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ENVIRONMENTAL MONITORING
AT AMES LABORATORY

Calendar Year 1979

Milo D. Voss

AMES LABORATORY, DOE
IOWA STATE UNIVERSITY
AMES, IOWA

Date Transmitted: April 1980

PREPARED FOR THE DEPARTMENT OF ENERGY
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ENVIRONMENTAL MONITORING AT AMES LABORATORY

Calendar Year 1979

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Environmental Monitoring at Ames Laboratory:

Calendar Year 1979

ABSTRACT

This is an annual report summarizing the effluent and environmental monitoring program at the Ames Laboratory of the Department of Energy.

Earlier reports in this series concerned only environmental radioactivity and were each entitled "Survey of Environmental Radioactivity." The report for 1973 included some information on effluents, both radioactive and non-radioactive, with an assessment of the radiation dose to the public.

The 1974 report was the first in the present series of reports. An inventory of the radioactive materials released to the environment is included. A summary of the radioactivity found in the environment is presented. An estimate of the radiation dose to the public resulting from the operations of the Ames Laboratory is stated.

The environmental program was modified in July of 1976, and again in 1978.

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1. Summary

The results and conclusions from the Ames Laboratory environmental monitoring programs for the Ames Laboratory Research Reactor (ALRR) are presented in this report. The major areas of radiological monitoring were ALRR effluent air, environmental air, effluent water and environmental water.

Analysis of air samples collected at the ALRR site showed detectable amounts of the radioisotope cobalt (Co-60). This isotope was $1.5 \times 10^{-4}\%$ of the concentration guide (1) and was probably due to ALRR operations. The radioisotope of significance in the ALRR stack effluent was tritium (H-3). The average yearly individual dose from H-3 at the exclusion fence was estimated to 0.0038 mRem and the estimated dose to the entire population within an 80 Km (50 mile) radius of the ALRR was 6.31 man-Rem. These values are 0.00076% and 0.0063%, respectively, of the doses derived from the concentration guides.

In the radioactive liquid waste released to the City of Ames sewage system from the ALRR complex, H-3 was the predominant isotope. After dilution with other waste water from the ALRR complex, the potential dose was not more than 0.59% of the dose derived from the concentration guide.

The environmental monitoring program was changed on July 1, 1976. The changes which were made are shown in a previous environmental monitoring report, IS-4139 (4). These changes were made in order to improve the cost effectiveness of the program in accord with the minimal impact of the ALRR on the surrounding environment. Media and sites which had shown no previous impact or correlation with reactor operations were eliminated. A new site

was added, and the media and sites which could show impacts were retained. The changes were subject to consideration and agreement with Chicago Operations Office of DOE.

On September 1, 1978, the ALRR site was connected to the City of Ames sanitary sewage system. All liquids (except building foundation and roof water) from the ALRR complex are now discharged to the sewage system negating the requirement for monitoring chemical constituents of effluent and environmental waters.

II. Ames Laboratory Facilities and Locality

The facilities of the Ames Laboratory include offices, laboratories, warehouses and service buildings located among university buildings on the campus of Iowa State University (I.S.U.) in Ames, Iowa. In addition to the facilities on campus, the Ames Laboratory Research Reactor (ALRR) together with a waste handling-decontamination facility and an office-warehouse is located on a 16.2 hectares (40 acre) site (Figure 1, page 26) approximately 2.4 Km (1.5 miles) northwest of the I.S.U. campus (Figure 2) and 4.8 Km (3 miles) west and north of downtown Ames (City Hall). The site of the ALRR is about 305 m (1,000 feet) above sea level and is enclosed by an exclusion fence at 213 m (700 feet) or more centered on the reactor. The nearest non-residential building (I.S.U.) is about 244 m (800 feet) east of the reactor and the nearest residential lot is about 381 m (1250 feet) south of the ALRR.

Ames is located in central Iowa where the Squaw Creek and Skunk River come together (Figures 3 and 4). The land is gently rolling "swell and swale". The flat upland is only a little greater than 30.5 m (100 feet) above the river flood plain. The general area is about 274 m (900 feet) above sea level. The City of Ames covers 42.5 Km² (16.4 square miles). The I.S.U. student population of about 19,000 is included in the Ames population numbering 40,000*. The major portion of Iowa State University and parts of Ames lie within a 3.2 Km (2 mile) radius of the Ames Laboratory Research Reactor. Within the 3.2 Km (2 mile) circle, the land usage is 33% residential (Ames and I.S.U.), 25% wooded, and 42% agricultural.

The climatology of the area is temperate and continental subject to wide seasonal range in temperature, precipitation and wind. The average

*From 1970 census

annual temperature is 9.4°C (49°F). The average annual precipitation is 18.3 cm (32 inches): 90% rain, 10% snow, with small amounts of sleet and hail.

In the colder months, the winds are mostly from the northwest sector averaging 29-32 Km/hour (18-20 miles/hour); in the warmer months, winds are from the southeast sector averaging 19-23 Km/hour (12-14 miles/hour).

One characterization of winds is the fraction of time the wind blows from a certain direction. In the Ames area, the variations of a given wind direction between the least time or frequency and the greatest time is about a factor of two.

The average wind speed at 3 m (10 feet) above the ground is estimated at 14.4 Km/hour (9 miles/hour) and at 30.5 m (100 feet) it is 20.9 Km/hour (13 miles/hour).

An inversion is an atmospheric condition which limits the upward rise of effluents from ventilation and smokestacks. This condition occurs in varying degrees about 290 times per year with an average duration of 14 hours.

The sources of water supply for Ames and Iowa State University are sand and gravel aquifers lying within two buried bedrock valleys, the Squaw and Skunk. Water is pumped for storage and distribution from a number of wells which are 30.5-39.6 m (100-130 feet) deep. The City of Ames pumped 7.9×10^9 liters (2092×10^6 gallons) from the well field in 1979. Surface water contributes to the recharge of the system as water is pumped from the wells. The travel time of water from the Skunk River to the well area is estimated at one year. The contribution to the recharge from Squaw Creek is less than that from the Skunk River. Recharge water

from Squaw Creek passes through absorbing and filtering material, a mixture of clay, silt and sand which lies over the waterbearing sand and gravel.

The surface streams of particular interest to the Ames Laboratory are the Onion Creek Gulch, Onion Creek, Squaw Creek and the Skunk River. Onion Creek and Onion Creek Gulch are intermittent and non-classified streams. Squaw Creek and the Skunk River are classed as B, fresh warm water, and thus protected for wildlife, fish, aquatic and semi-aquatic life and secondary contact recreation. The classifications have been established by the Iowa Water Quality Commission. The Skunk River is changed to a Class C, protected raw water source of potable water supply, at the point of withdrawal as Oskaloosa, Iowa, 137 Km (85 river miles) downstream from Ames.

The area around Ames is generally rural with farming producing important yields of corn, soybeans, and wheat. The neighboring towns (Figure 3) are mostly small communities.

<u>City</u>	<u>Population</u> [*]	<u>From Ames</u>
Nevada	5,000	11 Km (7 miles) east
Ankeny	9,000	35 Km (22 miles) south
Boone	12,500	21 Km (13 miles) west
Story City	2,100	23 Km (14 miles) north

The capital of Iowa, Des Moines, population 201,400^{*} lies 48 Km (30 miles) south of Ames.

The total population within a circle of 80 Km (50 miles) radius is 590,500^{*}.

^{*}From 1970 census

On December 31, 1977, the Ames Laboratory Research Reactor ceased operation. Decommissioning began on January 3, 1978, with expected completion by the end of 1980. All fuel elements, heavy water (D_2O), and thermal shield light water have been removed from the site and transferred to another Department of Energy (D.O.E.) facility. All experiments have either been transferred to other DOE facilities or have been placed in storage.

The waste disposal/decontamination facility houses a decontamination booth and special sinks with systems for complete collection of the cleanings, a solid waste compactor, tank storage for liquids (water) with filtration and ion exchange processing systems, and evaporation and distillation systems. The output of this facility is clean equipment for reuse and packaged solid waste for shipment to a radioactive waste burial site. As of September 1, 1978, the waste disposal and the ALRR facility were connected to the City of Ames sanitary sewer system.

The laboratories associated with the reactor and those in the Ames Laboratory complex on the Iowa State University campus that use radioactivity have relatively small amounts of radioactivity at any one time. The majority of the work deals with tracer studies employing relatively small amounts of radioisotopes (Ca-45, Cl-36, Co-60, Fe-59, Hf-175, Mn-54 and others). Waste from these experiments is collected and disposed of as radioactive waste.

Liquids released from the I.S.U. campus facilities are handled through the sanitary sewer system. Liquid and solid radioactive wastes in these facilities are collected and taken to the reactor site waste disposal facility for processing. Airborne releases are eliminated or minimized by

experiment system design or source limitation. The liquid and solid contaminated wastes generated at the reactor site are transferred to the waste disposal facility for processing. Irradiated air systems of the reactor are filtered before release and are monitored. Prior to September 1, 1978, all liquid effluents from the reactor and waste disposal facilities were released to a single outfall site. With the connection to the sanitary sewage system on this date, the only remaining sources of liquid effluent which are released to the outfall site originate from the ALRR building foundation and roof. This site has been and continues to be monitored.

The effluent monitoring pertaining to these facilities and the environmental monitoring are presented in this report.

III. Definition of Terms

Average Average as used in this report is the arithmetical mean of all sample results. The activity of a sample was set equal to zero when the count rate was less than background. When the count rate was less than the detection limit, which is a function of the minimum detectable activity (2) (but greater than the instrument background) the calculated activity was used in averaging. No yearly average is the mean of the monthly averages.

Confidence Limits The confidence limits given in Table 1 indicate the accuracy of the particular value based on considerations of the count rate, count time and background, not on the distribution of sample values (2). The limits in this table have been derived for and are applicable only to the value which is stated for each media. The values used in Table 1 are typical yearly averages which appear in each media type group; that is, air, water, and bottom sediment.

Table 1
95% Confidence Limits

<u>Media Type</u>	<u>Sample Size</u>	<u>Count Time</u>	<u>Average Activity (± 2σ)</u>
<u>Beta</u>			
Air	152 m ³	50 min	0.098 (±0.0094) x 10 ⁻¹² μCi/ml
Water	1 ℓ	30 min	6.07 (±1.35) x 10 ⁻⁹ μCi/ml
Bottom Sediment	4 g	30 min	10.33 (±0.71) x 10 ⁻⁶ μCi/ml
<u>Alpha</u>			
Air	Same as Beta		0.0027(±0.0037) x 10 ⁻¹² μCi/ml
Water			0.59 (±0.76) x 10 ⁻⁹ μCi/ml
Bottom Sediment			0.66 (±0.26) x 10 ⁻⁶ μCi/ml
<u>Tritium</u>			
Water			2.08 (±0.50) x 10 ⁻⁶ μCi/ml

Average Tritium Counting Efficiency = 23%

Detection Limit The minimum detectable activity (limit) is defined as that activity which, in the same counting time, yields a count which is more than the instrument background count by three times the standard deviation of the background count (2).

The detection limit is a value of radioactivity per unit volume or mass based on the sample volume or mass, the counting procedure, and the minimum detectable activity. The detection limit is stated in Table 2 for each media.

Table 2
Detection Limits, Radiological

	Air 10^{-15} $\mu\text{Ci/ml}$	Water 10^{-9} $\mu\text{Ci/ml}$	Bottom Sediment 10^{-9} $\mu\text{Ci/g}$
Beta	4.80	1.00	250.
Alpha	3.20	0.39	100.
Tritium	--	500.	--
Ag-110m	0.13	0.13	8.81
Ba-140	0.38	0.38	25.8
Be-7	1.23	1.20	82.8
Ce-141	0.18	0.17	15.1
Ce-144	0.72	0.67	48.6
Co-60	0.14	0.15	9.6
Cs-137	0.15	0.15	10.4
La-140	0.27	0.26	18.2
Nb-95	0.13	0.13	8.9
Ru-103	0.13	0.13	8.8
Ru-106	2.75	2.70	173.
Sb-124	0.14	0.13	9.2
Sb-125	0.41	0.40	27.4
Zn-65	0.25	0.24	17.1
Zr-95	0.26	0.25	17.3

With respect to the gamma detection limits, typical counting times were 333.3 minutes. Sample volumes for air and water were 1.50×10^{10} ml and 2.2×10^4 ml, respectively. Sample mass for bottom sediment averaged 400 grams.

IV. Radiological Monitoring Program

The Ames Laboratory radiological program monitors effluent (air particulate and water), environmental air particulate, river and well water in the Ames area. Gamma analysis is generally performed on composites of samples collected over a month, quarter or the entire year. The samples are analyzed using a Tracor Northern TN-1710 gamma spectrometer/microprocessor with a high resolution Ortec Ge(Li) detector.

Individual samples are submitted to gross beta and alpha analysis. This provides an indication of the activity of the sample within 3 weeks. All alpha and beta determinations are made in a 3-inch gas proportional Sharp Low Betamatic System. The activity concentration is calculated using the following equation:

$$\frac{\mu\text{Ci}}{\text{unit volume}} = \frac{(\text{Counts/Time}) - \text{Background}}{(\text{Counter Efficiency})(\text{Volume})(2.22 \times 10^6 \text{ dpm}/\mu\text{Ci})} \quad (1)$$

Self-absorption was not considered. As such, the results are easily compared to other samples and to previous years. Since the alpha and beta determination is basically a screening process, this purpose is served equally as well without self-absorption corrections.

Tritium activity in aqueous samples is determined by liquid scintillation technique. Five ml samples are analyzed with a dioxane-naphthalene cocktail and a Beckman Liquid Scintillation Counter. The tritium activity concentration is also calculated using equation 1.

A. Effluents

Air

Stack air particulate samples are collected on 5 cm (2 inch) Whatman #41 filter paper using a Gast pump with a flow rate of 85 liters per minute (3 CFM) from a sample point near the top of the ALRR stack (Figure 1). Comments describing the stack sampling program are as follows: (1) The air sampler system as operated in this sampling program, produces a particulate collection efficiency of >97% using the above filter paper, (2) Sampling is continuous with the filters being changed every working day, (3) Both sample and stack flow rates are recorded, (4) Gross beta and alpha activity is determined with the Sharp System after a seven day holding period, (5) Gamma analysis is performed on quarterly composites of the daily samples, (6) H-3 activity is determined daily from moisture in stack air collected with a cold-trap and analyzed by liquid scintillation technique. The Cs-137, Co-60, and Zn-65 isotopes listed were due to ALRR operations. The other isotopes listed were due to atmospheric weapons testing. See Appendix B, Tables B5 and B6 for a quarterly summary of the ALRR stack effluent results.

The activity concentration in the ALRR stack for 1979 is shown in Table 3. The stack discharge volume was 1.61×10^{14} ml for 1979.

Table 3
ALRR Stack Effluent
($\mu\text{Ci/ml}$)

<u>Isotope</u>	<u>Concentration</u>
Gross Beta	2.3×10^{-14}
Gross Alpha	6.0×10^{-16}
Be-7	6.98×10^{-15}
Co-60	8.85×10^{-15}
Cs-137	2.42×10^{-16}
H-3	2.81×10^{-7}
Zn-65	3.38×10^{-16}

Water

Water samples are collected twice daily, except weekends and holidays, from the ALRR outfall (Site 2R, Figure 1). Alpha and beta activity is determined by evaporating a 1 liter sample onto a 3-inch aluminum planchet and counting in a Sharp Low Betamatic. Tritium is determined in a 5 ml sample with a Beckman Scintillation Counter and dioxane-naphthalene cocktail. The tritium (H-3) discharge concentration range was from 0.0003 to 0.012 times the concentration guide with an overall average factor of 0.002. Gamma scan analyses were performed on monthly composites of the morning outfall samples, AM, and afternoon samples, PM. The Concentration Guides (CG's), based on radiation dose to individuals in uncontrolled areas, are shown in Appendix A. See Appendix B, Table B7 for a monthly summary of the outfall results. A summary for 1979 is shown in Table 4.

Table 4
Radioactivity in the ALRR Outfall
($\mu\text{Ci/ml}$)

	Number of Samples	Average Concentration	% CG ¹	High	Low
Gross Beta, 10^{-9}	322	4.00	0.13	16.1	NDA ²
Gross Alpha, 10^{-9}	322	0.15	0.50	3.24	NDA
H-3, 10^{-6}	322	5.52	0.18	35.4	0.99
Cs-137, 10^{-9}	composites	0.067	0.0003	0.069	NDA

¹Concentration Guide

²No Detectable Activity

Liquid radioactive waste is sampled and treated on a batch basis. Alpha and beta activities are determined by evaporating a 100 ml sample and counting. Equation 1 with self-absorption corrections is used to calculate the alpha and beta activity concentration. Self-absorption corrections are employed because an absolute activity concentration is desired for waste discharge and the sample residue is small, less than 0.1 g, making the corrections relatively low. The tritium activity concentration is determined for a 1 ml sample. The gamma analysis is performed on the residue of an evaporated 3 liter sample. All radioactive waste generated at the laboratories located on the I.S.U. campus is collected, evaporated and disposed of as solid waste. The radioactivity in liquid waste discharged to the Ames sewage system in 1979 is shown in Table 5.

The total volume of radioactive liquid waste discharged from the ALRR waste disposal facility to the Ames sewage system was 1.93×10^8 ml. The total volume of waste water discharged to the Ames sewage system from the ALRR complex was 9.23×10^9 ml. Table 5 concentrations reflect the effect of dilution from waste water discharged to the sewer. The concentration guides which apply in this case are from DOE Manual Chapter 0524, Table 1, Column 2 and is shown in Appendix A, Table A2.

Table 5
Liquid Radioactive Waste Discharged to the Ames Sewage System

Isotope	Amount, μCi	Concentration, $\mu\text{Ci/ml}$	% CG
Gross Beta	508.0	5.50×10^{-8}	1.83
Gross Alpha	13.2	1.43×10^{-9}	0.05
Co-60	105.0	1.14×10^{-8}	1.0×10^{-3}
Cs-134	2.97	3.22×10^{-10}	1.07×10^{-4}
Cs-137	42.1	4.56×10^{-9}	1.14×10^{-3}
H-3	5.44×10^6	5.89×10^{-4}	0.59
Sb-124	4.59	4.97×10^{-10}	7.10×10^{-5}
Sb-125	24.0	2.60×10^{-9}	8.66×10^{-5}
Zn-65	43.2	4.68×10^{-9}	1.56×10^{-4}

Liquid effluents leaving the I.S.U. campus facilities and ALRR complex via city sewage lines are sampled at the Ames Water Pollution Control Plant (Site 11R, Figure 3). Effluents are sampled weekly and a composite sludge sample is processed monthly. The effluent liquid is treated the same as a river or outfall sample. The sludge sample is mixed and a 100 ml portion is filtered. After drying, the filter paper is ashed and both portions are counted for gross beta and alpha activity. Gamma analysis is performed on a composite of the year's samples. The tritium concentration is not determined on the sludge samples. The concentration guides in Appendix A, Table A1 apply.

Table 6
Radioactivity in the Water Pollution Control Plant Samples (11R)
($\mu\text{Ci/ml}$)

	Number of Samples	Beta, 10^{-9}	% CG	Alpha, 10^{-9}	% CG	Number of Samples	Tritium 10^{-6}	% CG
Plant Effluent (Site 11R)	17					16		
Average		10.16	0.33	0.11	0.46		2.05	0.068
High		23.8		0.36			6.39	
Low		6.35		NDA			0.45	
Sludge Soluble	8							
Average		37.4		0.075			Not Determined	
High		93.7		0.60				
Low		21.6		NDA				
Sludge Insoluble	8							
Average		109.0		10.9			Not Determined	
High		232.0		21.0				
Low		41.9		4.81				

Gamma analyses of a composite sample of all soluble and insoluble sludge indicated the presence of Cs-137 at $8.15 \times 10^{-9} \mu\text{Ci/ml}$, which is 0.04% of the concentration guide and is probably due to fallout from past nuclear tests.

B. Environmental

Air Samples

Air samples are collected from two different locations at the Ames Laboratory on a daily (except weekends) basis for the purpose of monitoring the particulate radioactivity content of the atmosphere. The sites are located at the ALRR weather tower site (Site 1A, Figure 1) and the roof of Spedding Hall (Site 2A Figure 2). Samples are collected over a 24 hour period, held for 7 days to allow short-lived activities to decay and then analyzed. Samples are collected on Whatman #41 7.62 cm (3 inch) diameter filter paper using a Gast pump with a flow rate of 116 liters per minute (4.1 CFM). The samples are placed directly in a Sharp Low Betamatic three-inch gas proportional system and counted for gross alpha and beta activity. The filter papers are then retained until a composite sample for 90 days is collected. The composite sample is then analyzed for specific gamma emitting isotope content using a Ge(Li) detector/4096 channel analyzer. The isotopic activity that was detectable on the 1979 composites is summarized in Table 7 and shown quarterly in Appendix B, Tables B2 and B4. The gross beta and alpha activity is summarized in Table 8 and shown monthly in Appendix B, Tables B1 and B3. The Co-60 isotope shown was due to ALRR operations. The fission isotopes shown were due to fallout received from past atmospheric nuclear testing.

Table 7
Gamma Analysis of Air Samples
(10^{-15} $\mu\text{Ci/ml}$)

Isotope	ALRR-Site 1A		Spedding Hall-Site 2A	
	Avg	% CG	Avg	% CG
Be-7	89.2	2.22×10^{-4}	79.2	1.98×10^{-4}
Ce-144	4.66	2.33×10^{-3}	1.99	9.95×10^{-4}
Co-60	0.445	1.48×10^{-4}	NDA	
Cs-137	1.22	3.44×10^{-4}	0.85	1.70×10^{-4}
Ru-106	3.99	1.99×10^{-3}	1.73	8.65×10^{-4}
Sb-125	NDA		0.514	5.71×10^{-5}

Table 8
Radioactivity in Air
(10^{-12} $\mu\text{Ci/ml}$)

	Number of Samples	Beta	% CG	Alpha	% CG
ALRR--Site 1A	222				
Average		0.0426	0.043	0.0009	4.5
High		0.186		0.0061	
Low		0.007		NDA	
Spedding Hall-- Site 2A	170				
Average		0.0397	0.039	0.0011	5.5
High		0.128		0.038	
Low		0.005		NDA	

River Water Samples

River water samples are collected weekly and analyzed for tritium activity and gross alpha and beta activity. Samples are obtained from Onion Creek (Site 3R, 4R, Figure 2), the first flowing creek in the flow route of the ALRR drainage system, and the Skunk River (Site 11R, Figure 3) downstream from both the ALRR drainage system and the Ames Pollution Control Plant. In addition, samples (Clear Creek) are obtained from outside the

ALRR flow route. This constitutes a control site and is numbered nine in the data. Samples are obtained whenever possible. At times the creeks are completely dry in the late summer and fall and frozen solid in the winter. If water is flowing under the ice, a sample is obtained by chopping through the ice. If there is an unusually large amount of suspended material in the sample, the sample is filtered and the soluble and insoluble portions are counted separately; otherwise, the one liter sample is evaporated to near dryness and transferred to a planchet. The planchets are placed directly in the Sharp System for counting. Tritium is determined with a 5 ml sample using liquid scintillation technique. Gamma analysis is performed on quarterly composites of the weekly samples. The sample results are summarized in Table 9.

Table 9
Radioactivity in River Water
($\mu\text{Ci/ml}$)

	Number of Samples	Beta 10^{-9}	% CG	Alpha 10^{-9}	% CG	Number of Samples	Tritium 10^{-6}	% CG
<u>Downstream</u>								
<u>Sites 4R,</u>								
<u>8R</u>								
Soluble	19					19		
Avg		5.20	0.173	0.451	15.0		2.24	0.075
High		9.05		1.02			6.66	
Low		1.94		0.18			1.35	
Insoluble	0					0		
<u>Upstream</u>								
<u>Sites 1R,</u>								
<u>3R</u>								
Soluble	24					23		
Avg		4.52	0.150	0.379	12.6		2.25	0.075
High		12.8		0.90			5.86	
Low		1.08		NDA			0.45	
Insoluble	0					0		
<u>Control</u>								
<u>Site 9R</u>								
Soluble	12					12		
Avg		5.97	0.199	0.40	13.		2.07	0.069
High		8.24		0.961			5.14	
Low		3.56		NDA			0.36	
Insoluble	0					0		

Gamma analysis for River Sites 1R, 3R, 4R, 8R, and 9R yielded no detectable isotopes other than naturally occurring radionuclides.

Well Water Samples

Well water samples are obtained monthly from City of Ames wells (1W, Figure 3), Iowa State University (I.S.U.) campus wells (2W, Figure 2), and from a privately owned farm well (Martin) at a location two miles north of the ALRR. The sample size is one liter and is handled in the same manner as the river water samples. No gamma activity was observed in the yearly composites of the well samples other than naturally occurring radionuclides. The yearly data are presented in Table 10 and in Appendix B, Table B14.

Table 10
Radioactivity in Well Water Samples
($\mu\text{Ci/ml}$)

	Number of Samples	Beta 10^{-9}	% CG	Alpha 10^{-9}	% CG	Tritium 10^{-6}	% CG
Average	19	5.49	0.18	0.408	1.36	1.30	0.04
High		10.5		1.08		1.98	
Low		2.97		NDA		0.541	

Bottom Sediment

Bottom sediment samples are obtained at or near the river water site on a quarterly basis. Samples are analyzed for gross alpha and beta activity. A one-liter sample is obtained from the top 5-8 cm (2-3 inches) of bottom sediment in a semi-quiescent area. The sample is mixed thoroughly and a 3-4 gram counting sample is prepared. The counting samples are dried thoroughly in an oven and then counted directly in the Sharp System. The results for 1979 are shown in Table 11 and Appendix B, Table B15.

Table 11
Radioactivity in Bottom Sediments
(10^{-6} $\mu\text{Ci/g}$)

	Number of Samples	Beta			Alpha		
		Avg	High	Low	Avg	High	Low
Downstream Sites 2R, 2F, 4R, 8R	16	7.15	10.2	5.29	0.28	0.68	0.06
Upstream Sites 1R, 3R	8	6.47	7.98	4.80	0.19	0.56	0.03
Control Site 9R	3	6.01	6.82	5.43	0.13	0.24	0.05

Gamma analysis of bottom sediment samples (200-600 grams) indicated detectable amounts of Cs-137 at Sites 2F, 2R, 3R, and 8R. The presence of this isotope is due to past atmospheric nuclear testing. The yearly data are presented in Appendix B, Table B16.

C. Impact

From the effluent data, it has been shown that the contribution to the environmental radioactivity in air from Ames Laboratory operations consisted principally of radioactive tritium, H-3.

Applying principles of meteorological diffusion to the stack effluent, particularly section 3-5.5.4, Long-period Average Concentration of "Meteorology and Atomic Energy 1968", USAEC (3) the estimates have been made for the radiation dose at the exclusion fence. The man-rem dose for the population within an 80 Km (50 mile) radius of the reactor has been estimated using a cylindrical diffusion volume with an 80 Km (50 mile) radius and a height of 305 m (1,000 feet). The height used in the 1974 report was 610 m (2,000 feet).

Average Individual Dose at Fence Line for 1979

	Millirem
H-3 (tritium)	0.0038

The 80 Km (50 mile) Man-Rem Dose for 1979 (590,500 population)

	Man-Rem
H-3 (tritium)	6.31

The concentration guide values for an average dose taken as $0.5 \text{ Rem}/3 = 0.17 \text{ Rem}$ yielded 100,385 man-Rem for the population within 80 Km (50 miles). Thus the man-Rem dose, derived from the concentration guide, due to Ames Laboratory operations was 0.0063% of the Radiation Protection Standard.

Using the concentration guide value of 500 mRem for an individual at the exclusion fence, the dose was 0.00076% of the Radiation Protection Standard.

V. Sample Site Location

Table 12
Sample Site Location

AIR

<u>Figure Reference</u>	<u>Map Symbol</u>	
1	1A	The on-site monitoring station is located approximately 122 m (400 feet) south of the reactor.
2	2A	The off-site monitoring station is located on the Spedding Hall roof approximately 1.6 Km (one mile) southeast of the reactor.

RIVER AND BOTTOM SEDIMENT

<u>Figure Reference</u>	<u>Map Symbol</u>	<u>Table Symbol</u>	
1,2	1R	1-DD-U	This on-site sampling point is located just above the mixing zone of the outfall in Onion Creek Gulch.
1,2	2R	Outfall	This site is the outfall and is listed as such. The bottom sediment sample is just below the outfall point in Onion Creek Gulch.
1,2	2F	Fence	Site is approximately 91 m (300 feet) downstream from outfall point at Reactor site boundary fence.
2	3R	3-On-U	This site is in Onion Creek upstream from confluence with Onion Creek Gulch.
2	4R	4-On-D	Site is approximately 305 m (1000 feet) downstream from confluence point in Onion Creek.
3	8R	8-Sk-D	Site is in the Skunk River downstream from the Squaw Creek confluence.
2	9R	9-CC	This control site is located outside the flow pattern of ALRR effluent in Clear Creek.
3	11R	11-SK-S	This is a sample of the Ames Water Pollution Control Plant effluent.

WELLS

<u>Figure Reference</u>	<u>Map Symbol</u>	<u>Table Symbol</u>	
3	1W	City	The water wells for the City of Ames are all located east of Squaw Creek. The location indicated is the water treatment plant.
2	2W	I.S.U.	The Iowa State University wells are located west of Squaw Creek.
2	3W	Martin	The Martin site is a private farm well located 3.2 Km (two miles) north of the ALRR.

Figure 1: Ames Laboratory Research Reactor Site Plan. Map drawn to scale.

Figure 2: Environmental Sampling Sites within 3.2 Km (two miles) of ALRR. Map drawn to scale.

Figure 3: Environmental Sampling Sites within 25.7 Km (sixteen miles) of ALRR. Map drawn to scale.

Figure 4: State of Iowa. Map drawn to scale.

VII. References

1. DOEM 0524, "Standards for Radiation Protection".
2. "A Manual of Radioactivity Procedures", National Bureau of Standards Handbook 80, 1961.
3. Slade, D. H., Ed., "Meteorology and Atomic Energy 1968", U.S.A.E.C., 1968.
4. "Environmental Monitoring at Ames Laboratory", IS-4139, Ames Laboratory USDOE, Iowa State University, Ames, Iowa 50011.

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APPENDIX A. Applicable Standards

The radionuclide concentration standards for air and water applicable to ALRR operations are the Concentration Guides (CG's) given in Chapter 0524 of the DOE Manual (1). A summary of the concentration guides is given in Table A1 and A2. The most restrictive (uncontrolled area) Chapter 0524 Table 11 value, soluble or insoluble, is reported in Table A2.

Table A1
Concentration Guides (CG's)
Controlled Area

	In Water ($\times 10^{-9}$ $\mu\text{Ci/ml}$)	In Air ($\times 10^{-12}$ $\mu\text{Ci/ml}$)
Alpha	400	0.6
Beta	90,000	3,000
Be-7	50,000,000	1,000,000
Ce-144	300,000	6,000
Co-60	1,000,000	9,000
Cs-137	1,000,000	10,000
H-3	100,000,000	5,000,000
Ru-106	300,000	6,000
Sb-125	3,000,000	30,000
Zn-65	5,000,000	60,000

Table A2
Concentration Guides (CG's)
Uncontrolled Area

	In Water ($\times 10^{-9}$ $\mu\text{Ci/ml}$)	In Air ($\times 10^{-12}$ $\mu\text{Ci/ml}$)
Alpha	30	0.02
Beta	3,000	100
Be-7	2,000,000	40,000
Ce-144	10,000	200
Co-60	30,000	300
Cs-137	20,000	500
H-3	3,000,000	200,000
Ru-106	10,000	200
Sb-125	30,000	900
Zn-65	100,000	2,000

APPENDIX B. Radiological Results for Specific Sites

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Table B1
Air Site 1A, On-Site Station
(10⁻¹² μ Ci/ml)

	Number of Samples	Beta	Alpha
Jan	18	0.072	0.0020
Feb	19	0.067	0.0011
Mar	22	0.039	0.0009
Apr	18	0.035	0.0007
May	20	0.039	0.0011
Jun	17	0.045	0.0006
Jul	13	0.040	0.0008
Aug	20	0.031	0.0007
Sep	17	0.042	0.0011
Oct	21	0.027	0.0005
Nov	20	0.037	0.0001
Dec	17	0.041	0.0007
Total	222		
Average		0.0426	0.0009
High		0.186	0.0061
Low		0.007	NDA

Table B2
Gamma Analysis Air Site 1A
On-Site Station
(10⁻¹⁵ μ Ci/ml)

Isotope	Quarter				Average
	1	2	3	4	
Be-7	125.0	142.0	57.6	32.2	89.2
Ce-144	2.56	6.76	NDA	NDA	4.66
Cs-137	1.16	2.82	0.89	NDA	1.22
Ru-106	9.30	6.67	NDA	NDA	3.99
Co-60	0.49	0.81	0.48	NDA	0.445

Table B3
Air Site 2A, Off-Site Station
(10^{-12} $\mu\text{Ci/ml}$)

	Number of Samples	Beta	Alpha
Jan	18	0.073	0.0040
Feb	15	0.053	0.0009
Mar	16	0.034	0.0005
Apr	17	0.034	0.0007
May	15	0.037	0.0012
Jun	18	0.042	0.0005
Jul	13	0.039	0.0011
Aug	14	0.028	0.0005
Sep	11	0.034	0.0007
Oct	12	0.022	0.0009
Nov	11	0.031	0.0007
Dec	10	0.034	0.0008
Total	170		
Average		0.0397	0.0011
High		0.128	0.038
Low		0.005	NDA

Table B4
Gamma Analysis Air Site 2A
(10^{-15} $\mu\text{Ci/ml}$)

Isotope	Quarter				Average
	1	2	3	4	
Be-7	104.0	133.0	44.5	35.4	79.2
Ce-144	2.81	5.17	NDA	NDA	1.99
Cs-137	0.813	2.23	0.376	NDA	0.85
Ru-106	NDA	6.92	NDA	NDA	1.73
Sb-125	0.629	1.43	NDA	NDA	0.514

Table B5
ALRR Stack Effluent
(10^{-12} $\mu\text{Ci/ml}$)

	Number of Samples	Beta	Alpha
Jan	21	0.058	0.0015
Feb	19	0.036	0.0006
Mar	21	0.020	0.0005
Apr	21	0.024	0.0006
May	22	0.022	0.0008
Jun	21	0.028	0.0012
Jul	19	0.019	0.0008
Aug	21	0.013	0.0003
Sep	19	0.017	0.0005
Oct	23	0.012	0.0003
Nov	18	0.013	0.0004
Dec	18	0.008	0.0002
Total	243		
Average		0.023	0.0006
High		0.326	0.0115
Low		0.0002	NDA

Table B6
Gamma Analysis ALRR Stack Effluent
(10^{-15} $\mu\text{Ci/ml}$)

Isotope	Quarter				Average
	1	2	3	4	
Be-7	14.0	NDA	10.2	3.71	6.98
Co-60	30.3	2.87	1.81	0.422	8.85
Cs-137	0.769	NDA	NDA	0.200	0.242
Zn-65	NDA	NDA	1.35	NDA	0.338

Table B7
ALRR Outfall Activity (Map Site 2R)
($\mu\text{Ci}/\text{ml}$)

		Number of Samples	Beta 10^{-9}	Alpha 10^{-9}	Cs-137 10^{-9}	Number of Samples	Tritium 10^{-6}
Jan	AM	19	4.24	0.09	NDA	19	4.35
	PM	16	4.80	0.07	0.64	16	3.91
Feb	AM	15	3.94	0.11	NDA	14	6.68
	PM	18	3.86	0.15	NDA	18	5.55
Mar	AM	14	3.62	0.10	NDA	12	7.90
	PM	21	3.10	0.10	NDA	20	8.47
Apr	AM	11	3.91	0.05	NDA	9	7.52
	PM	17	4.05	0.06	NDA	16	6.50
May	AM	20	3.25	0.23	NDA	2	3.96
	PM	20	3.10	0.14	NDA	19	3.73
Jun	AM	16	5.79	0.22	NDA	16	10.52
	PM	16	6.26	0.48	NDA	16	6.13
Jul	AM	11	4.03	0.09	NDA	11	3.91
	PM	12	4.16	0.10	NDA	12	5.86
Aug	AM	0	--	--	--	0	--
	PM	21	3.74	0.15	NDA	20	5.35
Sep	AM	0	--	--	--	0	--
	PM	17	3.70	0.07	0.63	17	2.86
Oct	AM	0	--	--	--	0	--
	PM	21	3.65	0.19	NDA	21	3.14
Nov	AM	0	--	--	--	0	--
	PM	20	3.13	0.28	NDA	20	3.59
Dec	AM	0	--	--	--	0	--
	PM	17	4.00	0.24	0.60	16	2.96
Total		322				312	
Average			4.00	0.154	0.067		5.52
High			16.1	3.24	0.069		35.4
Low			NDA	NDA	NDA		0.99

Table B8
 River Site 1R
 Upstream, Onion Creek Gulch (Drainage Ditch) (1-DD-U)
 ($\mu\text{Ci/ml}$)

<u>Soluble Portion</u>					
	Number of Samples	Beta 10 ⁻⁹	Alpha 10 ⁻⁹	Number of Samples	Tritium 10 ⁻⁶
Jan	0	Site Dry		0	
Feb	0	Site Dry		0	
Mar	0	Site Dry		0	
Apr	1	3.02	0.24	1	0.45
May	1	7.39	0.30	1	2.07
Jun	3	4.72	0.34	3	4.05
Jul	0	Site Dry		0	
Aug	0	Site Dry		0	
Sep	0	Site Dry		0	
Oct	1	1.08	0.06	1	1.62
Nov	1	1.71	0.54	1	2.34
Dec	1	1.31	0.06	1	2.53
Total	8			8	
Average		3.581	0.278		2.646
High		7.39	0.54		5.86
Low		1.08	0.06		0.45

Table B9
 River Site 3R
 Upstream, Onion Creek (3-On-U)
 ($\mu\text{Ci/ml}$)

<u>Soluble Portion</u>					
	Number of Samples	Beta 10 ⁻⁹	Alpha 10 ⁻⁹	Number of Samples	Tritium 10 ⁻⁶
Jan	0	Site Dry		0	
Feb	0	Site Dry		0	
Mar	1	12.8	0.90	0	
Apr	3	5.17	0.46	3	1.65
May	1	3.56	0.72	1	0.72
Jun	3	6.01	0.48	3	3.75
Jul	0	Site Dry		0	
Aug	0	Site Dry		0	
Sep	3	5.42	0.32	3	1.05
Oct	2	4.55	0.39	2	1.31
Nov	1	3.47	0.42	1	2.25
Dec	1	3.15	0.60	1	1.35
Total	15			14	
Average		5.46	0.480		1.88
High		12.8	0.90		5.49
Low		3.15	NDA		0.451

Table B10
River Site 4R
Downstream, Onion Creek (4-On-D)
($\mu\text{Ci/ml}$)

	Number of Samples	<u>Soluble Portion</u>		Number of Samples	Tritium 10^{-6}
		Beta 10^{-9}	Alpha 10^{-9}		
Jan	0	Site Dry		0	
Feb	0	Site Dry		0	
Mar	0	Site Dry		0	
Apr	1	6.67	0.30	1	2.07
May	0	Site Dry		0	
Jun	2	6.55	0.96	2	5.06
Jul	0	Site Dry		0	
Aug	0	Site Dry		0	
Sep	3	5.60	0.34	3	1.56
Oct	1	3.33	0.18	1	1.44
Nov	0	Site Dry		0	
Dec	1	2.84	0.78	1	1.98
Total	8			8	
Average		5.34	0.53		2.53
High		7.43	1.02		5.68
Low		2.84	0.18		1.35

Table B11
River Site 8R
Downstream, Skunk River (8-Sk-D)
($\mu\text{Ci/ml}$)

	Number of Samples	<u>Soluble Portion</u>		Number of Samples	Tritium 10^{-6}
		Beta 10^{-9}	Alpha 10^{-9}		
Jan	1	6.13	0.72	1	1.35
Feb	0	Site Dry		0	
Mar	2	7.39	0.51	2	2.03
Apr	2	8.18	0.54	2	1.13
May	0	Site Dry		0	
Jun	2	4.10	0.72	2	3.78
Jul	0	Site Dry		0	
Aug	0	Site Dry		0	
Sep	0	Site Dry		0	
Oct	2	6.31	0.57	2	1.22
Nov	1	5.18	0.66	1	2.43
Dec	1	3.42	0.66	1	1.35
Total	11			11	
Average		6.06	0.37		1.95
High		9.05	0.36		6.66
Low		1.94	NDA		4.51

Table B12
River Site 9R
Control, Clear Creek (9-CC)
($\mu\text{Ci/ml}$)

	Number of Samples	<u>Soluble Portion</u>		Number of Samples	Tritium 10^{-6}
		Beta 10^{-9}	Alpha 10^{-9}		
Jan	0	Site Dry		0	
Feb	0	Site Dry		0	
Mar	1	7.25	0.18	1	2.97
Apr	3	5.41	0.30	3	1.65
May	1	4.96	0.42	1	0.45
Jun	3	6.86	0.72	3	3.30
Jul	0	Site Dry		0	
Aug	0	Site Dry		0	
Sep	2	4.60	0.39	2	1.76
Oct	2	4.48	0.18	2	1.49
Nov	0	Site Dry		0	
Dec	0	Site Dry		0	
Total	12			12	
Average		5.97	0.40		2.07
High		8.24	0.96		5.14
Low		3.56	NDA		0.36

Table B13
River Site 11R
Ames Water Pollution Control Facility Effluent (11-Sk-S)
($\mu\text{Ci/ml}$)

	Number of Samples	<u>Soluble Portion</u>		Number of Samples	Tritium 10^{-6}
		Beta 10^{-9}	Alpha 10^{-9}		
Jan	1	11.2	0.06	1	1.71
Feb	0	Site Dry		0	
Mar	2	10.3	NDA	1	0.54
Apr	3	7.8	0.04	3	1.14
May	1	6.71	0.36	1	0.54
Jun	3	13.5	0.16	3	4.14
Jul	0	Site Dry		0	
Aug	0	Site Dry		0	
Sep	3	9.82	0.06	3	1.95
Oct	2	9.96	0.15	2	1.76
Nov	1	10.2	NDA	1	2.43
Dec	1	10.5	0.36	1	2.43
Total	17			16	
Average		10.16	0.110		2.06
High		23.8	0.360		6.40
Low		6.35	NDA		0.451

Table B14
Radioactivity in Wells
($\mu\text{Ci/ml}$)

Site	Number of Samples	Beta 10^{-9}	Alpha 10^{-9}	Tritium 10^{-6}
City	7	4.41	0.46	1.31
Martin	6	6.66	0.21	1.26
I.S.U.	6	5.42	0.56	1.34
Total	19			
Average		5.50	0.423	1.30
High		10.5	1.08	1.98
Low		2.97	NDA	0.541

No detectable gamma activity

Table B15
Radioactivity in Bottom Sediment
(Ci/gm)

	Number of Samples	Beta 10^{-6}	Alpha 10^{-6}
<u>Upstream</u>			
1-DD-U	4	6.13	0.16
3-On-U	4	6.82	0.22
Total	8		
Average		6.47	0.19
High		7.98	0.56
Low		4.80	0.03
<u>Downstream</u>			
Outfall	4	6.90	0.18
2F-DD-D	4	7.25	0.28
4-On-D	4	6.59	0.27
8-Sk-D	4	7.87	0.37
Total	16		
Average		7.15	0.28
High		10.2	0.68
Low		5.29	0.06
<u>Control</u>			
9-CC	3		
Average		6.01	0.13
High		6.82	0.24
Low		5.43	0.045

Table B16
Gamma Analysis of Bottom Sediment
(10^{-9} $\mu\text{Ci/gm}$)

Upstream Site	Number of Samples	Cs-137
1-DD-U	3	NDA
3-On-U	4	23.6
Total	7	
Average		13.5
High		60.3
Low		3.42
Downstream Site		
2F-DD-D	4	18.9
4-On-D	4	NDA
8-Sk-D	4	7.2
Total	12	
Average		8.72
High		46.5
Low		28.8
Control Site		
9-CC	3	
Average		NDA
High		NDA
Low		NDA
Outfall		
Site 2R	4	
Average		6.0
High		24.0
Low		NDA

Distribution List

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