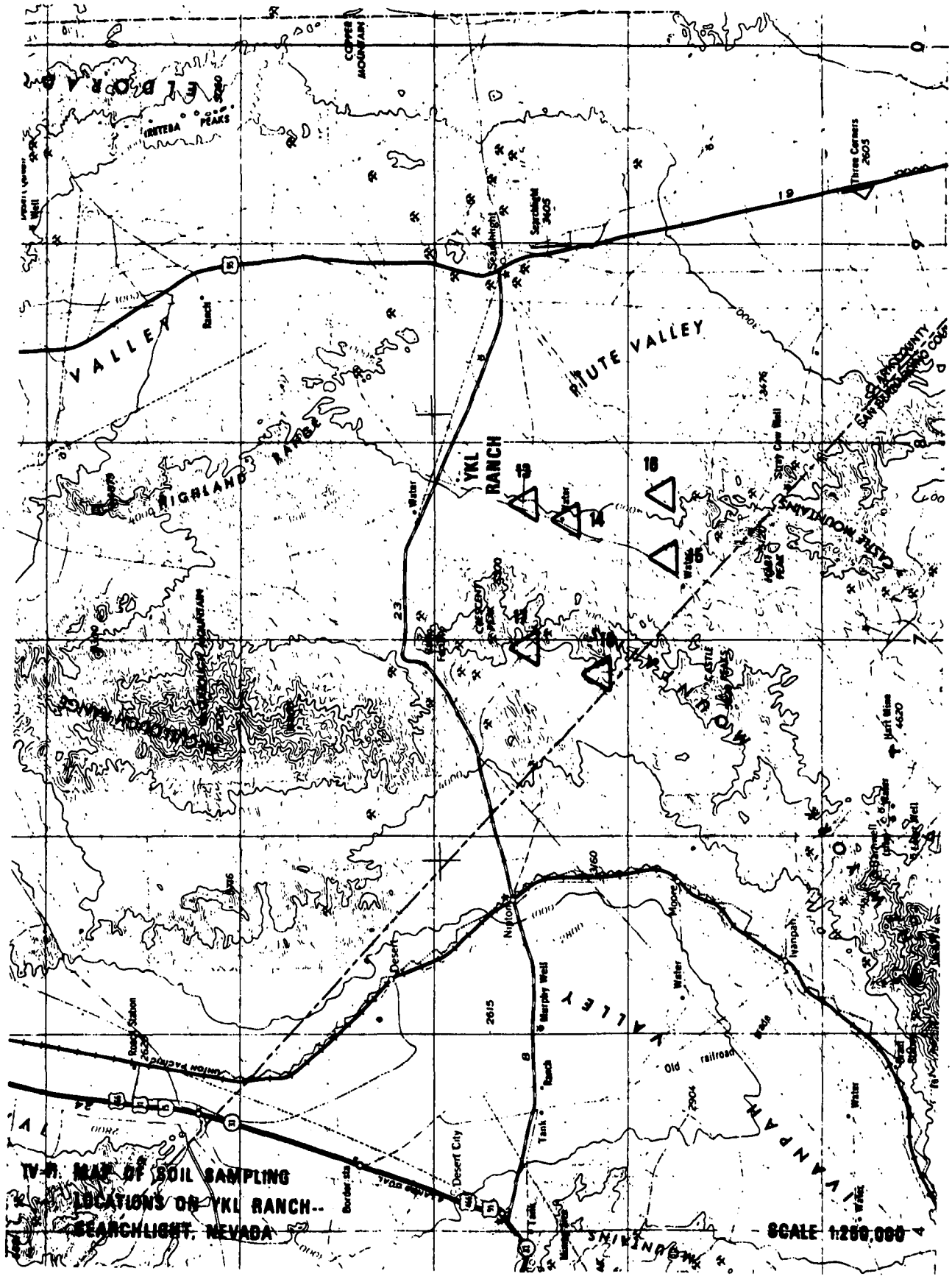
APPENDIX IV-9. Other Radionuclides Measured in Tissues from Searchlight Cattle - June 1972* (contd)

Sample No.	Location	Gamma Analysis K g/g	Gamma Analysis ^{137}Cs pCi/g	Sampling Information Wt. of soil <10 Mesh (g)	Sampling Information Total wt. of sample (g)	^{234}U pCi/g	^{235}U pCi/g	^{238}U pCi/g	^{238}Pu pCi/g	^{239}Pu pCi/g	^{239}Pu deposition mCi/km^2 surface
1	2.3 miles past corrals on right fork (see map).	0.024	0.35	6296	8110	0.9 ± 0.098	0.025 ± 0.015	0.84 ± 0.092	<0.018	<0.013	<0.83
2	South of water tank, 3.8 miles from corrals on right fork (see map).	0.028	0.57	4905	6945	1.4 ± 0.12	0.06 ± 0.024	1.5 ± 0.12	<0.02	0.018 ± 0.016	0.91 ± 0.81
3	3.9 miles south of location #2 to 3rd water tank, turn east just before corrals 0.1 mile (see map).	0.023	0.3	6735	9275	1.0 ± 0.097	0.024 ± 0.016	0.95 ± 0.091	<0.025	<0.014	<0.91
4	From 3rd water tank, east 1.6 miles to intersection. Then left 1 mile (see map).	0.022	0.38	6655	9196	1.2 ± 0.10	0.048 ± 0.021	1.3 ± 0.11	<0.017	<0.021	<1.4

APPENDIX IV-10. Analytical Data from Soil Samples Collected on YKL Ranch, Searchlight, Nevada - January 5, 1973

Sample No.	Location	Gamma Analysis K g/g	^{137}Cs pCi/g	Sampling Information Wt. of soil <10 Mesh (g)	Total wt. of sample (g)	^{234}U pCi/g	^{235}U pCi/g	^{238}U pCi/g	^{238}Pu pCi/g	^{239}Pu pCi/g	^{239}Pu deposition mCi/km^2 surface
5	4.2 miles west on NV Hwy 68 from intersection of Microwave Sta. Road. 3.3 miles south on main road to right-hand fork, then 0.3 miles to location.	0.031	0.71	4924	8130	0.9 ± 0.092	0.038 ± 0.019	0.92 ± 0.092	<0.018	<0.014	<0.71
6	From location #5, 0.2 mi south on main road, then 3.0 mi south on left fork.	0.025	0.61	5225	7986	0.99 ± 0.092	0.06 ± 0.022	1.0 ± 0.095	<0.026	<0.031	<1.6
MEDIAN		0.0245	0.475	5760	8120	0.995	0.043	0.975	<0.019	<0.016	<0.91
RANGE		0.022-0.031	0.3-0.71	4905-6735	6945-9275	0.9-1.4	0.024-0.06	0.84-1.5	<0.017-<0.026	<0.013-<0.031	<0.71-<1.6

APPENDIX IV-10. Analytical Data from Soil Samples Collected on YKL Ranch, Searchlight, Nevada - January 5, 1973 (contd)


IV-11. MAP OF SOIL SAMPLING
LOCATIONS ON YKL RANCH--
SEARCHLIGHT, NEVADA
SCALE 1:250,000
YKL
RANCH
PIUTE VALLEY
HIGHLAND RANGE
CASTLE MOUNTAINS
Searchlight
Nipton
Desert City
Three Corners
Old railroad
Water
Tank
Ranch
Station
Mine
Well
Spring
Peak
Mountain
Peaks
Criteria
Copper
Mountain
Mojave
Ivanpah
Murphy Well
Stony Cow Well
Marl Mine
Grant
Station
Desert
Moore
Wash
Valley
Mountains
Range
Highland
Piute
Valley
Nevada
Union Pacific
Railroad
Station
Ranch
Tank
Well
Water
Spring
Peak
Mountain
Peaks
Criteria
Copper
Mountain
El Dorado
Valley
Nevada
Mojave
Desert
Wash
Ivanpah
Grant
Station
Marl Mine
Stony Cow Well
Three Corners
Searchlight
Murphy Well
Nipton
Desert City
Old railroad
Tank
Ranch
Water
Well

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	% ash	Wet wt. (kg)	Ash wt (g)
1	11 ± 6 370 ± 200	42 ± 9 1400 ± 300	16 ± 4 530 ± 130	<0.7 <23	16 ± 3 530 ± 100	3.33	1.02	34
2	12 ± 8 180 ± 120	230 ± 30 3400 ± 450	38 ± 6 570 ± 90	1.3 ± 1.3 19 ± 19	33 ± 5 490 ± 75	1.49	1.54	23
3	16 ± 7 240 ± 100	160 ± 20 2400 ± 300	16 ± 3 240 ± 45	0.76 ± 0.69 11 ± 10	14 ± 3 200 ± 44	1.47	1.36	20
4	<4 <120	22 ± 8 660 ± 240	8 ± 2 240 ± 60	1 ± 1 30 ± 30	7 ± 2 210 ± 60	3.0	1.00	30
5	5 ± 3 97 ± 60	18 ± 4 350 ± 80	4.7 ± 1.7 92 ± 30	<0.5 <9.7	4.4 ± 1.6 86 ± 30	1.96	0.97	19
MEDIAN	11 180	42 1400	16 240	0.76 19	14 210	1.96		
RANGE	<4-16 97-370	18-230 350-3400	4.7-38 92-570	<0.5-1.3 <9.7-30	4.4-33 86-530	1.47- 3.33		
Dairy Cow #6	4 ± 4 250 ± 250	22 ± 5 1400 ± 300	6.7 ± 1.9 420 ± 120	<0.6 <37	6.2 ± 1 390 ± 62	6.24	2.42	151
Dairy Cow #7	<3 <240	9 ± 3 710 ± 240	4.7 ± 1.6 370 ± 120	<0.5 <39	3.9 ± 1.5 310 ± 120	7.94	3.01	239

*Wet weight

APPENDIX V-1. Actinide Concentrations in Lungs from NTS Cattle - May 1972

Animal No.	^{238}Pu pCi/g ash	^{238}Pu pCi/kg*	^{239}Pu pCi/g ash	^{239}Pu pCi/kg*	% Ash	Wet wt (kg)	Ash wt (g)
1	<0.08	<0.72	0.3 ± 0.1	2.7 ± 0.8	0.90	0.041	0.37
2	0.09 ± 0.08	0.92 ± 0.8	4.1 ± 0.3	42 ± 4	1.02	0.036	0.37
3	0.2 ± 0.1	1.3 ± 0.6	6.9 ± 0.6	44 ± 4	0.64	0.033	0.21
4	<0.08	<0.58	0.13 ± 0.06	0.95 ± 0.4	0.73	0.041	0.30
5	<0.08	<0.66	0.04 ± 0.04	0.33 ± 0.3	0.83	0.042	0.35
MEDIAN	<0.08	<0.72	0.3	2.70	0.83		
RANGE	<0.08-0.2	<0.58-1.3	0.04-6.9	0.33-44	0.64-1.02		
Dairy Cow #6	0.09 ± 0.08	0.85 ± 0.8	2.3 ± 0.2	22 ± 2	0.95	0.038	0.36
Dairy Cow #7	<0.04	<0.42	0.9 ± 0.1	9.5 ± 1	1.05	0.058	0.61

* Wet weight

APPENDIX V-2. Actinide Concentrations in Tracheo-Bronchial Lymph Nodes from NTS Cattle - May 1972

Animal No.	^{238}Pu fCi/g ash	^{238}Pu fCi/kg*	^{239}Pu fCi/g ash	^{239}Pu fCi/kg*	% Ash	Wet wt (kg)	Ash wt (g)
1	3 ± 3	140 ± 140	2 ± 2	94 ± 94	4.73	3.55	168
2	<3	<100	3 ± 2	100 ± 67	3.38	4.14	140
3	<3	<110	2 ± 1	71 ± 36	3.58	3.07	110
4	<3	<48	1 ± 1	16 ± 16	1.63	3.01	49
5	<2	<52	<1	<26	2.62	2.29	60
MEDIAN	<3	<100	2	71	3.38		
RANGE	<2-3	<48-140	<1-3	16-100	1.63-4.73		
Dairy Cow #6	<4	<210	<2	<100	5.21	4.28	223
6Fetus	<4	<72	3 ± 3	54 ± 54	1.82	0.33	6
Dairy Cow #7	<20	<1200	10 ± 10	620 ± 620	6.17	5.53	341

* Wet weight

APPENDIX V-3. Actinide Concentrations in Muscle from NTS Cattle - May 1972

Animal No.	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	% Ash	Wet wt. (kg)	Ash wt (g)
1	24 ± 9 110 ± 44	<4 <17	20 ± 9 88 ± 42	0.44	0.45	2
2	42 ± 17 490 ± 200	<3 <35	42 ± 17 490 ± 200	1.16	0.43	5
3	66 ± 10 720 ± 120	2 ± 1.9 22 ± 21	56 ± 10 610 ± 110	1.09	0.46	5
4	89 ± 13 870 ± 130	2 ± 2 20 ± 20	81 ± 13 790 ± 120	0.98	0.46	4.5
5	62 ± 11 630 ± 110	<2 <20	60 ± 11 610 ± 110	1.01	0.42	4.26
MEDIAN	62 630	2 22	56 610	1.01		
RANGE	24-89 110-870	<2-<4 <17-<35	20-81 88-790	0.44- 1.16		
Dairy Cow #6	100 ± 10 1000 ± 100	4.6 ± 2.4 48 ± 25	80 ± 10 840 ± 100	1.05	0.42	4.4
Dairy Cow #7	150 ± 10 1600 ± 100	6 ± 2.6 63 ± 27	150 ± 10 1600 ± 100	1.05	0.47	4.95

* Wet weight

APPENDIX V-4. Actinide Concentrations in Kidneys from NTS Cattle - May 1972

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	% Ash	Wet wt (kg)	Ash wt (g)
1	<9.6 <490	7.6 ± 4.5 390 ± 230	7.6 ± 2.2 390 ± 110	<0.5 <30	6 ± 3.8 310 ± 190	5.1	1.92	98
2	5 ± 5 260 ± 260	18 ± 7 930 ± 400	6.5 ± 2.3 340 ± 120	<0.7 <36	5.4 ± 2.1 280 ± 110	5.16	3.18	164
3	<4 <230	12 ± 5 700 ± 300	2.1 ± 1.1 120 ± 60	<0.3 <17	1.5 ± 0.9 88 ± 55	5.86	3.14	184
4	<2 <48	8 ± 3 190 ± 70	4 ± 1.5 95 ± 35	1.5 ± 0.9 36 ± 22	2.3 ± 1.1 55 ± 27	2.38	2.02	48
5	<3 <91	10 ± 3 300 ± 80	3.9 ± 1.3 120 ± 40	<0.4 <12	3.6 ± 1.3 110 ± 40	3.04	2.17	66
MEDIUM	<4 <230	10 390	4 120	<0.5 <30	3.6 110	5.1		
RANGE	<2-<9.6 <48-<490	7.6-18 190-93	2.1-7.6 95-390	<0.3-1.5 <12-36	1.5-6 55-310	2.38- 5.86		
Dairy Cow #6	9 ± 4 240 ± 100	22 ± 5 590 ± 140	7.8 ± 2.1 210 ± 60	<0.5 <13	6.3 ± 1.9 170 ± 50	2.70	3.70	100
Dairy Cow #7	<4 <94	31 ± 6 730 ± 100	3.5 ± 1.5 82 ± 34	0.59 ± 0.59 14 ± 14	2.6 ± 1.2 61 ± 28	2.36	5.30	125

* Wet weight

APPENDIX V-5. Actinide Concentrations in Liver from NTS Cattle - May 1972

Animal No.	^{238}Pu pCi/g ash pCi/kg*	^{239}Pu pCi/g ash pCi/kg*	^{234}U pCi/g ash pCi/kg*	^{235}U pCi/g ash pCi/kg*	^{238}U pCi/g ash pCi/kg*	% Ash	Wet wt (kg)	Ash wt (g)
1	0.2 ± 0.1 3.6 ± 2	0.8 ± 0.3 14 ± 6	0.19 ± 0.01 3.4 ± 0.2	0.0085 ± 0.0025 0.15 ± 0.05	0.15 ± 0.01 2.7 ± 0.2	1.79	3.13	56
2	0.03 ± 0.01 0.64 ± 0.2	0.17 ± 0.02 3.6 ± 0.5	0.1 ± 0.009 2.1 ± 0.2	0.0021 ± 0.0013 0.044 ± 0.027	0.095 ± 0.009 2 ± 0.2	2.12	4.86	103
3	0.04 ± 0.01 1 ± 0.2	0.22 ± 0.02 5.5 ± 0.6	0.074 ± 0.0065 1.8 ± 0.2	0.0014 ± 0.00081 0.035 ± 0.02	0.07 ± 0.0061 1.7 ± 0.2	2.49	3.21	80
4	<0.005 <0.072	0.14 ± 0.02 2 ± 0.3	0.073 ± 0.0096 1.1 ± 0.1	0.0053 ± 0.0025 0.077 ± 0.036	0.07 ± 0.0096 1 ± 0.1	1.46	3.50	51
5	0.012 ± 0.008 0.17 ± 0.1	0.18 ± 0.02 2.6 ± 0.3	0.07 ± 0.0093 1 ± 0.1	0.0046 ± 0.0025 0.066 ± 0.036	0.063 ± 0.0087 0.91 ± 0.1	1.44	4.50	65
MEDIAN	0.03 0.64	0.18 3.6	0.074 1.8	0.0046 0.044	0.07 1.7	1.79		
RANGE	<0.005-0.2 <0.072-3.6	0.14-0.8 2-14	0.07-0.19 1-3.4	0.0014-0.0085 0.035-0.15	0.063-0.15 0.91-2.7	1.44-2.49		
Dairy Cow #6	0.012 ± 0.007 0.28 ± 0.2	0.51 ± 0.05 12 ± 1	1.1 ± 0.036 26 ± 0.9	0.037 ± 0.0064 0.87 ± 0.15	0.91 ± 0.033 21 ± 0.8	2.35	3.27	77
Dairy Cow #7	<0.004 <0.055	0.037 ± 0.009 0.51 ± 0.1	0.36 ± 0.025 5 ± 0.4	0.013 ± 0.0043 0.18 ± 0.1	0.34 ± 0.024 4.7 ± 0.3	1.38	3.90	54

* Wet weight

APPENDIX V-6. Actinide Concentrations in Rumen Contents from NTS Cattle - May 1972

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	^{89}Sr pCi/g ash pCi/kg*	^{90}Sr pCi/g ash pCi/kg*	% Ash	Ca mg/g	Wet wt (kg)	Ash wt (g)
1	<0.3 <59	1.7 ± 0.4 340 ± 80	2 ± 0.3 400 ± 60	0.1 ± 0.07 20 ± 15	1.5 ± 0.3 300 ± 60	3 ± 2 600 ± 450	4 ± 1 790 ± 200	19.9	356	1.34	266
2	<0.3 <85	3.3 ± 0.5 940 ± 200	0.89 ± 0.23 250 ± 70	<0.05 <14	0.83 ± 0.22 240 ± 70	3 ± 3 860 ± 860	8 ± 2 2300 ± 470	28.5	366	0.89	254
3	<0.3 <82	2.2 ± 0.5 600 ± 100	1.4 ± 0.3 380 ± 80	<0.04 <11	1.3 ± 0.3 360 ± 180	<2 <550	4 ± 1 1100 ± 280	27.5	358	1.38	380
4	0.5 ± 0.4 130 ± 90	1.1 ± 0.4 280 ± 90	1.8 ± 0.3 460 ± 80	0.1 ± 0.08 26 ± 20	1.7 ± 0.3 440 ± 80	<2 <510	4 ± 1 1000 ± 260	26	359	0.96	246
5	<0.3 <75	0.9 ± 0.3 220 ± 80	1.8 ± 0.3 450 ± 80	0.1 ± 0.1 25 ± 25	1.7 ± 0.3 420 ± 80	<2 <500	2 ± 1 500 ± 250	25	356	0.76	190
MEDIAN	<0.3 <82	1.7 340	1.8 400	0.1 20	1.5 360	<2 <550	4 1000	26	359		
RANGE	<0.3-0.5 <59-130	0.9-3.3 220-940	0.89-2 250-460	<0.04-0.1 <11-26	0.83-1.7 240-440	<2-3 <500-860	2-8 500-2300	19.9- 28.5	356- 366		
Dairy Cow #6	<0.3 <75	1.2 ± 0.4 300 ± 100	3.2 ± 0.4 790 ± 100	0.07 ± 0.07 17 ± 17	2.5 ± 0.4 620 ± 90	<8 <2000	2.3 ± 0.8 570 ± 200	25	364	1.51	375
Dairy Cow #7	0.5 ± 0.4 160 ± 100	0.8 ± 0.3 250 ± 100	5.2 ± 0.5 1600 ± 150	0.2 ± 0.1 62 ± 31	3 ± 0.4 940 ± 120	<2 <620	3 ± 1 930 ± 310	31	362	1.57	490

* Wet weight

APPENDIX V-7. Actinide and Strontium Concentrations in Ribs from NTS Cattle - May 1972

Animal No.	Rumen Contents K g/g ^{95}Zr pCi/g ^{103}Ru pCi/g ^{140}Ba pCi/g ^{141}Ce pCi/g	Liver K g/g	Lungs K g/g ^{95}Zr pCi/g	Thyroid ^{131}I pCi/g	Kidney K g/g	Muscle K g/g ^{137}Cs pCi/g	Blood ^{3}H pCi/l
1	0.0012 0.15 0.11 <MDA 0.21	0.0038	0.0026 0.06	18.0	0.0026	0.0038 0.03	650±220
2	0.0021 0.5 0.2 0.12 0.48	0.0033	0.0029 0.09	18.0	0.0024	0.0035 0.04	500±220
3	0.0016 0.68 0.23 0.08 0.62	0.0032	0.0025 0.08	17.0	0.0022	0.004 <MDA	2100±240
4	0.0018 0.31 0.16 <MDA 0.27	0.0034	0.0049 <MDA	21.0	0.0017	0.0049 0.03	540±220
5	0.0014 0.43 0.12 0.11 0.3	0.0025	0.0029 0.05	19.0	0.002	0.0043 0.029	420±220
6	0.0031 0.10 0.06 <MDA 0.22	0.0028	0.0022 0.03	2.9	0.0023	0.0029 <MDA	4600±280

APPENDIX V-8. Other Radionuclides Measured in Tissues from NTS Cattle - May 1972*

Animal No.	Rumen Contents K g/g ^{95}Zr pCi/g ^{103}Ru pCi/g ^{140}Ba pCi/g ^{141}Ce pCi/g	Liver K g/g	Lungs K g/g ^{95}Zr pCi/g	Thyroid ^{131}I pCi/g	Kidney K g/g	Muscle K g/g ^{137}Cs pCi/g	Blood ^{3}H pCi/l
7	0.002 <MDA 0.09 <MDA <MDA	0.0033	0.0022 <MDA	2.0	0.0016	0.003 0.03	1000±230
MEDIAN	0.0018 0.37 0.12 0.11 0.285	0.0033	0.0026 0.06	18.0	0.0022	0.0038 0.03	650
RANGE	0.0012-0.0031 0.10-0.68 0.06-0.23 0.08-0.12 0.21-0.62	0.0025- 0.0038	0.0022- 0.0049 0.03- 0.09	2.0-21.0	0.0016- 0.0026	0.0029- 0.0049 0.029- 0.04	420-4600

*Wet weight
<MDA = Less than minimum detectable activity

APPENDIX V-8. Other Radionuclides Measured in Tissues from NTS Cattle - May 1972* (contd)

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	% Ash	Wet wt (kg)	Ash wt (g)
14	SAMPLE				LOST			
15	<24 <260	100 ± 58 1100 ± 630	12 ± 4 130 ± 46	<1 <11	11 ± 4 120 ± 46	1.1	2.01	22
16	SAMPLE				LOST			
17	<6 <49	70 ± 10 570 ± 100	68 ± 18 560 ± 150	<2 <16	64 ± 17 520 ± 140	0.81	1.71	14
18	<4.9 <52	3.5 ± 2.9 37 ± 32	13 ± 4.6 140 ± 51	<1.8 <19	12 ± 4.3 130 ± 47	1.1	2.99	32
MEDIAN	<6 <52	70 570	13 140	<1.8 <16	12 130	1.1		
RANGE	<4.9-<24 <49-<260	3.5-100 37-1100	12-68 130-560	<1-<2 <11-<19	11-64 120-520	0.81- 1.1		
19 Control Calf	<5.7 <62	3.9 ± 2.5 42 ± 27	340 ± 91 3700 ± 1000	37 ± 29 400 ± 320	320 ± 88 3500 ± 970	1.1	1.94	21

* Wet weight

APPENDIX VI-1. Actinide Concentrations in Lungs from Roller Coaster Feedlot Cattle - October 1972

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	% Ash	Wet wt (kg)	Ash wt (g)
14	<200 <1900	<100 <950	Sample not analyzed for U			0.95	0.019	0.18
15	<200 <1600	300 ± 200 2400 ± 1600	Sample not analyzed for U			0.81	0.025	0.20
16	<39 <940	48 ± 33 1200 ± 950	160 ± 50 3900 ± 1300	<10 <240	150 ± 50 3600 ± 1300	2.4	0.024	0.58
17	<120 <1200	<69 <720	380 ± 100 4000 ± 1100	41 ± 34 430 ± 360	340 ± 90 3500 ± 1000	1.04	0.024	0.25
18	<50 <180	<30 <110	Sample not analyzed for U			0.36	0.139	0.50
MEDIAN	<120 <1200	<69 <950	270 3950	<20 <340	250 3550	0.95		
RANGE	<39-<200 <180-<1900	<30-300 <110-2400	160-380 3900-4000	<10-41 <240-430	150-340 3500-3600	0.36-2.4		
19 Control Calf	<16 <470	<12 <350	110 ± 40 3200 ± 1100	6 ± 4 170 ± 110	100 ± 40 2900 ± 1100	2.9	0.048	1.4

* Wet weight

APPENDIX VI-2. Actinide Concentrations in Tracheo-Bronchial Lymph Nodes from Roller Coaster Feedlot Cattle - October 1972

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	% Ash	Wet wt (kg)	Ash wt (g)
14	<12 <81	<5.9 <40	16 ± 3.1 110 ± 21	4.1 ± 1.5 28 ± 10	15 ± 2.9 100 ± 20	0.68	6.19	42.1
15	<2.3 <19	12 ± 3.7 98 ± 30	88 ± 21 720 ± 170	6.3 ± 5.6 52 ± 46	82 ± 20 670 ± 160	0.82	6.44	52.8
16	<2.1 <18	15 ± 2.6 130 ± 22	20 ± 2.8 170 ± 24	4.7 ± 1.7 40 ± 15	19 ± 2.6 160 ± 22	0.86	5.59	48.0
17	<3.7 <26	15 ± 7 110 ± 49	Analysis Not Completed			0.71	4.81	34.2
18	<2.8 <31	280 ± 25 3000 ± 280	8.6 ± 2.5 95 ± 27	<1.8 <20	8.1 ± 2.4 89 ± 26	1.1	4.89	53.8
MEDIAN	<2.8 <26	15 110	18 140	4.4 34	17 130	0.82		
RANGE	<2.1-<12 <18-<81	<5.9-280 <40-3000	8.6-88 95-720	<1.8-6.3 <20-52	8.1-82 89-670	0.68-1.1		
19 Control Calf	<2.1 <23	<2.3 <25	<1.8 <20	<1.8 <20	<1.8 <20	1.1	6.37	70.1

* Wet weight

APPENDIX VI-3. Actinide Concentrations in Muscle from Roller Coaster Feedlot Cattle - October 1972

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	% Ash	Wet wt (kg)	Ash wt (g)
14	<29 <390	380 ± 120 5100 ± 1700	16 ± 5 220 ± 70	<1 <14	15 ± 5 200 ± 70	1.35	2.59	35
15	28 ± 11 280 ± 110	450 ± 46 4400 ± 450	16 ± 4 160 ± 44	<3 <29	12 ± 4 120 ± 37	0.98	2.74	27
16	<42 <540	350 ± 150 4500 ± 1900	49 ± 15 620 ± 200	<1 <13	46 ± 15 590 ± 19	1.3	3.45	44
17	<6.3 <160	310 ± 19 7600 ± 450	13 ± 3.3 320 ± 79	2.5 ± 1.4 62 ± 34	13 ± 3.1 320 ± 74	2.5	1.38	34
18	98 ± 88 1200 ± 1100	210 ± 140 2500 ± 1600	11 ± 4 130 ± 52	<2 <24	9 ± 4 110 ± 46	1.2	3.61	43
MEDIAN	28.5 <390	350 4500	16 220	<2 <24	13 200	1.3		
RANGE	<6.3-98 <160-1200	210-450 2500-7600	11-49 130-620	<1-<3 <13-62	9-46 110-590	0.98- 2.5		
19 Control Calf	<6.5 <82	25 ± 10 320 ± 130	17 ± 5 220 ± 65	<2 <25	15 ± 5 190 ± 60	1.3	2.13	27

* Wet weight

APPENDIX VI-4. Actinide Concentrations in Liver from Roller Coaster Feedlot Cattle - October 1972

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	% Ash	Wet wt (kg)	Ash wt (g)
14	<3.8 <53	46 ± 9.3 640 ± 130	310 ± 17 4300 ± 240	11 ± 3.1 150 ± 43	290 ± 16 4000 ± 220	1.4	3.83	53.6
15	<11 <180	36 ± 11 580 ± 180	1200 ± 42 19000 ± 680	37 ± 7.5 590 ± 120	1100 ± 40 18000 ± 640	1.6	3.39	54.2
16	19 ± 8.7 290 ± 130	1100 ± 80 16000 ± 1200	870 ± 35 13000 ± 530	27 ± 6.1 410 ± 92	800 ± 33 12000 ± 500	1.5	2.88	43.2
17	<4.8 <58	70 ± 10 840 ± 120	360 ± 22 4300 ± 260	12 ± 3.6 140 ± 43	340 ± 21 4100 ± 250	1.2	2.5	30.0
18	<6.3 <100	45 ± 16 720 ± 260	1500 ± 55 24000 ± 880	57 ± 10 910 ± 160	1400 ± 52 22000 ± 830	1.6	3.08	49.3
MEDIAN	<6.3 <100	46 720	870 13000	27 410	800 12000	1.5		
RANGE	<3.8-19 <53-290	36-1100 580-16000	310-1500 4300-24000	11-57 140-910	290-1400 4000-22000	1.2-1.6		
19 Control Calf	13 ± 8.8 210 ± 140	220 ± 30 3600 ± 490	1100 ± 37 18000 ± 610	37 ± 7 600 ± 110	920 ± 30 15000 ± 550	1.6	2.46	40.0

* Wet weight

APPENDIX VI-5. Actinide Concentrations in Rumen Contents from Roller Coaster Feedlot Cattle - October 1972

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	% Ash	Wet wt (kg)	Ash wt (g)
14	<20 <2000	40 ± 20 4000 ± 2000	6000 ± 2400 600000 ± 24000	160 ± 37 16000 ± 3700	5600 ± 2300 560000 ± 23000	10.0	0.039	3.9
15	<20 <4000	190 ± 50 38000 ± 10000	20000 ± 760 4000000 ± 150000	760 ± 140 150000 ± 28000	18000 ± 710 3600000 ± 140000	20.0	0.05	10.0
16	<20 <8200	30 ± 20 12000 ± 8000	17000 ± 610 7000000 ± 250000	460 ± 98 190000 ± 40000	16000 ± 560 6600000 ± 230000	40.7	0.128	52.5
17	SAMPLE				LOST			
18	<20 <4300	40 ± 20 8700 ± 4600	25000 ± 820 5400000 ± 180000	830 ± 140 180000 ± 32000	24000 ± 770 5200000 ± 150000	21.7	0.083	18.0
MEDIAN	<20 <4150	40 10400	18500 4700000	610 165000	17000 4400000	20.85		
RANGE	<20-<20 <2000-<8200	30-190 4000-38000	6000-25000 600000-7000000	160-830 16000-190000	5600-24000 560000-6600000	10-40.7		
19 Control Calf	<30 <14000	280 ± 70 134000 ± 34000	53000 ± 2900 25000000 ± 1400000	2200 ± 590 1060000 ± 280000	49000 ± 2800 24000000 ± 1300000	48.0	0.04	19.2

* Wet weight

APPENDIX VI-6. Actinide Concentrations in Reticulum Sediment from Roller Coaster Feedlot Cattle - October 1972

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	^{89}Sr pCi/g ash pCi/kg*	^{90}Sr pCi/g ash pCi/kg*	% Ash	Ca mg/g	Wet wt (kg)	Ash wt (g)
14	<2.5 <680	32 ± 5.9 8600 ± 1600	8.1 ± 2.1 2200 ± 580	<0.74 <200	7.8 ± 2 2100 ± 540	<1.4 <380	3.2 ± 1.3 860 ± 350	26.9	380	1.22	329.4
15	<1.3 <390	7 ± 1.9 2100 ± 580	5.3 ± 1.7 1600 ± 510	<0.33 <99	5 ± 1.6 1500 ± 480	<2.6 <780	4.3 ± 1.1 1300 ± 330	30.0	370	1.43	429
16	2.7 ± 1.7 810 ± 510	130 ± 11 39000 ± 3300	6.3 ± 1.9 1900 ± 580	<0.13 <39	6 ± 1.8 1800 ± 550	<2.7 <810	4 ± 1.1 1200 ± 330	30.0	380	1.54	462
17	<1.5 <360	50 ± 5 12000 ± 1200	9.6 ± 2 2300 ± 470	<0.29 <69	8.7 ± 1.9 2100 ± 450	<4 <960	4.6 ± 1.1 1100 ± 270	24.0	380	1.29	309.6
18	<1.3 <350	<1.8 <480	5.2 ± 1.5 1400 ± 400	0.56 ± 0.48 150 ± 130	4.8 ± 1.4 1300 ± 370	<2.8 <760	4.4 ± 1.1 1200 ± 300	26.9	380	1.72	464
MEDIAN	<1.5 <390	32 8600	6.3 1900	<0.33 <99	6 1800	<2.7 <780	4.3 1200	26.9	380		
RANGE	<1.3-2.7 <350-810	<1.8-130 <480-39000	5.2-9.6 1400-2300	<0.13-<0.74 <39-<200	4.8-8.7 1300-2100	<1.4-<4. <380-<960	3.2-4.6 860-1300	24-30	370-380		
19 Control Calf	<1.2 <230	2 ± 1.1 380 ± 200	10 ± 1.4 1900 ± 360	0.5 ± 0.4 94 ± 72	8.9 ± 1.9 1700 ± 360	<3.4 <640	2.1 ± 0.93 400 ± 170	19.0	390	1.34	254.6

* Wet weight

APPENDIX VI-7. Actinide and Strontium Concentrations in Femurs from Roller Coaster Feedlot Cattle - October 1972

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	^{89}Sr pCi/g ash pCi/kg*	^{90}Sr pCi/g ash pCi/kg*	% Ash	Ca mg/g	Wet wt (kg)	Ash wt (g)
14	<3.4 <1200	18 ± 5.4 6300 ± 1900	13 ± 3.1 4600 ± 1100	<0.57 <200	12 ± 2.9 4200 ± 1000	<4 <1400	4 ± 1.2 1400 ± 410	34.9	380	0.825	288.7
15	<1.2 <400	4.8 ± 1.5 1600 ± 510	7.3 ± 1.8 2400 ± 590	0.55 ± 0.48 180 ± 160	6.7 ± 1.7 2200 ± 560	<2.3 <760	3.9 ± 0.97 1300 ± 320	33.0	370	0.856	282.5
16	<1.2 <460	53 ± 5.8 20000 ± 2200	7.9 ± 1.8 3000 ± 690	<0.53 <200	7.4 ± 1.7 2800 ± 650	<2.9 <1100	3.4 ± 1.2 1300 ± 440	37.9	380	0.540	205.2
17	<1.5 <400	31 ± 3.4 8400 ± 910	10 ± 2 2700 ± 540	<0.37 <99	9.6 ± 1.9 2600 ± 510	<4.4 <1200	2.8 ± 1.0 760 ± 280	26.9	380	0.865	233.5
18	<1.5 <520	8.1 ± 2.1 2800 ± 720	6.3 ± 1.7 2200 ± 600	<0.57 <200	5.9 ± 1.6 2100 ± 560	<3.5 <1200	2.6 ± 1 910 ± 340	35.0	370	0.690	241.5
MEDIAN	<1.5 <460	18 6300	7.9 2700	0.55 <200	7.4 2600	<4 <1200	3.4 1300	34.9	380		
RANGE	<1.2-<3.4 <400-<1200	4.8-53 1600-20000	6.3-13 2200-4600	<0.37-<0.57 <99-<200	5.9-12 2100-4200	<2.3-<4.4 <760-<1400	2.6-4 760-1400	26.9-37.9	370-380		
19 Control Calf	<1.2 <350	<0.76 <220	17 ± 2.7 4900 ± 790	0.62 ± 0.48 180 ± 140	16 ± 2.5 4600 ± 730	<2.2 <630	3.4 ± 0.97 990 ± 280	28.9	370	0.597	173.1

* Wet weight

APPENDIX VI-8. Actinide and Strontium Concentrations in Ribs from Roller Coaster Feedlot Cattle - October 1972

Animal No.	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	^{89}Sr pCi/g ash pCi/kg*	^{90}Sr pCi/g ash pCi/kg*	% Ash	Ca mg/g	Wet wt (kg)	Ash wt (g)
14	<3.1 <620	40 ± 8.5 8000 ± 1700	10 ± 2.1 2000 ± 430	1 ± 0.9 200 ± 180	10 ± 2 2000 ± 400	<3.5 <700	3.2 ± 1 640 ± 200	20.0	380	0.857	171.4
15	<1.5 <240	8.1 ± 2.1 1300 ± 330	5.9 ± 1.3 940 ± 200	<0.4 <64	5.3 ± 1.4 850 ± 220	<2.2 <350	3.2 ± 1 510 ± 150	16.0	380	1.296	207.4
16	2.9 ± 1.5 580 ± 310	160 ± 1200 32000 ± 2400	7 ± 1.8 1400 ± 360	<0.2 <39	6.5 ± 1.7 1300 ± 340	<1.9 <380	2.3 ± 0.8 460 ± 160	20.0	380	1.411	282.2
17	<1.4 <210	73 ± 7.3 11000 ± 1100	8.7 ± 1.9 1300 ± 290	0.67 ± 0.49 100 ± 74	8 ± 1.8 1200 ± 270	<2.9 <430	3.7 ± 1.1 550 ± 170	14.9	380	1.338	200.7
18	<1 <180	10 ± 2.1 1800 ± 370	6.1 ± 1.4 1100 ± 260	0.52 ± 0.43 93 ± 77	5.6 ± 1.3 1000 ± 240	<3.4 <610	2.3 ± 0.89 410 ± 160	18.0	370	1.686	303.5
MEDIAN	<1.5 <240	40 8000	7 1300	0.52 93	6.5 1200	<2.9 <430	3.2 510	18	380		
RANGE	<1-<3.1 <180-<620	8.1-160 1300-32000	5.9-10 940-2000	<0.2-1 <39-200	5.3-10 850-2000	<1.9-<3.5 <350-<700	2.3-3.7 410-640	14.9-20	370-380		
19 Control Calf	<1.4 <170	2.8 ± 1.3 340 ± 160	14 ± 2.7 1700 ± 330	0.71 ± 0.57 85 ± 68	13 ± 2.6 1600 ± 310	<3.7 <440	1.9 ± 1 230 ± 120	11.9	380	1.866	223.9

* Wet weight

APPENDIX VI-9. Actinide and Strontium Concentrations in Vertebrae from Roller Coaster Feedlot Cattle - October 1972

Animal No.	Rumen Contents K g/g	Liver K g/g	Thyroid	Kidney K g/g	Muscle K g/g	Blood ^{3}H pCi/l
14	0.0014	0.0004	<MDA	0.0021	0.003	720 ± 270
15	0.0015	0.0025	<MDA	0.0013	0.0034	970 ± 260
16	0.0019	0.003	<MDA	0.0018	0.0043	1000 ± 280
17	0.004	0.0032	<MDA	0.0019	0.0039	960 ± 270
18	0.0031	0.0026	<MDA	0.0018	0.0031	830 ± 260
19	0.001	0.0023	<MDA	0.0023	0.0014	1000 ± 240
MEDIAN	0.0017	0.00255		0.00185	0.00325	965
RANGE	0.001-0.004	0.0004-0.0032		0.0013-0.0023	0.0014-0.0043	720-1000

*Wet weight
<MDA = Less than minimum detectable activity

APPENDIX VI-10. Other Radionuclides Measured in Tissues from Roller Coaster Feedlot Cattle - October 1972*

Food Type	^{238}Pu fCi/g ash fCi/kg*	^{239}Pu fCi/g ash fCi/kg*	^{234}U fCi/g ash fCi/kg*	^{235}U fCi/g ash fCi/kg*	^{238}U fCi/g ash fCi/kg*	Ash (%)	Wet wt (kg)	Ash wt (g)
Steer Concentrate	<1.1 <190	0.8 ± 0.65 140 ± 110	3700 ± 120 642000 ± 21000	120 ± 21 21000 ± 3500	3500 ± 120 607000 ± 21000	17.3	2.42	420
4-Way Grain	<4.1 <120	3.4 ± 2.9 99 ± 83	17 ± 5.2 500 ± 150	3 ± 2 870 ± 57	16 ± 4.8 460 ± 140	2.9	1.69	49
Alfalfa Hay	<0.9 <80	3 ± 1 300 ± 100	180 ± 9 16000 ± 800	11 ± 1 990 ± 130	170 ± 9 15000 ± 800	8.96	0.67	60
Area 15 Water	<400 fCi/l	20 ± 20 fCi/l	910 ± 80 fCi/l	27 ± 15 fCi/l	860 ± 80 fCi/l			

* Wet weight

APPENDIX VI-11. Actinide Concentrations of the Water and the Food from the Roller Coaster Feedlot Cattle - October 1972

APPENDIX VII. Minimum Detectable Activities for Radionuclide Analyses, Technical Support Laboratory, National Environmental Research Center, Las Vegas, Nevada.

The minimum detectable activities (MDA's) in terms of total activity per sample for standard geometries and counting times are based on a combination of a number of technical experiments and operational experience. By means of experimentation, the MDA has been defined as that activity which produced a ± 100 percent deviation at the 95 percent confidence level. These values are applicable to ideal conditions and simple complexes of nuclides. Complex spectra or spectra showing naturally occurring radionuclides can raise the MDA's considerably.

Minimum Detectable Activities in pCi for Total Sample

Isotope	10-Min Count	40-Min Count			100-Min Count		
	Planchet	Planchet	400 ml	3.5 l	400 ml	1,000 ml	3.5 l
^{54}Mn	50	25	40	35	25	25	22
^{65}Zn	500	250	400	350	250	250	220
^{60}Co	50	25	40	35	25	25	22
^{95}Zr	50	25	40	35	25	25	22
^{103}Ru	50	25	40	35	25	25	22
^{106}Ru	500	250	400	350	250	250	220
^{124}Sb	50	25	40	35	25	25	22
^{125}Sb	250	125	200	175	125	125	110
^{132}Te	50	25	40	35	25	25	22
^{131}I	50	25	40	35	25	25	22
^{133}I	50	25	40	35	25	25	22
^{137}Cs	50	25	40	35	25	25	22
^{140}Ba	50	25	40	35	25	25	22
^{141}Ce	250	125	200	175	125	125	110
^{144}Ce	500	250	400	350	250	250	220
^{181}W	600	300	475	425	300	300	260
K*	0.5	0.3	0.4	0.4	0.3	0.3	0.25

*Grams of stable potassium per kilogram of sample (wet weight) as determined from ^{40}K activity.

APPENDIX VII. Minimum Detectable Activities for Radionuclide Analyses contd

Isotope	Minimum Detectable Activity	Length of Count Time
^{3}H	0.2 pCi per ml of H_2O	200 minutes
^{89}Sr	5.0 pCi per sample	50 minutes
^{90}Sr	2.0 pCi per sample	50 minutes
^{238}Pu	0.02 pCi per sample	1,000 minutes
^{239}Pu	0.02 pCi per sample	1,000 minutes
^{234}U	0.02 pCi per sample	1,000 minutes
^{235}U	0.02 pCi per sample	1,000 minutes
^{238}U	0.02 pCi per sample	1,000 minutes

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