

SUMMARY REPORT OF THE GRAZING STUDIES CONDUCTED
ON A PLUTONIUM-CONTAMINATED RANGE IN
AREA 13 OF THE NEVADA TEST SITE

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

May 1979

This study performed under a Memorandum
of Understanding No. EY-76-A-08-0539
for the
U.S. DEPARTMENT OF ENERGY

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by
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May 1979

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ABSTRACT

Actinide concentrations in the tissues of beef animals periodically sacrificed and sampled during a 3-year grazing study on a plutonium-contaminated range of the Nevada Test Site are tabulated and discussed. The primary objective of this study was to determine the uptake and tissue distribution of the plutonium by ruminants. Other objectives were to evaluate maternal-fetal transfer, to determine uptake and distribution differences in young versus mature animals, and to compare these data with those collected from other contaminated areas. Steers with surgically prepared rumen fistulas served as biological samplers to determine grazing habits (quantity and type of forage ingested) as a function of seasonal plant availability and preference, to estimate intake of actinides over specified periods of time, and to determine the actinide ratios within these ingesta.

Food habit analyses of ingesta from rumen-fistulated steers and sacrificed cattle revealed that shrub species made up the major portion of their diet during most seasons of the year. Grasses were preferred during the spring months. An apparent relationship between actinide concentrations in these ingesta and *Eurotia lanata* was noted.

Using activity levels found in the rumen contents, it was estimated that a study cow ingested 100 microcuries of plutonium-239 prior to sacrifice. Of this, 16.4 microcuries was in rumen fluids from which a combined retention factor of 0.0034 percent was calculated for the bone, muscle, and liver. Comparisons of plutonium-239/plutonium-238 ratios in ingesta and tissues indicate that the plutonium-238 is more readily absorbed and retained.

All animals sacrificed were necropsied, and selected tissue and organ samples were collected for histopathological examination and actinide analyses. No radiologically significant lesions were found.

The gonadal concentrations of the actinides were significantly higher than those of blood and muscle and approached those of bone. These data indicate that consideration should be given to the plutonium-239 dose to gonads as well as that to bone, liver, and lungs of man.

Actinide concentrations in the skeletons of cows originally introduced into the study areas showed little increase with increased time of exposure, while those of animals born in the study areas showed an increasing trend with time.

Concentrations of plutonium-239 in the lung, liver, muscle, and femur tissues of the Area 13 cattle were significantly higher than in tissues

collected from grazing cattle from other Nevada Test Site areas, from Rocky Flats, Colorado, or from Searchlight, Nevada.

The plutonium-239 concentrations in bones, lungs, and livers collected from wildlife with free access to and from the contaminated zones ranged from 1 to 10 percent of those found in cattle restricted to the area. These lesser concentrations obviously reflect the "dilution" resulting from these animals ranging into less contaminated areas around the study sites.

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INTRODUCTION

In recent years, there have been several reports published that listed data on actinide levels in the tissues of grazing or browsing animals that periodically ranged over plutonium-contaminated areas or were exposed to worldwide fallout (Fountain, 1961; Brechbill, 1969; Hakonson *et al.*, 1973; Smith and Giles, 1974; Smith and Giles, 1975; Smith and Black 1975; Smith *et al.*, 1976b; Smith *et al.*, 1976c; and Brown *et al.*, 1976). Other studies have been conducted in which actinides were administered either orally, intravenously, or by inhalation (McClellan *et al.*, 1962; Moskalev *et al.*, 1969; Stanley *et al.*, 1974; Stanley *et al.*, 1975; and Sutton, 1976). However, as far as is known, only one study has been conducted in which reproducing beef cattle were restricted for an extended period of time to a plutonium-contaminated range whose native vegetation supplied all subsistence. This study, conducted under the auspices of the Nevada Applied Ecology Group (NAEG), took place within the fenced compounds of the Project 57 site in Area 13 of the Nevada Test Site (NTS) and extended from May 1973 to April 1976.

The primary objective of this study was to determine the uptake and tissue distribution of plutonium by ruminants maintained in an actual contaminated area. Other objectives were to compare tissue levels found in grazing animals (cattle) with those found in browsing animals (goats); to compare the relative contributions in grazing animals of plutonium incorporated within the plant and that on the plant surface or ingested as foreign matter during the grazing process; to evaluate maternal-fetal transfer; to determine any uptake and distribution differences observed in young versus mature animals; and to compare these data with data collected from other contaminated areas, and from control areas. The relation of food habits to tissue distribution was also evaluated. It was intended that data collected from the tissues and ingesta of these animals would provide an assessment of plutonium movement through an ecosystem contaminated by "real" plutonium releases, and that appropriate data collected would be used to evaluate transport and dose models being developed from controlled plutonium metabolism studies. .

Rumen-fistulated steers (steers with a capped tube inserted into a permanent surgical opening into the stomach) served as biological samplers for determining grazing habits as a function of plant availability and season, estimating plutonium intake over specified periods of time, and determining the ratio of the actinide isotopes in the ingesta. Through a contract with the University of Nevada, Reno (UNR), ingesta from the steers were analyzed to determine the digestibility and dry matter of the forages consumed at various seasons of the year. Plutonium intake was also partitioned into organic and inorganic plutonium; i.e., plutonium incorporated with the plant

tissues versus that on the exterior of the plant.

In addition to the ingested samples collected periodically from the rumen-fistulated steers, tissue samples were collected from 20 cattle, 4 fetuses, 2 goats, and selected wildlife. The goat portion of the study was abandoned after predators (coyotes) destroyed two bands of goats.

As data became available during the course of these studies, they were tabulated and presented at the periodic information meetings of NAEG or other symposia and published as part of the transactions of these meetings. In order to summarize all of the data from the entire study, this report will present modified excerpts from these published reports as well as all data not previously reported. However, data collected by the UNR are not currently available and will be published as a separate report at a later date.

EXPERIMENTAL DESIGN

General Procedures

In April 1973, nine pregnant beef cows (three in each trimester of pregnancy) were procured from a control herd pastured near Kingman, Arizona. These animals and their descendants grazed within the Area 13 compound for the duration of the study. After 6 months, a pregnant mature cow, a cow nursing a male calf (less than 3 months old), and a cow and grazing male calf (3 to 6 months old) were removed from the herd, sacrificed, necropsied, and sampled. Thereafter, animals were periodically selected for sacrifice, necropsy, and sampling.

Tissues analyzed for plutonium content included bones (femurs and vertebrae), lung, liver, muscle, tracheobronchial lymph nodes, blood, gonads, rumen contents, and reticulum sediment. In addition, tissues were analyzed for other radionuclides of interest, i.e., americium and uranium. Botanical and radionuclide data collected from the rumen contents supplemented data collected from the rumen-fistulated steer portion of the study.

Monthly for the first 6 months, and quarterly thereafter, four rumen-fistulated steers were placed in the inner compound of Area 13 for a 48-hour acclimation period. The rumen was then completely emptied of all ingesta and the steers were allowed to graze for a specific period of time. All ingesta were then removed for various analyses.

During 1974, a contract (number 68-03-2047) was awarded to UNR for a study that complemented the grazing studies conducted by the Environmental Monitoring and Support Laboratory-Las Vegas (EMSL-LV). The contractor is determining (1) the dry matter and plutonium intake in the diet of grazing animals sampled at various seasons of the year, (2) the digestibility of range plants grown on plutonium-contaminated soils, and (3) the fractions of the total plutonium intake originating from plants, i.e., "plant plutonium," and the fraction that came from soil ingested incidentally during the

mechanical grazing process, "soil plutonium." As mentioned previously, the final report concerning these data is still being prepared.

Wildlife were collected as targets of opportunity during routine operations at the Area 13 site. Species collected included jackrabbit, coyote, and fox. These animals were collected by shooting. Tissues sampled and analyzed corresponded to those collected from the cattle.

Routine Husbandry Procedures

The Area 13 study area is shown in Figure 1. Originally, seven of the study cows were maintained within the outer fence and the remaining two cows within the inner fence. The outer fence enclosed an area of approximately 400 hectares and consisted of four strands of barbed wire attached to steel tee posts. A single strand of electrified fence wire was added at the 0.8-meter level of this fence. The inner fence enclosed approximately 100 hectares and consisted of six strands of barbed wire attached to steel tee posts.

The holding corral was 4.9 meters by 14.6 meters with a 52-meter wing. The corral and wing were constructed of commercial 4.9-meter metal panels. Each panel was constructed of steel pipe and was 1.5 meters high.

The main waterer was located within the holding corral so that it could be filled from outside the fenced area. The pipe and pressure pump used to fill the waterer within the inner compound were located at the same position. The filling pipe was run through Transite® pipe lying on the surface of the ground near the wing. The Transite® pipe protected the waterline from freezing and damage from livestock. Waterers were galvanized stock tanks which were partially covered to reduce evaporation loss.

Placement of the animals and other entries into Area 13 were coordinated with the NAEG of the U.S. Department of Energy, Nevada Operations Office (DOE/NV), and with the Operations Coordination Center at the NTS control point.

The study area was designed so that personnel would not be required to enter either fenced area during periodic replenishment of water and salt. Personnel entering the fenced areas were accompanied by a certified monitor. Appropriate anti-contamination (anti-c) protective clothing (coveralls, gloves, and protective footwear) were worn. Respirators were required if entry was on windy, dusty days or when activities involved soil disturbances. If contamination of personnel and/or equipment was found by the monitor, standard decontamination procedures were conducted. Used protective clothes were placed in plastic bags and returned to the NTS Radiation Safety laundry facility.

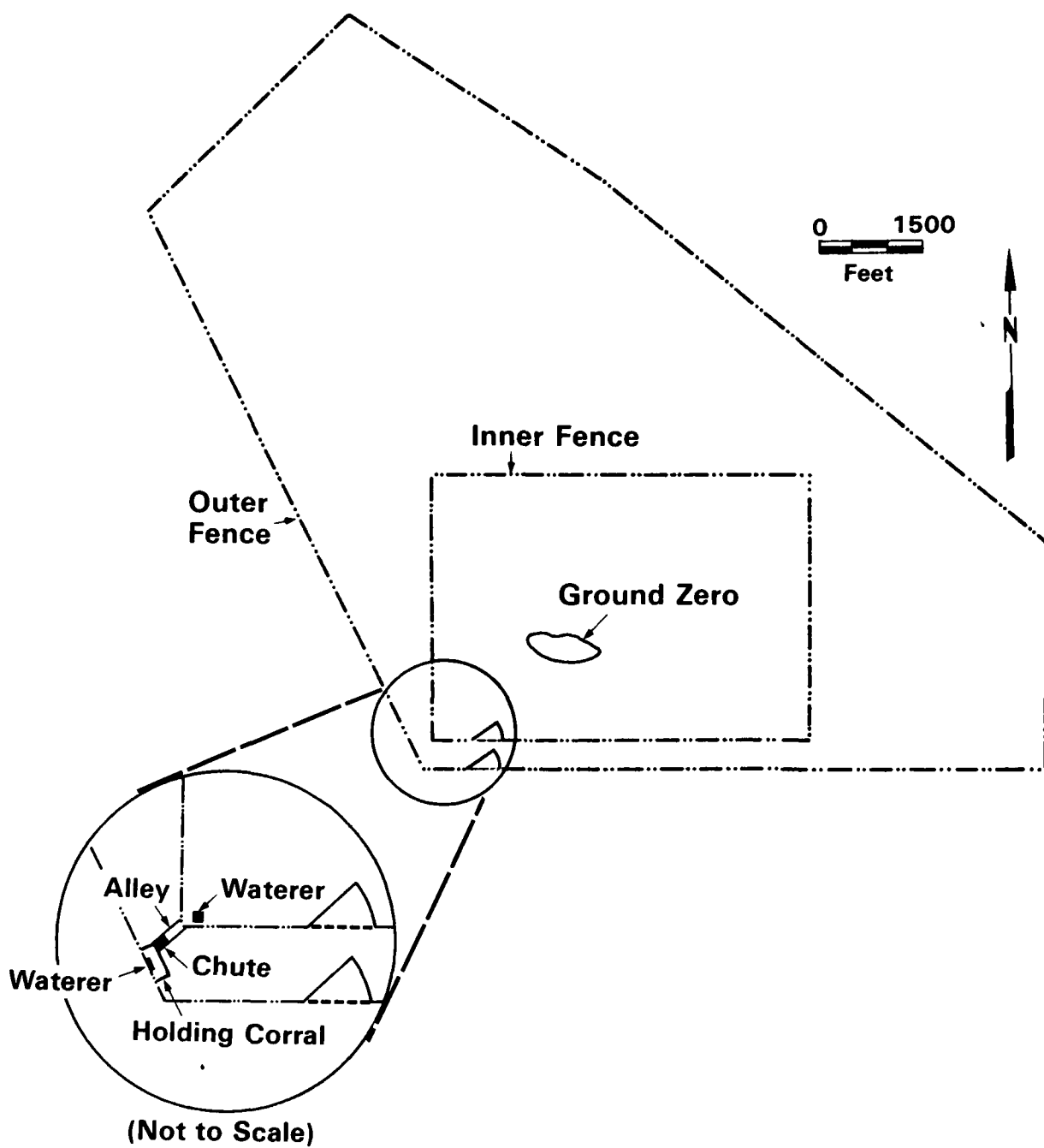


Figure 1. Sketch of Area 13 study compounds and holding corrals

Rumen-Fistulated Steer Study Procedure

According to the sampling schedule mentioned previously, the rumen-fistulated steers were loaded in a trailer, transported to Area 13, and released in the inner compound. After a 48-hour acclimation period, the steers were corralled within the holding chute, all ingesta were removed from the rumen, and the rumen was washed. (A portion of these ingesta was saved as an inoculum of rumen microflora and fauna for the steers prior to their return to Area 15.) They were then released to graze freely for an additional 24 hours. The animals were again corralled and all ingesta removed. These ingesta were separated into fluid and solid components and any sediment collected. These different fractions were weighed. Samples of all three fractions were packaged and transported to the analyzing laboratory in accordance with procedures outlined below. All ingesta surplus to sampling requirements were left within the Area 13 fenced areas.

Personnel involved in each initial release followed the radiation safety procedures outlined for the routine animal husbandry. A certified monitor accompanied personnel involved in the activities of 48-hour ingesta removal, and during the final capture and return to Area 15. Personnel involved in capture activities wore anti-c clothing. Respirators were worn if conditions were windy or dusty. In addition to this clothing, rubber obstetrical (OB) sleeves covered by disposable OB gloves were worn by personnel removing contaminated rumen ingesta.

Upon their return to Area 15, the steers and horses used during the roundup were placed on the individual pen pad (which drains into the radiation waste sump) and thoroughly washed with the Clean King® high pressure washer. The horses were then released into their normal corral. Trailers used in transporting the animals were also decontaminated on the pad. Swipe tests were conducted on all returned animals and vehicles.

Upon completion of the sampling and decontamination activities, the personnel involved showered in the Area 15 barn. After sampling, the steers were maintained in individual pens on the pad for 3 days. All wastes were washed from the pad into the radioactive waste sump. The steers were then released into their pens.

Sacrifice and Tissue-Collection Procedures

At the end of the first 6 months, a pregnant cow and two cow-calf pairs were removed from the compound and transported to Area 15 for sacrifice and sampling. Thereafter, at approximately 6-month or 1-year intervals, selected animals were removed for sacrifice and sampling.

Personnel involved in the capture efforts followed the radiation safety procedures outlined above. The horses and transport equipment were decontaminated as described previously.

Upon arrival at Area 15, the study animals were placed in holding

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facilities on the individual pen pad. They were then decontaminated with the Clean King® and held overnight in pens on the pad. The next morning they were again washed with high-pressure water.

Following their final decontamination, the animals were transferred to the slaughter facility where they were sacrificed by firing a .243-caliber bullet into the brain. They were then hoisted and exsanguinated by severing the jugular vein. The skin was removed in such a manner that the hair side never touched the flesh. Equipment (knives and gloves) that touched the skin was not used for any other procedure.

Selected tissue samples were then collected. As tissue concentrations could be expected to be several orders of magnitude lower than the concentrations found in the ingesta, all tissue samples were collected prior to collection of samples from the digestive tract.

Personnel assisting in the sacrifice and sample collection and preparation were dressed in protective footwear, anti-c coveralls, and latex gloves. Liquid wastes (blood and wash water) were flushed into the radioactive waste sump. Any other materials not collected for analysis were disposed of as solid wastes as described below. Following each sacrifice, the area was decontaminated and monitored under supervision of the EMSL-LV Radiation Safety Officer. The personnel involved then showered in the Area 15 facility.

Sample-Preparation, Storage, and Transportation Procedures

All samples for actinide analysis were placed within a 1-gallon (3.8 liter) paint can lined with a plastic bag. The can was closed and double-bagged and each bag individually heat-sealed. The samples were stored in the Area 15 freezers until they were transported to the laboratory for analysis.

The soft tissues of sufficient volume were prepared for gamma analysis by grinding and sealing in a 200-milliliter (ml) aluminum can. They were preserved with 10-percent buffered formaldehyde. Those of smaller volume, e.g., thyroid, were prepared for analysis by macerating in a blender and were suspended in agar in a 200-ml container. Sample preparation was done within the controlled area of the Area 15 barn. All equipment (blender, grinder, etc.) was thoroughly decontaminated under the supervision of a certified monitor.

All sample containers were sealed and packaged for shipment to the analyzing laboratory in accordance with U.S. Department of Transportation regulations and were coordinated with Reynolds Electrical and Engineering Company (REECo) Radiation Materials Control. The samples for gamma and tritium analyses were counted at the EMSL-LV. Samples for actinide analysis were shipped to the EMSL-LV or to independent contractor laboratories.

Samples of rumen contents collected for botanical analysis were frozen until analyzed. They were prepared for botanical analysis by washing and screening a random aliquot at the sample-preparation area of the Area 15 barn.

The samples were then transported to the EMSL-LV for botanical examination.

Waste Disposal Procedures

All anti-c clothing used in animal husbandry, rumen-fistulated steer study, and sacrifices were placed in plastic bags at Area 15 and transported to the NTS Radiation Safety laundry facility for decontamination. If deemed necessary by the EMSL-LV Radiation Safety Officer, disposable equipment used in these procedures and the solid waste, i.e., rumen contents, tissues, feces, etc., were placed in plastic-lined, 55-gallon (208 liter) drums for disposal. The carcasses and wastes were transported to the sanitary landfill for disposal.

Liquid wastes (blood, wash water, etc.) were flushed into the radioactive waste sump at Area 15. Contaminated equipment (knives, trailers, etc.) were decontaminated by washing in areas that drain into the radioactive sump. The adequacy of decontamination was determined by certified monitors under the direction of the EMSL-LV Radiation Safety Officer.

Special Study to Determine Soil in Ingesta Procedures

At several of the early information meetings of NAEG, there were frequent questions and discussions about the amount of soil a cow ingested during the grazing processes. Estimates of soil ingestion have been in excess of 2 kilograms per day. A simple study was devised to provide an indication of the amount of soil ingested.

After the rumens of two rumen-fistulated steers were completely emptied of all ingesta, the rumen and reticulum were rinsed with water and the wash water bailed out to remove any residual sediments. This cleansing process was repeated three times. The animals were allowed to graze for 24 hours on the selected range. Areas grazed included the well-grazed inner compound of Area 13 and an ungrazed range near White Rock Spring.

Following the grazing period, the ingesta were removed and agitated with water. The ingesta were washed through a screen (1.2- × 1.6-mm mesh) and the wash water saved. The rumen and reticulum were flushed with water three times and this wash water added to the ingesta wash water. The supernatant liquid was poured off and the sediments collected and heated at 450° C for 3 hours. This procedure oxidized any residual bits of vegetation. The residues were weighed.

The same procedures were followed in the examination of the entire gastrointestinal tract for a cow sacrificed on January 28, 1976. This cow had grazed the outer compound of Area 13 her entire life.

ANALYTICAL METHODS

Tissues were prepared for actinide analysis by ashing. The actinides were eluted by using ion exchange and then analyzed by alpha spectrometry using plutonium-236, americium-243, and uranium-232 as internal tracers. Details of these analytical procedures have been published previously by Talvitie (1971 and 1972), Wish and Rowell (1956), Mitchell (1960), Hagan and Arrhenius (1963), and Major *et al.* (1975).

Selected soft tissues were qualitatively and quantitatively analyzed for gamma-emitting radionuclides through 1,200-minute counts on lithium-drifted germanium detectors. Blood samples were analyzed for tritium content. Bones were analyzed for strontium-89 and -90. Details of these analytical procedures were published by Johns (1975).

Tissue and lesion samples collected for histopathological examination were first fixed in a 10-percent Formalin® solution. They were then dehydrated with alcohol and embedded in paraffin prior to sectioning with a microtome. A 5-micrometer section was placed on a glass slide, stained with hematoxylin and eosin, and delivered to a pathologist for interpretation.

When available, 2 milliliters of fresh blood was withdrawn from the jugular vein and placed in a heparinized tube. Two blood-smear slides were then made. These were airmailed to the United Medical Laboratories, Inc., of Portland, Oregon, where a complete blood-cell count and a differential count were made. Other analyses performed included hemoglobin, hematocrit, and packed cell volume.

Botanical analyses of the rumen-content samples were done by washing random aliquots of the ingesta with water. After washing, the samples were placed in a shallow pan and suspended in approximately 200 milliliters of water. Identification of the vegetation was completed by examining each fragment with the aid of a binocular microscope. Following the identification, a visual estimate of the percentage composition for each species was made and recorded. The shrubs and forbs were identified according to Munz and Keck (1965) and McMin (1964) and the grasses according to Hitchcock (1950).

Actinide analyses were performed by the Monitoring Systems Research and Development Division of the EMSL-LV; by LFE Environmental Analysis Laboratories Division, Richmond, California; or by the Eberline Instrument Corporation, Albuquerque, New Mexico. All of the analyses for strontium, tritium, and the gamma-emitting radionuclides were performed by the EMSL-LV.

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The activity values for plutonium-239 listed in this report actually are the sum of the individual isotopic activities of plutonium-239 and -240. The alpha emissions of these two isotopes cannot be separately identified (resolved) by alpha spectrometric analysis (Bernhardt, 1976). As LFE Environmental Analysis Laboratories Division performed total uranium analyses, the uranium-238 concentrations listed in this report were calculated assuming that the uranium isotopes were present in the same ratios as found in nature.

All data are reported with the 95 percent confidence level counting error and are corrected to time of sample collection. Results which show a net sample activity less than the two-sigma counting error are reported as less than the minimum detectable activity. The approximate minimum detectable activities and the analytical procedures are summarized in Appendix I.

Quality assurance samples were included in each group of samples submitted for plutonium analyses. These were either duplicate tissue or ash samples collected from sacrificed animals and submitted under a blind identification number, or they consisted of similar tissues purchased at a local meat market to which a known amount of plutonium was added. Data from the duplicate quality assurance samples are included in data tables of Appendix II while data from the spiked samples are presented in Table 1.

TABLE 1. QUALITY ASSURANCE RESULTS

Tissue	ACTIVITY ADDED		ACTIVITY REPORTED	
	²³⁸ Pu (pCi/Sample)	²³⁹ Pu (pCi/Sample)	²³⁸ Pu (pCi/Sample)	²³⁹ Pu (pCi/Sample)
Liver ¹	0.536	1.487	1.5 ± 0.75	3.5 ± 1.25
Liver ¹	0.536	3.457	0.514 ± 0.257	3.855 ± 0.514
Liver ¹	0	0	<0.618	<0.618
Liver ¹	0	1.34	<0.568	1.704 ± 0.568
Liver ¹	0.536	0	<0.500	<0.500
Muscle ¹	0.536	0.992	<0.744	1.116 ± 0.372
Muscle ¹	0	0	<0.348	0.348
Muscle ¹	0.536	0.67	<0.148	0.666 ± 0.222
Muscle ¹	0	0	<0.446	0.669 ± 0.223
Muscle ¹	0.536	3.35	0.46 ± 0.23	3.45 ± 0.69
Muscle ²	1.07	0	5.5 ± 0.8	2.9 ± 0.5
Muscle ²	1.07	0	4.5 ± 0.7	0.9 ± 0.3

¹Source of tissue was from local meat markets

²Composite sample from two NTS mule deer

RESULTS AND DISCUSSION

Rumen-Fistulated Steers

Four rumen-fistulated steers were placed in the inner compound at monthly intervals during the first 6 months and quarterly thereafter (Smith, 1979). Summaries of the botanical composition of the ingesta collected from these steers are presented graphically in Figure 2. Shrub species made up the bulk of the diet except during the spring and early summer months when grass species were preferred. Forb species were a minor component of the diet at all times of the year.

Comparison of the botanical composition of the diets of the rumen-fistulated steers (Table 2) with that of sacrificed resident Area 13 beef animals (Table 3) reveals only one major difference. This was in July 1974 when grasses made up the majority of the diet of the sacrificed animals. However, these animals were all from the outer compound which contained a greater concentration of grasses than did the inner compound where the rumen-fistulated steers grazed. Grasses also made up the major portion of the diet of animal number 30 which was sacrificed at a location near Bald Mountain approximately 22 kilometers northeast of the study areas.

As listed in Appendixes III and IV, the preferred shrub species of both the rumen-fistulated steers and the resident cattle were shadscale (*Atriplex confertifolia*), four-winged saltbush (*Atriplex canescens*), and winter fat (*Eurotia lanata*). The most consumed grass species was Indian ricegrass (*Oryzopsis hymenoides*), while Russian thistle (*Salsola paulsenii*) was the most sought after forb.

The actinide concentrations in the solid or vegetative component of the rumen contents are listed in Appendix V, those in the fluid component are listed in Appendix VI. Appendix VII contains the values reported for the reticulum sediment.

The mean plutonium-239 concentrations in the rumen vegetation and rumen fluids are displayed in Figures 3 and 4. Generally, the mean plutonium-239 values in the vegetation ranged between 10 and 30 nanocuries per kilogram, while the concentrations in the fluid components ranged between 1 and 5 nanocuries per kilogram. Concentrations in both components were several times higher in August 1974. It has been postulated that this increased activity was related to the vegetative state of the *Eurotia lanata* which made up the bulk of the diet. The foliage of this perennial plant is covered with a dense coating of star-shaped and unbranched hairs that might serve as traps for resuspended soil particles. Moreover, during the reproduction phase

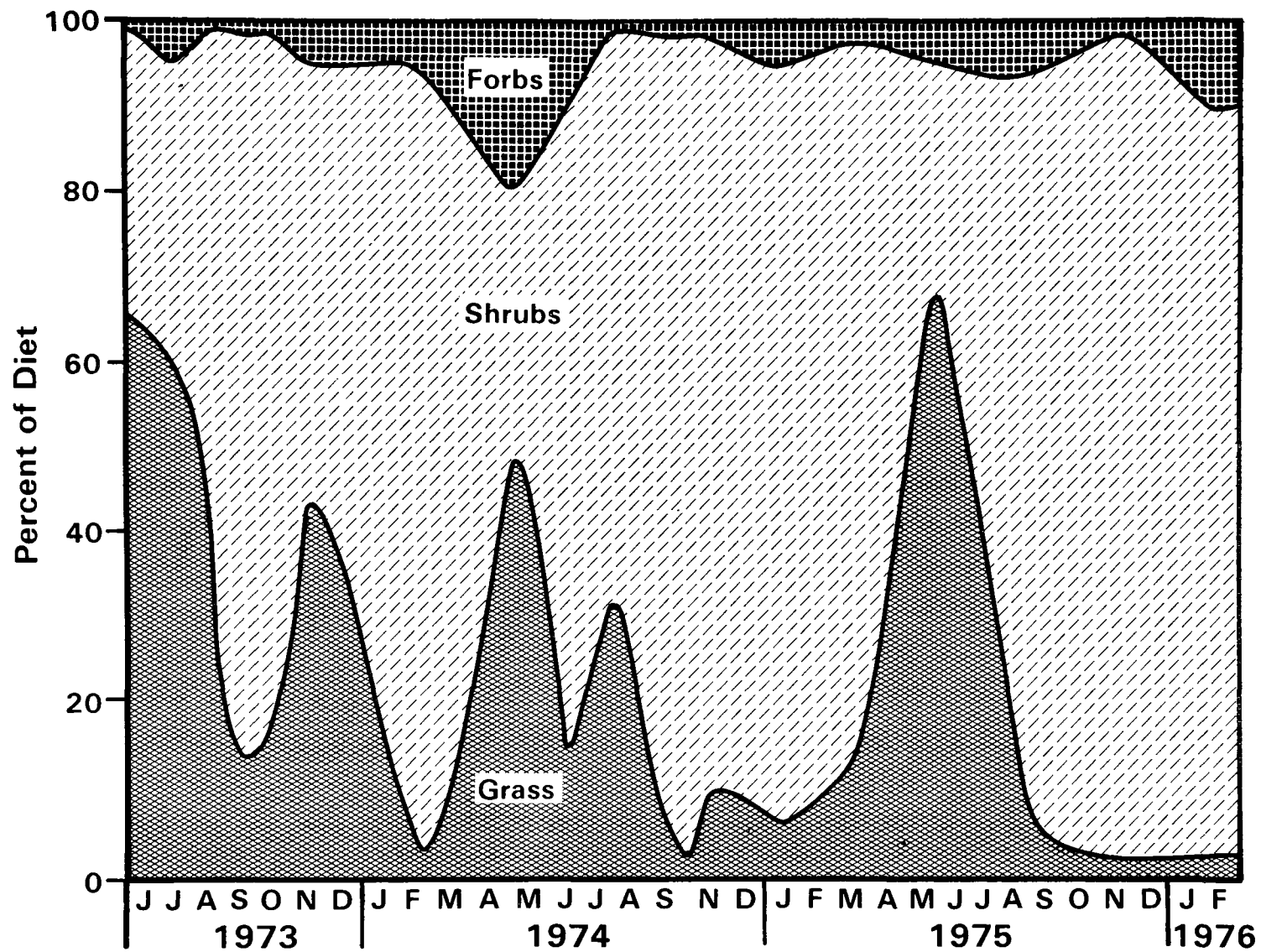


Figure 2. Botanical composition of rumen contents from rumen-fistulated steers grazing Area 13, NTS

TABLE 2. AVERAGE BOTANICAL COMPOSITION OF RUMEN CONTENTS FROM RUMEN-FISTULATED STEERS (Modified from Smith 1979)

Date Collected	Number of Animals	Grasses (%)	Forbs (%)	Shrubs (%)
06/12/73	2	64.5	2.0	33.5
07/10/73	4	59.3	4.7	36.0
08/08/73	4	28.8	1.5	69.7
09/08/73	4	13.0	1.3	85.7
10/01/73	3	16.4	1.3	82.3
11/06/73	4	43.0	4.2	52.8
02/20/74	4	2.3	4.7	93.0
05/21/74	4	49.0	20.0	31.0
06/30/74*	4	12.6	14.3	73.1
08/07/74	4	31.7	0.3	68.0
10/03/74†	4	1.0	1.7	97.3
11/05/74	4	9.0	2.8	88.2
01/19/75‡	4	5.4	1.0	93.6
03/12/75	4	11.0	2.0	87.0
08/23/75	4	4.5	6.5	89.0
11/13/75	4	1.0	1.2	97.8
02/19/76	4	1.8	10.4	87.8

*Average of three collections on 06/28, 06/30, and 07/02.

†Average of three collections on 10/01, 10/03, and 10/05.

‡Average of three collections on 01/17, 01/19, and 01/21.

TABLE 3. AVERAGE BOTANICAL COMPOSITION OF RUMEN CONTENTS FROM SACRIFICED ANIMALS--AREA 13 (Modified from Smith 1979)

Date Collected	Number of Animals	Grasses (%)	Forbs (%)	Shrubs (%)
08/09/73	1*	19.0	71.0	10.0
10/25/73	4	43.5	3.3	53.2
10/25/73	1*	53.0	2.0	45.0
07/09/74	3	73.2	3.3	23.3
01/29/75	3	15.3	3.5	81.2
01/28/76	4	7.5	2.0	90.5
03/31/76	3	19.0	0.7	80.3

*Goat

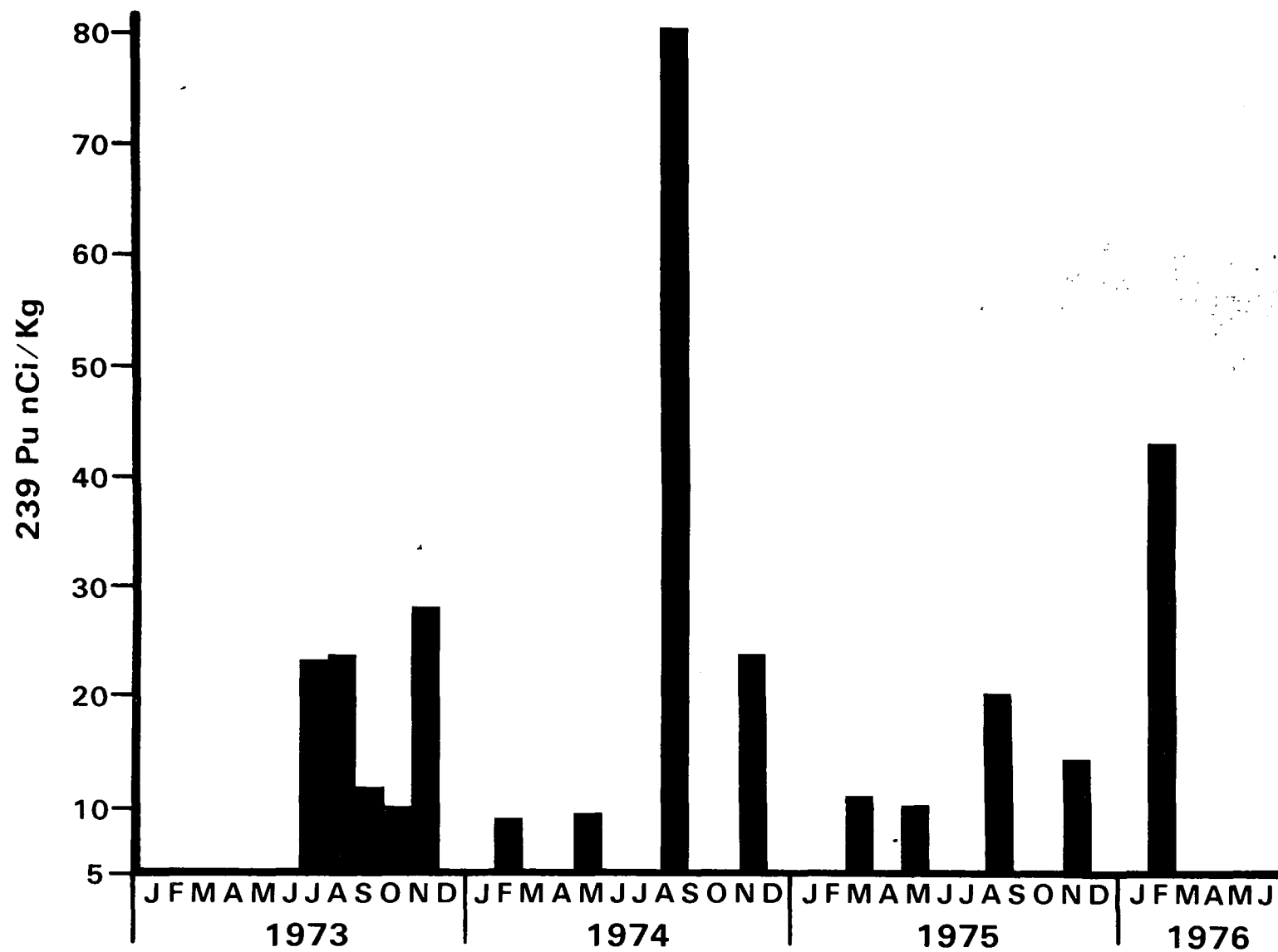


Figure 3. Mean ^{239}Pu concentrations in vegetative component of rumen contents from rumen-fistulated steers (wet wt)

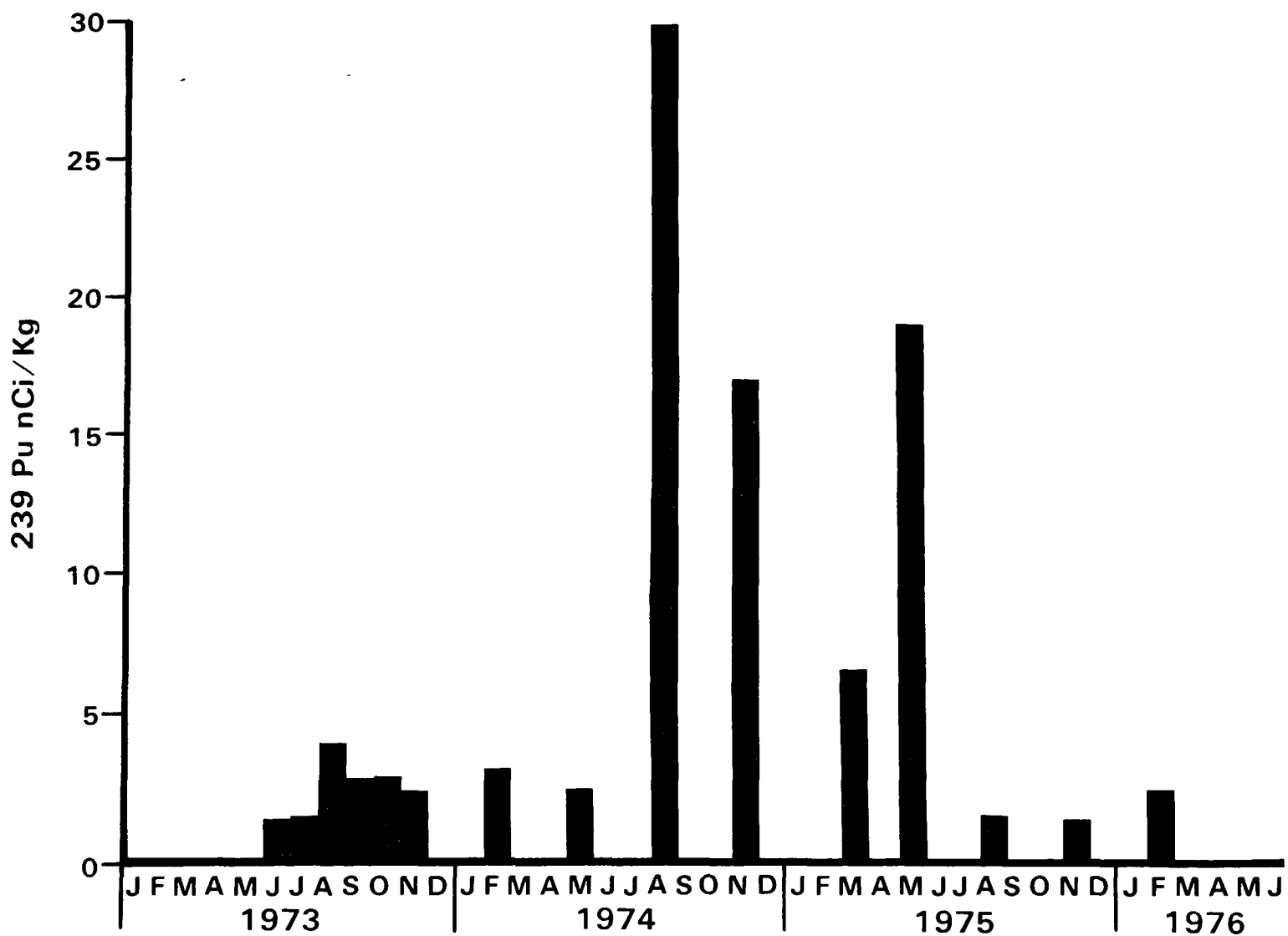


Figure 4. Mean ^{239}Pu concentrations in fluid component of rumen contents from rumen-fistulated steers (wet wt)

which may occur from April through August, dense masses of flowers and fruits are produced which are also covered with hairs.

The plutonium-239/americiu-241 and plutonium-239/plutonium-238 ratios in both the fluid and vegetation components of the ingesta were quite constant with mean ratios of 8.4 and 41.8, respectively, for the fluid and 7.6 and 41.4, respectively, for the vegetation. These ratios were apparently unaffected by season or vegetative makeup.

As shown in Figure 5, the mean plutonium-239/americiu-241 ratio for the rumen vegetation from the steers was quite consistent with these activity ratios (listed in Appendixes VIII and IX) found in selected tissues collected from the cattle that resided in the Area 13 study compounds. This suggests that there is little differentiation in the gastrointestinal absorption of plutonium-239 and americiu-241 by cattle. However, as shown in Figure 6, these median values of plutonium-239/plutonium-238 ratios in all tissues except the lungs were about one-half to one-twentieth of those of the ingesta. This may suggest that plutonium-238 is more readily absorbed than plutonium-239. Brown and McFarlane (1977) and Brown (1978) also reported that plutonium-238 is more readily taken up and translocated to the aerial portion of plants than is plutonium-239. These observations are probably the result of higher specific activity of the plutonium-238 as reported by Raabe *et al.* (1973) and Patterson *et al.* (1974). These higher ratios in the lung tissue might indicate that these tissues contained inhaled soil particles with the same ratio of plutonium-238/plutonium-239 as those particles ingested with the plants.

Reticulum sediment samples are essentially soil samples with comparable sampling and analytical problems and therefore might be expected to show highly variable results. This proved to be true as there was a wide range in concentrations in samples collected for different animals during the same time period. The plutonium-239/americiu-241 ratios in all samples were fairly consistent with a mean ratio of 8.2, which compares closely with those reported in the fluid and vegetative components of the ingesta. However, these plutonium-239/plutonium-238 ratios in the reticulum sediment were quite variable with a mean ratio of 28 compared to that of approximately 41 found in the other two components.

As discussed by Smith (1977a), a special soil-in-ingesta study was carried out to provide information on the amount of soil ingested during grazing by the study animals. Determined were the soil weights in the rumen contents of rumen-fistulated steers that grazed different ranges and the soil weights in the portions of the gastrointestinal tract from cow number 10. The findings from both the rumen-fistulated steers and the sacrificed cow are summarized in Table 4. It must be recognized that the sediment weights are approximate in that only those soil particles heavier than water were collected and undoubtedly some particles were entrapped in the villi or vegetation and were not released during the washing processes. Moreover, the data apply only to the individual animals on the day collected. However, the data from the permanent resident of the area (cow number 10) are considered to be significant as there would not be any reason to believe that her grazing habits and patterns would change significantly from day to day.

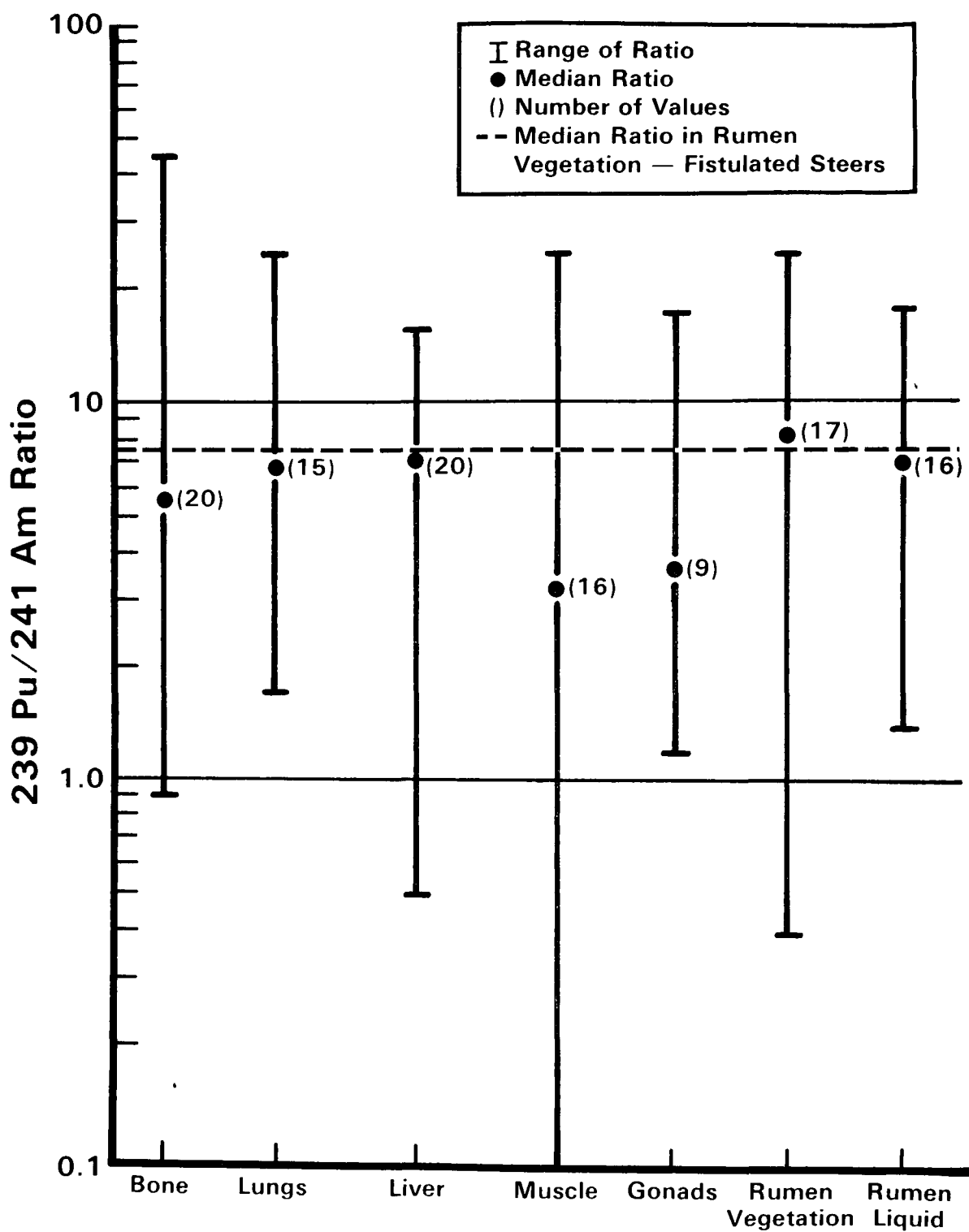


Figure 5. Relationship of $^{239}\text{Pu}/^{241}\text{Am}$ ratios in tissues from Area 13 cattle to those of the rumen vegetation from the rumen-fistulated steers

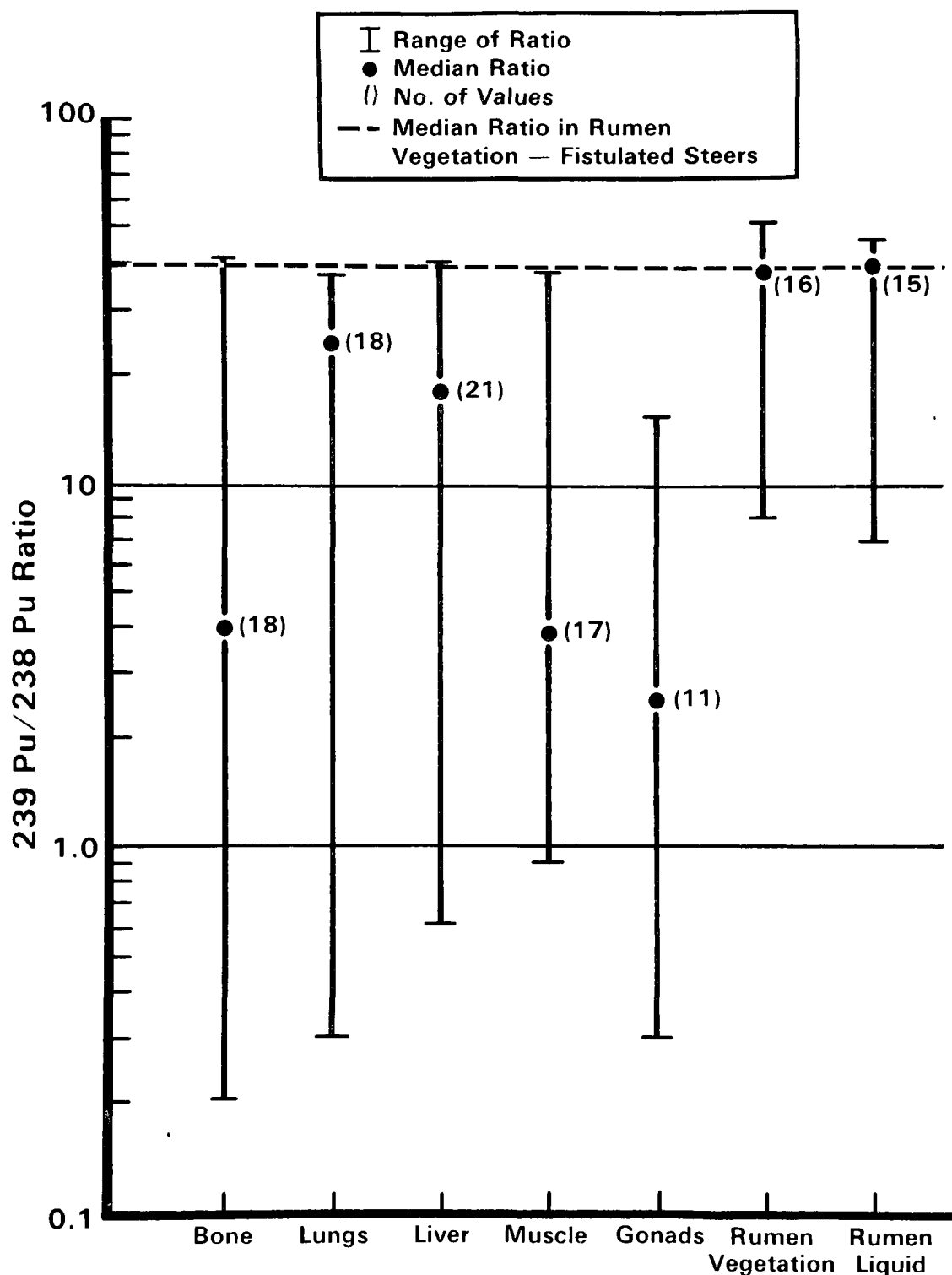


Figure 6. Relationship of $^{239}\text{Pu}/^{238}\text{Pu}$ ratios in tissues from Area 13 cattle to those of the rumen vegetation from the rumen-fistulated steers

TABLE 4. SOIL SEDIMENTS IN INGESTA (Modified from Smith 1977a)

Animal No.	Date Sampled	Area Grazed	Wet Weight of Ingesta (kg)	Location of Sediment	Weight of Sediment (g)
761	01/21/76	Inner compound Area 13	14.0	Reticulum & Rumen	57.3
774	01/21/76	Inner compound Area 13	22.0	Reticulum & Rumen	278
729	01/30/76	White Rock Springs	9.3	Reticulum & Rumen	2.0
707	01/30/76	White Rock Springs	6.4	Reticulum & Rumen	28.9
10	01/28/76	Outer compound Area 13	Not weighed ~25	Reticulum & Rumen	8.5
10	01/28/76	Outer compound Area 13	Not weighed	Omasum	8.6
10	01/28/76	Outer compound Area 13	Not weighed	Abomasum	8.2
10	01/28/76	Outer compound	Not weighed	Intestines	8.9

These data suggest that the total amount of soil ingested is less than 2 kilograms per day, and that a reasonable estimate would be between 0.25 to 0.5 kilograms. These values agree with those reported by Mayland and Florence (1975) from a study conducted with cattle grazing a semiarid range in Idaho. By analyzing titanium in the feces, they estimated that the amount of soil ingested ranged from 0.1 to 1.5 kilograms with a median of 0.5 kilograms of soil per day.

This is still a significant amount, as some of the sand particles ingested could remain in the gastrointestinal tract for more than a week. This residence time was shown in retention studies using silica sand labeled by fusion with a gamma-emitting radioisotope, Smith *et al.* (1976a) and Patzer *et al.* (1977). Even if the soil particles contain relatively insoluble trans-uranic elements, this period would provide more time for reactions involved in gastrointestinal absorption, and could result in greater uptake than would be derived from conventional ruminant digestion studies.

When these rumen-fistulated steer data are examined, it is obvious that more soil is ingested from a heavily grazed area than from an ungrazed area. Also, the amount of soil increased with the amount of vegetation ingested. Neither of these observations is surprising. The greater amount of sediment found in the rumens and reticula of the rumen-fistulated steers probably results from overeager grazing to fill the empty rumens. The steers begin grazing with empty rumens whereas the resident cow's rumen always contains some ingesta from the day before.

Cow number 2, whose weight was 409 kilograms, was sacrificed 177 days after being placed into the inner study compound. As discussed by Smith *et al.* (1976a), her calculated intake of plutonium-239 from ingestion during this period was approximately 100 microcuries or 0.565 microcurie per day. This was calculated by multiplying the average daily intake of 30 kilograms of vegetation times the average activities found in components of the rumen contents of the rumen-fistulated steers. This estimate of the ingested dose of plutonium agrees fairly well with those reported by other investigators (Gilbert *et al.*, 1977). Their estimates were based on the average plutonium-239 concentration in the vegetation and/or on mathematical models.

Activity levels in selected tissues are presented in Table 5. The calculated total plutonium-239 burden in each tissue is also shown in Table 5.

The rate of increase of activity in the bone and soft tissues can be expressed as a formula:

$$\text{rate of change} = \text{retention factor} \times \text{intake} - \text{loss}$$

or

$$dN = kAdt - \lambda Ndt$$

If T_{eff} is long, then λ is very small and λN can be neglected. Integrating the remainder of the expression yields $N = kAt$: where N = amount in organs, k is organ retention factor, and At = intake of 100 microcuries for cow

number 2. The retention factor can be calculated from $k = N/At$.

For bone + muscle + liver, $k = \frac{561 \times 10^{-6}}{100} = 5.6 \times 10^{-6} = 5.6 \times 10^{-4} \%$, or a retention factor of 0.00056 percent. If it is assumed that the assimilable plutonium-239 is related more closely to the concentration in the liquid fraction of these rumen ingesta, then the same calculations can be made using 16.4 microcuries, rather than 100 microcuries, as the total intake. The combined retention percentages for bone, muscle, and liver would then be 0.0034 percent. This retention percentage compares closely to those of approximately 0.03 percent and 0.004 percent as reported by Stanley *et al.* (1975) following a study using dairy cows that had been administered oral doses of plutonium-238 in the citrate and oxide forms, respectively. The latter result might suggest that the retention in the range cow was due to ingestion of plutonium oxide.

TABLE 5. PLUTONIUM-239 BURDEN IN SELECTED TISSUES OF A 409 kg COW (376 kg EMPTY)* (Modified from Smith *et al.*, 1976a)

	Tissue		
	Skeleton	Muscle	Liver
Tissue (% of body weight)	15% (empty)	50% (empty)	1.63% (empty)
Calculated tissue weight (kg)	56.4	188	6.13
²³⁹ Pu pCi/kg wet weight	5.38	0.19	39.0
²³⁹ Pu pCi/kg in control cattle	0.22	0.02	0.15
Net activity (pCi/kg)	5.16	0.17	38.85
²³⁹ Pu in total organ (pCi)	291	32.0	238.2

*empty defines the total animal carcass less the contents of the gastrointestinal tract.

Plutonium Concentrations in Tissues

During the course of this study, tissue samples were collected from animals that resided in or adjacent to the study compounds. Animals sampled included 20 cattle, 4 bovine fetuses, 2 goats, and selected wildlife. Also sampled were three cattle that wandered through another plutonium-contaminated area in Area 5 of the NTS. Sampling information on all these animals is presented in Table 6.

Analytical data from the tissues of cattle and goats that resided within the inner compound are listed in Appendix VIII, data for tissues from the cattle that lived within the outer compound are listed in Appendix IX, and data from cattle that were collected away from the study compounds are listed in Appendix X.

TABLE 6. SAMPLING INFORMATION FOR AREA 13 AND AREA 5 STUDY ANIMALS (Modified from Smith and Bernhardt, 1977)

Animal No.	Species	Date of Birth or Entry into Study Area	Sex	Wt (kg)	Compound Location	Date of Sampling	Duration in Study Area	Age at Sampling	Breed	Remarks
1	Bovine	May 2, 1973	F	252	Outer	07/09/74	431 days	12 yrs.*	Angus-Hereford	30-day fetus--entire fetus submitted as sample.
2	Bovine	May 2, 1973	F	409	Inner	10/25/73	176 days	10 yrs.*	Angus-Hereford cross	
3	Bovine	May 2, 1973	F	432	Outer	10/25/73	176 days	10-11 yrs.*	Angus-Hereford cross	8-month fetus--tissues sampled.
4	Bovine	May 2, 1973	F	300	Outer	07/09/74	431 days	11 yrs.*	Hereford	
5	Bovine	May 2, 1973	F	298	Outer	01/29/75	636 days	8-9 yrs.*	Angus-Hereford cross	Delivered calf evening of 01/28/75--#17.
6	Bovine	May 2, 1973	F	325	Outer	07/09/74	431 days	12 yrs.*	Angus-Hereford cross	45-day fetus--entire fetus submitted as sample.
7	Bovine	May 2, 1973	F	Unk	Outer	04/17/75	730 days*		Angus-Hereford cross	Died in compound early April 1975. No samples collected.
8	Bovine	May 2, 1973	F	328	Outer	10/25/73	176 days	10 yrs.*	Angus-Hereford cross	
9	Bovine	May 2, 1973	F	382	Outer	03/31/76	1,064 days	10 yrs.*	Angus	8-month fetus--tissues sampled.
10	Bovine	Born April 26, 1973.	F	285	Inner	01/28/76	1,001 days	2.8 yrs.	Angus-Hereford cross	Lived in inner compound entire life. Dam #7.
11	Bovine	October 20, 1973	F	32	Inner	10/25/73	5 days	5 days	Angus-Hereford	Dam was #2.
12		May 15, 1973	F	93	Outer	10/25/73	163 days	5.5 mos.	Hereford-Angus	Brachycephalic dwarf. Dam was #8.

TABLE 6. SAMPLING INFORMATION FOR AREA 13 AND AREA 5 STUDY ANIMALS (Modified from Smith and Bernhardt, 1977) (Continued)

Animal No.	Species	Date of Birth or Entry into Study Area	Sex	Wt (kg)	Compound Location	Date of Sampling	Duration in Study Area	Age at Sampling	Breed	Remarks
13	Bovine	August 3, 1973	M	250	Outer	01/29/75	544 days	1.5 yrs.	Angus-Hereford	Dam was #5.
14	Bovine	Born October 7, 1973.	F	405	Outer	01/28/76	843 days	2.4 yrs.	Angus	Dam was #6.
15	Bovine	July 2, 1973	M	311	Outer	01/29/75	576 days	1.5 yrs.	Angus-Hereford	Dam was #4.
16	Bovine	Born August 26, 1973.	M	409	Outer	03/31/76	948 days	2.5 yrs.	Angus	Dam was #9.
17	Bovine	Born January 28, 1975.	F	24	Outer	01/29/75		1 day	Angus-Hereford cross	Dam was #5. Died from exposure to elements.
18	Bovine	Born June 16, 1975.	F	184	Inner	01/28/76	226 days	7.5 mos.	Hereford	Dam was #10.
19	Bovine	Born June 16, 1975.	F	173	Outer	01/28/76	226 days	7.5 mos.	Angus	Dam was #14.
20	Bovine	Born November 10, 1973.	M	302	Outer	03/31/76	872 days	2.25 yrs.	Angus-Hereford	Dam was #1.
30	Bovine	Unknown	F	205*	Outer	01/16/76	10-30 days*	1-1.5 yrs.*	Hereford-Charolais cross	Wandered into Area 13 in November-December 1975. Periodically observed in outer compound. Was purchased and sampled.
1	Goat	May 6, 1973	F	27	Inner	08/07/73	93 days	1 yrs.*	Mixed	
2	Goat	May 6, 1973	F	32	Inner	10/25/73	172 days	3 yrs.*	Mixed	
1	Coyote	Unknown	M	12	Area 13	10/09/74	Unknown	Adult		Suspected goat killer confirmed by stomach contents.

TABLE 6. SAMPLING INFORMATION FOR AREA 13 AND AREA 5 STUDY ANIMALS (Modified from Smith and Bernhardt, 1977) (Continued)

Animal No.	Species	Date of Birth or Entry into Study Area	Sex	Wt (kg)	Compound Location	Date of Sampling	Duration in Study Area	Age at Sampling	Breed	Remarks
1	Fox	Unknown	F	1.8	Area 13	05/20/74	Unknown	Adult		South side of compound.
2	Fox	Unknown	M	2	Area 13	05/20/74	Unknown	Adult		South side of compound.
3	Fox	Unknown	M	1	Area 13	05/20/74	Unknown	6 mos.*		South side of compound.
1	Rabbit	Unknown	M	1	Area 13	05/20/74	Unknown	Adult	Jackrabbit	Hunter kill NW corner of outer compound.
BOV-1-A5	Bovine	Unknown	F	186	Area 5	05/06/76	Unknown	1.5 yrs.*	Hereford	Belonged to a private citizen in Alamo, NV. Found in Area 5, NTS, on April 9. Kept in Area 15 corrals until May 6. Ingesta samples not collected.
BOV-2-A5	Bovine	Unknown	F	295	Area 5	05/05/76	Unknown	8 yrs.*	Hereford	Remarks same as for BOV-1-A5.
BOV-3-A5	Bovine	Unknown	M	169	Area 5	05/06/76	Unknown	0.75 yr.*	Angus-Hereford	Remarks same as for BOV-1-A5.

*Estimated

The plutonium-239 activities in femur tissue from each animal versus days in the study area are plotted in Figure 7. Other factors shown in this graph are the study area grazed and whether the animal was introduced as an adult or whether it was born into the study area.

As discussed by Smith and Bernhardt (1977), this graph indicates that plutonium concentrations in the femurs from the original mature animals show little increase with length of exposure. Conversely, concentrations in the femurs from adult animals born within the study areas are consistently higher than those of the original cows and show a continuing upward trend with increased time of exposure. These observations are based on statistical tests of these data, i.e., a regression line gives a better fit to the data for cattle born in the area than an averaging of the data. A weighted mean is the best way to describe the data for the original, imported cows.

A log-log plot (Figure 8) of plutonium-239 concentrations in the femurs of animals born within the outer compound shows that the increase in concentration follows a power function. The equation for this function was:

$$\text{Concentration} \left(\frac{\text{pCi}}{\text{kg}} \right) = \frac{T^{2.216}}{3.1287 \times 10^{-5}}$$

where T is time in days in the outer compound (including time *in utero*). This indicates that deposition of plutonium-239 began *in utero* and continued throughout the lifetime of the animals. The muscle and liver of a near-term fetus from a cow that had grazed the outer compound for 1½ years contained nearly identical levels of plutonium-239 as did the dam. Activity in the muscle of the dam was 0.22 ± 0.05 picocuries per kilogram and that of the fetus was 0.16 ± 0.06 picocuries per kilogram, while the activity in the dam's liver was 5.4 ± 0.4 picocuries per kilogram and that of the fetus was 2.7 ± 0.4 picocuries per kilogram. These findings indicate placental transfer of the plutonium.

For a given length of exposure, with one exception, higher concentrations were found in the femurs of those animals grazing the area of higher contamination (inner compound). The plutonium-239 activity levels in the vertebrae and femur in a 6-month-old calf from the outer compound were found to range from 200 to 1,000 picocuries per kilogram. This value probably should be discounted as the calf was a brachycephalic dwarf and its metabolism could have been abnormal. This type of achondroplasia is of genetic origin and probably results from the presence of one or more recessive genes. This calf was born approximately 1 week after the cows were placed in the study compound.

Similar plots, not included in this report, of plutonium-239 burdens in other tissues (i.e., muscle, liver, lungs, etc.) indicate that there was no consistent increase in concentrations with increased exposure time and that there was little variation between the aged cows and the mature animals born within the compound. The fetal-dam relationships in their tissues were similar to those for femurs except for muscle where fetal levels were nearly

239 Pu Concentrations in Fresh Femur Tissues from Area 13 Cattle

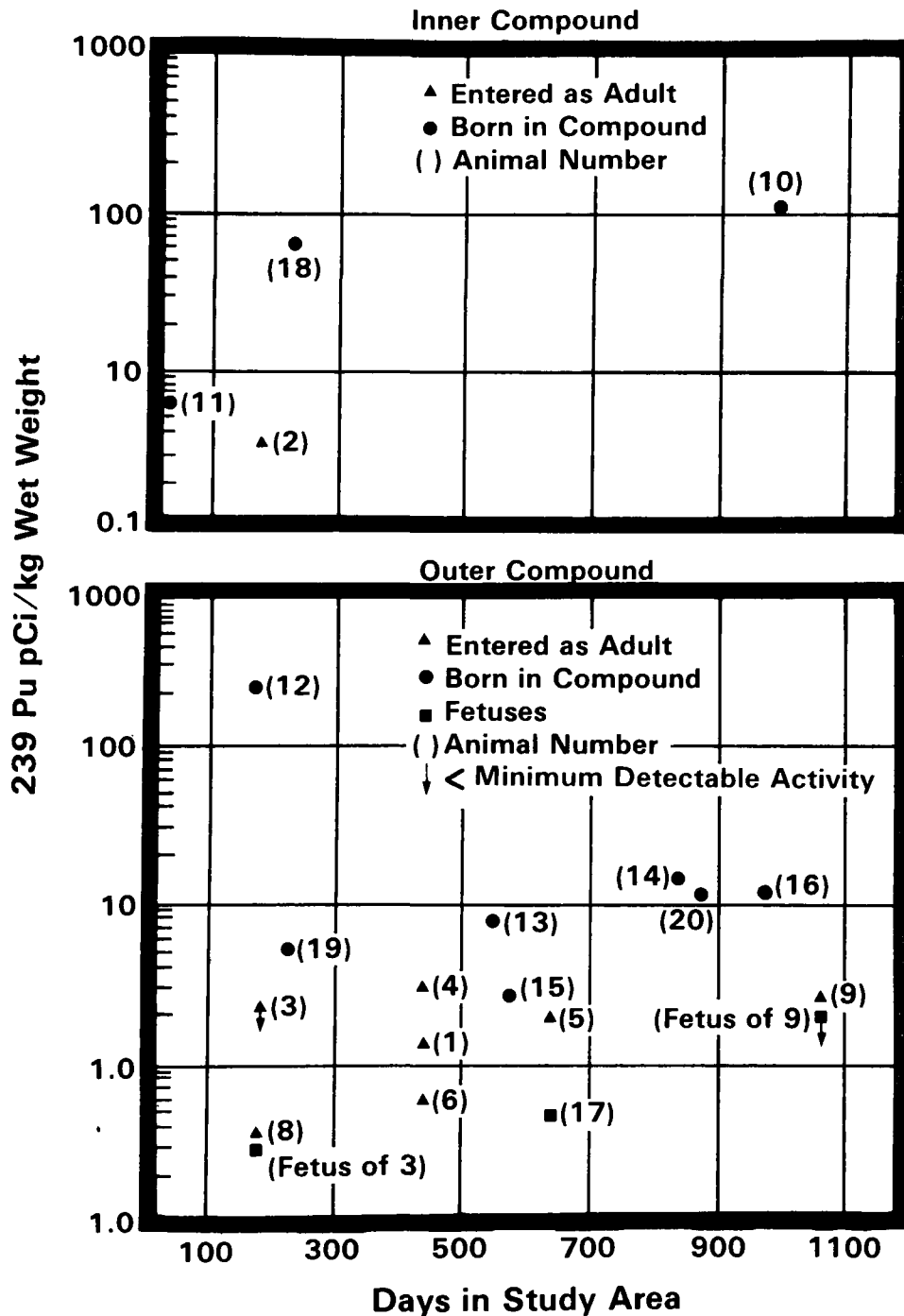


Figure 7. ^{239}Pu concentrations in femur tissues from Area 13 cattle

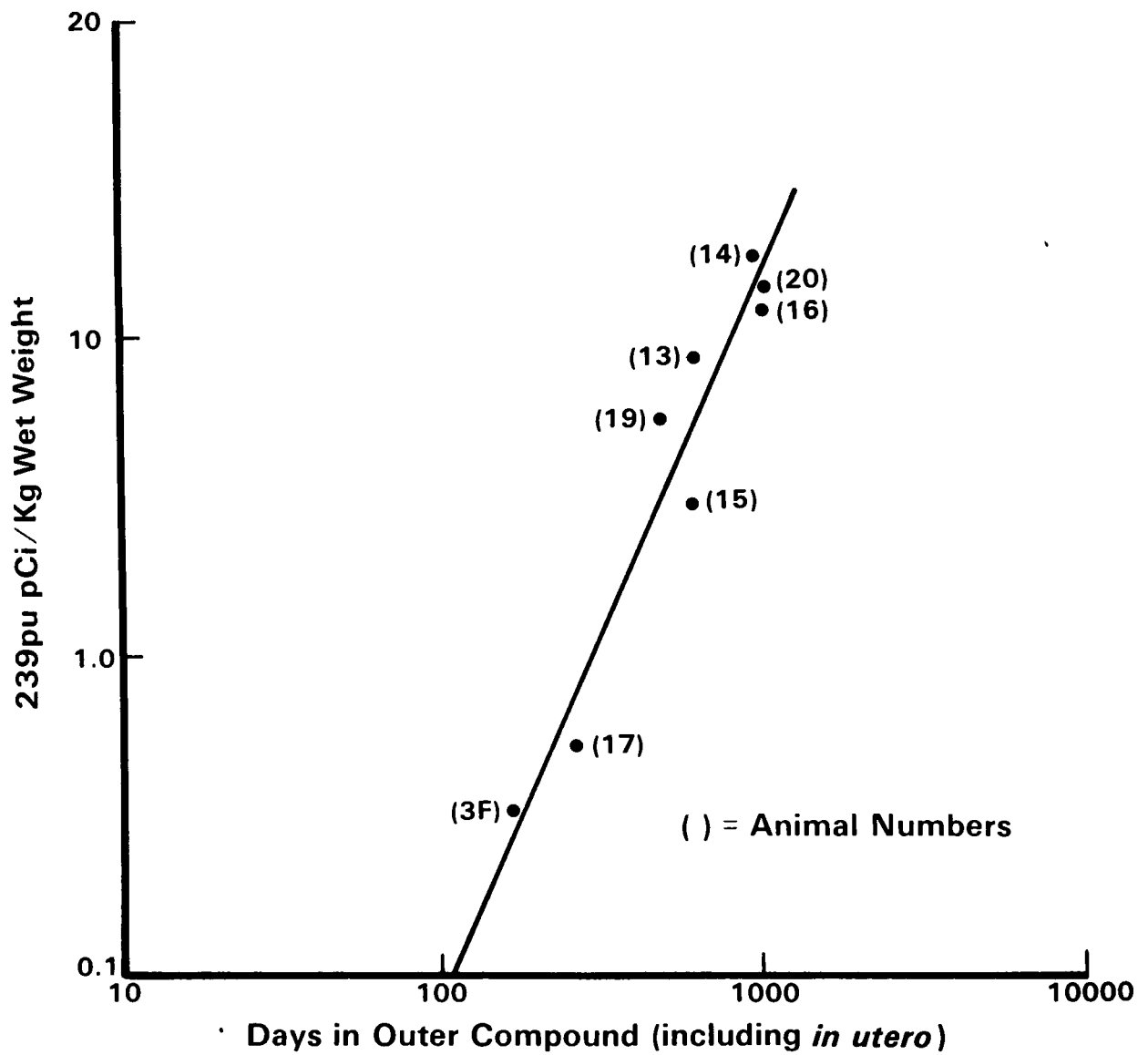


Figure 8. ^{239}Pu concentrations in femurs of cattle born within the outer compound versus time

identical with their dams. Again, tissue burdens were higher in the animals that grazed the area of higher contamination.

In January 1976, two nearly identical cow-calf pairs which had grazed the two different study compounds were sacrificed. The pair that grazed the inner compound consisted of a 2.8-year-old cow and her 7.5-month-old female calf. The pair that grazed the outer compound consisted of a 2.4-year-old cow and her 7.5-month-old male calf. All four of these animals were born within their respective compounds and spent their entire lives there. Data from their tissues are displayed in Figure 9. It is obvious that the tissue concentrations are higher in the animals that grazed the inner compound. Tissue concentrations are slightly lower for the calves than for their dams, which may imply a general increase in tissue concentrations with time. Unfortunately, the gonad tissues from both of the calves were lost during the analytical procedures.

Plutonium-239 in Gonads

As discussed by Smith and Bernhardt (1977), there is only a limited amount of data on the deposition of plutonium in various organs of the human body (ICRP, 1972). Although it is recognized that there are differences between bovine and human metabolisms, some insights on the deposition of plutonium in the human body may be obtained by considering the data from bovine studies. This is especially true for the gonads, for which reliable human data are very scarce (Richmond and Thomas, 1975). The greater mass of hundreds of grams for bovine testes tissues versus about 35 grams for humans allows for a much greater sensitivity of analysis for the bovine tissues. Although bovine ovary tissue masses of 5 to 20 grams are similar to the 11 grams for humans (ICRP, 1975), the concentrations (and thus the quantities) of plutonium in the Area 13 cattle are generally greater than those reported for humans (Richmond and Thomas, 1975). The following comments are predicated on the hypothesis that after plutonium is taken up into the blood system, the transfer of plutonium to different organs within the body is similar for bovine and humans.

Data related to the sensitivity of analysis for the gonad samples are summarized in Table 7. The minimum amount of recovered plutonium-239 on the alpha-counted planchet for reasonable alpha spectroscopy analysis is 20 femtocuries (Bernhardt, 1976). Although several of the samples for ovaries were at or below the detection level, most of the samples were well above the minimum level of detection.

The relative concentrations of radionuclides in the various organs were evaluated on a fresh-weight basis by using the Sign Test as described by Siegel (1956) and Dixon and Massey (1969). For this test, the actinide levels listed in Appendixes VIII and IX for each animal's gonads were compared with those reported from the muscle, liver, lung, femur, blood serum, and blood cell tissues of the same animal and the expected probability percentage calculated that gonad levels could exceed the tissue levels. These probability percentages are listed in Table 8 and show that a nearly 100 percent probability exists that levels in the gonads are greater than those

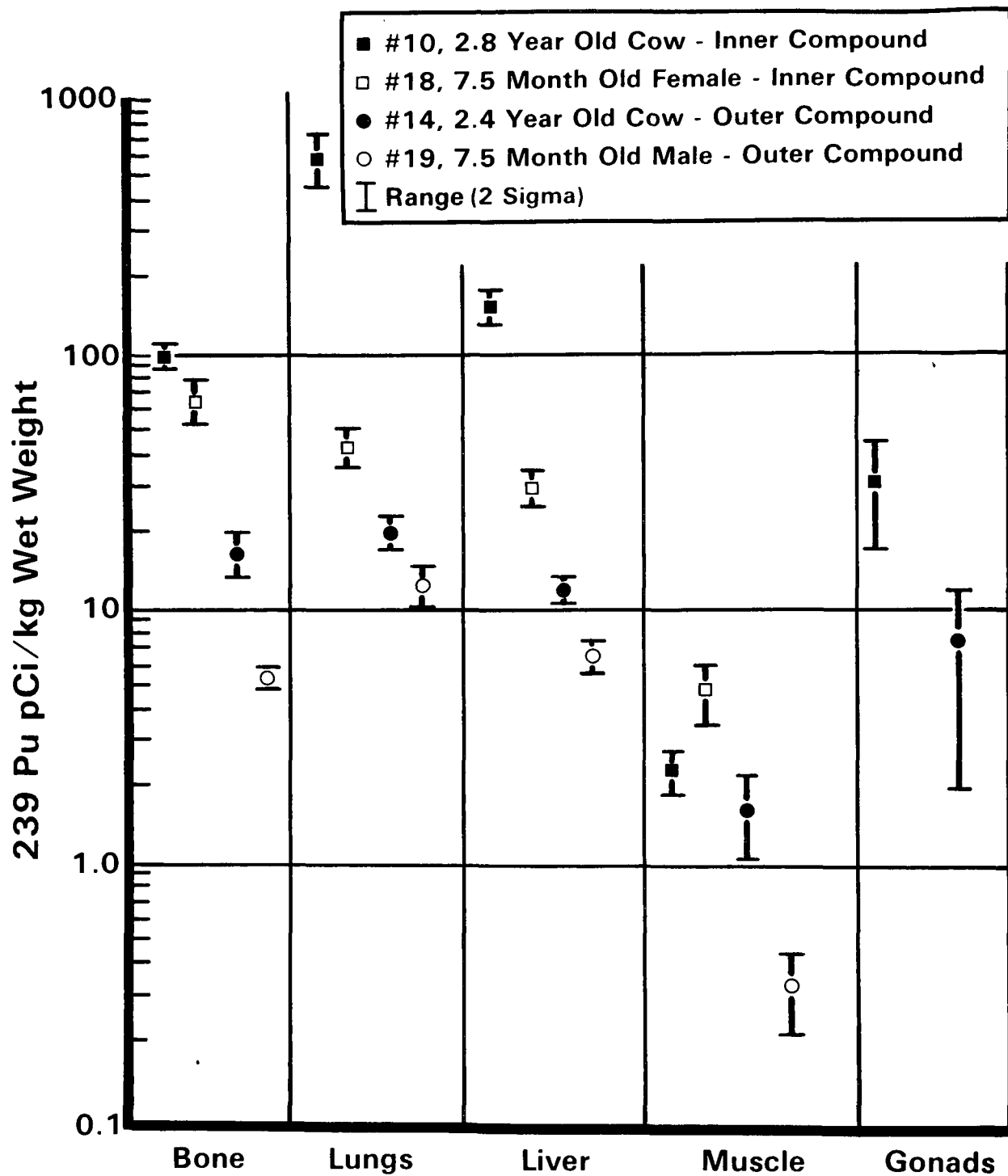


Figure 9. Comparison of ^{239}Pu concentrations in selected tissues from cow-calf pairs from Area 13 inner compound (#10 & #18) and outer compound (#14 & #19)

detected in muscle or in blood elements. This latter observation tends to confirm that the gonadal levels must be the result of some concentration mechanism rather than due to the presence of circulating blood in the organ. Conversely, there is approximately a 100 percent probability that plutonium-239 and americium-241 levels in lungs will exceed that of the gonads. This probability is 100 percent if the fetal lung tissues are eliminated from consideration. In the six tissue types submitted to the Sign Test, only plutonium-239 and americium-241 in the lungs and livers have a significant probability of being higher than the levels found in the gonads.

TABLE 7. PLUTONIUM-239 DATA FROM GONADS OF AREA 13 CATTLE (Modified from Smith and Bernhardt, 1977)

Animal No.	Sex	Weight of Gonad (g)	Chemical Yield (%)	Plutonium Concentration (pCi/kg)	Plutonium Counted Total Sample (fCi)
1	F	14.6	39.0	1.8	10.0
4	F	5.8	61.0	6.9	24.0
6	F	19.4	59.0	<1.3	<15.0
9	F	4.0	100	<10.0	<40.0
10	F	14.0	25.0	32.0	110
14	F	13.0	94.0	6.9	84.0
18	F	12.0	--	Lost	--
9 fetus	M	8.0	100	11.0	90.0
15	M	393	65.0	45.0	11,500
16	M	568	40.0	3.1	700
19	M	206	--	Lost	--
20	M	579	79.0	0.56	260
13	M	538	49.0	2.5	660

TABLE 8. PROBABILITY PERCENTAGE FROM THE SIGN TEST* THAT ACTINIDE LEVELS IN AREA 13 CATTLE GONADS EXCEED THOSE FROM SELECTED TISSUES (Modified from Smith and Bernhardt, 1977)

Tissue	Actinides			
	^{238}Pu	^{239}Pu	^{241}Am	^{238}U
Muscle	~100	~100	~100	99.8
Lungs	72.6	0.3	1.9	95.4
Liver	72.6	3.3	38.7	95.4
Femur	88.7	72.6	92.7	95.4
Blood Cells	98.9	99.9	~100	~100
Blood Serum	98.0	99.8	~100	~100

*Siegel (1956); Dixon and Massey (1969)

The data for plutonium-239 concentrations in various bovine tissues are summarized in Table 9. This summary is limited to plutonium-239 not only for simplicity of the comparison, but also because this is the actinide analysis of greatest reliability.

The ratios of the plutonium-239 concentrations in bone to those in various other tissues are compiled into different data groups at the bottom of Table 9. These compilations are based on the geometric mean and geometric standard deviation (ratio of the 84.1 percent probability value divided by the geometric mean or 50 percent probability value). These ratios generally indicate that the lung has the highest tissue concentration (e.g., about 4.3 times the femur), and the liver has the next highest concentration (e.g., about 1.7 times the femur).

TABLE 9. RELATIVE CONCENTRATIONS OF PLUTONIUM-239/240 IN VARIOUS ORGANS COMPARED TO THAT IN BONE (Modified from Smith and Bernhardt, 1977)

Animal No.	Sex	Conc. in Bone (pCi/kg)	Ratio of Conc. in Organ to That in Bone*			
			Gonad	Lung	Liver	Muscle
1	F	1.4	1.3	53.0	11.0	0.04
4	F	3.0	2.3	17.0	5.3	0.07
6	F	0.59	<2.2	30.0	18.0	--
9	F	<2.9	>3.4	>11.0	>1.8	0.21
9 fetus	M	<2.0	>5.6	--	>0.15	0.13
10	F	100	0.32	5.8	1.5	0.02
13	M	8.3	0.30	2.1	1.6	0.03
14	F	17.0	0.41	1.2	0.71	0.09
15	M	2.9	16.0	5.2	2.5	0.06
16	M	12.0	0.26	1.2	1.2	0.05
18	F	69.0	Lost	0.65	0.43	0.07
19	M	5.4	Lost	2.3	1.3	0.06
20	M	14.0	0.04	1.0	1.0	0.011

Data Summary: Geometric Mean (Geometric Standard Deviation)

Female	1.2 (2.7)			
Male (except 9 fetus)	0.47 (12.0)			
Total	0.98 (5.5)	4.3 (4.2)	1.7 (3.6)	0.05 (2.2)

*These ratios are based on the data in Appendixes VIII and IX. Minimum detectable activities (MDA) were assumed to be equal to the MDA.

Because of the large difference in masses between female and male gonads, these gonad ratios were broken into several subgroups. The geometric mean for all of the data indicates that the concentration in the gonads nearly equals that in the femur and thus is slightly greater than one-half of that in the liver. The relationship with the lung concentration would not appear to pertain to man because much of the dust that grazing cattle inhale would appear to be related to grazing. The concentration ratios for gonads presented in Table 9 indicate that the relative concentration in the ovaries (1.2 times bone) is higher than that in the testes (0.47 times bone). However, the ratios are not statistically different. Furthermore, the highest concentration ratio observed for the gonad:bone was for the testes (16.0). This high value seems questionable but there is no reason to disregard this point.

Figure 10 is a histogram of all of the gonad:bone concentration ratios. It is evident that, although the highest frequency is less than one, the distribution is skewed to the left, inferring the applicability of a lognormal versus normal distribution.

The dose to the various organs is generally relatable to the observed concentrations of radionuclides in the tissue mass. An exception to this is the factor of five in the quality factor for bone, which compensates for nonuniform deposition (ICRP, 1959). Including this factor of five, the dose guides for the general population of ICRP (1959 and 1965) are similar for the bone and gonads, and indicate a reduced sensitivity of about three for the liver and lung. Thus, given the ratios in Table 9, it appears that concentrations of plutonium in the liver, bone, and gonads of cattle are of similar significance, i.e., the bone or liver is not clearly the critical organ in relation to the gonads.

Ellett *et al.* (1976) in a recent review of the health risks of plutonium have proposed a "distribution factor" for plutonium in bone of 30 versus 5 (ICRP, 1959). This distribution factor is actually a ratio of the relative toxicity of plutonium versus radium-226 in bone. The use of a factor of 30 for these bovine data makes the bone the critical organ.

For large populations, the ICRP (1965) recommends reducing the yearly gonad dose guide by a factor of three (e.g., 5 rem in 30 years). There is also the consideration that there should be a distribution factor of greater or less than one in gonads, depending on where plutonium is distributed in the gonads.

Also, there is the uncertainty as to whether the bovine data have an applicability to man. Nevertheless, data summarized by Richmond and Thomas (1975) indicate somewhat similar ratios to those reported here.

In summary, these data and the previous data of Smith and Black (1975) indicate plutonium concentrations in bovine gonads similar to those in bone and liver, and greater than that which can be explained by the presence of plutonium in the blood contained in the gonads. Assuming this information has some pertinence to plutonium deposition in man, consideration should be given to the dose to the gonads, as well as the doses to liver, bone, and lung.

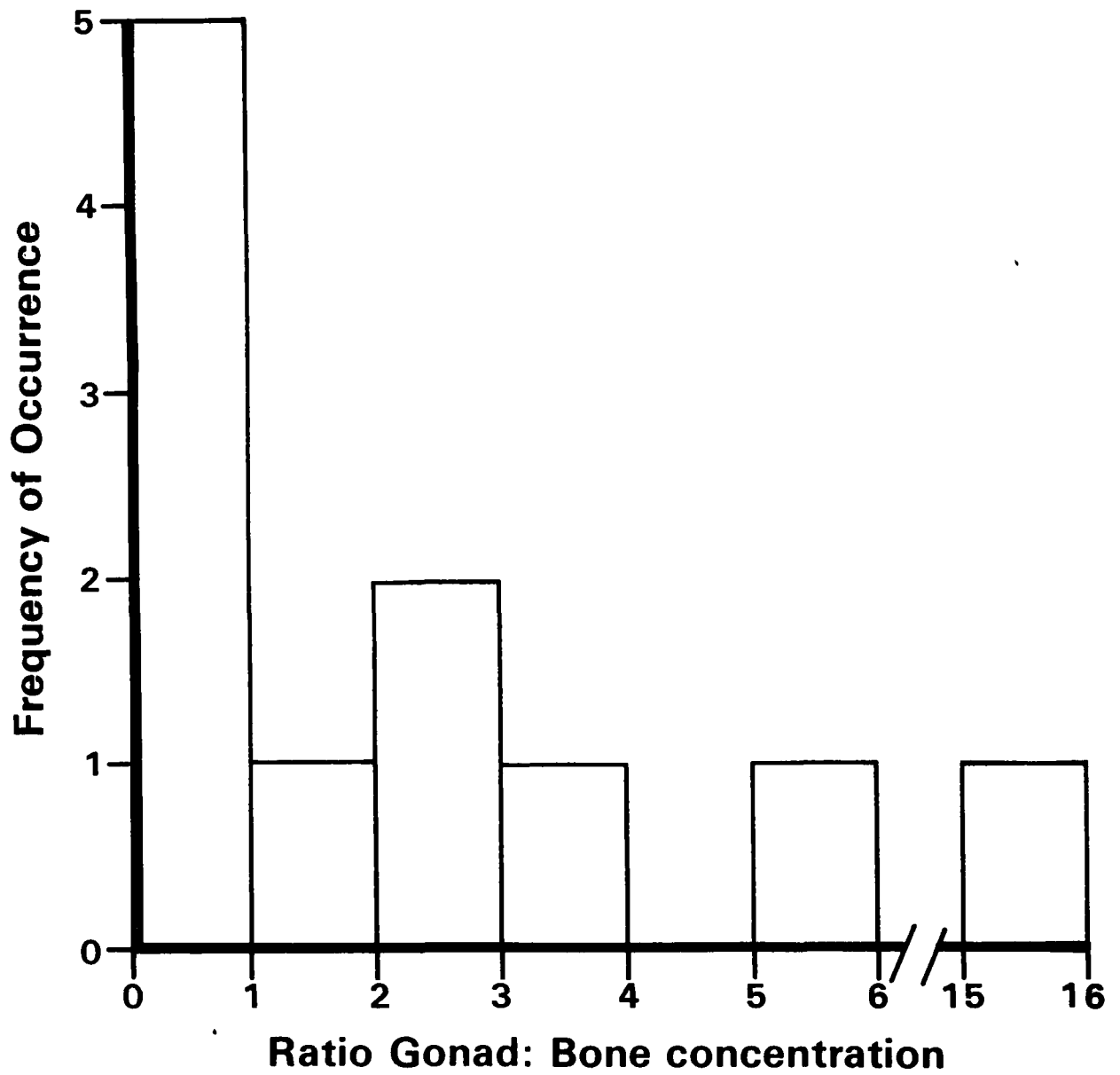


Figure 10. Histogram of gonad:bone concentration ratios

In general, the plutonium-239 concentrations measured in tissues collected from the Area 13 cattle, on a wet weight basis, fell within the ranges listed in Table 10. The elevated activities observed in the hair and skin samples are thought to be the result of external contamination, i.e., soil and dust particles remain trapped in the hair even after the cattle are washed.

TABLE 10. PLUTONIUM-239 RANGES IN THE TISSUES OF AREA 13 CATTLE
(Modified from Smith, 1979)

Activity Range (pCi/kg wet wt)	Tissues
<MDA to 5	Kidneys, muscle, blood serum, blood cells, and whole fetus (less than 3 months)
1 to 20	Bone, liver, and gonads
10 to 100	Lungs
100 to 500	Tracheobronchial lymph nodes and reticulum sediment
500 to 1,000	Rumen fluid
1,000 to 5,000	Rumen vegetation
5,000 to 20,000	Skin and hair

At each of the sacrifices, a few tissues were selected for gamma spectral, strontium, and tritium analyses (see Appendixes VII and IX). Concentrations of these radionuclides were found to be similar to those reported in previous years for the NTS beef herd (Smith and Giles, 1975; Smith *et al.*, 1976b; Smith *et al.*, 1976c; and Smith *et al.*, 1977). Tritium concentrations in urine or blood samples collected from 14 animals ranged from <220 picocuries per liter to 800 picocuries per liter with a median value of 400 picocuries per liter. Strontium-90 values in femur samples from six animals ranged from 1.2 to 3.9 picocuries per gram of ash with a median value of 2.9 picocuries per gram of ash. The only gamma-emitting radionuclide detected, other than naturally occurring potassium-40, was cesium-137, which was found in 23 of the 68 soft tissues analyzed. These values ranged from 10 to 57 picocuries per kilogram of wet weight with a median value of 36 picocuries per kilogram.

During April 1976, three cattle were found in Area 5 of the NTS; a 1.5-year-old heifer, a 9-year-old cow, and her 9-month-old steer calf. Investigation revealed that these cattle came from an off-site herd whose home range was approximately 32 kilometers to the east of the Area 13 study compounds. As these animals may have wandered through a plutonium-contaminated area in Area 11, arrangements were made for their purchase and subsequent sacrifice and sampling. Ingesta samples were not collected as the animals were maintained on alfalfa hay for several weeks prior to sacrifice. The analytical data from their tissues are listed in Appendix X. Tissue concentrations of plutonium-239, expressed as picocuries per kilogram of wet weight, from the three animals, respectively, are listed in Table 11 (Smith and Bernhardt, 1977).

TABLE 11. PLUTONIUM-239 ACTIVITY IN SELECTED TISSUES FROM AREA 5 CATTLE
(Modified from Smith and Bernhardt, 1977)

Tissues	^{239}Pu Activities (pCi/kg wet wt)
gonads	<1.8 and <5.1, not collected from the steer
femurs	<0.05, <0.7, and <0.02
liver	<0.07, 0.4 ± 0.1 , and 0.5 ± 0.1
lung	1.6 ± 0.3 , 0.5 ± 0.1 , and 0.3 ± 0.1
muscle	0.3 ± 0.1 , <0.07, and <0.02.

With the exception of one muscle value, the validity of which is questionable, these tissues concentrations are substantially lower than comparable tissue concentrations reported for the Area 13 study cattle.

Also included in Appendix X are analytical data from animal number 30, which periodically grazed the outer compound during the last quarter of 1975. Again the levels seen in ingesta, femur, liver, lungs, and skin are lower than those observed in the tissues collected from the permanent residents of the study compounds.

Comparison of Tissue Concentrations of Plutonium-239 with Those Reported in Other Herds

Concentrations of plutonium-239 in lung, liver, muscle, and femur tissues collected from cattle grazing the inner and outer compounds of Area 13 and Area 5 were compared with the same tissues collected from cattle grazing on plutonium-contaminated ranges in Area 18 of the NTS (Smith *et al.*, 1978) and Rocky Flats, Colorado, (Smith and Black, 1975); and from a control herd near Searchlight, Nevada (Smith *et al.*, 1976b). Initial statistical examination of these data indicated that they best fit a lognormal distribution rather than normal distribution. A one-way analysis of variance showed significant differences between groups. Duncan's Multiple Range Tests (extended for unequal sizes) were then applied to all the log-transformed data from all four tissue types. It was found that in all tissues the plutonium-239 activity was significantly higher for the cattle from the inner compound of Area 13. For lungs and liver the next significant activity group was from cattle of the outer compound of Area 13 followed by another significantly different group from Area 18. The lung and liver concentrations were not significantly different from the Rocky Flats, Searchlight, and Area 5 herds.

Activities in the muscle and femur tissues fell into three significantly different groups, the highest being from the inner compound of Area 13. The intermediate group consisted of tissues from cattle grazing the outer compound of Area 13 and Areas 18 and 5 of the NTS. The lowest group consisted of tissues from cattle from Rocky Flats and Searchlight.

Area 13 Wildlife

Several species of wildlife were periodically observed at the Area 15 study compounds. Three foxes, one coyote, and one jackrabbit were collected from the study area. The foxes were collected near the air-sampling station just outside the south fence of the outer compound, the coyote and rabbit were collected near the northwest corner of the outer compound. The foxes and rabbit were collected in May 1974 and the coyote in October 1974. These animals were necropsied and selected tissues collected for actinide analyses. These analytical data from these samples are listed in Appendix XI.

As was expected, those samples subject to external contaminants, i.e., the skin and digestive tract, contained elevated concentrations of the actinides. Levels in the stomach contents were approximately 5 percent of those reported from ingesta of the steers sampled at a similar period of time. However, the wildlife were not restricted to the higher contaminated areas as were the steers, and the predators do not subsist to a significant degree on forage.

A comparison of plutonium-239 levels found in the bones and soft tissues of these animals to those in several beef cattle that were permanent residents of study compounds is depicted in Figure 11. The plutonium-239 concentrations in the bones, lungs, and liver from the wildlife generally ranged between 1 and 10 percent of those found in the cattle. The elevated plutonium-239 values observed in the wildlife muscle tissues are probably from gross contamination introduced into the muscles by the shotgun pellets passing through the contaminated pelts.

NECROPSY AND HISTOPATHOLOGICAL EXAMINATIONS

All sacrificed animals were necropsied, with selected tissue and lesion samples collected for histopathological evaluation. The gross and microscopic pathology observed is listed in Appendix XII. Also included in this appendix are the results of the hematology examinations. Some of the blood values may not be representative, as most of the samples were collected after death.

Sarcocysts were frequently detected in both skeletal and cardiac muscle. This is a ubiquitous parasite of both warm- and cold-blooded vertebrates and is considered to have little clinical significance (Merck and Company, 1973).

Ocular squamous cell carcinoma, seen in cow number 4, is frequently observed in aged Hereford cattle exposed to the sun (Moulton, 1961).

Several animals had lesions associated with traumatic reticulitis (hardware disease), i.e., liver abscess, adhesions between diaphragm and reticulum, pericarditis, etc. As stated by Merck and Company (1973), foreign objects are common in the stomach of cattle because they do not discriminate against foreign bodies in the feed and incompletely masticate food at time

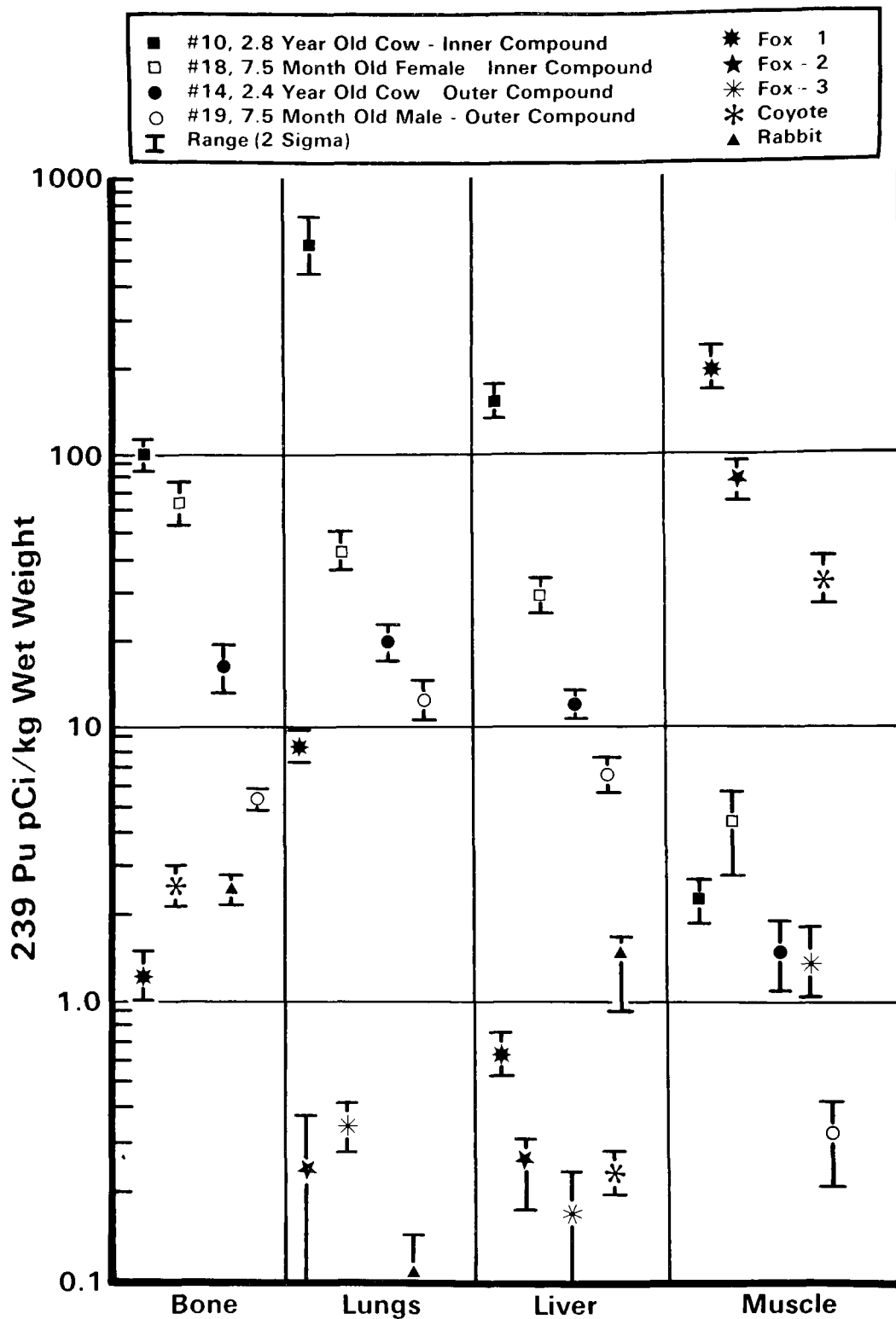


Figure 11. Comparison of ^{239}Pu concentrations in selected tissues from various wildlife to those from cow-calf pairs from Area 13 inner compound (#10 & #18) and outer compound (#14 & #19)

of ingestion. Swallowed metallic objects such as nails or pieces of wire are gravitated to the reticulum where the digestive contractions may cause them to penetrate the reticulum wall and diaphragm which results in peritonitis and/or pericarditis.

Other occasionally observed histologic findings, e.g., hemosiderosis of the spleen, capsular melanosis of the adrenal, emphysema and atelectosis of the lungs, etc., were felt to be within normal limits by the examining pathologist or were due to agonal struggles. No pathology was observed that could be directly attributed to ionizing radiation.

SUMMARY

A long-term (3-year) grazing study was conducted on a plutonium-contaminated range to determine the uptake and tissue distribution of actinides by ruminants. A reproducing herd of beef cattle and a small band of goats obtained all subsistence from the native vegetation on this range. Periodically, rumen-fistulated steers were placed in the study area and samples of rumen ingesta collected for botanical and actinide analyses. Also sampled were wildlife that frequented the study area.

Food habit analyses of the rumen content indicate that shrub species made up the bulk of the diet except during the spring and early summer months when grasses were preferred. Forbs made up a minor portion of the diet. Increased concentrations of the actinides were noted during months in which *Eurotia lanata* made up the bulk of the diet.

Plutonium-239/ameridium-241 ratios in tissue and ingesta suggest little differentiation in the uptake of these radionuclides. However, the plutonium-239/plutonium-238 ratios indicate that plutonium-238 is more readily absorbed.

Data collected suggest that the Area 13 cattle ingested soil at the rate of 0.25 to 0.5 kilograms per day.

A plutonium-239 retention factor of 0.00056 percent for bone plus muscle plus liver was calculated on the basis of these total rumen ingesta levels. The retention factor for the same tissues would be 0.0034 percent if it were based on the plutonium-239 level in the liquid portion of these rumen ingesta. This retention percentage compares closely to those of approximately 0.03 percent and 0.004 percent observed in dairy cows administered oral doses of plutonium-238 in the citrate and oxide forms, respectively.

In general, the plutonium-239 activities measured in tissues on a wet weight basis fell within the following categories:

<MDA to 5 Kidneys, muscle, blood serum, blood cells, and whole fetus
(less than 3 months)

1 to 20 Bone, liver, and gonads

10 to 100 Lungs

100 to 500 Tracheobronchial lymph nodes

The gonadal concentrations of the actinides were significantly higher than those of blood and muscle and approached those of bone. These data suggest that consideration should be given to the plutonium-239 dose to gonads as well as that to bone, liver, and lungs for man.

Actinide concentrations in the skeletons of the cows originally introduced into the study areas showed little increase with increased time of exposure; those of animals born in the study areas showed a continued upward trend with time.

It was found that actinides crossed the placental barrier and were deposited in fetal tissue at nearly the same levels as found in the dam's corresponding tissues.

At each of the Area 13 sacrifices, a few tissues were selected for gamma spectral, strontium, and tritium analyses. Radionuclide concentrations were found to be similar to those reported in previous years for the NTS beef herd.

The plutonium-239 concentrations in bones, lungs, and livers collected from wildlife with free access to and from the contaminated zones ranged from 1 to 10 percent of those found in cattle restricted to the area.

No significant lesions relating to plutonium exposure were found upon necropsy or histopathological examination. Reproduction was normal. The natural mortality rate was low as only one aged cow died during the 3-year study period.

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APPENDIX I. SUMMARY OF ANALYTICAL PROCEDURES AND MINIMUM DETECTABLE ACTIVITIES

Type of Analysis	Analytical Equipment	Counting Period (Min)	Analytical Procedures	Sample Size	Minimum Detectable Activities (pCi/total sample)*
Gamma spectrometry	Lithium-drifted germanium detectors calibrated at approximately 0.5 keV per channel input to 4096 channels resident in the core of the PDP 11/20 computer.	~1,200	Radionuclide concentrations quantitated from gamma spectrum by PDP 11/20 computer using a least squares technique.	200-ml aluminum cans	For: ^{54}Mn , ^{60}Co , ^{95}Zr , ^{103}Ru , ^{124}Sb , ^{132}Te , ^{131}I , ^{134}I , ^{137}Cs , ^{140}Ba - 7 pCi For: ^{125}Sb , ^{141}Ce - 30 pCi For: ^{65}Zn , ^{106}Ru , ^{144}Ce - 20 pCi For: ^{181}W - 85 pCi For: ^{241}Am - 35 pCi For: ^{22}Na - 4 pCi For: K - 0.08 g
$^{89-90}\text{Sr}$	Low-background thin-window, gas-flow proportional counter with a 5.7-cm diameter window ($80 \mu\text{g}/\text{cm}^2$).	50	Chemical separation by ion exchange. Separated sample counted successively; activity calculated by simultaneous equations.	2 g of ash	For: ^{89}Sr - 5 pCi ^{90}Sr - 2 pCi
^3H	Automatic liquid scintillation counter with output printer.	200	Sample prepared by distillation.	5 ml	~0.2 pCi/ml H_2O
$^{238-239}\text{Pu}$ 234,235 , ^{238}U	Alpha spectrometer with silicon surface barrier detectors operated in vacuum chambers.	400- 1,400	Ash sample is digested with acid, purified by solvent extraction and/or ion exchange, electroplated on stainless steel planchet, and counted by alpha spectrometer.	100 g - 1 kg wet weight 1-10 g ash	For all isotopes - ~0.02 pCi

*The minimum detectable activities (MDA) 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 were defined as those activities which produced ± 100 percent deviations at the 95 percent confidence level. These values are approximations and are applicable to ideal conditions and simple complexes of nuclides. Complex spectra or spectra showing naturally occurring radionuclides can raise the MDA considerably. The detection limit for each sample is defined as that radioactivity which equals the two-sigma counting error.

APPENDIX II. QUALITY ASSURANCE RESULTS

Animal No.	Sample Type	Analytical Laboratory	Analytical Results				Ash (%)	Type of Quality Assurance Analysis
			²³⁸ Pu (pCi/g Ash) (pCi/kg*)	²³⁹ Pu (pCi/g Ash) (pCi/kg*)	²⁴¹ Am (pCi/g Ash) (pCi/kg*)	²³⁸ U (pCi/g Ash) (pCi/kg*)		
2	Femur	EMSL-LV	0.08 ± 0.006	<0.006	NA	0.0053 ± 0.004	28	Duplicate ash samples analyzed by two laboratories.
	Ash	LFE	0.04 ± 0.003	0.012 ± 0.001	0.005 ± 0.001	0.03	—	
11	Femur	EMSL-LV	<0.009	0.047 ± 0.007	NA	<0.001	15	Duplicate ash samples analyzed by two laboratories.
	Ash	LFE	0.006 ± 0.001	0.06 ± 0.003	0.006 ± 0.002	0.12	—	
8	Femur	EMSL-LV	<0.004	<0.0056	NA	0.0060 ± 0.002	25	Duplicate ash samples analyzed by two laboratories.
	Ash	LFE	0.004 ± 0.001	0.001 ± 0.0008	0.0004 ± 0.0002	0.07	—	
12	Femur	EMSL-LV	0.11 ± 0.008	1.0 ± 0.084	NA	<0.002	35	Duplicate ash samples analyzed by two laboratories.
	Ash	LFE	0.098 ± 0.005	0.63 ± 0.02	0.09 ± 0.003	0.03	—	
2	Vertebrae	EMSL-LV	<0.0051	0.021 ± 0.010	NA	0.0027 ± 0.007	19	Duplicate ash samples analyzed by two laboratories.
	Ash	LFE	0.002 ± 0.001	0.04 ± 0.002	0.006 ± 0.001	0.02	—	
5	Liver	LFE	0.0048 ± 0.002	0.18 ± 0.013	<MDA	0.083	2.9	Duplicate blind samples.
			0.14 ± 0.05	5.4 ± 0.04	<MDA	2.4	—	
			0.004 ± 0.001	0.013 ± 0.003	0.018 ± 0.004	0.08	4.5	
			0.19 ± 0.02	5.7 ± 0.11	0.8 ± 0.19	3.3	—	

APPENDIX II. QUALITY ASSURANCE RESULTS (Continued)

Animal No.	Sample Type	Analytical Laboratory	Analytical Results					Type of Quality Assurance Analysis
			²³⁸ Pu (pCi/g Ash) (pCi/kg*)	²³⁹ Pu (pCi/g Ash) (pCi/kg*)	²⁴¹ Am (pCi/g Ash) (pCi/kg*)	²³⁸ U (pCi/g Ash) (pCi/kg*)	Ash (%)	
13	Liver	LFE	0.010 + 0.002	0.37 + 0.015	0.044 + 0.015	0.12	3.4	Duplicate blind samples.
			0.35 ± 0.067	13 ± 0.41	1.5 ± 0.5	4.0		
			<MDA <MDA	0.006 ± 0.002 0.23 ± 0.05	<MDA <MDA	0.09 3.2	3.6	
15	Liver	LFE	0.0085 + 0.004	0.2 ± 0.017	0.022 + 0.003	0.056	3.4	Duplicate blind samples.
			0.29 ± 0.12	7.3 ± 0.58	0.76 ± 0.11	1.9		
			0.003 ± 0.005 0.17 ± 0.03	0.12 ± 0.004 7.8 ± 0.23	0.005 ± 0.002 0.33 ± 0.1	0.023 1.5	6.6	
5	Muscle	LFE	0.0017 + 0.001	0.0044 + 0.001	0.0034 + 0.003	0.02	5	Duplicate blind samples.
			0.085 ± 0.042	0.22 ± 0.053	0.17 ± 0.15	1.2		
			<MDA <MDA	0.004 ± 0.001 0.099 ± 0.018	0.006 ± 0.002 0.15 ± 0.05	0.1 2.8	2.8	
13	Muscle	LFE	<MDA <MDA	0.017 + 0.003 0.22 ± 0.04	0.011 + 0.005 0.15 ± 0.073	0.12 1.6	1.3	Duplicate blind samples.
			<MDA <MDA	<MDA <MDA	0.009 ± 0.0005 0.38 ± 0.02	0.02 0.9	3.4	
			<MDA <MDA	0.0033 ± 0.001 0.18 ± 0.04	0.0018 ± 0.0009 0.1 ± 0.05	0.022 1.2	5.5	
15	Muscle	LFE	0.005 + 0.001	0.2 ± 0.004	0.024 + 0.004	0.05	5	Duplicate blind samples.
			0.26 ± 0.029	10 ± 0.2	1.2 ± 0.19	2.5		

APPENDIX II. QUALITY ASSURANCE RESULTS (Continued)

Animal No.	Sample Type	Analytical Laboratory	Analytical Results					Type of Quality Assurance Analysis
			²³⁸ Pu (pCi/g Ash) (pCi/kg*)	²³⁹ Pu (pCi/g Ash) (pCi/kg*)	²⁴¹ Am (pCi/g Ash) (pCi/kg*)	²³⁸ U (pCi/g Ash) (pCi/kg*)	Ash (%)	
5	Femur	LFE	0.0021 ± 0.0008 0.62 ± 0.25	0.0063 ± 0.001 2.0 ± 0.42	0.0057 ± 0.0007 1.7 ± 0.2	0.017 5.2	30	Duplicate blind samples.
			<MDA <MDA	0.012 ± 0.002 2.5 ± 0.48	0.004 ± 0.001 0.81 ± 0.19	0.04 7.2	20.3	
			<MDA <MDA	0.033 ± 0.003 8.3 ± 0.66	0.0027 ± 0.002 0.69 ± 0.52	0.0083 2.1	25.4	
13	Femur	LFE	0.001 ± 0.001 0.2 ± 0.19	0.033 ± 0.003 8.2 ± 0.65	0.006 ± 0.001 1.4 ± 0.32	0.01 3.2	24.4	Duplicate blind samples.
			<MDA <MDA	0.012 ± 0.001 2.9 ± 0.35	0.006 ± 0.001 1.6 ± 0.25	0.014 3.5	25.3	
			0.008 ± 0.001 2.0 ± 0.24	0.009 ± 0.001 0.4 ± 0.26	<MDA <MDA	0.01 2.6	26.5	
10	Liver	Eberline	0.54 ± 0.094 5.3 ± 0.93	15 ± 2 150 ± 20	1.7 ± 0.23 17 ± 2.2	0.46 ± 0.09 4.5 ± 0.9	0.99	Duplicate blind samples.
			0.43 ± 0.08 5.7 ± 1	13 ± 1.9 181 ± 26	1.6 ± 0.27 21.8 ± 2.8	0.38 ± 0.07 5.1 ± 0.9	1.3	

APPENDIX II. QUALITY ASSURANCE RESULTS (Continued)

Animal No.	Sample Type	Analytical Laboratory	Analytical Results					Type of Quality Assurance Analysis
			²³⁸ Pu (pCi/g Ash) (pCi/kg*)	²³⁹ Pu (pCi/g Ash) (pCi/kg*)	²⁴¹ Am (pCi/g Ash) (pCi/kg*)	²³⁸ U (pCi/g Ash) (pCi/kg*)	Ash (%)	
9	Liver	Eberline	0.0023 ± 0.002 0.11 ± 0.09	0.11 ± 0.02 5.3 ± 0.86	0.029 ± 0.02 1.4 ± 0.92	0.012 ± 0.007 0.55 ± 0.32	4.7	Duplicate blind samples.
			0.02 ± 0.02 0.6 ± 0.36	0.13 ± 0.034 3.9 ± 1	0.02 ± 0.016 0.57 ± 0.47	<0.006 <0.16	2.9	
10	Lung	Eberline	0.89 ± 0.56 24 ± 16	22 ± 6.2 580 ± 170	1.7 ± 0.43 46 ± 12	0.54 ± 0.19 15 ± 5.4	2.7	Duplicate blind samples.
			2.0 ± 0.34 15.2 ± 2.6	43.6 ± 6.4 328 ± 48	13.6 ± 3 103 ± 23	0.1 ± 0.03 0.8 ± 0.3	0.75	
9	Lung	Eberline	<0.55 <1.9	9.5 ± 1.9 32 ± 6.4	5.6 ± 1.9 75 ± 6.6	<0.23 <0.8	0.33	Duplicate blind samples.
			0.07 ± 0.018 1.1 ± 0.3	1.9 ± 0.25 30 ± 3.9	0.27 ± 0.09 4.1 ± 1.3	0.09 ± 0.03 1.5 ± 0.4	1.5	
10	Muscle	Eberline	<0.005 <0.05	0.22 ± 0.054 2.3 ± 0.55	0.021 ± 0.01 0.22 ± 0.1	0.14 ± 0.03 1.4 ± 0.34	1	Duplicate blind samples.
			<0.001 <0.02	0.046 ± 0.014 1.0 ± 0.3	0.009 ± 0.005 0.19 ± 0.1	0.01 ± 0.006 0.23 ± 0.12	2.2	
9	Muscle	Eberline	<0.007 <0.02	0.019 ± 0.009 0.6 ± 0.28	<0.0017 <0.05	0.025 ± 0.009 0.76 ± 0.3	3.1	Duplicate blind samples.
			<0.017 <0.62	0.026 ± 0.015 1.0 ± 0.6	<0.02 <0.8	<0.01 <0.4	3.8	

APPENDIX II. QUALITY ASSURANCE RESULTS (Continued)

Animal No.	Sample Type	Analytical Laboratory	Analytical Results					Type of Quality Assurance Analysis
			²³⁸ Pu (pCi/g Ash) (pCi/kg*)	²³⁹ Pu (pCi/g Ash) (pCi/kg*)	²⁴¹ Am (pCi/g Ash) (pCi/kg*)	²³⁸ U (pCi/g Ash) (pCi/kg*)	Ash (%)	
10	Femur	Eberline	<0.003 <0.94	0.33 ± 0.05 100 ± 16	0.03 ± 0.008 9.9 ± 2.7	<0.008 <2.6	31.6	Duplicate blind samples.
			<0.012 <3.3	0.22 ± 0.07 63 ± 19	0.068 ± 0.034 19.2 ± 9.6	0.04 ± 0.02 11.2 ± 5.5	28.2	
9	Femur	Eberline	<0.003 <0.98	<0.01 <2.9	<0.003 <0.84	<0.013 <3.8	29.4	Duplicate blind samples.
			<0.0001 <0.03	0.0092 ± 0.0067 2.9 ± 2.1	<0.015 <1.5	0.0029 ± 0.0026 0.94 ± 0.84	31.5	
9	Vertebrae	Eberline	<0.0006 <0.12	0.044 ± 0.013 9.1 ± 2.7	0.0091 ± 0.005 1.9 ± 0.96	<0.004 <0.9	20.8	Duplicate blind samples.
			<0.0004 <0.08	0.067 ± 0.037 12.8 ± 7	<0.016 <3.1	0.009 ± 0.008 1.7 ± 1.5	19.4	
20	Rumen	Eberline	1.5 ± 0.43 50 ± 10	67 ± 10 2200 ± 350	8.9 ± 1.8 300 ± 60	0.57 ± 0.47 19 ± 16	3.4	Laboratory rerun of sample.
	Vegetation		1.5 ± 0.56 50 ± 10	67 ± 14 2300 ± 420	7 ± 1.2 240 ± 40	0.23 ± 0.21 7.7 ± 7.0		
18	Skin and	Eberline	2.5 ± 0.41 280 ± 46	110 ± 17 11000 ± 1900			11.1	Laboratory rerun of sample.
	Hair		2.1 ± 0.34 240 ± 38	130 ± 20 14000 ± 2200				

APPENDIX II. QUALITY ASSURANCE RESULTS (Continued)

Animal No.	Sample Type	Analytical Laboratory	Analytical Results					Type of Quality Assurance Analysis
			²³⁸ Pu (pCi/g Ash) (pCi/kg*)	²³⁹ Pu (pCi/g Ash) (pCi/kg*)	²⁴¹ Am (pCi/g Ash) (pCi/kg*)	²³⁸ U (pCi/g Ash) (pCi/kg*)	Ash (%)	
14	Rumen	Eberline	0.9 ± 0.14 11 ± 1.8	22 ± 2.4 280 ± 31		0.12 ± 0.05 1.5 ± 0.6	1.3	Laboratory rerun of sample.
	Fluid		1.1 ± 0.2 14 ± 2.4	35 ± 5 440 ± 64		0.13 ± 0.04 1.7 ± 0.52		
19	Lung	Eberline	1.6 ± 0.2 63 ± 7.1	0.44 ± 0.08 17 ± 3			3.9	Laboratory rerun of sample.
			1.1 ± 0.17 44 ± 6.7	0.32 ± 0.07 12 ± 2				
3	Liver	EMSL-LV	<0.03 <0.6	0.65 ± 0.04 17 ± 2.1	NA	0.02 ± 0.005 0.6 ± 0.3	2.6	Duplicate blind samples.
		LFE	0.0094 ± 0.00078 0.15 ± 0.13	0.38 ± 0.027 6.1 ± 0.4	0.16 ± 0.022 2.5 ± 0.36	0.65 10	1.6	

* Wet weight

NA = Not analyzed

<MDA = values below the detectable limit when the minimum detectable activity was not reported.

EMSL-LV = Environmental Monitoring and Support Laboratory, Las Vegas, Nevada.

LFE = LFE Environmental Analysis Laboratories, Richmond, California.

Eberline = Eberline Instrument Corporation, Albuquerque, New Mexico.

APPENDIX III. BOTANICAL ANALYSIS OF INGESTA COLLECTED FROM RUMEN-FISTULATED STEERS GRAZING ON
THE AREA 13 RANGE

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Steer No.	Date Collected	Percentage of Grasses					Percentage of Forbs								Percentage of Shrubs										
		<i>Hilaria jamesii</i>	<i>Oryzopsis hymenoides</i>	<i>Sitanion jubatum</i>	<i>Stipa speciosa</i>	<i>Sporobolus</i> sp.	Unidentified grasses	<i>Salsola paulsenii</i>	<i>Sphaeralcea ambigua</i>	<i>Eriogonum</i> sp.	<i>Chaenactis</i> sp.	<i>Chenopodium</i> sp.	<i>Malacothrix</i> sp.	<i>Ambrosia acanthicarpa</i>	<i>Phlox</i> sp.	<i>Gilia</i> sp.	Unidentified forbs	<i>Eurotia lanata</i>	<i>Atriplex canescens</i>	<i>Atriplex confertifolia</i>	<i>Lycium andersonii</i>	<i>Grayia spinosa</i>	<i>Suaeda</i> sp.	<i>Kochia americana</i>	Unidentified shrubs
707	06/12/73	←										SAMPLE NOT COLLECTED										→			
729		←										SAMPLE NOT COLLECTED										→			
761*		8	32	1					T								2	44	13						
774*			88					1	T	1								8	2						
707	07/10/73	17	41			T		2	T								1	24	15						
729		49	42							T							T	5	3						
761		1	12	1				14									2	29	41						
774		43	31														T	26	1						
707	08/08/73	11	29						1								1	5	53						
729		11	19							T							2	27	41						
761		9	13	T				1										15	62						
774		7	16														1	10	65	1					
707	09/05/73	16															1	29	54						
729		19						1		T	1							38	42	T					
761		8				1											2	43	46						
774		6					2											15	76	1					

APPENDIX III. BOTANICAL ANALYSIS OF INGESTA COLLECTED FROM RUMEN-FISTULATED STEERS GRAZING ON THE AREA 13 RANGE (Continued)

Steer No.	Date Collected	Percentage of Grasses					Percentage of Forbs							Percentage of Shrubs											
		<i>Hilaria jamesii</i>	<i>Oryzopsis hymenoides</i>	<i>Sitanion jubatum</i>	<i>Stipa speciosa</i>	<i>Sporobolus</i> sp.	Unidentified grasses	<i>Salsola paulsenii</i>	<i>Sphaeralcea ambigua</i>	<i>Eriogonum</i> sp.	<i>Chaenactis</i> sp.	<i>Chenopodium</i> sp.	<i>Malacothrix</i> sp.	<i>Ambrosia acanthiocalpa</i>	<i>Phlox</i> sp.	<i>Gilia</i> sp.	Unidentified forbs	<i>Eurotia lanata</i>	<i>Atriplex canescens</i>	<i>Atriplex confertifolia</i>	<i>Lycium andersonii</i>	<i>Grayia spinosa</i>	<i>Suaeda</i> sp.	<i>Kochia americana</i>	Unidentified shrubs
707	10/01/73	10	4															19	65	2					
729		← SAMPLE LOST →																							
761		14	2			1				T							2	23	58						
774		16				2											2	18	62						
707	11/06/73	32	5					4								3	49	7							
729		36						1			2		2				54	7						T	
761		79						2		3								13							
774		16	4									2						65	7						6
707	02/20/74					3	1	10			1					1	76		T			8			
729		2					1	3	1	T							85		2		6				
761								2	T								83	9	2	4					
774							2			1								85	3	3	6				
707	05/21/74	1	2	70							8	6	2	T		T	6	4	T			1			
729			3	42				T			12		3			4	26	5	T			3		2	
761			6	26	3				6	1	5		3				38					12			
774			13	23			3		T	2	5	1	6			7	33		2			1		4	

APPENDIX III. BOTANICAL ANALYSIS OF INGESTA COLLECTED FROM RUMEN-FISTULATED STEERS GRAZING ON THE AREA 13 RANGE (Continued)

Steer No.	Date Collected	Percentage of Grasses					Percentage of Forbs								Percentage of Shrubs									
		<i>Hilaria jamesii</i>	<i>Oryzopsis hymenoides</i>	<i>Sitanion jubatum</i>	<i>Stipa speciosa</i>	<i>Sporobolus</i> sp.	Unidentified grasses	<i>Salsola paulsenii</i>	<i>Sphaeralcea ambigua</i>	<i>Eriogonum</i> sp.	<i>Chaenactis</i> sp.	<i>Chenopodium</i> sp.	<i>Malacothrix</i> sp.	<i>Ambrosia acanthicarpa</i>	<i>Phlox</i> sp.	<i>Gilia</i> sp.	Unidentified forbs	<i>Eurotia lanata</i>	<i>Atriplex canescens</i>	<i>Atriplex confertifolia</i>	<i>Lycium andersonii</i>	<i>Grayia spinosa</i>	<i>Suaeda</i> sp.	<i>Kochia americana</i>
707	06/28/74	4	28	15	2			32									3	5	3			6		2
729				3	1			6									1	63	3			21		2
761			2	4	1			10									4	36	6	1		30		6
774			3	6				T		T							1	32	1			55		2
707	06/30/74	3		7	4		3	4	T	4							2	33	9	19		8		4
729		5	5	8	8					11	3	5					2	6	14	29				4
761		T	2	3	5			1		1					T	T		46	6	34		2		
774			2	6	3	1				1	3						1	18	6	44		12		3
707	07/02/74		2	5				14		2							4	39	4	14		10		6
729				3	1			16	1								4	57	6	T		9		3
761				1				16	T	T							2	61	4	4		11		1
774			3	2				16		T							2	39	9	1		25		3
707	08/07/74		39					1		T								43	12	4		1		
729			23	8						T								68				1		
761			29	T						T								39	6	4		22		
774			26	2				T		T								66				6		

APPENDIX III. BOTANICAL ANALYSIS OF INGESTA COLLECTED FROM RUMEN-FISTULATED STEERS GRAZING ON
THE AREA 13 RANGE (Continued)

Steer No.	Date Collected	Percentage of Grasses					Percentage of Forbs							Percentage of Shrubs										
		<i>Hilaria jamesii</i>	<i>Oryzopsis hymenoides</i>	<i>Sitanion jubatum</i>	<i>Stipa speciosa</i>	<i>Sporobolus</i> sp.	Unidentified grasses	<i>Salsola paulsenii</i>	<i>Sphaeralcea ambigua</i>	<i>Eriogonum</i> sp.	<i>Chaenactis</i> sp.	<i>Chenopodium</i> sp.	<i>Malacothrix</i> sp.	<i>Ambrosia acanthicarpa</i>	<i>Phlox</i> sp.	<i>Gilia</i> sp.	Unidentified forbs	<i>Eurotia lanata</i>	<i>Atriplex canescens</i>	<i>Atriplex confertifolia</i>	<i>Lycium andersonii</i>	<i>Grayia spinosa</i>	<i>Suaeda</i> sp.	<i>Kochia americana</i>
707	10/01/74							3										19	9	69				
729			1							1								46		40			12	
761			T							T								38		62			7	
774								1		4								29		59				
707	10/03/74		8						1									23	3	65				
729								3		1								24	7	49			16	
761																		19		55			26	
774			1	T						T								19		80				
707	10/05/74		1						T									7		92				
729			T															21		77			2	
761								T		T								56		44				
774								6		T								9	14	59			12	
707	11/05/74		19	2				6	1							1		33		38				
729			5						1									59		35				
761			10					T	1							T		62		27				
774								2	T							T		46	1	51				

APPENDIX III. BOTANICAL ANALYSIS OF INGESTA COLLECTED FROM RUMEN-FISTULATED STEERS GRAZING ON
THE AREA 13 RANGE (Continued)

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Steer No.	Date Collected	Percentage of Grasses					Percentage of Forbs							Percentage of Shrubs											
		<i>Hilaria jamesii</i>	<i>Oryzopsis hymenoides</i>	<i>Sitanion jubatum</i>	<i>Stipa speciosa</i>	<i>Sporobolus</i> sp.	Unidentified grasses	<i>Salsola paulsenii</i>	<i>Sphaeralcea ambigua</i>	<i>Eriogonum</i> sp.	<i>Chaenactis</i> sp.	<i>Chenopodium</i> sp.	<i>Malacothrix</i> sp.	<i>Ambrosia acanthiocalpa</i>	<i>Phlox</i> sp.	<i>Gilia</i> sp.	Unidentified forbs	<i>Eurotia lanata</i>	<i>Atriplex canescens</i>	<i>Atriplex confertifolia</i>	<i>Lycium andersonii</i>	<i>Grayia spinosa</i>	<i>Suaeda</i> sp.	<i>Kochia americana</i>	Unidentified shrubs
707	01/17/75								T										100						
729			3				T	T	T									14		83					
761							1		T								2	18		79					
774							T		T									16		84					T
707	01/19/75		3	1				1	T								7	2		86					
729				1					T											99					
761																		10	4	86					T
774										T										98					2
707	01/21/75			6	8				T									T	7	79					
729			19	6					1								3	34	9	28					
761			4				3										T	61	4	28					
774			8	2				1	T		T						.	48	9	32					
707	03/12/75						4	3	T								1	39	1	52					
729			27	T	4			1										52		10				6	
761							2	1	T									32		61				4	
774			4				3	2	1									38		46					6

APPENDIX III. BOTANICAL ANALYSIS OF INGESTA COLLECTED FROM RUMEN-FISTULATED STEERS GRAZING ON
THE AREA 13 RANGE (Continued)

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Steer No.	Date Collected	Percentage of Grasses					Percentage of Forbs							Percentage of Shrubs											
		<i>Hilaria jamesii</i>	<i>Oryzopsis hymenoides</i>	<i>Sitanion jubatum</i>	<i>Stipa speciosa</i>	<i>Sporobolus</i> sp.	Unidentified grasses	<i>Salsola paulsenii</i>	<i>Sphaeralcea ambigua</i>	<i>Eriogonum</i> sp.	<i>Chaenactis</i> sp.	<i>Chenopodium</i> sp.	<i>Malacothrix</i> sp.	<i>Ambrosia acanthiocalpa</i>	<i>Phlox</i> sp.	<i>Gilia</i> sp.	Unidentified forbs	<i>Eurotia lanata</i>	<i>Atriplex canescens</i>	<i>Atriplex confertifolia</i>	<i>Lycium andersonii</i>	<i>Grayia spinosa</i>	<i>Suaeda</i> sp.	<i>Kochia americana</i>	Unidentified shrubs
707	05/29/75	4	66	18				7									1		1						2
729			7	33	29												5	16		4					6
761			6	21	40												1	29	T	3					T
774			3	17	28					T							3	46	1	2					
707	08/23/75		15		1				T								1	42	7	29					5
729								18										43	6	26				7	
761					1					1							T	39	4	37				15	3
774				1					2	1							3	41		46					6
707	11/13/75			1														32		64					3
729						1			2	1								49	8	39					
761									1									41		52					6
774				2						1								43		51					3
707	02/19/76		1	T				1										T		98					
729				4				33		3								6		54					
761				T				2		T								7	2	89					
774					2					3								2		93					

*Steers grazed outer compound this date. All other collections from inner compound.

T = Trace, less than 1 percent.

APPENDIX IV. BOTANICAL ANALYSIS OF INGESTA COLLECTED FROM SACRIFICED ANIMALS GRAZING ON THE AREA 13 RANGE

Animal No.	Date Collected	Percentage of Grasses						Percentage of Forbs				Percentage of Shrubs								
		<i>Hilaria jamesii</i>	<i>Oryzopsis hymenoides</i>	<i>Sitanion jubatum</i>	<i>Sitanion hystrix</i>	<i>Stipa speciosa</i>	<i>Bromus tectorum</i>	Unidentified grasses	<i>Salsola paulsenii</i>	<i>Sphaeralcea ambigua</i>	<i>Eriogonum</i> sp.	<i>Chaenactis</i> sp.	Unidentified forbs	<i>Ephedra viridis</i>	<i>Eurotia lanata</i>	<i>Cowania mexicana</i>	<i>Atriplex canescens</i>	<i>Atriplex confertifolia</i>	<i>Grayia spinosa</i>	Unidentified shrubs
¹ Goat #1	08/09/73		19						68	T	T	3		4		6				
² Cow #2		37										4		4		43	7		5	
¹ Cow #3		31							2			4		4		54	3		2	
¹ Cow #8	10/25/73		33			T						2		6		44	12		3	
¹ Calf #12*			70	3								1				22	3		1	
¹ Goat #2			53									2		6		39				
¹ Cow #1			92			4				T						3			1	
¹ Cow #4	07/09/74		41	9					1		1			8		38			2	
¹ Cow #6		1	69	4			T		4	3	1			8		10				
¹ Cow #5			17	8					2		T			36		15	16		6	
¹ Bull #15	01/29/75		11	2					4			1		24		9	34		15	
¹ Bull #13			6					2	2		1			34		13	40	2		
³ Calf #30	01/18/76		27		49	8	6				1		1	3		3			2	

APPENDIX IV . BOTANICAL ANALYSIS OF INGESTA COLLECTED FROM SACRIFICED ANIMALS GRAZING ON
THE AREA 13 RANGE (Continued)

Animal No.	Date Collected	Percentage of Grasses						Percentage of Forbs				Percentage of Shrubs							
		<i>Hilaria jamesii</i>	<i>Oryzopsis hymenoides</i>	<i>Sitanion jubatum</i>	<i>Sitanion hystrix</i>	<i>Stipa speciosa</i>	<i>Bromus tectorum</i>	Unidentified grasses	<i>Salsola paulsenii</i>	<i>Sphaeralcea ambigua</i>	<i>Eriogonum</i> sp.	<i>Chaenactis</i> sp.	Unidentified forbs	<i>Ephedra viridis</i>	<i>Eurotia lanata</i>	<i>Cowanina mexicana</i>	<i>Atriplex canescens</i>	<i>Atriplex confertifolia</i>	<i>Grayia spinosa</i>
² Cow #10	01/28/76	3	1						T	T				8		12	76		
¹ Cow #14		4	3							2	1						86		4
² Calf #18		8	3							1	1			1			85		1
¹ Calf #19		5	3							1	2						88		1
¹ Cow #9	03/13/76	5	18							1			26		3	43	4		
¹ Cow #16		3	15					4		1			36			35	6		
¹ Bull #20		2	8					2		T			23			65			

¹Grazed outer compound

²Grazed inner compound

³Animal sampled at Bald Mountain.

*This sample contained rubberized and cloth material.

T = Trace, less than 1 percent.

APPENDIX V. ACTINIDE CONCENTRATIONS IN THE VEGETATION COMPONENT OF THE RUMEN CONTENTS FROM STEERS
GRAZING AREA 13 (wet wt)

Animal No.	Date Collected	^{238}Pu (nCi/kg)	^{239}Pu (nCi/kg)	^{241}Am (nCi/kg)	$^{239}\text{Pu}; ^{238}\text{Pu}$ Ratio	$^{239}\text{Pu}; ^{241}\text{Am}$ Ratio
707	06/12/73	← SAMPLE NOT COLLECTED →				
729		← SAMPLE NOT COLLECTED →				
761*		0.0020 ± 0.0007	0.060 ± 0.004	0.0091 ± 0.007	30	6.6
774*		0.0051 ± 0.0009	0.200 ± 0.01	0.047 ± 0.028	39	4.3
707	07/10/73	0.56 ± 0.039	22.2 ± 1.6	3.2 ± 0.097	39.6	6.9
729		0.38 ± 0.015	16.7 ± 0.67	2.6 ± 0.052	43.9	6.4
761		0.33 ± 0.037	13.5 ± 0.81	1.9 ± 0.076	40.9	7.1
774		0.91 ± 0.091	39.1 ± 2.7	6.7 ± 0.067	43	5.8
707	08/07/73	0.27 ± 0.011	11.7 ± 0.35	1.9 ± 0.058	43.3	6.2
729		0.32 ± 0.032	14.7 ± 0.74	2.1 ± 0.083	45.9	7
761		1.1 ± 0.056	48.3 ± 2.4	7.5 ± 0.075	43.9	6.4
774		0.48 ± 0.043	20.7 ± 1.7	3.5 ± 0.07	43.1	5.9
707	09/05/73	0.16 ± 0.023	6.0 ± 0.9	1.6 ± 0.032	37.5	3.8
729		← SAMPLE LOST →				
761		0.64 ± 0.045	25.8 ± 1.3	2.9 ± 0.11	40.3	8.9
774		0.12 ± 0.036	5.0 ± 1.4	1.8 ± 0.018	41.7	2.8
707	10/01/73	0.23 ± 0.007	9.8 ± 0.2	2.0 ± 0.04	42.6	4.9
729		0.24 ± 0.026	10.1 ± 1.0	2.1 ± 0.08	42.1	4.8
761		0.14 ± 0.011	5.7 ± 0.4	1.5 ± 0.046	40.7	3.8
774		0.37 ± 0.07	15.9 ± 2.9	1.9 ± 0.039	43	8.4
707	11/06/73	0.61 ± 0.03	25.3 ± 1.3	4.8 ± 0.048	41.5	5.3
729		1.0 ± 0.09	43.5 ± 3.0	5.4 ± 0.054	43.3	8.1
761		0.78 ± 0.085	27.3 ± 2.2	4.2 ± 0.042	35	6.5
774		0.04 ± 0.028	17.2 ± 1.0	4.2 ± 0.17	43	4.1

APPENDIX V. ACTINIDE CONCENTRATIONS IN THE VEGETATION COMPONENT OF THE RUMEN CONTENTS FROM STEERS
GRAZING AREA 13 (wet wt) (Continued)

Animal No.	Date Collected	^{238}Pu (nCi/kg)	^{239}Pu (nCi/kg)	^{241}Am (nCi/kg)	$^{239}\text{Pu}:^{238}\text{Pu}$ Ratio	$^{239}\text{Pu}:^{241}\text{Am}$ Ratio
707	02/20/74	0.21 ± 0.013	8.8 ± 0.44	1.3 ± 0.03	41.9	6.8
729		0.14 ± 0.017	6.5 ± 0.65	0.25 ± 0.005	46.4	26
761		0.23 ± 0.011	9.9 ± 0.39	1.4 ± 0.03	43	7.1
774		0.21 ± 0.013	9.3 ± 0.47	1.6 ± 0.05	44.3	5.8
707	05/21/74	0.20 ± 0.008	8.5 ± 0.25	1.2 ± 0.037	42.5	7.1
729		0.21 ± 0.024	9.1 ± 0.91	1.6 ± 0.096	43.3	5.7
761		0.25 ± 0.025	11.3 ± 1.0	2.0 ± 0.02	45.2	5.7
774		0.20 ± 0.02	8.0 ± 0.56	1.2 ± 0.05	40	6.7
707	08/07/74	2.5 ± 0.98	105.0 ± 4.2	12.7 ± 0.13	42	8.3
729		2.4 ± 0.14	100.0 ± 6.0	14.7 ± 0.15	41.7	6.8
761		0.11 ± 0.005	4.3 ± 0.21	10.6 ± 0.11	39.1	0.4
774		2.6 ± 0.16	116.0 ± 5.8	20.6 ± 0.21	44.7	5.6
707	11/05/74	0.51 ± 0.026	22.3 ± 1.1	4.7 ± 0.8	43.7	4.8
729		0.77 ± 0.038	33.2 ± 1.3	6.9 ± 0.55	43.1	4.8
761		0.72 ± 0.043	31.7 ± 1.6	5.9 ± 0.12	44	5.4
774		0.17 ± 0.012	7.3 ± 0.37	1.2 ± 0.05	42.9	6.1
707	03/12/75	0.38 ± 0.03	15.3 ± 0.92	3.4 ± 0.34	40.3	4.5
729		0.15 ± 0.012	6.7 ± 0.36	1.2 ± 0.059	44.7	5.
761		0.33 ± 0.023	14.2 ± 0.71	4.2 ± 1.2	43	3.4
774		0.22 ± 0.011	9.6 ± 0.38	1.6 ± 0.11	43.6	6
707	05/29/75	0.16 ± 0.011	6.4 ± 0.32	1.1 ± 0.054	40	5.8
729		0.40 ± 0.02	17.8 ± 0.72	2.8 ± 0.11	44.5	6.4
761		0.18 ± 0.01	6.9 ± 0.28	1.5 ± 0.073	38.3	4.6
774		← SAMPLE LOST →				

APPENDIX V. ACTINIDE CONCENTRATIONS IN THE VEGETATION COMPONENT OF THE RUMEN CONTENTS FROM STEERS
GRAZING AREA 13 (wet wt.) (Continued)

Animal No.	Date Collected	^{238}Pu (nCi/kg)	^{239}Pu (nCi/kg)	^{241}Am (nCi/kg)	$^{239}\text{Pu}:^{238}\text{Pu}$ Ratio	$^{239}\text{Pu}:^{241}\text{Am}$ Ratio
707	08/23/75	0.38 ± 0.08	16.5 ± 2.9	0.75 ± 0.14	43.4	22
729		0.090 ± 0.02	3.7 ± 0.74	0.38 ± 0.05	41	9.7
761		0.71 ± 0.11	24.4 ± 3.1	1.7 ± 0.5	34.4	14.4
774		1.1 ± 0.19	47.3 ± 6.7	5.2 ± 0.7	43	9.1
707	11/13/75	0.38 ± 0.09	16.5 ± 3.0	1.9 ± 0.26	43.4	8.7
729		0.13 ± 0.03	5.5 ± 1.1	0.56 ± 0.06	42.3	9.8
761		0.12 ± 0.02	4.3 ± 0.49	0.4 ± 0.01	35.9	10.8
774		0.71 ± 0.19	32.5 ± 6.6	2.1 ± 0.8	45.8	15.5
707	02/19/76	0.020 ± 0.01	0.45 ± 0.1	0.05 ± 0.02	22.5	9
729		0.52 ± 0.14	20.3 ± 4.7	2.0 ± 0.31	39	10.2
761		3.3 ± 0.39	141.0 ± 15.0	6.2 ± 1.1	42.7	22.7
774		0.31 ± 0.09	10.4 ± 1.6	0.94 ± 0.18	33.5	11.1

*Steers grazed outer compound this date. All other collections from inner compound.

APPENDIX VI. ACTINIDE CONCENTRATIONS IN THE FLUID COMPONENT OF THE RUMEN CONTENTS FROM STEERS
GRAZING AREA 13 (wet wt)

Animal No.	Date Collected	^{238}Pu (nCi/kg)	^{239}Pu (nCi/kg)	^{241}Am (nCi/kg)	$^{239}\text{Pu}:^{238}\text{Pu}$ Ratio	$^{239}\text{Pu}:^{241}\text{Am}$ Ratio
707	06/12/73	SAMPLE NOT COLLECTED				
729		SAMPLE NOT COLLECTED				
761*		0.0043 ± 0.0006	0.22 ± 0.009	0.031 ± 0.002	51	7.1
774*		0.00046 ± 0.0002	0.021 ± 0.001	0.0037 ± 0.0002	46	5.7
707	07/10/73	0.075 ± 0.007	3.1 ± 0.18	0.48 ± 0.014	41.3	6.5
729		0.034 ± 0.003	1.5 ± 0.07	0.22 ± 0.004	44.1	6.8
761		0.0042 ± 0.0007	0.16 ± 0.006	0.026 ± 0.0008	38.0	6.2
774		0.024 ± 0.001	0.98 ± 0.03	0.14 ± 0.004	40.8	7
707	08/07/73	0.10 ± 0.004	4.5 ± 0.13	0.81 ± 0.024	45	5.6
729		0.021 ± 0.003	0.76 ± 0.045	0.11 ± 0.005	36.2	6.9
761		0.023 ± 0.0009	1.0 ± 0.03	0.18 ± 0.007	43.5	5.6
774		0.017 ± 0.0007	0.76 ± 0.015	0.14 ± 0.007	44.7	5.4
707	09/05/73	0.12 ± 0.009	4.6 ± 0.14	0.46 ± 0.014	38.3	10
729		0.0097 ± 0.00097	0.36 ± 0.011	0.042 ± 0.002	37.1	8.6
761		0.054 ± 0.003	2.3 ± 0.091	0.28 ± 0.009	42.6	8.2
774		0.099 ± 0.006	3.8 ± 0.12	0.52 ± 0.016	38.4	7.3
707	10/01/73	0.13 ± 0.011	5.3 ± 0.21	0.56 ± 0.028	40.8	9.5
729		0.068 ± 0.003	3.0 ± 0.089	0.42 ± 0.013	44.1	7.1
761		0.057 ± 0.005	2.5 ± 0.13	0.34 ± 0.01	43.9	7.4
774		0.019 ± 0.002	0.79 ± 0.032	0.12 ± 0.002	41.6	6.6
707	11/06/73	0.040 ± 0.003	1.8 ± 0.053	0.26 ± 0.005	45	6.9
729		0.041 ± 0.003	1.8 ± 0.09	0.27 ± 0.008	43.9	6.7
761		0.065 ± 0.008	2.8 ± 0.23	0.40 ± 0.012	43.1	7
774		0.059 ± 0.007	2.8 ± 0.19	0.36 ± 0.011	47.5	7.8

APPENDIX VI. ACTINIDE CONCENTRATIONS IN THE FLUID COMPONENT OF THE RUMEN CONTENTS FROM STEERS
GRAZING AREA 13 (Wet wt) (Continued)

Animal No.	Date Collected	^{238}Pu (nCi/kg)	^{239}Pu (nCi/kg)	^{241}Am (nCi/kg)	$^{239}\text{Pu}:^{238}\text{Pu}$ Ratio	$^{239}\text{Pu}:^{241}\text{Am}$ Ratio
707	02/20/74	0.075 \pm 0.005	3.3 \pm 0.13	0.47 \pm 0.014	44	7
729		0.061 \pm 0.003	2.7 \pm 0.08	0.40 \pm 0.02	44.3	6.8
761		0.031 \pm 0.003	1.3 \pm 0.05	0.20 \pm 0.004	42	6.5
774		0.14 \pm 0.010	5.0 \pm 0.25	0.82 \pm 0.025	35.7	6.1
707	05/21/74	0.020 \pm 0.001	0.88 \pm 0.018	0.16 \pm 0.003	44	5.5
729		0.085 \pm 0.003	3.6 \pm 0.11	0.51 \pm 0.015	42.3	7.1
761		0.079 \pm 0.006	3.4 \pm 0.17	0.46 \pm 0.014	43	7.4
774		0.049 \pm 0.002	2.1 \pm 0.062	0.29 \pm 0.006	42.9	7.2
707	08/07/74	0.55 \pm 0.039	23.8 \pm 1.4	3.4 \pm 0.2	43.3	7
729		0.88 \pm 0.026	38.6 \pm 1.2	5.3 \pm 0.16	43.9	7.3
761		0.49 \pm 0.020	21.5 \pm 0.86	3.4 \pm 0.13	43.9	6.3
774		0.84 \pm 0.067	36.0 \pm 2.5	5.2 \pm 0.05	42.9	6.9
707	11/05/74	0.15 \pm 0.011	6.2 \pm 0.31	0.95 \pm 0.038	41.3	6.5
729		0.31 \pm 0.022	12.8 \pm 0.64	0.26 \pm 0.019	41.3	49.2
761		0.37 \pm 0.048	17.1 \pm 0.86	5.9 \pm 0.12	46.2	2.9
774		0.78 \pm 0.063	32.8 \pm 2.3	4.6 \pm 0.32	42.1	7.1
707	03/12/75	0.22 \pm 0.02	8.1 \pm 0.5	1.4 \pm 0.08	36.8	5.8
729		0.097 \pm 0.01	4.1 \pm 0.25	0.14 \pm 0.01	42.3	29.3
761		0.24 \pm 0.02	9.8 \pm 0.59	0.75 \pm 0.03	40.8	13.1
774		0.10 \pm 0.01	4.4 \pm 0.27	0.70 \pm 0.056	44	0.62
707	05/29/75	0.56 \pm 0.033	24.5 \pm 1.2	4.3 \pm 0.086	43.8	5.7
729		0.24 \pm 0.027	10.7 \pm 0.86	0.81 \pm 0.016	44.6	13.2
761		0.64 \pm 0.032	27.4 \pm 1.1	4.5 \pm 0.22	42.8	6.1
774		0.34 \pm 0.017	14.7 \pm 0.59	2.0 \pm 0.14	43.2	7.4

APPENDIX VI. ACTINIDE CONCENTRATIONS IN THE FLUID COMPONENT OF THE RUMEN CONTENTS FROM STEERS
GRAZING AREA 13 (wet wt) (Continued)

Animal No.	Date Collected	^{238}Pu (nCi/kg)	^{239}Pu (nCi/kg)	^{241}Am (nCi/kg)	$^{239}\text{Pu}:^{238}\text{Pu}$ Ratio	$^{239}\text{Pu}:^{241}\text{Am}$ Ratio
707	08/23/75	0.040 \pm 0.01	1.6 \pm 0.17	0.080 \pm 0.02	40	20
729		0.080 \pm 0.02	2.3 \pm 0.47	0.24 \pm 0.05	28.8	9.6
761		0.040 \pm 0.01	1.6 \pm 0.17	0.18 \pm 0.04	40	8.9
774		0.010 \pm 0.01	0.61 \pm 0.08	0.080 \pm 0.02	61	7.6
707	11/13/75	0.010 \pm 0.01	0.34 \pm 0.06	0.060 \pm 0.01	34	5.7
729		0.030 \pm 0.01	1.3 \pm 0.21	0.16 \pm 0.01	43.3	8.1
761		0.080 \pm 0.02	3.4 \pm 0.68	0.36 \pm 0.04	42.5	9.4
774		0.020 \pm 0.01	0.64 \pm 0.1	0.090 \pm 0.03	32	7.1
707	02/19/76	0.10 \pm 0.05	2.3 \pm 0.76	0.49 \pm 0.1	23	4.7
729		0.12 \pm 0.02	5.1 \pm 0.68	0.99 \pm 0.11	42.5	5.7
761		0.040 \pm 0.01	1.6 \pm 0.25	0.15 \pm 0.04	40	10.7
774		0.030 \pm 0.01	1.3 \pm 0.21	0.24 \pm 0.05	43.3	5.4

*Steers grazed outer compound this date. All other collections from inner compound.

APPENDIX VII. ACTINIDE CONCENTRATIONS IN THE RETICULUM SEDIMENT FROM STEERS GRAZING AREA 13 (wet wt.)

Animal No.	Date Collected*	^{238}Pu (nCi/kg)	^{239}Pu (nCi/kg)	^{241}Am (nCi/kg)	$^{239}\text{Pu} : ^{238}\text{Pu}$ Ratio	$^{239}\text{Pu} : ^{241}\text{Am}$ Ratio	
707	06/12/73	← SAMPLE NOT COLLECTED →				25.5	
729		← SAMPLE NOT COLLECTED →					
761†		0.002 ± 0.0008	0.051 ± 0.003	NA			
774†		<MDA	0.002 ± 0.005	NA			
707	07/10/73	← SAMPLE NOT COLLECTED →					
729		<MDA	0.087 ± 0.008	NA			
761		← SAMPLE NOT COLLECTED →					
774		← SAMPLE NOT COLLECTED →					
707	08/07/73	0.16 ± 0.005	7.1 ± 3.0	NA	44.4		
729		← SAMPLE NOT COLLECTED →					
761		← SAMPLE NOT COLLECTED →					
774		0.02 ± 0.001	1.5 ± 0.1	NA	75		
707	08/07/74	← SAMPLE NOT COLLECTED →				13.8	5
729		0.51 ± 0.071	6.9 ± 0.48	1.4 ± 0.069			
761		← SAMPLE NOT COLLECTED →					
774		5.4 ± 0.43	202 ± 81	26.0 ± 1.3	38		
707	11/05/74	0.21 ± 0.015	1.8 ± 0.92	0.28 ± 0.019	8.6	6.4	
729		0.21 ± 0.041	0.97 ± 0.097	0.14 ± 0.036	4.6	6.9	
761		0.07 ± 0.008	1.9 ± 0.058	0.24 ± 0.017	27.1	7.9	
774		0.49 ± 0.039	21.8 ± 0.66	3.3 ± 0.17	44.5	6.6	
707	08/23/75	0.49 ± 0.22	9.7 ± 2.1	0.66 ± 0.34	19.8	14.7	
729		2.9 ± 0.49	100 ± 14	10 ± 2.3	34.5	10	
761		2.8 ± 0.46	110 ± 13	9.3 ± 2.2	39.3	11.8	
774		2.5 ± 0.6	87 ± 12	12 ± 2.1	34.8	7.3	

APPENDIX VII. ACTINIDE CONCENTRATIONS IN THE RETICULUM SEDIMENT FROM STEERS GRAZING AREA 13 (wet wt.)
(Continued)

Animal No.	Date Collected*	^{238}Pu (nCi/kg)	^{239}Pu (nCi/kg)	^{241}Am (nCi/kg)	$^{239}\text{Pu}:^{238}\text{Pu}$ Ratio	$^{239}\text{Pu}:^{241}\text{Am}$ Ratio
707	11/13/75	<0.08	5.0 ± 1.1	<0.18	--	--
729		0.52 ± 0.20	11.0 ± 2.2	1.6 ± 0.85	21	6.9
761		3.2 ± 0.52	140.0 ± 15.0	17.0 ± 3.2	43.8	8.2
774		0.81 ± 0.26	21.0 ± 3.2	2.3 ± 0.7	17	9.1
707	02/19/76	0.020 ± 0.010	0.45 ± 0.10	<0.20	22.5	--
729		1.4 ± 0.42	55.0 ± 11.0	5.4 ± 1.7	39.3	10.2
761		0.50 ± 0.16	10.0 ± 1.5	1.5 ± 0.6	20	6.7
774		0.82 ± 0.26	5.1 ± 0.87	0.94 ± 0.18	6.2	5.4

*Sediment samples not collected on 09/05/73, 10/01/73, 11/06/73, 02/20/74, 05/21/74, 03/12/75, and 05/29/75.

†Steers grazed outer compound this date. All other collections from inner compound.

NA = Samples not analyzed.

<MDA = Less than minimum detectable activity.

APPENDIX VIII. RADIONUCLIDE CONCENTRATIONS IN TISSUES COLLECTED FROM
ANIMALS GRAZING THE INNER COMPOUND, AREA 13, NTS

Notes:

* All strontium, tritium, and gamma spectral analyses by EMSL-LV.

† Wet weight

† Activity expressed in pCi/l

¹ Actinide analyses by LFE

² Actinide analyses by EMSL-LV

³ Actinide analyses by Eberline

NA = Not analyzed

<MDA = values below the detectable limit when the minimum detectable activity was not reported.

APPENDIX VIII. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM ANIMALS GRAZING THE INNER COMPOUND, AREA 13, NTS

Cow Number 2 Data collected 10/25/73

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Tissue Type	²³⁸ Pu (pCi/g Ash) (pCi/kg ⁺)		²³⁹ Pu (pCi/g Ash) (pCi/kg ⁺)		²⁴¹ Am (pCi/g Ash) (pCi/kg ⁺)		²³⁸ U (pCi/g Ash) (pCi/kg ⁺)	⁸⁹ Sr (pCi/g Ash) (pCi/kg ⁺)	⁹⁰ Sr (pCi/g Ash) (pCi/kg ⁺)	Ash (%)	³ H (pCi/l)	K (g/kg ⁺)	¹³⁷ Cs (pCi/kg ⁺)
Rumen vegetation ¹	13.0 ± 1.0 270 ± 22.0	560 ± 39.0 12,000 ± 820	110 ± 2.2 2,300 ± 46.0	0.63 13.0	NA	NA	2.1	NA	NA	NA	NA	NA	NA
Rumen fluid ¹	4.5 ± 0.27 46.0 ± 10.0	190 ± 7.5 1,900 ± 76.0	24.0 ± 0.7 240 ± 7.3	0.63 6.3	NA	NA	1.0	NA	NA	NA	NA	NA	NA
Reticulum sediment ²	<0.11 <11	0.81 ± 0.11 81.0 ± 11.5	NA	0.38 ± 0.038 38.0 ± 3.8	NA	NA	10	NA	NA	NA	NA	NA	NA
Liver ¹	0.11 ± 0.04 1.4 ± 0.6	3.1 ± 0.2 39.0 ± 2.7	0.4 ± 0.04 5.5 ± 0.4	1.3 16.0	NA	NA	1.25	NA	1.3	NA	NA	NA	NA
Lung ²	0.28 ± 0.06 3.4 ± 0.6	11.0 ± 1.4 130 ± 17.0	NA	0.032 ± 0.008 0.38 ± 0.10	NA	NA	1.2	NA	0.8	NA	NA	NA	NA
Tracheobronchial lymph nodes ²	1.3 ± 0.4 19.0 ± 5.4	54.0 ± 4.4 810 ± 66.0	NA	0.13 ± 0.09 2.0 ± 1.4	NA	NA	1.5	NA	NA	NA	NA	NA	NA
Muscle ²	0.0037 ± 0.001 0.048 ± 0.015	0.015 ± 0.002 0.19 ± 0.027	NA	<MDA	NA	NA	1.3	NA	NA	NA	NA	NA	NA
Gonads	SAMPLE NOT COLLECTED												
Blood cells ²	<0.04 <0.3	<0.07 <0.52	NA	0.013 ± 0.012 0.098 ± 0.093	NA	NA	0.8	NA	NA	NA	NA	NA	NA
Blood serum ²	<0.011 <0.24	<0.012 <0.25	NA	0.002 0.045	NA	NA	2.1	530 ± 240	NA	NA	NA	NA	NA
Femur ¹	0.043 ± 0.0026 12.0 ± 7.3	0.012 ± 0.0013 3.3 ± 0.36	0.0045 ± 0.001 1.3 ± 0.28	0.029 8.1	<0.9 <260	3.9 ± 0.86 1,100 ± 240	28	NA	NA	NA	NA	NA	NA
Vertebrae ¹	0.0024 ± 0.0007 0.46 ± 0.13	0.039 ± 0.002 7.4 ± 0.38	0.0058 ± 0.0012 1.1 ± 0.23	0.022 4.2	<13 <2,400	27 ± 10 5,100 ± 1,900	19	NA	NA	NA	NA	NA	NA
Skin ²	12.0 ± 1.4 220 ± 25.0	470 ± 50 8,400 ± 900	NA	0.42 ± 0.036 7.6 ± 0.65	NA	NA	1.8	NA	NA	NA	NA	NA	NA
Skin and hair ²	51.0 ± 180 500 ± 180	2,100 ± 700 21,000 ± 7,000	NA	0.64 ± 0.045 6.3 ± 0.44	NA	NA	0.99	NA	NA	NA	NA	NA	NA
Kidney ²	NA	NA	NA	NA	NA	NA	NA	NA	2.4	NA	NA	<MDA	NA
Thyroid ²	NA	NA	NA	NA	NA	NA	NA	NA	GAMMA SPECTRUM	NEGLIGIBLE	NA	NA	NA

APPENDIX VIII. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM ANIMALS GRAZING THE INNER COMPOUND, AREA 13, NTS (Continued)

Calf Number 11 Data collected 10/25/73

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Tissue Type	²³⁸ Pu (pCi/g Ash) (pCi/kg ⁺)	²³⁹ Pu (pCi/g Ash) (pCi/kg ⁺)	²⁴¹ Am (pCi/g Ash) (pCi/kg ⁺)	²³⁸ U (pCi/g Ash) (pCi/kg ⁺)	⁸⁹ Sr (pCi/g Ash) (pCi/kg ⁺)	⁹⁰ Sr (pCi/g Ash) (pCi/kg ⁺)	Ash (%)	³ H (pCi/l)	K (g/kg ⁺)	¹³⁷ Cs (pCi/kg ⁺)
Rumen vegetation	SAMPLE NOT COLLECTED									
Rumen fluid	SAMPLE NOT COLLECTED									
Reticulum sediment	SAMPLE NOT COLLECTED									
Liver ¹	0.020 ± 0.006 0.36 ± 0.11	0.24 ± 0.017 4.4 ± 0.3	<MDA	0.20 3.6	NA	NA	1.8	NA	2.5	<MDA
Lung ¹	SAMPLE LOST							NA	3.0	<MDA
Tracheobronchial lymph nodes ²	0.65 ± 0.5 31 ± 24.0	<0.71 <34	NA	<0.13 <6.4	NA	NA	4.8	NA		
Muscle ¹	0.38 ± 0.03 4.4 ± 0.3	16.0 ± 0.48 180 ± 5.5	1.5 ± 0.04 16.0 ± 0.44	0.04 0.44	NA	NA	1.1	NA	0.9	10
Gonads	SAMPLE NOT COLLECTED									
Blood cells ²	<0.031 <0.34	0.043 ± 0.035 0.47 ± 0.38	NA	<0.025 <0.28	NA	NA	1.1	NA	NA	NA
Blood serum ²	<0.025 <0.22	0.074 ± 0.032 0.65 ± 0.28	NA	<0.006 <0.054	NA	NA	0.88	NA	NA	NA
Femur ²	<0.009 <1.3	0.047 ± 0.007 7.1 ± 2.0	NA	<0.001 <0.21	<1.5 <200	1.2 ± 1.1 180 ± 170	15	NA	NA	NA
Vertebrae ²	<0.005 <0.47	0.038 ± 0.011 3.4 ± 0.9	NA	<0.001 <0.1	<1.2 <110	<0.96 <85.0	8.9	NA	NA	NA
Skin ²	5.7 ± 0.47 43.0 ± 3.6	78.0 ± 5.7 590 ± 43.0	NA	0.12 ± 0.036 0.88 ± 0.27	NA	NA	0.76	NA	NA	NA
Skin and hair ²	22.0 ± 5.2 280 ± 69.0	770 ± 180 10,000 ± 2,400	NA	0.45 ± 0.072 5.8 ± 0.94	NA	NA	1.3	NA	NA	NA
Kidney ²	NA	NA	NA	NA	NA	NA	NA	NA	3.8	<MDA
Thyroid ²	NA	NA	NA	NA	NA	NA	NA	NA	GAMMA SPECTRUM NELIBILE	

APPENDIX VIII. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM ANIMALS GRAZING THE INNER
COMPOUND, AREA 13, NTS (Continued)

Cow Number 10 Data collected 01/28/76

Tissue Type	²³⁸ Pu (pCi/g Ash) (pCi/kg ⁺)	²³⁹ Pu (pCi/g Ash) (pCi/kg ⁺)	²⁴¹ Am (pCi/g Ash) (pCi/kg ⁺)	²³⁸ U (pCi/g Ash) (pCi/kg ⁺)	⁸⁹ Sr (pCi/g Ash) (pCi/kg ⁺)	⁹⁰ Sr (pCi/g Ash) (pCi/kg ⁺)	Ash (%)	³ H (pCi/l)	K (g/kg ⁺)	¹³⁷ Cs (pCi/kg ⁺)
Rumen vegetation ³	0.29 ± 0.14 4.8 ± 2.3	8.3 ± 1.8 140 ± 30.0	23.0 ± 3.2 380 ± 54.0	<0.009 <0.17	NA	NA	1.7	NA	1.8 ± 0.58	42.0 ± 7.1
Rumen fluid ³	<0.14 <0.17	30.0 ± 7.1 37.0 ± 8.7	14.0 ± 3.8 17.0 ± 4.7	<0.56 <0.64	NA	NA	0.1	NA	NA	NA
Reticulum sediment ³	<0.2 <80.0	1.2 ± 0.43 500 ± 180	13.0 ± 2.9 5,400 ± 1,300	1.4 ± 1.1 610 ± 470	NA	NA	43.3	NA	NA	NA
Liver ³	0.54 ± 0.094 5.3 ± 0.93	15.0 ± 2.0 150 ± 20.0	1.7 ± 0.23 17.0 ± 2.2	0.46 ± 0.09 4.5 ± 0.9	NA	NA	0.99	NA	3.0 ± 0.32	<MDA
Lung ³	0.89 ± 0.56 24.0 ± 16.0	22.0 ± 6.2 580 ± 170	1.7 ± 0.43 46.0 ± 12.0	0.54 ± 0.19 15.0 ± 5.4	NA	NA	2.7	NA	5.0 ± 0.44	<MDA
Tracheobronchial lymph nodes ³	2.0 ± 0.76 71.0 ± 27.0	66.0 ± 16.0 2,300 ± 570	18.0 ± 7.1 650 ± 250	<0.043 <1.5	NA	NA	3.5	NA	NA	NA
Muscle ³	<0.005 <0.05	0.22 ± 0.054 2.3 ± 0.55	0.021 ± 0.01 0.22 ± 0.1	0.14 ± 0.03 1.4 ± 0.34	NA	NA	1.0	NA	4.2 ± 0.44	43.0 ± 8.6
Gonads ³	<0.157 <4.3	1.1 ± 0.55 32.0 ± 16.0	<0.35 <12.0	<0.025 <0.71	NA	NA	2.9	NA	NA	NA
Blood cells ³	<0.002 <0.05	0.021 ± 0.01 0.47 ± 0.27	<0.015 <0.33	<0.001 <0.02	NA	NA	2.2	NA	NA	NA
Blood serum ³	<0.0074 <0.14	0.15 ± 0.04 2.8 ± 0.79	<0.013 <0.25	0.017 ± 0.013 0.32 ± 0.25	NA	NA	1.9	800 ± 260	NA	NA
Femur ³	<0.003 <0.94	0.33 ± 0.05 100 ± 16.0	0.03 ± 0.008 9.9 ± 2.7	<0.008 <2.6	NA	NA	31.6	NA	NA	NA
Vertebrae ³	0.014 ± 0.007 1.4 ± 0.7	0.67 ± 0.067 68.0 ± 6.7	0.043 ± 0.015 4.4 ± 1.5	<0.015 <1.5	NA	NA	10.1	NA	NA	NA
Skin and hair ³	0.18 ± 0.13 3.6 ± 2.6	4.1 ± 1.1 83.0 ± 21.0	<0.023 <0.4	<0.1 <2.0	NA	NA	2.0	NA	NA	NA
Kidney ³	0.047 ± 0.033 0.47 ± 0.3	1.1 ± 0.3 11.0 ± 3.0	<0.018 <0.18	<0.015 <0.15	NA	NA	1.0	NA	NA	NA

APPENDIX VIII. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM ANIMALS GRAZING THE INNER COMPOUND, AREA 13, NTS (Continued)

Calf Number 18 Data collected 01/28/76

Tissue Type	²³⁸ Pu (pCi/g Ash) (pCi/kg)	²³⁹ Pu (pCi/g Ash) (pCi/kg†)	²⁴¹ Am (pCi/g Ash) (pCi/kg†)	²³⁸ U (pCi/g Ash) (pCi/kg†)	⁸⁹ Sr (pCi/g Ash) (pCi/kg†)	⁹⁰ Sr (pCi/g Ash) (pCi/kg†)	Ash (%)	³ H (pCi/l)	K (g/kg†)	¹³⁷ Cs (pCi/kg†)
Rumen vegetation ³	37.0 ± 1.3 460 ± 170	1,900 ± 680 24,000 ± 85,000	170 ± 121 2,200 ± 260	0.50 ± 0.11 6.2 ± 1.4	NA	NA	1.25	NA	0.9 ± 0.2	41.0 ± 5.7
Rumen fluid ³	4.3 ± 0.8 50.0 ± 8.8	200 ± 34.0 2,300 ± 380	28.0 ± 3.8 317 ± 43.0	0.12 ± 0.06 1.3 ± 0.62	NA	NA	1.1	NA	NA	NA
Reticulum sediment ³	1.7 ± 0.4 120 ± 30.0	46.0 ± 5.0 3,300 ± 360	10.0 ± 3.0 720 ± 200	<0.43 <31.0	NA	NA	7.3	NA	NA	NA
Liver ³	<0.033 <1.7	0.58 ± 0.08 30.0 ± 4.1	0.16 ± 0.03 8.2 ± 1.7	0.056 ± 0.02 2.9 ± 0.9	NA	NA	5.2	NA	NA	<MDA
Lung ³	0.52 ± 0.08 70.0 ± 13.0	0.33 ± 0.07 45.0 ± 8.8	0.19 ± 0.03 26.0 ± 4.5	<0.006 <0.84	NA	NA	13.5	NA	2.3 ± 0.24	36.0 ± 5.1
Tracheobronchial lymph nodes ³	← SAMPLE LOST → ← IN ANALYSIS →	9.3 ± 1.9 120 ± 24.0	<0.33 <3.8	NA	NA	1.3	NA	NA	NA	NA
Muscle ³	0.048 ± 0.016 0.48 ± 0.16	0.48 ± 0.16 4.8 ± 1.6	<0.035 <0.35	3.6 ± 0.5 36.0 ± 5.4	NA	NA	0.99	NA	3.3 ± 0.41	38.0 ± 6.6
Gonads ³	← SAMPLE LOST → ← IN ANALYSIS →	<0.4 <3.3	<0.1 <0.83	NA	NA	0.8	NA	NA	NA	NA
Blood cells ³	<0.014 <0.7	0.75 ± 0.26 36.0 ± 12.0	0.067 ± 0.026 3.2 ± 2.7	<0.001 <0.06	NA	NA	4.8	NA	NA	NA
Blood serum ³	← SAMPLE LOST → ← IN ANALYSIS →	<0.006 <0.09	0.013 ± 0.008 0.21 ± 0.13	NA	NA	1.6	450 ± 260	NA	NA	NA
Femur ³	0.008 ± 0.007 1.9 ± 1.8	0.27 ± 0.056 69.0 ± 14.0	0.039 ± 0.01 9.7 ± 2.6	0.017 ± 0.01 4.3 ± 2.5	NA	NA	25.6	NA	NA	NA
Vertebrae ³	<0.006 <0.91	0.42 ± 0.09 58.0 ± 13.0	0.041 ± 0.014 5.8 ± 2.0	0.017 ± 0.005 2.4 ± 1.1	NA	NA	14.2	NA	NA	NA
Skin and hair ³	2.1 ± 0.34 240 ± 38.0	130 ± 20.0 14,000 ± 2,200	12.0 ± 1.5 1,300 ± 170	0.045 ± 0.021 4.9 ± 2.3	NA	NA*	11.1	NA	NA	NA
Kidney ³	0.078 1.1	0.04 0.56	1.4 ± 0.63 20 ± 8.9	0.062 ± 0.027 0.87 ± 0.38	0.58 ± 0.09 8.1 ± 1.3	NA	NA	1.4	NA	NA

APPENDIX VIII. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM ANIMALS GRAZING THE INNER
COMPOUND, AREA 13, NTS (Continued)

Goat Number 1 Data collected 08/07/73

Tissue Type	^{238}Pu (pCi/g Ash) (pCi/kg ⁺)		^{239}Pu (pCi/g Ash) (pCi/kg ⁺)		^{241}Am (pCi/g Ash) (pCi/kg ⁺)		^{238}U (pCi/g Ash) (pCi/kg ⁺)	$^{89}\text{Sr}/^{90}\text{Sr}$ (pCi/g Ash) (pCi/kg ⁺)	Ash (%)	^3H (pCi/l)	K (g/kg ⁺)	^{137}Cs (pCi/kg ⁺)
Rumen vegetation ¹	2.9 ± 0.3 67.0 ± 7.0		130 ± 7.6 2,900 ± 170		20.0 ± 0.8 450 ± 18.0		0.62 14.0	NA	2.3	NA	NA	NA
Rumen fluid ¹	0.97 ± 0.14 12.0 ± 1.6		460 ± 2.3 500 ± 28.0		7.4 ± 0.3 90.0 ± 3.6		0.13 1.5	NA	1.2	NA	NA	NA
Reticulum sediment	← SAMPLE NOT COLLECTED →											
Liver ¹	0.042 ± 0.01 0.42 ± 0.13		0.18 ± 0.02 1.8 ± 0.2		0.21 ± 0.01 2.2 ± 0.2		1.8 20.0	NA	1.0	NA	NA	NA
Lung ¹	0.030 ± 0.01 0.3 ± 0.1		1.2 ± 0.05 14.0 ± 0.6		0.12 ± 0.03 1.3 ± 0.3		1.5 15.0	NA	1.0	NA	NA	NA
Tracheobronchial lymph nodes ¹	0.35 ± 0.32 370 ± 335		11.0 ± 0.76 1,100 ± 803		0.56 ± 0.16 59.0 ± 17.0		13.0 1,400	NA	10.5	NA	NA	NA
Muscle	0.021 ± 0.003 0.52 ± 0.07		0.071 ± 0.005 1.7 ± 0.1		0.02 ± 0.004 0.4 ± 0.1		0.04 1.10	NA	2.4	NA	NA	NA
Gonads	← SAMPLE NOT COLLECTED →											
Blood cells ^{1†}	0.20 ± 0.1		1.1 ± 0.28		0.2 ± 0.85		27.0	NA	NA	NA	NA	NA
Blood serum ^{1†}	0.15 ± 0.074		0.83 ± 0.15		<MDA		8.7	NA	NA	NA	NA	NA
Femur ¹	0.0079 ± 0.001 1.3 ± 0.2		0.0050 ± 0.001 0.80 ± 0.2		0.002 ± 0.0005 0.3 ± 0.1		<MDA	NA	16.5	NA	NA	NA
Vertebrae	← SAMPLE NOT COLLECTED →											
Skin and hair ¹	3.5 ± 0.4 29.0 ± 3.4		120 ± 8.4 1,000 ± 70.0		17.0 ± 2.8 150 ± 23.0		1.6 14.0	NA	0.9	NA	NA	NA
Kidney ¹	0.060 ± 0.03 0.66 ± 0.3		0.17 ± 0.05 1.9 ± 0.5		<MDA		6.0 74.0	NA	1.1	NA	NA	NA

APPENDIX VIII. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM ANIMALS GRAZING THE INNER COMPOUND, AREA 13, NTS (Continued)

Goat Number 2 Data collected 10/25/73

Tissue Type	²³⁸ Pu (pCi/g Ash) (pCi/kg ⁺)	²³⁹ Pu (pCi/g Ash) (pCi/kg ⁺)	²⁴¹ Am (pCi/g Ash) (pCi/kg ⁺)	²³⁸ U (pCi/g Ash) (pCi/kg ⁺)	⁸⁹ Sr (pCi/g Ash) (pCi/kg ⁺)	⁹⁰ Sr (pCi/g Ash) (pCi/kg ⁺)	Ash (%)	³ H (pCi/l)	K (g/kg)	¹³⁷ Cs (pCi/kg ⁺)
Rumen vegetation ¹	3.4 ± 0.58 57.0 ± 9.7	150 ± 15.0 2,500 ± 250	20.0 ± 0.8 240 ± 130	0.64 8.1	NA	NA	1.7	NA	NA	NA
Rumen fluid	SAMPLE NOT COLLECTED									
Reticulum sediment	SAMPLE NOT COLLECTED									
Liver	SAMPLE LOST IN ANALYSIS							NA	3.2	<MDA
Lung ¹	0.091 ± 0.02 1.0 ± 0.3	0.63 ± 0.05 6.9 ± 0.56	0.13 ± 0.015 1.4 ± 0.16	1.5 1.7	NA	NA	1.1	NA	2.2	<MDA
Tracheobronchial lymph nodes ²	<0.7 <38.0	<1.0 <58.0	NA	<0.16 <8.8	NA	NA	5.6	NA	NA	NA
Muscle ¹	0.032 ± 0.005 0.38 ± 0.06	1.1 ± 0.03 14.0 ± 0.4	0.15 ± 0.01 1.8 ± 0.1	<MDA	NA	NA	1.2	NA	1.2	30
Gonads	SAMPLE NOT COLLECTED									
Blood cells ²	0.35 ± 0.03 2.8 ± 0.4	0.063 ± 0.01 0.50 ± 0.2	NA	0.016 ± 0.006 0.13 ± 0.09	NA	NA	0.8	NA	NA	NA
Blood serum ²	<0.02 <0.24	0.042 ± 0.01 0.40 ± 0.2	NA	<0.0042 <0.040	NA	NA	0.96	300 ± 240	NA	NA
Femur ²	0.33 ± 0.032 100 ± 9.5	0.006 ± 0.006 1.8 ± 1.8	NA	0.0012 ± 0.0011 0.35 ± 0.33	<1.1 <320	2.1 ± 0.9 640 ± 270	30.0	NA	NA	NA
Vertebrae ²	0.0052 ± 0.0046 0.62 ± 0.55	0.042 ± 0.01 5.0 ± 1.2	NA	<0.0025 <0.3	<1.4 <170	1.8 ± 1.2 220 ± 140	10.0	NA	NA	NA
Skin ²	3.7 ± 0.2 45.0 ± 2.1	150 ± 6.5 1,900 ± 65.0	NA	0.54 ± 0.07 6.5 ± 0.5	NA	NA	1.2	NA	NA	NA

APPENDIX IX. RADIONUCLIDE CONCENTRATIONS IN TISSUES COLLECTED FROM CATTLE
GRAZING THE OUTER COMPOUND, AREA 13, NTS

Notes:

* All strontium, tritium, and gamma spectral analyses by EMSL-LV.

† Wet weight

† Activity expressed in pCi/l

¹ Actinide analyses by LFE

² Actinide analyses by EMSL-LV

³ Actinide analyses by Eberline

NA = Not analyzed

<MDA = values below the detectable limit when the minimum detectable activity was not reported.

APPENDIX IX. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM CATTLE GRAZING THE OUTER COMPOUND,
AREA 13, NTS

Cow Number 3 Data collected 10/25/73

Tissue Type	²³⁸ Pu (pCi/g Ash) (pCi/kg†)	²³⁹ Pu (pCi/g Ash) (pCi/kg†)	²⁴¹ Am (pCi/g Ash) (pCi/kg†)	²³⁸ U (pCi/g Ash) (pCi/kg†)	⁸⁹ Sr (pCi/g Ash) (pCi/kg†)	⁹⁰ Sr (pCi/g Ash) (pCi/kg†)	Ash (%)	H (pCi/l)	K (g/kg†)	¹³⁷ Cs (pCi/kg†)
Rumen vegetation ¹	6.2 ± 0.8 16.0 ± 1.6	250 ± 20.0 3,100 ± 250	34.0 ± 1.0 430 ± 13.0	1.9 25.0	NA	NA	1.3	NA	NA	NA
Rumen fluid ¹	0.56 ± 0.056 78.0 ± 10.0	21.0 ± 0.6 610 ± 18.0	3.1 ± 0.09 86.0 ± 2.5	0.83 25.0	NA	NA	2.9	NA	NA	NA
Reticulum sediment ²	0.30 ± 0.08 78.0 ± 19.0	0.8 ± 0.1 220 ± 36.0	NA	3.2 ± 0.16 830 ± 41.0	NA	NA	26.0	NA	NA	NA
Liver ¹	0.0094 ± 0.00078 0.15 ± 0.13	0.38 ± 0.027 6.1 ± 0.4	0.16 ± 0.022 2.5 ± 0.36	0.65 10.0	NA	NA	1.6	NA	1.4	<MDA
Lung ²	0.027 ± 0.004 0.30 ± 0.05	0.78 ± 0.035 8.6 ± 0.38	NA	0.055 ± 0.007 0.60 ± 0.08	NA	NA	1.1	NA	0.9	40.0
Tracheobronchial lymph nodes ²	<0.23 <3.0	<0.45 <5.8	NA	0.17 ± 0.11 2.2 ± 1.4	NA	NA	1.3	NA	NA	NA
Muscle ²	0.0065 ± 0.007 0.13 ± 0.13	<0.004 <0.08	NA	0.0027 ± 0.0026 0.055 ± 0.052	NA	NA	2.0	NA	1.4	20.0
Gonads	SAMPLE NOT COLLECTED									
Blood cells ²	<0.018 <0.16	0.055 ± 0.023 0.48 ± 0.2	NA	0.0095 ± 0.008 0.084 ± 0.072	NA	NA	0.88	NA	NA	NA
Blood serum ²	<0.017 <0.25	0.030 ± 0.013 0.45 ± 0.19	NA	0.0041 ± 0.002 0.062 ± 0.03	NA	NA	1.5	410 ± 240	NA	NA
Femur ²	<0.006 <1.7	<0.007 <2.0	NA	<0.002 <0.54	<1.1 <310	3.9 ± 1.0 1,100 ± 280	28.0	NA	NA	NA
Vertebrae ²	<0.004 <0.88	<0.006 <1.3	NA	0.0029 ± 0.02 0.64 ± 0.47	NA	NA	22.0	NA	NA	NA
Skin and hair ²	4.5 ± 0.22 2,000 ± 9.5	200 ± 7.5 8,800 ± 340	NA	0.84 ± 0.048 37.0 ± 2.1	NA	NA	4.4	NA	NA	NA
Kidneys ²	NA	NA	NA	NA	NA	NA	NA	NA	2.7	<MDA
Thyroid ²	NA	NA	NA	NA	NA	NA	GAMMA	SPECTRUM	NELIGIBLE	

APPENDIX IX. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM CATTLE GRAZING THE OUTER COMPOUND,
AREA 13, NTS (Continued)

Fetus of Cow Number 3 Data collected 10/25/73

Tissue Type	²³⁸ Pu (pCi/g Ash) (pCi/kg†)	²³⁹ Pu (pCi/g Ash) (pCi/kg†)	²⁴¹ Am (pCi/g Ash) (pCi/kg†)	²³⁸ U (pCi/g Ash) (pCi/kg†)	⁸⁹ Sr (pCi/g Ash) (pCi/kg†)	⁹⁰ Sr (pCi/g Ash) (pCi/kg†)	Ash (%)	³ H (pCi/l)	K (g/kg†)	¹³⁷ (pCi/kg†)
Rumen vegetation	SAMPLE NOT COLLECTED									
Rumen fluid	SAMPLE NOT COLLECTED									
Reticulum sediment	SAMPLE NOT COLLECTED									
Liver	SAMPLE LOST IN ANALYSIS									
Lung	SAMPLE LOST IN ANALYSIS									
Tracheobronchial lymph nodes	SAMPLE NOT COLLECTED									
Muscle ²	0.032 ± 0.020 0.30 ± 0.19	0.10 ± 0.33 0.96 ± 0.31	NA	0.0096 ± 0.009 0.090 ± 0.085	NA	NA	0.94	NA	NA	NA
Gonads	SAMPLE NOT COLLECTED									
Blood cells	SAMPLE NOT COLLECTED									
Blood serum	SAMPLE NOT COLLECTED									
Femur ¹	<MDA	0.002 ± 0.001 0.32 ± 0.20	<MDA	0.082 11.2	NA	NA	13.7	NA	NA	NA
Vertebrae	SAMPLE NOT COLLECTED									
Placenta ¹	0.019 ± 0.008 0.19 ± 0.08	0.070 ± 0.011 0.70 ± 0.11	0.025 ± 0.005 0.25 ± 0.005	0.32 3.2	NA	NA	1.0	NA	NA	NA

APPENDIX IX. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM CATTLE GRAZING THE OUTER COMPOUND,
AREA 13, NTS (Continued)

Cow Number 8 Data collected 10/25/73

Tissue Type	²³⁸ Pu (pCi/g Ash) (pCi/kg ⁺)	²³⁹ Pu (pCi/g Ash) (pCi/kg ⁺)	²⁴¹ Am (pCi/g Ash) (pCi/kg ⁺)	²³⁸ U (pCi/g Ash) (pCi/kg ⁺)	⁸⁹ Sr (pCi/g Ash) (pCi/kg ⁺)	⁹⁰ Sr (pCi/g Ash) (pCi/kg ⁺)	Ash (%)	³ H (pCi/l)	K (g/kg ⁺)	¹³⁷ Cs (pCi/kg ⁺)
Rumen vegetation ¹	SAMPLE LOST IN ANALYSIS									
Rumen fluid ¹	4.4 ± 0.3 52.0 ± 3.7	190 ± 5.7 2,300 ± 68.0	28.0 ± 1.1 330 ± 13.0	<MDA	NA	NA	1.2	NA	NA	NA
Reticulum sediment ²	<0.073 <16.0	<0.09 <21.0	NA	7.3 ± 0.5 1,600 ± 110	NA	NA	22.0	NA	NA	NA
Liver ¹	0.016 ± 0.005 0.18 ± 0.053	0.15 ± 0.014 1.7 ± 0.16	0.034 ± 0.009 0.41 ± 0.1	<MDA	NA	NA	1.2	NA	1.1	<MDA
Lung ¹	0.090 ± 0.08 1.2 ± 1.0	3.3 ± 0.3 44.0 ± 3.9	0.57 ± 0.003 7.3 ± 0.04	0.56 7.3	NA	NA	1.3	NA	1.1	<MDA
Tracheobronchial lymph nodes ²	<0.23 <6.3	<0.23 <6.2	NA	0.23 ± 0.14 6.3 ± 3.7	NA	NA	2.7	NA	NA	NA
Muscle ¹	0.0074 ± 0.006 0.072 ± 0.06	0.037 ± 0.009 0.36 ± 0.09	0.013 ± 0.009 0.13 ± 0.09	0.017 ± 0.004 0.9 ± 0.22	NA	NA	0.97	NA	1.2	20.0
Gonads	SAMPLE NOT COLLECTED									
Blood cells ²	<0.009 <0.07	0.027 ± 0.007 0.21 ± 0.11	NA	0.035 ± 0.01 0.28 ± 0.085	NA	NA	0.79	NA	NA	NA
Blood serum ²	0.026 ± 0.008 0.24 ± 0.14	0.028 ± 0.009 0.26 ± 0.17	NA	<0.004 <0.04	NA	NA	0.92	NA	NA	NA
Femur ¹	0.0043 ± 0.00098 1.1 ± 0.25	0.0014 ± 0.00084 0.35 ± 0.21	0.00041 ± 0.00024 0.10 ± 0.06	0.072 18.0	<0.8 <200	3.4 ± 0.76 860 ± 190	25.0	NA	NA	NA
Vertebrae ¹	0.0015 ± 0.00061 0.33 ± 0.13	0.0063 ± 0.00082 1.4 ± 0.18	0.0033 ± 0.00082 0.73 ± 0.18	0.043 9.5	1.1 ± 0.6 250 ± 120	1.2 ± 0.5 270 ± 110	22.0	NA	NA	NA
Skin ²	9.3 ± 2.4 790 ± 200	360 ± 93.0 31,000 ± 7,200	NA	0.89 ± 0.09 76.0 ± 8.0	NA	NA	8.5	NA	NA	NA
Skin and hair ²	7.1 ± 1.9 320 ± 84	290 ± 67.0 13,000 ± 3,000	NA	1.0 ± 0.1 45.0 ± 4.4	NA	NA	4.5	NA	NA	NA
Kidney ²	NA	NA	NA	NA	NA	NA	NA	NA	2.3	<MDA

APPENDIX IX. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM CATTLE GRAZING THE OUTER COMPOUND,
AREA 13, NTS (Continued)

Calf Number 12 Data collected 10/25/73

	²³⁸ Pu (pCi/g Ash) (pCi/kg+)	²³⁹ Pu (pCi/g Ash) (pCi/kg+)	²⁴¹ Am (pCi/g Ash) (pCi/kg+)	²³⁸ U (pCi/g Ash) (pCi/kg+)	⁸⁹ Sr (pCi/g Ash) (pCi/kg+)	⁹⁰ Sr (pCi/g Ash) (pCi/kg+)	Ash (%)	³ H (pCi/l)	K (g/kg+)	¹³⁷ Cs (pCi/kg+)
Rumen vegetation ¹	1.6 ± 0.2 31.0 ± 4.0	54.0 ± 4.3 1,000 ± 83.0	9.6 ± 0.29 190 ± 5.6	0.29 5.5	NA	NA	1.9	NA	NA	NA
Rumen fluid ²	0.19 ± 0.037 1.6 ± 0.3	6.8 ± 0.2 56.0 ± 1.7	0.94 ± 0.2 8.3 ± 1.0	3.0 24.0	NA	NA	0.8	NA	NA	NA
Reticulum sediment ²	<0.05 <0.25	0.7 ± 0.05 360 ± 26.0	NA	1.0 ± 0.13 510 ± 64.0	NA	NA	50.0	NA	NA	NA
Liver ¹	0.011 ± 0.007 0.14 ± 0.09	0.29 ± 0.033 3.8 ± 0.42	0.059 ± 0.011 0.77 ± 0.15	0.21 2.7	NA	NA	1.3	NA	1.4	<MDA
Lung ¹	SAMPLE LOST IN ANALYSIS									
Tracheobronchial lymph nodes ²	<0.5 <7.5	<0.8 <12.0	NA	<0.15 <2.3	NA	NA	1.5	NA	NA	NA
Muscle ¹	0.0039 ± 0.003 0.043 ± 0.031	0.028 ± 0.005 0.32 ± 0.057	0.014 ± 0.004 0.15 ± 0.044	0.17 1.9	NA	NA	1.1	NA	1.0	20.0
Gonads	SAMPLE NOT COLLECTED									
Blood cells ²	<0.08 <0.7	0.10 ± 0.043 0.92 ± 0.38	NA	<0.031 <0.27	NA	NA	0.88	NA	NA	NA
Blood serum ²	<0.03 <0.8	<0.04 <1.0	NA	<0.01 <0.26	NA	NA	2.6	NA	NA	NA
Femur ¹	0.098 ± 0.0049 340 ± 1.7	0.63 ± 0.019 220 ± 6.7	0.087 ± 0.0026 30.0 ± 0.91	<0.034 <12.0	<0.9 <310	2.3 ± 0.8 790 ± 280	35.0	NA	NA	NA
Vertebrae ¹	0.39 ± 0.012 55.0 ± 1.7	16.0 ± 0.33 2,300 ± 46.0	2.2 ± 0.066 308 ± 9.2	<0.034 <4.1	<1.2 <110	<1.0 <850	14.0	NA	NA	NA
Skin ²	2.7 ± 0.14 35.0 ± 1.9	120 ± 4.6 1,500 ± 60.0	NA	0.35 ± 0.038 4.5 ± 0.5	NA	NA	1.4	NA	NA	NA
Skin and hair ²	1.9 ± 0.96 26.0 ± 1.4	66.0 ± 2.4 930 ± 34.0	NA	0.79 11.0	0.06 0.75	NA	1.4	NA	NA	NA
Kidney ²	NA	NA	NA	NA	NA	NA	NA	NA	2.0	<MDA
Thyroid ²	NA	NA	NA	NA	NA	NA	NA	GAMMA SPECTRUM NEGLIGIBLE		

APPENDIX IX. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM CATTLE GRAZING THE OUTER COMPOUND,
AREA 13, NTS (Continued)

Cow Number 1 Data collected 07/09/74

Tissue Type	²³⁸ Pu (pCi/g Ash) (pCi/kg ⁺)	²³⁹ Pu (pCi/g Ash) (pCi/kg ⁺)	²⁴¹ Am (pCi/g Ash) (pCi/kg ⁺)	²³⁸ U (pCi/g Ash) (pCi/kg ⁺)	⁸⁹ Sr (pCi/g Ash) (pCi/kg ⁺)	⁹⁰ Sr (pCi/g Ash) (pCi/kg ⁺)	Ash (%)	³ H (pCi/l)	K (g/kg ⁺)	¹³⁷ Cs (pCi/kg ⁺)
Rumen vegetation ¹	3.7 ± 0.4 83.0 ± 9.2	170 ± 8.5 3,800 ± 0.91	26.0 ± 1.3 590 ± 30.0	0.38 8.6	NA	NA	2.3	NA	NA	NA
Rumen fluid ¹	1.6 ± 0.13 19.0 ± 1.5	74.0 ± 2.9 870 ± 35.0	9.8 ± 0.59 120 ± 6.9	0.21 2.5	NA	NA	1.2	NA	NA	NA
Reticulum sediment ²	0.12 ± 0.04 69.0 ± 23.0	0.28 ± 0.05 160 ± 30.0	0.13 ± 0.04 71.0 ± 24.0	0.59 330	NA	NA	56.3	NA	NA	NA
Liver ¹	0.031 ± 0.015 0.43 ± 0.2	1.1 ± 0.065 15.0 ± 0.88	0.19 ± 0.036 2.5 ± 0.48	0.039 0.54	NA	NA	1.4	NA	1.4 ± 0.1	26.0 ± 4.0
Lung ¹	0.048 ± 0.004 2.1 ± 0.17	1.6 ± 0.05 74.0 ± 2.1	0.24 ± 0.02 11.0 ± 1.1	0.12 5.2	NA	NA	4.4	NA	0.9 ± 0.12	25.0 ± 4.0
Tracheobronchial lymph nodes ¹	0.74 ± 0.3 7.6 ± 3.2	7.4 ± 0.74 79.0 ± 7.9	<MDA	33.0 350	NA	NA	1.1	NA	NA	NA
Muscle ¹	<MDA	0.0010 ± 0.0003 0.050 ± 0.02	0.00040 ± 0.0003 0.020 ± 0.01	0.027 1.4	NA	NA	5.2	NA	1.2 ± 0.1	<MDA
Gonads ¹	<MDA	0.029 ± 0.02 1.8 ± 1.3	<MDA	0.58 36.0	NA	NA	6.2	NA	NA	NA
Blood cells ^{1†}	<MDA	0.61 ± 0.2	<MDA	9.1	NA	NA	NA	NA	NA	NA
Blood serum ^{1†}	<MDA	1.3 ± 0.09	<MDA	12.0	NA	NA	NA	280 ± 220	NA	NA
Femur ¹	0.00053 ± 0.0004 0.13 ± 0.11	0.0057 ± 0.001 1.4 ± 0.25	0.0020 ± 0.001 0.40 ± 0.14	0.023 5.7	NA	NA	24.5	NA	NA	NA
Vertebrae ¹	<MDA	0.035 ± 0.003 6.0 ± 0.5	0.0043 ± 0.003 0.72 ± 0.45	0.020 3.3	NA	NA	16.9	NA	NA	NA
Skin and hair ¹	0.21 ± 0.03 1.7 ± 0.24	9.8 ± 0.49 78.0 ± 3.9	1.6 ± 0.13 13.0 ± 1.0	0.25 2.0	NA	NA	0.8	NA	NA	NA
Fetus ¹	3.1 ± 0.6 6.2 ± 1.2	0.30 ± 0.2 0.60 ± 0.5	0.80 ± 0.5 1.6 ± 1.0	17.0 32.0	NA	NA	0.2	NA	NA	NA
Kidney ²	<MDA	0.012 ± 0.003 0.56 ± 0.15	0.015 ± 0.006 0.67 ± 0.27	0.18 7.9	NA	NA	4.5	NA	NA	NA
Thyroid ²	NA	NA	NA	NA	NA	NA	NA	GAMMA SPECTRUM NELIGIBLE		

APPENDIX IX. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM CATTLE GRAZING THE OUTER COMPOUND,
AREA 13, NTS (Continued)

Cow Number 4 Data collected 07/09/74

Tissue Type	²³⁸ Pu (pCi/g Ash) (pCi/kg ⁺)	²³⁹ Pu (pCi/g Ash) (pCi/kg ⁺)	²⁴¹ Am (pCi/g Ash) (pCi/kg ⁺)	²³⁸ U (pCi/g Ash) (pCi/kg ⁺)	⁸⁹ Sr (pCi/g Ash) (pCi/kg ⁺)	⁹⁰ Sr (pCi/g Ash) (pCi/kg ⁺)	Ash (%)	³ H (pCi/l)	K (g/kg ⁺)	¹³⁷ Cs (pCi/kg ⁺)
Rumen vegetation ¹	3.4 ± 0.57 52.0 ± 8.9	140 ± 9.8 2,200 ± 140	21.0 ± 1.2 380 ± 19.0	0.53 8.3	NA	NA	1.6	NA	NA	NA
Rumen fluid ¹	1.6 ± 0.11 16.0 ± 1.1	73.0 ± 2.9 760 ± 30.0	12.0 ± 0.82 120 ± 8.5	0.22 2.2	NA	NA	1.0	NA	NA	NA
Reticulum sediment ¹	<MDA	0.29 ± 0.11 200 ± 73.0	0.07 ± 0.03 47.0 ± 19.0	0.95 640	NA	NA	67.5	NA	NA	NA
Liver ¹	0.01 ± 0.003 0.6 ± 0.18	0.26 ± 0.016 16.0 ± 0.95	0.079 ± 0.007 4.8 ± 0.43	0.0050 0.30	NA	NA	6.1	NA	2.4 ± 0.1	<MDA
Lung ¹	0.036 ± 0.005 1.5 ± 0.19	1.3 ± 0.063 51.0 ± 2.6	0.18 ± 0.013 7.5 ± 0.53	0.044 1.8	NA	NA	4.1	NA	0.7 ± 0.2	<MDA
Tracheobronchial lymph nodes ¹	<MDA	1.2 ± 0.19 14.0 ± 2.2	0.68 ± 0.36 8.1 ± 4.3	59.0 710	NA	NA	1.2	NA	NA	NA
Muscle ¹	0.0011 ± 0.006 0.036 ± 0.017	0.0063 ± 0.001 0.20 ± 0.03	0.0017 ± 0.001 0.062 ± 0.036	0.0094 0.30	NA	NA	3.2	NA	1.6 ± 0.1	49.0 ± 5.0
Gonads ¹	<MDA	0.031 ± 0.016 6.9 ± 3.7	0.013 ± 0.012 2.9 ± 2.6	0.35 1.7	NA	NA	22.0	NA	NA	NA
Blood cells ^{1†}	2.1 ± 0.55	0.43 ± 0.26	<MDA	11.0	NA	NA	NA	NA	NA	NA
Blood serum ^{1†}	0.73 ± 0.15	0.35 ± 0.12	0.20 ± 0.14	4.4	NA	NA	NA	300 ± 220	NA	NA
Femur ¹	<MDA	0.011 ± 0.002 3.0 ± 0.6	0.0057 ± 0.002 1.6 ± 0.45	0.016 4.3	NA	NA	27.9	NA	NA	NA
Vertebrae ¹	0.0020 ± 0.0006 0.30 ± 0.1	0.030 ± 0.002 5.8 ± 0.46	0.15 ± 0.026 30.0 ± 5.0	0.020 3.9	NA	NA	19.5	NA	NA	NA
Skin ¹	0.30 ± 0.02 9.2 ± 0.65	13.0 ± 0.5 380 ± 15.0	1.5 ± 0.05 47.0 ± 1.4	0.27 8.3	NA	NA	3.1	NA	NA	NA
Kidney ¹	<MDA	0.016 ± 0.003 2.1 ± 0.39	0.0040 ± 0.003 0.50 ± 0.31	0.11 13.0	NA	NA	12.3	NA	1.0 ± 0.4	<MDA
Thyroid ²	NA	NA	NA	NA	NA	NA	NA	NA	GAMMA SPECTRUM NEGLIGIBLE	

APPENDIX IX. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM CATTLE GRAZING THE OUTER COMPOUND,
AREA 13, NTS (Continued)

Cow Number 6 Data collected 07/09/74

Tissue Type	²³⁸ Pu (pCi/g Ash) (pCi/kg†)	²³⁹ Pu (pCi/g Ash) (pCi/kg†)	²⁴¹ Am (pCi/g Ash) (pCi/kg†)	²³⁸ U (pCi/g Ash) (pCi/kg†)	⁸⁹ Sr (pCi/g Ash) (pCi/kg†)	⁹⁰ Sr (pCi/g Ash) (pCi/kg†)	Ash (%)	³ H (pCi/l)	K (g/kg†)	¹³⁷ Cs (pCi/kg†)
Rumen vegetation ¹	2.9 ± 0.26 46.0 ± 4.1	110 ± 3.2 1,700 ± 50.0	150 ± 0.6 240 ± 9.6	0.85 13.0	NA	NA	1.6	NA	NA	NA
Rumen fluid ¹	2.8 ± 0.3 12.0 ± 1.4	130 ± 6.3 560 ± 28.0	28.0 ± 1.1 130 ± 5.0	1.4 6.1	NA	NA	71.5	NA	NA	NA
Reticulum sediment ¹	<MDA	0.2 ± 0.03 160 ± 19.0	0.042 ± 0.012 30.0 ± 8.7	2.3 1,600	NA	NA	5.1	NA	1.7 ± 0.13	<MDA
Liver ¹	0.0060 ± 0.004 0.30 ± 0.19	0.22 ± 0.017 11.0 ± 0.87	0.016 ± 0.004 0.79 ± 0.22	0.030 1.53	NA	NA	5.1	NA	1.7 ± 0.13	<MDA
Lung ¹	0.028 ± 0.003 0.59 ± 0.059	0.85 ± 0.026 18.0 ± 0.55	0.12 ± 0.007 2.5 ± 0.15	0.081 1.7	NA	NA	2.1	NA	NA	NA
Tracheobronchial lymph nodes ¹	<MDA	4.4 ± 0.35 41.0 ± 3.3	0.89 ± 0.2 8.2 ± 1.8	5.5 51.0	NA	NA	0.9	NA	NA	NA
Muscle ¹	<MDA		0.00075 ± 0.0005 0.043 ± 0.031	0.021 1.2	NA	NA	5.7	NA	2.6 ± 0.17	<MDA
Gonads ¹	0.054 ± 0.033 3.1 ± 1.9	<0.02 <1.3	<MDA	0.64 36.0	NA	NA	5.7	NA	NA	NA
Blood cells ^{1†}	0.097 ± 0.072	0.12 ± 0.072	<MDA	8.3	NA	NA	NA	NA	NA	NA
Blood serum ^{1†}	<MDA	0.6 ± 0.16	0.28 ± 0.16	8.6	NA	NA	NA	<220	NA	NA
Femur ¹	0.0014 ± 0.0009 0.18 ± 0.11	0.0047 ± 0.001 0.59 ± 0.17	0.0022 ± 0.0009 0.28 ± 0.11	0.019 2.6	NA	NA	12.6	NA	NA	NA
Vertebrae ¹	0.0010 ± 0.002 0.20 ± 0.05	0.023 ± 0.001 4.7 ± 0.23	0.010 ± 0.002 2.1 ± 4.7	0.012 2.5	NA	NA	20.6	NA	NA	NA
Skin ¹	0.36 ± 0.039 2.8 ± 0.31	14.0 ± 0.7 110 ± 5.5	2.3 ± 0.23 18.0 ± 1.8	0.18 1.4	NA	NA	0.8	NA	NA	NA
Kidney ¹	<MDA	0.016 ± 0.01 0.33 ± 0.2	0.022 ± 0.014 0.26 ± 0.29	0.27 5.6	NA	NA	2.1	NA	1.3 ± 0.24	<MDA
Fetus ¹	<MDA	0.054 ± 0.047 0.43 ± 0.38	0.037 ± 0.02 0.29 ± 0.16	170 13.0	NA	NA	0.8	NA	NA	NA
Thyroid ²	NA	NA	NA	NA	NA	NA	NA	NA	<MDA	<MDA

APPENDIX IX. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM CATTLE GRAZING THE OUTER COMPOUND,
AREA 13, NTS (Continued)

Bull Number 13 Data collected 01/29/75

Tissue Type	²³⁹ Pu (pCi/g Ash) (pCi/kg ⁺)	²³⁹ Pu (pCi/g Ash) (pCi/kg ⁺)	²⁴¹ Am (pCi/g Ash) (pCi/kg ⁺)	²³⁸ U (pCi/g Ash) (pCi/kg ⁺)	⁸⁹ Sr (pCi/g Ash) (pCi/kg ⁺)	⁹⁰ Sr (pCi/g Ash) (pCi/kg ⁺)	Ash (%)	³ H (pCi/l)	K (g/kg ⁺)	¹³⁷ Cs (pCi/kg ⁺)
Rumen vegetation ¹	1.2 ± 0.035 23.0 ± 0.68	52.0 ± 1.0 1,000 ± 20.0	7.3 ± 0.22 140 ± 4.2	0.05 1.0	NA	NA	1.9	NA	NA	NA
Rumen fluid ¹	0.82 ± 0.41 8.4 ± 0.42	0.034 ± 0.001 0.34 ± 0.001	4.3 ± 0.086 43.0 ± 0.85	0.34 3.4	NA	NA	1.0	NA	NA	NA
Reticulum sediment ¹	0.067 ± 0.023 28.0 ± 9.7	0.72 ± 0.064 300 ± 27.0	0.25 ± 0.084 110 ± 38.0	2.1 850	NA	NA	41.5	NA	NA	NA
Liver ¹	0.010 ± 0.002 0.35 ± 0.067	0.37 ± 0.015 13.0 ± 0.41	0.044 ± 0.015 1.5 ± 0.5	0.12 4.1	NA	NA	3.4	NA	3.3 ± 0.2	26.0 ± 49.0
Lung ¹	0.013 ± 0.002 0.52 ± 0.068	0.44 ± 0.013 17.0 ± 0.51	0.073 ± 0.004 2.9 ± 0.17	0.049 1.9	NA	NA	3.9	NA	NA	NA
Tracheobronchial lymph nodes ¹	0.063 ± 0.023 6.4 ± 2.3	2.5 ± 0.1 260 ± 10.0	0.18 ± 0.051 18.0 ± 4.2	3.0 306	NA	NA	10.2	NA	NA	NA
Muscle ¹	<MDA	0.017 ± 0.003 0.22 ± 0.04	0.011 ± 0.005 0.15 ± 0.073	0.12 1.6	NA	NA	1.3	NA	3.3 ± 0.1	50.0 ± 4.8
Gonads ¹	0.018 ± 0.011 0.16 ± 0.1	0.28 ± 0.031 2.5 ± 0.28	0.24 ± 0.042 2.1 ± 0.38	1.4 12.0	NA	NA	0.9	NA	NA	NA
Blood cells ⁺	<MDA	0.29 ± 0.21	<MDA	8.2	NA	NA	NA	NA	NA	NA
Blood serum ¹	<MDA	0.9 ± 0.2	0.2 ± 0.1	42.0	NA	NA	NA	360 ± 220	NA	NA
Femur ¹	<MDA	0.033 ± 0.003 8.3 ± 0.66	0.0027 ± 0.002 0.69 ± 0.52	0.0083 2.1	NA	NA	25.4	NA	NA	NA
Vertebrae ¹	0.0016 ± 0.001 0.27 ± 0.11	0.071 ± 0.004 12.0 ± 0.74	0.0086 ± 0.01 1.5 ± 0.18	0.043 7.4	NA	NA	17.4	NA	NA	NA
Skin ¹	0.51 ± 0.025 45.0 ± 2.2	22.0 ± 0.9 2,000 ± 79.0	15.0 ± 0.44 1,300 ± 39.0	0.16 14.0	NA	NA	8.9	NA	NA	NA
Kidney ¹	<MDA	0.0076 ± 0.003 0.28 ± 0.11	0.012 ± 0.006 0.44 ± 0.23	0.24 8.9	NA	NA	3.7	NA	NA	NA

APPENDIX IX. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM CATTLE GRAZING THE OUTER COMPOUND,
AREA 13, NTS (Continued)

Bull Number 15 Data collected 01/29/75

Tissue Type	²³⁸ Pu (pCi/g Ash) (pCi/kg ⁺)	²³⁹ Pu (pCi/g Ash) (pCi/kg ⁺)	²⁴¹ Am (pCi/g Ash) (pCi/kg ⁺)	²³⁸ U (pCi/g Ash) (pCi/kg ⁺)	⁸⁹ Sr (pCi/g Ash) (pCi/kg ⁺)	⁹⁰ Sr (pCi/g Ash) (pCi/kg ⁺)	Ash (%)	³ H (pCi/l)	K (g/kg ⁺)	¹³⁷ Cs (pCi/kg ⁺)
Rumen vegetation ¹	0.14 ± 0.002 18.0 ± 1.9	4.1 ± 0.15 650 ± 20.0	0.84 ± 0.04 110 ± 5.4	0.0075 0.96	NA	NA	12.8	NA	GAMMA SPECTRUM NEGLIGIBLE	
Rumen fluid ¹	0.17 ± 0.014 0.95 ± 0.076	6.8 ± 0.2 37.0 ± 1.1	4.9 ± 0.098 27.0 ± 0.54	0.73 4.0	NA	NA	0.6	NA	NA	NA
Reticulum sediment ¹	SAMPLE NOT COLLECTED									
Liver ¹	0.0085 ± 0.004 0.29 ± 0.12	0.21 ± 0.017 7.3 ± 0.58	0.022 ± 0.003 0.76 ± 0.11	0.056 1.9	NA	NA	3.4	NA	3.6 ± 0.14	NA
Lung ¹	0.036 ± 0.01 0.55 ± 0.16	1.0 ± 0.07 15.0 ± 11.0	0.17 ± 0.009 2.6 ± 0.13	0.31 4.7	NA	NA	1.5	NA	2.7 ± 0.3	29.0 ± 5.0
Tracheobronchial lymph nodes ¹	0.12 ± 0.031 12.0 ± 3.2	2.5 ± 0.15 250 ± 15.0	0.48 ± 0.087 49.0 ± 8.7	2.4 240	NA	NA	10.0	NA	NA	NA
Muscle ¹	<MDA	0.0033 ± 0.0007 0.18 ± 0.04	0.0018 ± 0.0009 0.10 ± 0.05	0.022 1.2	NA	NA	5.5	NA	GAMMA SPECTRUM NEGLIGIBLE	
Gonads ¹	1.4 ± 0.6 22.0 ± 9.1	2.9 ± 0.2 45.0 ± 3.2	0.52 ± 0.07 8.3 ± 1.1	0.97 15.0	NA	NA	1.6	NA	NA	NA
Blood cells ^{1†}	0.06 ± 0.03	0.38 ± 0.05	<MDA	3.2	NA	NA	NA	NA	NA	NA
Blood serum ^{1†}	<MDA	0.2 ± 0.08	0.090 ± 0.03	8.9	NA	NA	NA	440 ± 200	NA	NA
Femur ¹	<MDA	0.012 ± 0.001 2.9 ± 0.35	0.006 ± 0.001 1.6 ± 0.75	0.014 3.5	NA	NA	25.3	NA	NA	NA
Vertebrae ¹	0.0014 ± 0.001 0.29 ± 0.26	0.049 ± 0.005 10.0 ± 1.1	0.0083 ± 0.002 1.7 ± 0.34	0.036 7.3	NA	NA	20.5	NA	NA	NA
Skin ¹	0.57 ± 0.029 49.0 ± 2.4	26.0 ± 1.0 2,200 ± 89.0	0.57 ± 0.029 220 ± 13.0	0.12 10.0	NA	NA	8.5	NA	NA	NA
Kidney ¹	<MDA	0.11 ± 0.04 1.4 ± 0.5	0.049 ± 0.006 0.64 ± 6.1	0.63 8.2	NA	NA	1.3	NA	2.9 ± 0.2	50.0 ± 6.0

APPENDIX IX. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM CATTLE GRAZING THE OUTER COMPOUND,
AREA 13, NTS (Continued)

Calf Number 17 Data collected 01/29/75

Tissue Type	²³⁸ Pu (pCi/g Ash) (pCi/kg ⁺)	²³⁹ Pu (pCi/g Ash) (pCi/kg ⁺)	²⁴¹ Am (pCi/g Ash) (pCi/kg ⁺)	²³⁸ U (pCi/g Ash) (pCi/kg ⁺)	⁸⁹ Sr (pCi/g Ash) (pCi/kg ⁺)	⁹⁰ Sr (pCi/g Ash) (pCi/kg ⁺)	Ash (%)	³ H (pCi/l)	K (g/kg ⁺)	¹³⁷ Cs (pCi/kg ⁺)
Rumen vegetation	SAMPLE NOT COLLECTED									
Rumen fluid	SAMPLE NOT COLLECTED									
Reticulum sediment	SAMPLE NOT COLLECTED									
Liver ¹	0.25 ± 0.03 4.8 ± 0.5	0.13 ± 0.02 2.7 ± 0.38	0.0081 ± 0.006 0.17 ± 0.12	0.53 11.0	NA	NA	2.1	NA	GAMMA SPECTRUM NEGLIGIBLE	
Lung ¹	<MDA	<MDA	0.020 ± 0.007 0.20 ± 0.072	2.0 20.0	NA	NA	1.0	NA	NA	NA
Tracheobronchial lymph nodes	SAMPLE NOT COLLECTED									
Muscle ¹	<MDA	0.0059 ± 0.002 0.20 ± 0.006	0.0029 ± 0.001 0.1 ± 0.03	0.12 4.1	NA	NA	3.4	NA	3.9 ± 3.7	<MDA
Gonads	SAMPLE NOT COLLECTED									
Blood cells	SAMPLE NOT COLLECTED									
Blood serum	SAMPLE NOT COLLECTED									
Femur ¹	<MDA	0.0029 ± 0.001 0.52 ± 0.17	<MDA	0.074 13.0	NA	NA	17.7	NA	NA	NA
Vertebrae ¹	0.0018 ± 0.001 0.18 ± 0.12	0.11 ± 0.007 11.0 ± 0.66	<MDA	0.23 23.0	NA	NA	9.8	NA	NA	NA
Skin and hair	SAMPLE NOT COLLECTED									
Kidney ¹	0.013 ± 0.007 0.42 ± 0.2	0.31 ± 0.015 9.7 ± 0.49	0.038 ± 0.011 1.2 ± 0.34	1.2 38.0	NA	NA	3.2	NA	7.6 ± 2.0	<MDA

APPENDIX IX. RADIONUCLIDE CONCENTRATIONS IN TISSUES COLLECTED FROM CATTLE GRAZING THE OUTER COMPOUND,
AREA 13, NTS (Continued)

Cow Number 5 Data collected 01/29/75

Tissue Type	²³⁸ Pu (pCi/g Ash) (pCi/kg ⁺)	²³⁹ Pu (pCi/g Ash) (pCi/kg ⁺)	²⁴¹ Am (pCi/g Ash) (pCi/kg ⁺)	²³⁸ U (pCi/g Ash) (pCi/kg ⁺)	⁸⁹ Sr (pCi/g Ash) (pCi/kg ⁺)	⁹⁰ Sr (pCi/g Ash) (pCi/kg ⁺)	Ash (%)	³ H (pCi/l)	K (g/kg ⁺)	¹³⁷ Cs (pCi/kg ⁺)
Rumen vegetation ¹	2.7 ± 0.11 46.0 ± 4.1	110 ± 34.0 1,700 ± 50.0	14.0 ± 0.98 240 ± 9.6	0.56 13.0	NA	NA	0.6	NA	NA	NA
Rumen fluid ¹	0.94 ± 0.05 8.5 ± 0.5	42.0 ± 0.84 380 ± 7.6	5.8 ± 1.6 52.0 ± 15.0	4.5 41.0	NA	NA	0.9	NA	NA	NA
Reticulum sediment ¹	0.057 ± 0.006 36.0 ± 3.6	0.68 ± 0.028 430 ± 17.0	<MDA	0.66 420	NA	NA	63.8	NA	NA	NA
Liver ¹	0.0048 ± 0.002 0.14 ± 0.05	0.18 ± 0.013 5.4 ± 0.4	<MDA	0.083 2.4	NA	NA	2.9	NA	GAMMA SPECTRUM NEGLECTIBLE	
Lung ¹	0.068 ± 0.005 1.5 ± 0.12	1.9 ± 0.006 41.0 ± 1.2	0.25 ± 0.03 5.5 ± 0.66	0.16 3.4	NA	NA	2.2	NA	4.2 ± 1.1	<MDA
Tracheobronchial lymph nodes ¹	0.068 ± 0.04 5.4 ± 3.7	4.9 ± 0.25 440 ± 22.0	0.99 ± 0.24 79.0 ± 21.0	3.9 350	NA	NA	8.0	NA	NA	NA
Muscle ¹	0.0017 ± 0.001 0.085 ± 0.042	0.0044 ± 0.001 0.22 ± 0.053	0.0034 ± 0.003 0.17 ± 0.15	0.023 1.2	NA	NA	5.0	NA	1.9 ± 1.4	<MDA
Gonads	SAMPLE NOT COLLECTED									
Blood cells ^{1†}	<MDA	0.23 ± 0.18	<MDA	5.1	NA	NA	NA	NA	NA	NA
Blood serum ^{1†}	0.43 ± 0.11	0.7 ± 0.1	0.17 ± 0.085	5.3	NA	NA	NA	570 ± 220	NA	NA
Femur ¹	0.0021 ± 0.0008 0.62 ± 0.25	0.0063 ± 0.001 1.9 ± 0.42	0.0057 ± 0.0007 1.7 ± 0.2	0.017 5.2	NA	NA	30.0	NA	NA	NA
Vertebrae ¹	0.0020 ± 0.001 0.42 ± 0.25	0.025 ± 0.003 5.2 ± 0.72	0.0030 ± 0.0006 0.60 ± 0.13	0.044 9.1	NA	NA	20.9	NA	NA	NA
Skin ¹	2.9 ± 0.12 300 ± 12.0	130 ± 4.1 13,000 ± 520	1.5 ± 0.045 150 ± 4.6	0.22 23.0	NA	NA	10.2	NA	NA	NA
Kidney ¹	0.0050 ± 0.002 0.10 ± 0.05	0.044 ± 0.004 0.99 ± 0.099	0.050 ± 0.013 1.1 ± 0.3	0.23 4.1	NA	NA	2.2	NA	NA	NA

APPENDIX IX. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM CATTLE GRAZING THE OUTER COMPOUND,
AREA 13, NTS (Continued)

Cow Number 14 Data collected 01/28/76

Tissue Type	²³⁸ Pu (pCi/g Ash) (pCi/kg ⁺)	²³⁹ Pu (pCi/g Ash) (pCi/kg ⁺)	²⁴¹ Am (pCi/g Ash) (pCi/kg ⁺)	²³⁸ U (pCi/g Ash) (pCi/kg ⁺)	⁸⁹ Sr (pCi/g Ash) (pCi/kg ⁺)	⁹⁰ Sr (pCi/g Ash) (pCi/kg ⁺)	Ash (%)	³ H (pCi/l)	K (g/kg ⁺)	¹³⁷ Cs (pCi/kg ⁺)
Rumen vegetation ³	31.0 ± 7.1 73.0 ± 17.0	1,100 ± 240 2,600 ± 570	480 ± 78.0 110 ± 18.0	2.9 ± 0.7 6.8 ± 1.7	NA	NA	0.2	NA	1.6 ± 0.5	54.0 ± 6.0
Rumen fluid ³	1.1 ± 0.2 14.0 ± 2.4	35.0 ± 5.0 440 ± 64.0	4.1 ± 0.8 540 ± 10.0	0.13 ± 0.04 1.7 ± 0.52	NA	NA	1.3	NA	NA	NA
Reticulum sediment	SAMPLE NOT COLLECTED									
Liver ³	0.13 ± 0.02 6.2 ± 0.87	0.25 ± 0.03 12.0 ± 1.6	0.035 ± 0.009 1.7 ± 0.44	0.026 ± 0.011 3.6 ± 0.5	NA	NA	4.8	NA	3.4 ± 0.2	<MDA
Lung ³	0.14 ± 0.04 1.3 ± 0.3	2.2 ± 0.33 20.0 ± 3.1	0.26 ± 0.1 2.5 ± 0.9	0.059 ± 0.02 0.53 ± 0.15	NA	NA	0.9	NA	1.3 ± 0.6	<MDA
Tracheobronchial lymph nodes ³	<0.2 <2.86	14.0 ± 2.4 210 ± 34.0	0.85 ± 0.55 12.0 ± 7.9	<0.4 <5.7	NA	NA	1.4	NA	NA	NA
Muscle ³	0.034 ± 0.010 0.32 ± 0.09	0.17 ± 0.053 1.6 ± 0.5	<0.01 <0.2	0.10 ± 0.03 0.95 ± 0.26	NA	NA	0.95	260 ± 260	4.1 ± 0.1	16.0 ± 2.0
Gonads ³	<0.075 <2.3	0.23 ± 0.18 6.9 ± 5.4	SAMPLE LOST		NA	NA	3.1	NA	NA	NA
Blood cells ³	<0.002 <0.1	0.0084 ± 0.006 0.41 ± 0.29	<0.001 <0.07	<0.001 <0.07	NA	NA	4.9	NA	NA	NA
Blood serum ³	SAMPLE LOST		<0.002 <0.03	<0.007 <0.1	NA	NA	1.4	NA	NA	NA
Femur ³	<0.0004 <0.17	0.042 ± 0.01 17.0 ± 4.2	0.0078 ± 0.004 3.1 ± 1.7	0.004 ± 0.002 1.7 ± 0.9	NA	NA	39.5	NA	NA	NA
Vertebrae ³	0.012 ± 0.008 1.9 ± 1.3	0.21 ± 0.05 34.0 ± 7.4	0.0089 ± 0.004 1.4 ± 0.6	0.006 ± 0.005 0.95 ± 0.83	NA	NA	15.8	NA	NA	NA
Skin and hair ³	1.8 ± 0.63 180 ± 63.0	75.0 ± 240 7,500 ± 2,500	6.6 ± 1.7 660 ± 170	0.039 ± 0.02 3.9 ± 1.9	NA	NA	10.1	NA	NA	NA
Kidney ³	<0.003 <0.12	0.16 ± 0.024 3.7 ± 0.86	<0.002 <0.06	0.018 ± 0.007 0.64 ± 0.26	NA	NA	3.6	NA	NA	NA

APPENDIX IX. RADIONUCLIDE CONCENTRATIONS^a IN TISSUES COLLECTED FROM CATTLE GRAZING THE OUTER COMPOUND,
AREA 13, NTS (Continued)

Calf Number 19 Data collected 01/28/76

Tissue Type	²³⁸ Pu (pCi/g Ash) (pCi/kg ⁺)	²³⁹ Pu (pCi/g Ash) (pCi/kg ⁺)	²⁴¹ Am (pCi/g Ash) (pCi/kg ⁺)	²³⁸ U (pCi/g Ash) (pCi/kg ⁺)	⁸⁹ Sr/ ⁹⁰ Sr (pCi/g Ash) (pCi/kg ⁺)	Ash (%)	³ H (pCi/l)	K (g/kg ⁺)	¹³⁷ Cs (pCi/kg ⁺)
Rumen vegetation ³	3.1 ± 0.97 28.0 ± 8.7	120 ± 33.0 1,100 ± 300	4.8 ± 1.5 43.0 ± 13.0	0.44 ± 0.16 4.8 ± 1.4	NA	0.9	NA	0.6 ± 0.3	<MDA
Rumen fluid ³	0.93 ± 0.22 17.0 ± 2.9	28.0 ± 4.8 360 ± 63.0	2.2 ± 0.3 28.0 ± 4.2	0.19 ± 0.08 2.5 ± 1.0	NA	1.3	NA	NA	NA
Reticulum sediment ³	0.31 ± 0.2 160 ± 90.0	4.4 ± 0.8 2,400 ± 430	40.0 ± 8.7 21,000 ± 4,800	0.74 ± 0.44 410 ± 240	NA	55.0	NA	NA	NA
Liver ³	0.059 ± 0.013 1.2 ± 0.26	0.34 ± 0.04 6.9 ± 0.83	0.023 ± 0.012 0.46 ± 0.24	0.083 ± 0.036 1.7 ± 0.74	NA	2.1	NA	5.8 ± 0.25	57.0 ± 7.0
Lung ³	1.1 ± 0.17 44.0 ± 6.7	0.32 ± 0.07 12.0 ± 2.0	<0.013 <0.5	0.038 ± 0.031 1.5 ± 1.2	NA	3.9	NA	0.5 ± 0.4	17.0 ± 6.0
Tracheobronchial lymph nodes ³	SAMPLE LOST IN ANALYSIS		<0.05 <0.7	0.75 ± 0.4 12.0 ± 6.2	NA	1.5	NA	NA	NA
Muscle ³	<0.003 <0.03	0.031 ± 0.011 0.32 ± 0.11	0.0090 ± 0.006 0.090 ± 0.06	0.060 ± 0.01 0.60 ± 0.1	NA	1.0	NA	3.0 ± 0.5	36.0 ± 6.0
Gonads ³	SAMPLE LOST IN ANALYSIS		<0.002 <0.05	0.095 ± 0.05 2.3 ± 1.1	NA	2.4	NA	NA	NA
Blood cells ³	SAMPLE LOST IN ANALYSIS		<0.001 <0.04	0.0020 ± 0.002 0.070 ± 0.06	NA	3.7	NA	NA	NA
Blood serum ³	SAMPLE LOST IN ANALYSIS		<0.003 <0.03	0.068 ± 0.03 0.61 ± 0.3	NA	0.9	390 ± 220	NA	NA
Femur ³	<0.006 <1.6	0.021 ± 0.012 5.4 ± 3.0	<0.004 <0.95	0.017 ± 0.009 4.4 ± 2.2	NA	25.3	NA	NA	NA
Vertebrae ³	<0.011 <1.6	0.16 ± 0.05 22.0 ± 7.3	0.0082 ± 0.006 1.3 ± 0.8	0.014 ± 0.005 2.1 ± 1.1	NA	15.8	NA	NA	NA
Skin and hair ³	1.9 ± 0.77 210 ± 84.0	85.0 ± 1.9 9,300 ± 210	1.9 ± 0.22 213 ± 24.0	0.055 ± 0.01 6.1 ± 1.1	NA	11.0	NA	NA	NA
Kidney ³	SAMPLE LOST IN ANALYSIS		<0.002 <0.02	0.027 ± 0.02 0.41 ± 0.25	NA	1.5	NA	NA	NA

APPENDIX IX. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM CATTLE GRAZING THE OUTER COMPOUND,
AREA 13, NTS (Continued)

Cow Number 9 Data collected 03/31/76

Tissue Type	²³⁸ Pu		²³⁹ Pu		²⁴¹ Am		²³⁸ U		⁸⁹ Sr	⁹⁰ Sr	Ash	³ H	K	¹³⁷ Cs
	(pCi/g Ash)	(pCi/kg+)	(pCi/g Ash)	(pCi/kg+)	(pCi/g Ash)	(pCi/kg+)	(pCi/g Ash)	(pCi/kg+)	(pCi/g Ash)	(pCi/kg+)	(%)	(pCi/l)	(g/kg+)	(pCi/kg+)
Rumen vegetation ³	3.4 ± 0.82		100 ± 17.0		8.1 ± 1.9		<0.62		NA	NA	2.6	NA	NA	NA
	90.0 ± 20.0		2,700 ± 450		210 ± 50.0		<16.0							
Rumen fluid ³	<0.12		5.4 ± 1.9		1.1 ± 0.7		<0.14		NA	NA	1.3	NA	NA	NA
	<0.2		8.7 ± 3.0		1.8 ± 1.2		<0.22							
Reticulum sediment ³	0.94 ± 0.4		16.0 ± 2.3		1.4 ± 0.7		<0.4		NA	NA	64.0	NA	NA	NA
	600 ± 240		10,000 ± 3,600		900 ± 460		<280							
Liver ³	0.0023 ± 0.002		0.11 ± 0.02		0.029 ± 0.02		0.012 ± 0.007		NA	NA	4.7	NA	NA	NA
	0.11 ± 0.09		5.3 ± 0.86		1.4 ± 0.92		0.55 ± 0.32							
Lung ³	<0.55		9.5 ± 1.9		5.6 ± 1.9		<0.23		NA	NA	0.3	NA	NA	NA
	<1.9		32.0 ± 6.4		17.0 ± 6.6		<0.8							
Tracheobronchial lymph nodes ³	1.1 ± 0.45		42.0 ± 6.3		9.4 ± 2.4		0.35 ± 0.25		NA	NA	1.1	NA	NA	NA
	12.0 ± 4.7		450 ± 66.0		98.0 ± 25.0		3.7 ± 2.6							
Muscle ³	<0.0007		0.019 ± 0.009		<0.0017		0.025 ± 0.009		NA	NA	3.1	NA	NA	NA
	<0.02		0.60 ± 0.28		<0.05		0.76 ± 0.3							
Gonads ³	<0.1		<0.8		<0.14		<0.77		NA	NA	1.3	NA	NA	NA
	<1.3		<10		<1.8		<10.0							
Blood cells ³	<0.003		0.030 ± 0.01		<0.04		<0.030		NA	NA	0.5	NA	NA	NA
	<0.1		0.20 ± 0.08		<0.2		<0.15							
Blood serum ³	0.020 ± 0.005		0.14 ± 0.02		<0.01		0.047 ± 0.01		NA	NA	1.7	NA	NA	NA
	0.34 ± 0.08		2.4 ± 0.3		<0.2		0.80 ± 0.2							
Femur ³	<0.0001		0.0092 ± 0.0007		<0.015		0.0029 ± 0.0026		NA	NA	31.5	NA	NA	NA
	<0.03		2.9 ± 2.1		<1.5		0.94 ± 0.84							
Vertebrae ³	<0.0006		0.044 ± 0.013		0.0091 ± 0.005		<0.004		NA	NA	20.8	NA	NA	NA
	<0.12		9.1 ± 2.7		1.9 ± 0.96		<0.9							
Skin ³	<0.01		0.45 ± 0.09		0.035 ± 0.02		<0.003		NA	NA	12.6	NA	NA	NA
	<1.6		58.0 ± 12.0		4.5 ± 2.8		<0.3							
Kidney ³	<0.005		0.068 ± 0.021		<0.021		<0.0021		NA	NA	1.9	NA	NA	NA
	<0.09		1.3 ± 0.4		<0.42		<0.05							

APPENDIX IX. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM CATTLE GRAZING THE OUTER COMPOUND,
AREA 13, NTS (Continued)

Fetus from Cow Number 9 Data collected 03/31/76

Tissue Type	²³⁸ Pu (pCi/g Ash) (pCi/kg ⁺)	²³⁹ Pu (pCi/g Ash) (pCi/kg ⁺)	²⁴¹ Am (pCi/g Ash) (pCi/kg ⁺)	²³⁸ U (pCi/g Ash) (pCi/kg ⁺)	⁸⁹ Sr (pCi/g Ash) (pCi/kg ⁺)	⁹⁰ Sr (pCi/g Ash) (pCi/kg ⁺)	Ash (%)	³ H (pCi/l)	K (g/kg ⁺)	¹³⁷ Cs (pCi/kg ⁺)
Rumen vegetation	SAMPLE NOT COLLECTED									
Rumen fluid	SAMPLE NOT COLLECTED									
Reticulum sediment	SAMPLE NOT COLLECTED									
Liver ³	<0.004 <0.02	0.047 ± 0.03 0.30 ± 0.2	<0.004 <0.03	0.024 ± 0.021 0.16 ± 0.13	NA	NA	0.64	NA	NA	NA
Lung ³	<0.001 <0.02	<0.0029 <0.05	<0.0004 <0.01	0.0041 ± 0.003 0.070 ± 0.05	NA	NA	1.7	NA	NA	NA
Tracheobronchial lymph nodes	SAMPLE NOT COLLECTED									
Muscle ³	<0.01 <0.1	0.038 ± 0.002 0.3 ± 0.1	<0.001 <0.01	0.029 ± 0.002 0.23 ± 0.16	NA	NA	0.8	NA	NA	NA
Gonads ³	<1.3 <6.3	2.3 ± 1.5 11.0 ± 7.5	0.23 ± 0.2 1.1 ± 1.0	2.5 ± 2.0 13.0 ± 10.0	NA	NA	0.5	NA	NA	NA
Blood cells	SAMPLE NOT COLLECTED									
Blood serum	SAMPLE NOT COLLECTED									
Femur ³	<0.01 <1.0	<0.02 <2.0	<0.003 <0.3	<0.06 <5.4	NA	NA	9.4	NA	NA	NA
Vertebrae ³	<0.001 <0.05	0.38 ± 0.014 2.0 ± 0.7	0.030 ± 0.026 1.6 ± 1.4	<0.04 <2.2	NA	NA	5.3	NA	NA	NA
Skin ³	<0.04 <0.6	<0.04 <0.6	<0.02 <0.3	<0.08 <1.4	NA	NA	1.7	NA	NA	NA
Kidney ³	<0.02 <0.1	0.063 ± 0.03 0.44 ± 0.17	<0.01 <0.07	<0.04 <0.3	NA	NA	0.7	NA	NA	NA
Thymus ³	<0.02 <0.8	0.035 ± 0.025 1.4 ± 1.0	<0.005 <0.17	<0.05 <1.9	NA	NA	3.8	NA	NA	NA
Placenta ³	<0.005 <0.09	0.071 ± 0.03 1.2 ± 0.5	<0.003 <0.05	<0.008 <0.14	NA	NA	1.7	NA	NA	NA

APPENDIX IX. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM CATTLE GRAZING THE OUTER COMPOUND,
AREA 13, NTS (Continued)

Bull Number 16 Data collected 03/31/76

Tissue Type	²³⁸ Pu (pCi/g Ash) (pCi/kg†)	²³⁹ Pu (pCi/g Ash) (pCi/kg†)	²⁴¹ Am (pCi/g Ash) (pCi/kg†)	²³⁸ U (pCi/g Ash) (pCi/kg†)	⁸⁹ Sr/ ⁹⁰ Sr (pCi/g Ash) (pCi/kg†)	Ash (%)	³ H (pCi/l)	K (g/kg†)	¹³⁷ Cs (pCi/kg†)
Rumen vegetation ³	0.56 ± 0.23 10.0 ± 5.0	15.0 ± 2.5 360 ± 60.0	0.65 ± 0.23 20.0 ± 10.0	<0.14 <3.3	NA	2.4	NA	NA	NA
Rumen fluid ³	4.7 ± 1.0 43.0 ± 10.0	43.0 ± 18.0 390 ± 170	4.4 ± 2.8 40.0 ± 26.0	8.5 ± 7.0 78.0 ± 64.0	NA	0.9	NA	NA	NA
Reticulum sediment ³	1.3 ± 0.7 770 ± 390	7.3 ± 2.0 4,500 ± 1,300	16.0 ± 3.4 9,700 ± 2,100	<0.79 <480	NA	61.3	NA	NA	NA
Liver ³	0.026 ± 0.008 0.55 ± 0.17	0.64 ± 0.1 14.0 ± 2.1	0.063 ± 0.014 1.3 ± 0.3	<0.02 <0.05	NA	2.1	NA	NA	NA
Lung ³	<0.12 <1.4	1.3 ± 0.5 14.0 ± 5.4	0.39 ± 0.23 4.4 ± 2.5	0.20 ± 0.15 2.2 ± 1.7	NA	1.1	NA	NA	NA
Tracheobronchial lymph nodes ³	3.1 ± 2.4 30.0 ± 22.0	44.0 ± 15.0 410 ± 140	5.8 ± 3.3 55.0 ± 31.0	<0.25 <2.4	NA	1.0	NA	NA	NA
Muscle ³	0.022 ± 0.008 0.23 ± 0.08	0.051 ± 0.02 0.56 ± 0.17	0.0036 ± 0.003 0.04 ± 0.03	0.033 ± 0.023 0.36 ± 0.25	NA	1.1	NA	NA	NA
Gonads ³	<0.04 <0.25	0.48 ± 0.19 3.1 ± 1.2	0.030 ± 0.02 0.18 ± 0.12	0.12 ± 0.09 0.74 ± 0.56	NA	0.6	NA	NA	NA
Blood cells ³	1.0 ± 0.67 0.80 ± 0.5	3.4 ± 1.5 2.8 ± 1.2	1.1 ± 1.0 0.88 ± 0.8	<0.4 <0.32	NA	0.08	NA	NA	NA
Blood serum ³	0.078 ± 0.05 0.75 ± 0.48	0.19 ± 0.09 1.9 ± 0.9	<0.013 <0.12	<0.02 <0.2	NA	1.0	NA	NA	NA
Femur ³	0.043 ± 0.017 16.0 ± 6.2	0.032 ± 0.01 12.0 ± 4.0	0.0041 ± 0.002 1.5 ± 0.8	<0.0007 <0.23	NA	36.7	NA	NA	NA
Vertebrae ³	0.011 ± 0.009 2.1 ± 1.7	0.13 ± 0.05 25.0 ± 8.9	0.012 ± 0.004 2.3 ± 0.7	<0.002 <0.42	NA	19.3	NA	NA	NA
Skin ³	<5.9 <130	24.0 ± 15.0 510 ± 310	11.0 ± 4.8 230 ± 100	10.0 ± 7.8 220 ± 170	NA	2.1	NA	NA	NA
Kidney ³	0.022 ± 0.011 0.18 ± 0.09	0.24 ± 0.05 1.9 ± 0.4	0.057 ± 0.03 0.47 ± 0.25	<0.004 <0.04	NA	0.8	NA	NA	NA

APPENDIX IX. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM CATTLE GRAZING THE OUTER COMPOUND,
AREA 13, NTS (Continued)

Bull Number 20 Data collected 03/31/76

T6

Tissue Type	²³⁸ Pu (pCi/g Ash) (pCi/kg ⁺)	²³⁹ Pu (pCi/g Ash) (pCi/kg ⁺)	²⁴¹ Am (pCi/g Ash) (pCi/kg ⁺)	²³⁸ U (pCi/g Ash) (pCi/kg ⁺)	⁸⁹ Sr/ ⁹⁰ Sr (pCi/g Ash) (pCi/kg ⁺)	Ash (%)	³ H (pCi/l)	K (g/kg ⁺)	¹³⁷ Cs (pCi/kg ⁺)
Rumen vegetation ³	1.5 ± 0.43 50.0 ± 10.0	67.0 ± 10.0 2,200 ± 350	8.8 ± 1.8 300 ± 60.0	0.57 ± 0.47 19.0 ± 16.0	NA	3.4	NA	NA	NA
Rumen fluid ³	<3.2 <40.0	22.0 ± 8.3 280 ± 110	5.8 ± 4.5 76.0 ± 57.0	<1.1 <14.0	NA	1.3	NA	NA	NA
Reticulum sediment ³	0.55 ± 0.3 370 ± 230	2.7 ± 0.9 1,800 ± 630	3.5 ± 1.1 2,800 ± 760	2.7 ± 2.4 1,800 ± 1,600	NA	67.5	NA	NA	NA
Liver ³	0.023 ± 0.007 0.85 ± 0.27	0.38 ± 0.06 14.0 ± 2.1	0.053 ± 0.013 1.9 ± 0.5	<0.001 <0.05	NA	3.6	NA	NA	NA
Lung ³	<0.14 <1.3	1.6 ± 0.51 14.0 ± 1.7	<0.19 <1.7	<0.05 <0.46	NA	0.9	NA	NA	NA
Tracheobronchial lymph nodes ³	1.2 ± 0.4 19.0 ± 6.4	20.0 ± 3.4 330 ± 55.0	2.4 ± 0.6 44.0 ± 10.0	<0.17 <2.7	NA	1.8	NA	NA	NA
Muscle ³	<0.006 <0.05	0.019 ± 0.005 0.16 ± 0.04	<0.003 <0.02	0.0067 ± 0.006 0.06 ± 0.05	NA	0.9	NA	NA	NA
Gonads ³	<0.008 <0.1	0.045 ± 0.02 0.59 ± 0.25	<0.012 <0.15	<0.012 <0.15	NA	1.3	NA	NA	NA
Blood cells ³	0.086 ± 0.04 0.55 ± 0.26	0.34 ± 0.09 2.4 ± 0.62	<0.21 <0.09	<0.02 <0.15	NA	0.7	NA	NA	NA
Blood serum ³	<0.22 <0.17	0.021 ± 0.013 0.19 ± 0.1	<0.01 <0.09	<0.004 <0.04	NA	0.9	NA	NA	NA
Femur ³	<0.002 <1.0	0.031 ± 0.013 14.0 ± 5.9	<0.004 <1.7	0.0022 ± 0.0020 1.0 ± 0.9	NA	44.9	NA	NA	NA
Vertebrae ³	0.006 ± 0.004 1.2 ± 0.83	0.068 ± 0.02 14.0 ± 3.9	0.0043 ± 0.02 0.87 ± 0.42	<0.001 <0.33	NA	20.3	NA	NA	NA
Skin ³	<3.1 <190	39.0 ± 14.0 3,700 ± 910	12.0 ± 3.7 770 ± 230	<0.74 <46.0	NA	6.2	NA	NA	NA
Kidney ³	0.017 ± 0.05 0.12 ± 0.08	0.081 ± 0.02 1.3 ± 0.1	<0.005 <0.08	0.015 ± 0.007 0.24 ± 0.12	NA	1.6	NA	NA	NA

APPENDIX X. RADIONUCLIDE CONCENTRATIONS IN TISSUES COLLECTED FROM
CATTLE GRAZING NEAR AREA 13 OR AREA 5, NTS

Notes:

* All strontium, tritium, and gamma spectral analyses by EMSL-LV.

† Wet weight

³Actinide analyses by Eberline

NA = Not analyzed

<MDA = values below the detectable limit when the minimum detectable activity was not reported.

APPENDIX X. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM CATTLE GRAZING NEAR AREA 13 OR AREA 5, NTS

Calf Number 30 Data collected 01/16/76

Tissue Type	²³⁸ Pu (pCi/g Ash) (pCi/kg ⁺)	²³⁹ Pu (pCi/g Ash) (pCi/kg ⁺)	²⁴¹ Am (pCi/g Ash) (pCi/kg ⁺)	²³⁸ U (pCi/g Ash) (pCi/kg ⁺)	⁸⁹ Sr/ ⁹⁰ Sr (pCi/g Ash) (pCi/kg ⁺)	Ash (%)	³ H (pCi/l)	K (g/kg ⁺)	¹³⁷ (pCi/kg ⁺)
Rumen vegetation ³	0.15 ± 0.11 10.0 ± 5.0	0.95 ± 0.5 80.0 ± 20.0	0.41 ± 0.19 70.0 ± 10.0	<0.05 <2.1	NA	4.3	NA	2.1 ± 0.7	140 ± 15.0
Rumen fluid	SAMPLE NOT COLLECTED								
Reticulum sediment	SAMPLE NOT COLLECTED								
Liver ³	0.011 ± 0.010 0.12 ± 0.11	0.087 ± 0.031 0.96 ± 0.33	<0.037 <0.4	<0.002 <0.1	NA	1.1	NA	2.3 ± 0.4	<MDA
Lung ³	0.14 ± 0.08 3.2 ± 1.9	0.19 ± 0.09 4.5 ± 2.2	<0.029 <0.7	<0.061 <1.5	NA	2.4	NA	2.0 ± 0.4	<MDA
Tracheobronchial lymph nodes	SAMPLE NOT COLLECTED								
Muscle ³	<0.003 <0.14	0.0077 ± 0.005 0.34 ± 0.22	<0.002 <0.11	<0.002 <0.08	NA	4.4	NA	5.7 ± 0.7	29.0 ± 6.0
Gonads	SAMPLE NOT COLLECTED								
Blood cells	SAMPLE NOT COLLECTED								
Blood serum	SAMPLE NOT COLLECTED								
Femur ³	0.0043 ± 0.004 1.1 ± 0.96	0.016 ± 0.008 4.1 ± 2.0	<0.002 <0.61	0.0054 ± 0.004 1.4 ± 0.94	NA	25.7	NA	NA	NA
Vertebrae	SAMPLE NOT COLLECTED								
Skin ³	0.31 ± 0.2 5.2 ± 3.5	0.42 ± 0.24 7.3 ± 4.2	<0.031 <0.5	0.097 ± 0.087 1.7 ± 1.5	NA	1.7	NA	1.7 ± 0.5	NA
Kidney ³	<0.003 <0.12	0.041 ± 0.015 1.5 ± 0.52	<0.017 <0.6	0.019 ± 0.01 0.67 ± 0.36	NA	3.5	<310	2.2 ± 0.3	28.0 ± 4.0

APPENDIX X. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM CATTLE GRAZING NEAR AREA 13 OR AREA 5, NTS (Continued)

Cow Number BOV-1-A5 Data collected 05/06/76

Tissue Type	²³⁸ Pu (pCi/g Ash) (pCi/kg ⁺)	²³⁹ Pu (pCi/g Ash) (pCi/kg ⁺)	²⁴¹ Am (pCi/g Ash) (pCi/kg ⁺)	²³⁸ U (pCi/g Ash) (pCi/kg ⁺)	⁸⁹ Sr (pCi/g Ash) (pCi/kg ⁺)	⁹⁰ Sr (pCi/g Ash) (pCi/kg ⁺)	Ash (%)	³ H (pCi/l)	K (g/kg ⁺)	¹³⁷ Cs (pCi/kg ⁺)
Rumen vegetation	SAMPLE NOT COLLECTED									
Rumen fluid	SAMPLE NOT COLLECTED									
Reticulum sediment	SAMPLE NOT COLLECTED									
Liver ³	0.011 ± 0.057 0.15 ± 0.08	0.11 ± 0.021 1.6 ± 0.3	0.019 ± 0.0086 0.26 ± 0.12	0.0043 ± 0.0029 0.060 ± 0.4	NA	NA	1.4	NA	1.4 ± 0.72	<MDA
Lung ³	<0.0032 <0.032	<0.0074 <0.0074	<0.0021 <0.02	0.020 ± 0.0074 0.19 ± 0.07	NA	NA	0.94	NA	1.4 ± 0.72	<MDA
Tracheobronchial lymph nodes ³	<0.094 <1.6	<0.094 <1.6	<0.046 <0.79	<0.046 <0.79	NA	NA	1.7	NA	NA	NA
Muscle ³	0.013 ± 0.0061 0.23 ± 0.11	0.018 ± 0.0072 0.33 ± 0.13	<0.0039 <0.07	<0.005 <0.09	NA	NA	1.8	NA	NA	NA
Gonads ³	<0.11 <1.9	<0.11 <1.9	<0.11 <1.9	<4.5 <7.6	NA	NA	1.7	NA	NA	NA
Whole blood	NA	NA	NA	NA	NA	NA	NA	2,700 ± 2,200	NA	NA
Kidney	NA	NA	NA	NA	NA	NA	NA	NA	2.2 ± 0.36	NA
Femur ³	<0.00019 <0.05	<0.00019 <0.05	<0.000038 <0.01	<0.000077 <0.2	<15.0 <3,800	34.0 ± 77.0 880 ± 200	26.0	NA	NA	NA
Vertebrae	SAMPLE NOT COLLECTED									
Skin	SAMPLE NOT COLLECTED									

APPENDIX X. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM CATTLE GRAZING NEAR AREA 13 OR
AREA 5, NTS (Continued)

Cow Number BOV-2-A5 Data collected 05/06/76

Tissue Type	²³⁸ Pu (pCi/g Ash) (pCi/kg†)	²³⁹ Pu (pCi/g Ash) (pCi/kg†)	²⁴¹ Am (pCi/g Ash) (pCi/kg†)	²³⁸ U (pCi/g Ash) (pCi/kg†)	⁸⁹ Sr (pCi/g Ash) (pCi/kg†)	⁹⁰ Sr (pCi/g Ash) (pCi/kg†)	Ash (%)	³ H (pCi/l)	K (g/kg†)	¹³⁷ Cs (pCi/kg†)
Rumen vegetation	← SAMPLE NOT COLLECTED →									
Rumen fluid	← SAMPLE NOT COLLECTED →									
Reticulum sediment	← SAMPLE NOT COLLECTED →									
Liver ³	0.0069 ± 0.0038 0.0090 ± 0.005	0.037 ± 0.0092 0.48 ± 0.12	<0.0054 <0.07	0.018 ± 0.0092 23.0 ± 0.12	NA	NA	1.3	NA	3.4 ± 0.28	<MDA
Lung ³	0.0024 ± 0.0018 0.041 ± 0.03	0.025 ± 0.0059 0.42 ± 0.1	<0.0053 <0.09	0.011 ± 0.0053 0.19 ± 0.09	NA	NA	1.7	NA	2.6 ± 0.38	<MDA
Tracheobronchial lymph nodes ³	<0.031 <0.49	<0.094 <1.5	<0.062 <0.99	<0.031 <0.49	NA	NA	1.6	NA	NA	NA
Muscle ³	<0.00024 <0.01	<0.00024 <0.01	<0.0012 <0.05	<0.00073 <0.003	NA	NA	4.1	NA	NA	NA
Gonads ³	47.0 ± 14.0 710 ± 210	<0.34 <5.1	<0.087 <1.3	<0.087 <1.3	NA	NA	1.5	NA	NA	NA
Whole blood	NA	NA	NA	NA	NA	NA	NA	<2,200	NA	NA
Femur ³	<0.000067 <0.05	<0.00089 <0.67	<0.00004 <0.03	<0.00004 <0.03	<10.0 <0.0075	1.5 ± 0.53 100 ± 400	75.0	NA	NA	NA
Kidney ³	NA	NA	NA	NA	NA	NA	NA	NA	1.7 ± 0.41	<MDA

APPENDIX X. RADIONUCLIDE CONCENTRATIONS* IN TISSUES COLLECTED FROM CATTLE GRAZING NEAR AREA 13 OR AREA 5, NTS (Continued)

Cow Number BOV-3-A5 Data collected 05/06/76

Tissue Type	²³⁸ Pu (pCi/g Ash) (pCi/kg ⁺)	²³⁹ Pu (pCi/g Ash) (pCi/kg ⁺)	²⁴¹ Am (pCi/g Ash) (pCi/kg ⁺)	²³⁸ U (pCi/g Ash) (pCi/kg ⁺)	⁸⁹ Sr (pCi/g Ash) (pCi/kg ⁺)	⁹⁰ Sr (pCi/g Ash) (pCi/kg ⁺)	Ash (%)	³ H (pCi/l)	K (g/kg ⁺)	¹³⁷ Cs (pCi/kg ⁺)
Rumen vegetation	← SAMPLE NOT COLLECTED →									
Rumen fluid	← SAMPLE NOT COLLECTED →									
Reticulum sediment	← SAMPLE NOT COLLECTED →									
Liver ³	0.0083 ± 0.0048 0.19 ± 0.11	0.015 ± 0.0065 0.34 ± 0.15	<0.00087 <0.02	<0.0017 <0.004	NA	NA	2.3	NA	3.2 ± 0.2	21.0 ± 3.0
Lung ³	<0.0019 <0.03	0.030 ± 0.0081 0.48 ± 0.13	<0.0094 <0.15	<0.0012 <0.02	NA	NA	1.6	NA	1.7 ± 0.34	<MDA
Tracheobronchial lymph nodes ³	<0.087 <1.4	<0.17 <2.7	<0.042 <0.68	<0.042 <0.68	NA	NA	4.8	NA	4.0 ± 0.22	32.0 ± 3.4
Muscle ³	<0.00042 <0.02	<0.00042 <0.02	<0.0019 <0.09	<0.0023 <0.11	NA	NA	4.7	NA	NA	NA
Whole blood	NA	NA	NA	NA	NA	NA	NA	2,500 ± 2,200	NA	NA
Femur ³	<0.0001 <0.02	<0.0001 <0.02	<0.0002 <0.04	<0.00015 <0.03	<11.0 <0.0022	1.6 ± 0.6 330 ± 120	20.0	NA	NA	NA
Kidney	NA	NA	NA	NA	NA	NA	NA	NA	1.9 ± 0.35	<MDA
Skin	NA	NA	NA	NA	NA	NA	NA	NA	3.2 ± 0.2	<MDA

APPENDIX XI. ACTINIDE CONCENTRATIONS IN SELECTED TISSUES FROM WILDLIFE, AREA 13, NTS (wet wt)

Animal	LUNG			KIDNEY		
	^{238}Pu (pCi/kg)	^{239}Pu (pCi/kg)	^{241}Am (pCi/kg)	^{238}Pu (pCi/kg)	^{239}Pu (pCi/kg)	^{241}Am (pCi/kg)
Fox 1	0.3 ± 0.063	8.7 ± 0.26	0.17 ± 0.13	<MDA	<MDA	<MDA
Fox 2	<MDA	0.22 ± 0.14	0.57 ± 0.47	<MDA	0.35 ± 0.078	1.3 ± 0.65
Fox 3	<MDA	0.33 ± 0.0046	6.1 ± 0.68	<MDA	0.5 ± 0.075	0.3 ± 1.2
Coyote	← SAMPLE NOT COLLECTED →			← SAMPLE NOT COLLECTED →		
Rabbit	0.048 ± 0.039	0.097 ± 0.043	2.1 ± 0.045	← SAMPLE NOT COLLECTED →		

Animal	MUSCLE			LIVER		
	^{238}Pu (pCi/kg)	^{239}Pu (pCi/kg)	^{241}Am (pCi/kg)	^{238}Pu (pCi/kg)	^{239}Pu (pCi/kg)	^{241}Am (pCi/kg)
Fox 1	4.4 ± 0.49	190 ± 4.9	25.0 ± 4.9	<MDA	0.63 ± 0.07	0.23 ± 0.17
Fox 2	3.9 ± 1.7	86.0 ± 7.7	17.0 ± 1.9	<MDA	0.23 ± 0.07	1.7 ± 0.55
Fox 3	<MDA	1.4 ± 0.48	<MDA	<MDA	0.16 ± 0.1	0.33 ± 0.072
Coyote	0.98 ± 0.32	36.0 ± 1.8	4.7 ± 0.75	0.045 ± 0.01	0.24 ± 0.032	NA
Rabbit	← SAMPLE LOST →			0.13 ± 0.062	1.3 ± 0.15	0.98 ± 0.34

APPENDIX XI. ACTINIDE CONCENTRATIONS IN SELECTED TISSUES FROM WILDLIFE, AREA 13, NTS (wet wt)
(continued)

Animal	BONE			SKIN		
	^{238}Pu (pCi/kg)	^{239}Pu (pCi/kg)	^{241}Am (pCi/kg)	^{238}Pu (pCi/kg)	^{239}Pu (pCi/kg)	^{241}Am (pCi/kg)
Fox 1	1.1 ± 0.26	1.3 ± 0.22	NA	19.0 ± 0.75	730 ± 15.0	160 ± 9.9
Fox 2	0.45 ± 0.22	<MDA	NA	40.0 ± 4.8	1,500 ± 62.0	200 ± 20.0
Fox 3	<MDA	<MDA	NA	28.0 ± 3.0	930 ± 56.0	120 ± 6.1
Coyote	<MDA	2.6 ± 0.44	1.5 ± 0.55	← SAMPLE LOST →		
Rabbit	0.5 ± 0.19	2.3 ± 0.34	NA	20.0 ± 0.16	800 ± 24.0	120 ± 4.9

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Animal	INTESTINES AND CONTENTS			STOMACH CONTENTS		
	^{238}Pu (pCi/kg)	^{239}Pu (pCi/kg)	^{241}Am (pCi/kg)	^{238}Pu (pCi/kg)	^{239}Pu (pCi/kg)	^{241}Am (pCi/kg)
Fox 1	0.83 ± 0.28	0.63 ± 0.31	0.26 ± 0.15	3.3 ± 0.33	130 ± 3.8	19.0 ± 1.1
Fox 2	← SAMPLE LOST →			19.0 ± 1.5	710 ± 210	100 ± 5.1
Fox 3	1.4 ± 0.25	35.0 ± 1.4	5.9 ± 0.76	0.23 ± 0.05	8.2 ± 0.16	1.0 ± 0.23
Coyote	← SAMPLE NOT COLLECTED →			<MDA	5,200 ± 210	630 ± 31.0
Rabbit	2.6 ± 0.26	80.0 ± 2.4	21.0 ± 1.9	8.0 ± 0.96	240 ± 12.0	36.0 ± 2.2

<MDA = values below the detectable limit when the minimum detectable activity was not reported.

NA = Not analyzed

APPENDIX XII. GROSS* AND MICROSCOPIC PATHOLOGY[†] FOUND IN NECROPSIED ANIMALS

Area 13 Cattle

1. Necropsy findings: No gross lesions noted.
Histopathological findings: Hemosiderosis of the spleen, cystic follicles in ovaries and sarcocysts in the cardiac muscle.
Hematological findings: Blood sample unsuitable for examination.
Clinical diagnosis: Normal mature lactating cow.
2. Necropsy findings: No gross lesions noted.
Histopathological findings: Cystic follicles in the ovaries, sarcocysts in the muscles and melanosis in the adrenal.
Hematological findings: Blood sample clotted.
Clinical diagnosis: Normal mature lactating cow.
3. Necropsy findings: Adhesions and small abscess between reticulum and diaphragm, adhesions between lung and diaphragm, fibrinous pericardial eudate. Uterus contains 8 month fetus. No gross lesions noted in fetus.
Histopathological findings: Sarcocysts in cardiac muscle, melanosis of the adrenals and mononuclear cell infiltrate in the interstitial tissue of the kidneys.
Hematological findings: RBC/ μ l 8.3×10^6 , WBC/ μ l 7.4×10^3 , MCV/fl 50, Hb g % 14.2, Hematocrit % 7.4, Neutrophils % 72, Lymphocytes % 25, Monocytes % 3.
Clinical diagnosis: Lesions of traumatic reticulitis. Probably associated with advanced pregnancy.
4. Necropsy findings: Small squamous-cell carcinoma on nictating membrane of right eye. Adhesions between reticulum and diaphragm.
Histopathological findings: Squamous-cell carcinoma of conjunctiva, hemosiderosis of spleen and sarcocyst in cardiac and body muscles.
Hematological findings: RBC/ μ l 8.1×10^6 , WBC/ μ l 3.2×10^3 , MCV/fl 49, Hb g % 12.9, Hematocrit % 40. Severe white cell destruction of sample so unable to obtain valid differential.
Clinical diagnosis: Normal mature cow with ocular squamous-cell carcinoma.
5. Necropsy findings: Cow is in poor condition and is lactating. Recently gave birth. Much of body fat has been replaced with mucoid material. Approximately 1,000 cc of serous fluid in abdominal cavity.
Histopathological findings: Mild peribronchial lymphoid cuffs, sarcocysts in cardiac muscle, hemosiderosis of spleen, and lesions of a chronic endometrites.

APPENDIX XII. GROSS* AND MICROSCOPIC PATHOLOGY[†] FOUND IN NECROPSIED ANIMALS
(Continued)

Area 13 Cattle

5. Hematological findings: RBC/ μ l 6.7×10^6 , WBC/ μ l 4×10^6 , MCV/fl 49, Hb g % 11.6, Hematocrit % 11.6, Neutrophils % 66, Lymphocytes % 33, Eosinophils % 1.
Clinical diagnosis: Mature cow showing signs of malnutrition.
6. Necropsy findings: Lactating cow in fair condition. Is a diaphragmatic hernia present with protusion of liver into thoracic cavity, 45 day fetus in right horn of uterus.
Histopathological findings: Sarcocysts in cardiac muscle, hemosiderosis of spleen, peribronchial lymphoid cuffs in lung.
Hematological findings: RBC/ μ l 6.3×10^6 , WBC/ μ l 4.1×10^3 , MCV/fl 58, Hb g % 11.1, Hematocrit % 37. Severe white cell destruction of sample so unable to obtain valid differential.
Clinical diagnosis: Normal adult cow.
7. Animal found dead. No necropsy was performed as the carcass was extensively decomposed and damaged by scavengers. Cause of death not determined.
8. Necropsy findings: No gross lesions noted.
Histopathological findings: Melanosis of adrenals and hemosiderosis of spleen.
Hematological findings: RBC/ μ l 8.5×10^6 , WBC/ μ l 7.3×10^3 , MCV/fl 48, Hb g % 14.3, Hematocrit % 41, Neutrophils % 67, Lymphocytes % 28, Eosinophils % 4, Monocyte % 1.
Clinical diagnosis: Normal mature cow.
9. Necropsy findings: Rubber booties in rumen, fibrinous adhesions between reticulum and diaphragm. Liver contains several scars. Uterus contains near-term male fetus. No lesions noted in fetus.
Histopathological findings: Sarcocysts in cardiac muscle, focal interstitial lymphoid aggregates in kidneys, small microabscesses in liver. No significant lesions in fetus.
Hematological findings: RBC/ μ l 7.6×10^6 , WBC/ μ l 6×10^3 , MCV/fl 59, Hb g % 14.7, Hematocrit % 45, Neutrophils % 43, Lymphocytes % 50, Monocytes % 7.
Clinical diagnosis: Normal pregnant mature cow that has had mild traumatic reticulitis in the past.
10. Necropsy findings: No gross lesions noted. Plastic bag in rumen.

APPENDIX XII. GROSS* AND MICROSCOPIC PATHOLOGY[†] FOUND IN NECROPSIED ANIMALS
(Continued)

Area 13 Cattle

10. Histopathological findings: Hemosiderosis of spleen, sarcocysts in cardiac muscle.
Hematological findings: RBC/ μ l 6.6×10^6 , WBC/ μ l 7×10^3 , MCV/fl 59, Hb g % 12.9, Hematocrit % 39, Neutrophils % 60, Lymphocytes % 27, Eosinophils % 7, Monocytes % 6.
Clinical diagnosis: Normal young cow.
11. Necropsy findings: No gross lesions noted.
Histopathological findings: Melanosis of adrenal.
Hematological findings: RBC/ μ l 9.4×10^6 , WBC/ μ l 7.9×10^3 , MCV/fl 38, Hb g % 11.6, Hematocrit % 36, Neutrophils % 49, Lymphocytes % 39, Monocytes % 6, Eosinophils % 1.
Clinical diagnosis: Normal newborn calf.
12. Necropsy findings: 6-month-old, brachycephalic dwarf female. Forehead bulges, enlarged abdomen, prognathic, short legs. No gross lesions noted.
Histopathological findings: Diffuse hepatic lipidosis.
Hematological findings: RBC/ μ l 11.3×10^6 , WBC/ μ l 12×10^3 , MCV/fl 40, Hb g % 15.6, Hematocrit % 45, Neutrophils % 10, Lymphocytes % 87. Three atypical lymphocytes.
Clinical diagnosis: Brachycephalic dwarf--genetic origin.
13. Necropsy findings: Atelectic lobule on left apical lobe of lung.
Histopathological findings: The lung shows focal hemorrhage, edema, emphysema and atelectasis which are attributable to terminal agonal changes.
Hematological findings: RBC/ μ l 9.3×10^6 , WBC/ μ l 5×10^3 , MCV/fl 42, Hb g % 12.9, Hematocrit % 40, Neutrophils % 36, Lymphocytes % 60, Eosinophils % 3, Monocytes % 1.
Clinical diagnosis: Normal yearling bull.
14. Necropsy findings: No gross lesions noted. Plastic tape in rumen.
Histopathological findings: Hemosiderosis of spleen.
Hematological findings: RBC/ μ l 7.7×10^6 , WBC/ μ l 5×10^3 , MCV/fl 53, Hb g % 13.9, Hematocrit % 41, Neutrophils % 41, Lymphocytes % 57, Eosinophils % 1, Monocytes % 2.
Clinical diagnosis: Normal 2-year-old cow.

APPENDIX XII. GROSS* AND MICROSCOPIC PATHOLOGY[†] FOUND IN NECROPSIED ANIMALS
(Continued)

Area 13 Cattle

15. Necropsy findings: No gross lesions noted except small atelectic area on margin of left diaphragmatic lobe of the lung.

Histopathological findings: Hemosiderosis of spleen, lymphoid hyperplasia of a lymph node.

Hematological findings: RBC/ μ l 9.6×10^6 , WBC/ μ l 4.5×10^3 , MCV/fl 44, Hb g % 15.3, Hematocrit % 43, Neutrophils % 32, Lymphocytes % 62, Eosinophils % 4, Monocytes 2.

Clinical diagnosis: Normal yearling bull.

16. Necropsy findings: Mid-portion of right 13th rib has recent fracture. Rumen contained plastic bags, rope, and rubber booties.

Histopathological findings: Sarcocysts in cardiac muscle, mature spermatozoa in testes.

Hematological findings: RBC/ μ l 9.5×10^6 , WBC/ μ l 6.9×10^3 , MCV/fl 53, Hb g % 16.1, Hematocrit % 16.1, Neutrophils % 40, Lymphocytes % 57, Eosinophils % 2, Monocytes % 1.

Clinical diagnosis: Normal adult bull.

17. Necropsy findings: Full-term female calf. Lungs are one-fourth atelectic so calf took a few breaths prior to death.

Histopathological findings: Lung is atelectic.

Hematological findings: Blood sample not collected.

Clinical diagnosis: Normal calf--died shortly after birth from exposure to the elements.

18. Necropsy findings: No gross lesions noted.

Histopathological findings: No lesions noted. Follicular activity in the ovaries.

Hematological findings: RBC/ μ l 8.6×10^6 , WBC/ μ l 7×10^3 , MCV/fl 49, Hb g % 13.9, Hematocrit % 42, Neutrophils % 41, Lymphocytes % 52, Eosinophils % 6, Monocytes % 1.

Clinical diagnosis: Normal 6-month-old female calf.

19. Necropsy findings: No gross lesions noted.

Histopathological findings: No lesions noted. No activity in testes which appear hypoplastic.

Hematological findings: RBC/ μ l 7.9×10^6 , WBC/ μ l 7×10^3 , MCV/fl 49, Hb g % 13.7, Hematocrit % 34, Neutrophils % 23, Lymphocytes % 65, Eosinophils % 6, Monocytes % 6.

APPENDIX XII. GROSS* AND MICROSCOPIC PATHOLOGY[†] FOUND IN NECROPSIED ANIMALS
(Continued)

Area 13 Cattle

19. Clinical diagnosis: Normal male calf.
20. Necropsy findings: Small atelectic areas in diaphragmatic lobe of left lung, probably due to agonal struggling.
- Histopathological findings: Mild hemosiderosis of the spleen. Mature sperm in testes.
- Hematological findings: RBC/ μ l 6.5×10^6 , WBC/ μ l 4.3×10^3 , MCV/fl 60, Hb g % 13.1, Hematocrit % 39, Neutrophils % 50, Lymphocytes % 46, Eosinophils % 2, Monocytes % 2.
- Clinical diagnosis: Normal mature bull.

Area 13 Goats

1. Necropsy findings: No gross lesions, lungs are congested and frothy which is the result of dyspnea associated with exsanguination.
- Histopathological findings: Sample not collected.
- Hematological findings: RBC/ μ l 8.5×10^6 , WBC/ μ l 9.5×10^3 , MCV/fl 21, Hb g % 13.7, Hematocrit % 38, Neutrophils % 71, Lymphocytes % 28, Eosinophils % 1.
- Clinical diagnosis: Normal mature female.
2. Necropsy findings: Lungs are consolidated and frothy probably from dyspnea associated with exsanguination.
- Histopathological findings: Spleen congested, lungs are hemorrhagic and heart shows fatty infiltration.
- Hematological findings: RBC/ μ l 19.7×10^6 , WBC/ μ l 8×10^3 , MCV/fl 17, Hb g % 11.6, Hematocrit % 33, Neutrophils % 35, Lymphocytes % 62, Eosinophils % 1, Monocytes % 2.
- Clinical diagnosis: Normal mature female.

Cattle from Adjacent Areas

30. Necropsy findings: No gross lesions noted.
- Histopathological findings: Sarcocysts in cardiac muscle.
- Hematological findings: Samples not collected.
- Clinical diagnosis: Normal yearling female.

APPENDIX XII. GROSS* AND MICROSCOPIC PATHOLOGY[†] FOUND IN NECROPSIED ANIMALS
(Continued)

Cattle from Adjacent Areas

1-A5 Necropsy findings: No gross lesions noted.

Histopathological findings: Focal interstitial lymphoid aggregates in kidney, lymphoid hyperplasia of lymph node.

Hematological findings: RBC/ μ l 8.3×10^6 , WBC/ μ l 6.5×10^3 , MCV/fl 55, Hb g % 16.2, Hematocrit % 46, Neutrophils % 14, Lymphocytes % 72, Eosinophils % 6, Monocytes % 8.

Clinical diagnosis: Normal female.

2-A5 Necropsy findings: Mature cow in poor condition, fibrinous adhesions between reticulum and diaphragm, atelectric areas in left apical and cardiac lobes of the lungs.

Histopathological findings: Hemosiderosis of spleen, sarcocyst in cardiac muscle. Alveolar hemorrhage in lungs.

Hematological findings: RBC/ μ l 6.7×10^6 , WBC/ μ l 6.9×10^3 , MCV/fl 57, Hb g % 13.3, Hematocrit % 38, Neutrophils % 28, Lymphocytes % 65, Eosinophils % 3, Basophils % 1, Monocytes % 3.

Clinical diagnosis: Normal mature cow.

3-A5 Necropsy findings: Adhesions between reticulum and liver which incorporate an abscess 3 cm in diameter.

Histopathological findings: Random focal aggregates of neutrophils and lymphocytes in the liver which indicate mild subacute to chronic focal hepatitis, parabronchial lymphoid nodules in the lungs.

Hematological findings: RBC/ μ l 8.2×10^6 , WBC/ μ l 4.1×10^3 , MCV/ fl 57, Hb g % 16.2, Hematocrit % 47, Neutrophils % 16, Lymphocytes % 83, Monocytes % 1.

Clinical diagnosis: Chronic traumatic reticulitis that has been walled off.

Wildlife Area 13 (3 foxes, 1 coyote, and 1 rabbit)

Necropsy findings: No gross lesions noted.

Histopathological findings: Samples not collected.

Hematological findings: Samples not collected.

Clinical diagnosis: Normal animals.

*As reported by author.

[†]As reported by Dr. Billy C. Ward, College of Veterinary Medicine, Drawer V, Mississippi State University, Starkville, Mississippi.

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