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ENVIRONMENTAL MONITORING

AT AMES LABORATORY:

Calendar Year 1975

MASTER

Milo D. Voss

AMES LABORATORY, USERDA

IOWA STATE UNIVERSITY

AMES, IOWA

Date of Transmittal: April 1976

PREPARED FOR THE U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
UNDER CONTRACT W-7405-eng-82

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Prepared for the U.S. Energy Research and Development Administration
Division of Research

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Environmental Monitoring at Ames Laboratory:
Calendar Year 1975

ABSTRACT

This is an annual report summarizing the effluent and environmental monitoring program at the Ames Laboratory of the United States Energy Research and Development Administration.

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 and certain chemicals 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.

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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. Effluent and environmental water were also monitored for chemical constituents which could be present from ALRR operations.

Air sampling showed that the isotopes detectable by gamma analyses in the ALRR stack effluent were lower in concentration than isotopes in the environmental air samples. Therefore, ALRR operations did not contribute anything to the particulate gamma activity in the atmosphere. Radioisotopes that were above background in the stack were radioactive hydrogen (H-3 or tritium) and radioactive argon (AR-41). The average individual dose from AR-41 and H-3 at the exclusion fence was estimated to be 3.56 mrem for 1975, 0.7% of that derived from the concentration guide. The estimated dose to the entire population with a 50 mile radius of the ALRR was 180.0 man-Rem, 0.18% of that derived from the concentration guide (1).

In the liquid released from the ALRR complex, H-3 was the predominant isotope. With respect to the percentage of the concentration guide value, H-3 was a factor of 10 higher than any other constituent. Before stream dilution the average individual dose from H-3 was 2.2% of the dose derived from the concentration guide. After mixing in the receiving stream the potential dose was not more than 0.06% of that derived from the concentration guide (1).

The ALRR has operated calendar 1975 under an interim National Pollutant Discharge Elimination System (NPDES) permit issued by the Environmental Protection Agency. The pH effluent limit of 10.0 was exceeded by 0.2 in

one of 497 samples (NPDES permit requires 12 samples). The highest pH value observed in Onion Creek downstream from the ALRR effluent was 8.8.

The daily maximum discharge limit for zinc was 0.12 Kg/day. This was exceeded in one of 51 samples by 10 grams. The daily maximum concentration, 2 mg/l, was never exceeded. All remaining NPDES conditions were satisfied. The final NPDES permit will have an effluent limit for hexavalent chromium. Ames Laboratory is presently meeting the instream limits for hexavalent chromium set by the State of Iowa. Samples taken in Onion Creek downstream from the ALRR effluent confluence point averaged 0.02 mg/l in hexavalent chromium, 40% of Iowa's standard. The non-radiological impact of ALRR operations on Onion Creek and subsequent streams is negligible.

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 40 acre site approximately (Figure 1, page 34) 1.5 miles northwest of the I.S.U. campus (Figure 2) and 3 miles west and north of downtown Ames (City Hall). The site of the ALRR is about 1,000 feet above sea level and is enclosed by an exclusion fence at 700 feet or more centered on the reactor. The nearest non-residential building (I.S.U.) is about 800 feet east of the reactor and the nearest residential lot is about 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 100 feet above the river flood plain. The general area is about 900 feet above sea level. The City of Ames covers 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 2 mile radius of the Ames Laboratory Research Reactor. Within the 2 mile circle the land usage is 33% residential (Ames and ISU), 25% wooded, and 42% agricultural.

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

*From 1970 census

annual temperature is 49° F. The average annual precipitation is 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 18-20 miles/hour; in the warmer months winds are from the southeast sector averaging 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 between the least time or frequency and the greatest time is about a factor of two.

The average wind speed at 10 feet above the ground is estimated as 4.0 meters/sec (9 miles/hr) and at 100 feet it is 5.8 meters/sec (13 miles/hr).

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 the Skunk. Water is pumped for storage and distribution from a number of wells which are 100-130 feet deep. The city of Ames pumped $1,525 \times 10^6$ gallons from the well field in 1975. In addition, Iowa State University pumped 560×10^6 gallons in the same period, making the total pumped from the well field $2,085 \times 10^6$ gallons. 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 at Oskaloosa, Iowa, 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	7 miles east
Ankeny	9,000	22 miles south
Boone	12,500	13 miles west
Story City	2,100	14 miles north

The capitol of Iowa, Des Moines, population 201,400* lies 30 miles south of Ames. Fort Dodge, 31,000*, one of our sampling locations, lies 43 miles northwest of Ames (Figure 4).

The total population within a circle of 50 mile radius is 590,500*.

*From 1970 census

The Ames Laboratory Research Reactor is fueled with uranium-235, with circulating heavy water as the coolant and moderator. The primary coolant, heavy water (D_2O), is circulated through the reactor in a closed system with a heat exchanger. The secondary heat removal system uses city supplied softened water circulated through the heat exchanger and an open cooling tower.

The reactor operates at 5,000 kilowatts thermal power level on a continuous schedule. The reactor produces up to 10^{14} neutrons/cm²/sec in various experimental facilities. The principal uses of the reactor are the production of fission products which are separated and studied, the irradiation of crystals for the study of structures and energy levels by neutron diffraction, the irradiation of materials, especially metals, for the study of radiation effects, the production of radioisotopes which are used in a variety of tracer studies, and activation of elements in materials for analytical studies.

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 re-use, Class C or better water for release to the environment, and packaged solid waste for shipment to a radioactive waste burial site.

The laboratories associated with the reactor and 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.

The principal potential sources for release of radioisotopes and chemicals to the environment are the research reactor and the waste disposal/decontamination facility. Liquids released on the I.S.U. campus Ames Laboratory 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. The liquid effluents from the reactor site are monitored at a single outfall site where all such wastes are released.

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 (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 I 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 (4). 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 I are typical yearly averages which appear in each media type group; that is, air, water, soil and vegetation.

Table 1
95% Confidence Limits

<u>Media Type</u>	<u>Sample Size</u>	<u>Count Time</u>	<u>Average Activity ($\pm 2\sigma$)</u>
<u>Beta</u>			
Air	152 m ³	50 min	0.098 (± 0.0094) $\times 10^{-12}$ $\mu\text{Ci/ml}$
Water	1 l	30 min	6.07 (± 1.35) $\times 10^{-9}$ $\mu\text{Ci/ml}$
Soil, Bottom Sediment	4 g	30 min	10.33 (± 0.71) $\times 10^{-6}$ $\mu\text{Ci/ml}$
Vegetation	0.8 g	30 min	22.83 (± 2.50) $\times 10^{-6}$ $\mu\text{Ci/ml}$
<u>Alpha</u>			
Air	Same as Beta		0.0027 (± 0.0037) $\times 10^{-12}$ $\mu\text{Ci/ml}$
Water			0.59 (± 0.76) $\times 10^{-9}$ $\mu\text{Ci/ml}$
Soil, Bottom Sediment			0.66 (± 0.26) $\times 10^{-6}$ $\mu\text{Ci/ml}$
Vegetation			0.42 (± 0.90) $\times 10^{-6}$ $\mu\text{Ci/ml}$
<u>Tritium</u>			
Water			2.08 (± 0.50) $\times 10^{-6}$ $\mu\text{Ci/ml}$

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 (4).

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} $\mu\text{Ci/ml}$	Soil, Bottom Sediment 10^{-9} $\mu\text{Ci/g}$	Vegetation 10^{-6} $\mu\text{Ci/g}$
Beta	4.80	1.00	250.	2.07
Alpha	3.20	0.39	100.	0.78
Tritium	--	500	--	0.36*
Ag-110m	0.32	0.30	22.4	
Be-7	1.46	1.71	154.	
Ce-141	0.95	0.13	16.3	
Ce-144	0.58	0.66	65.3	
Co-60	0.31	0.37	30.0	
Cs-134	0.18	0.18	13.4	
Cs-137	0.22	0.27	23.1	
Na-22	0.27	0.32	27.4	
Nb-95	0.18	0.26	23.3	
Ru-103	0.16	0.19	17.5	
Ru-106	3.86	4.68	385.	
Zn-65	0.54	0.52	37.6	
Zr-95	0.36	0.43	40.3	

*Based on the average moisture content of 72%.

With respect to the gamma detection limits, typical counting times were 1333.3 minutes. Sample volumes for air and water were 1.50×10^{10} ml and 2.2×10^4 ml, respectively. Sample mass for soil and bottom sediment averaged 400 grams.

The non-radiological detection limits are shown in Table 3. Values less than the detection limits can be obtained. However, the values will be significantly less accurate since more judgement on the part of the analyst is needed.

Table 3

Detection Limits, Non-Radiological

Chloride	2.5 mg/l
Hexavalent Chromium	0.05 mg/l
Zinc	0.1 mg/l
Turbidity	0.01
Flow	1 l/min
BOD	0.25 mg/l
Fecal Coliform	1 organism/100 ml

High All highs given in this report are individual sample highs.

Low All lows given in this report are individual sample lows.

NDA No detectable activity.

IV. Radiological Monitoring Program

The Ames Laboratory radiological program monitors effluent (air particulate and water), environmental air particulate, river, pond, well, precipitation, soil and vegetation samples 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 Nuclear Data 4096 Channel Gamma spectrometer with a high resolution Ge(Li) detector. A computer program based on ICPEAX (5) is used to determine peak energies and areas based on a gaussian fitting routine.

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:

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

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.

The tritium activity is determined on a 5 ml sample using a dioxane-naphthalene cocktail and a Beckman Scintillation Counter. The tritium activity concentration is also calculated using Equation 1.

A. Effluents

Air

Stack air particulate samples are collected on 2 inch Whatman #41 filter paper using a Gast pump with a flow rate of 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) Sampling is continuous with the filters being changed every working day, (2) both sample and stack flow rates are recorded, (3) gross beta and alpha activity is determined with the Sharp System after a seven day holding period, (4) gamma analysis is performed on quarterly composites of the daily samples. The Ar-41 is continuously monitored with readings taken hourly during reactor operations. The Ar-41 detector, a geiger mueller type, is calibrated twice a year. The H-3 effluent is an estimate based on the loss of primary coolant for the year and its average H-3 concentration.

The activity concentration in the ALRR stack for 1975 is shown in Table 4. The stack volume for 1975 was 2.38×10^{14} ml.

Table 4

ALRR Stack Effluent

($\mu\text{Ci/ml}$)

<u>Isotope</u>	<u>Concentration</u>
Gross Beta	5.20×10^{-14}
Gross Alpha	2.10×10^{-15}
Ar-41	3.35×10^{-5}
Bc-7	3.79×10^{-14}
Ce-144	6.10×10^{-15}
Cs-137	1.34×10^{-15}
H-3	3.14×10^{-6}
Nb-95	1.27×10^{-15}
Zr-95	4.11×10^{-15}

Water

Water samples are collected twice daily, except weekends and holidays from the ALRR outfall, discharge point for the ALRR complex (Site 2R, Figure 1). Alpha and beta activity is determined by evaporating a 1 liter sample into a 3 inch aluminum planchet and counting in a Sharp Low Beta-matic. Tritium is determined on a 5 ml sample with a Beckman Scintillation Counter and dioxane-naphthalene cocktail. Gamma scan analyses were performed on monthly composites of the morning outfall samples, AM, and afternoon samples, PM. The Concentration Guides (CG's) are summarized in Appendix A. See Appendix B for a monthly summary of the outfall results. A summary for 1975 is shown in Table 5.

Table 5
Radioactivity in the ALRR Outfall
($\mu\text{Ci/ml}$)

	Number of Samples	Concentration	% CG	High	Low
Gross Beta, 10^{-9}	499	7.34	0.24	22.5	1.26
Gross Alpha, 10^{-9}	499	0.13	0.43	2.82	NDA
H-3, 10^{-6}	493	13.3	0.44	1440.0	1.19
Co-60, 10^{-9}	composites	0.73	0.0024	3.72	NDA
Cs-137, 10^{-9}	composites	0.25	0.0012	1.22	NDA

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 on 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 released to the environment in 1975 is shown in Table 6.

The average outfall flow rate for 1975 was 58 liters per minute. This yields a total volume for 1975 of 3.0×10^{10} ml. Table 6 concentrations reflect the total isotopic amount divided by the total volume. The concentration guides for release to an uncontrolled area appear in Appendix A.

Table 6

Liquid Radioactive Waste Released to the Environment

<u>Isotope</u>	<u>Amount, μCi</u>	<u>Concentration, $\mu\text{Ci/ml}$</u>	<u>% CG</u>
Gross Beta	28.9	9.63×10^{-10}	3.2×10^{-2}
Gross Alpha	1.58	5.27×10^{-11}	1.8×10^{-1}
Ag-110m	1.83	6.10×10^{-11}	2.0×10^{-4}
Ce-141	0.0526	1.75×10^{-12}	1.9×10^{-6}
Ce-144	0.414	1.38×10^{-11}	1.4×10^{-4}
Co-60	2.60	8.67×10^{-11}	2.9×10^{-4}
Cs-134	0.234	7.80×10^{-12}	8.7×10^{-6}
Cs-137	3.12	1.04×10^{-10}	5.2×10^{-4}
H-3	1.94×10^6	6.47×10^{-6}	2.2
Zn-65	0.157	5.23×10^{-12}	5.2×10^{-6}

In monitoring effluent from the I.S.U. campus facilities, the Ames Water Pollution Control Plant (Site 11R, Figure 3) effluent is 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.

Table 7

Radioactivity in the Water Pollution Control Plant Samples (11-Sk-S)

(μCi/ml)

	<u>Number of Samples</u>	<u>Beta, 10⁻⁹</u>	<u>% CG</u>	<u>Alpha, 10⁻⁹</u>	<u>% CG</u>	<u>Number of Samples</u>	<u>Tritium, 10⁻⁶</u>	<u>% CG</u>
Plant Effluent (Site R11)	53					35		
Average		11.6	0.39	0.22	0.75		2.32	0.077
High		18.8		1.08			4.93	
Low		4.2		NDA			0.29	
Sludge Soluble Portion	12							
Average		47.0		1.60			Not Determined	
High		170.		6.61				
Low		17.6		NDA				
Sludge Insoluble Portion	12							
Average		146.		20.7			Not Determined	
High		259.		37.2				
Low		56.3		7.31				
Sludge--Ft. Dodge								
Soluble	1	96.8		6.01			Not Determined	
Insoluble	1	421.		81.1			Not Determined	

The result of gamma analyses on the Ames sludge and the Fort Dodge sludge shows no detectable gamma activity. Cs-137 was detected in the third quarter's effluent (liquid, Site R11) composite sample, 0.60×10^{-9} $\mu\text{Ci/ml}$. This yielded an average Cs-137 activity of 0.15×10^{-9} $\mu\text{Ci/ml}$ (7.5×10^{-4} % CG) for 1975.

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 3 inch diameter filter paper using a Gast pump with a flow rate of 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 1975 composites is summarized in Table 8 and shown quarterly in Appendix B, Tables B2 and B4. The gross beta and alpha activity is summarized in Table 9 and shown monthly in Appendix B, Tables B1 and B3.

Table 8

Gamma Analysis of Air Samples

(10⁻¹⁰ μ Ci/ml)

Isotope	ALRR--Site 1A		Spedding Hall--Site 2A	
	Ave	% CG	Ave	% CG
Be-7	60.54	1.5×10^{-4}	79.14	1.9×10^{-4}
Ce-141	NDA		0.27	5.4×10^{-6}
Ce-144	11.80	5.9×10^{-3}	14.88	7.4×10^{-3}
Cs-137	2.03	4.1×10^{-4}	2.07	4.1×10^{-4}

Table 8 Continued

<u>Isotope</u>	<u>ALRR--Site 1A</u>		<u>Spedding Hall--Site 2A</u>	
	<u>Ave</u>	<u>% CG</u>	<u>Ave</u>	<u>% CG</u>
Nb-95	6.60	2.2×10^{-4}	8.32	2.8×10^{-4}
Ru-103	0.40	1.3×10^{-6}	0.49	1.6×10^{-6}
Ru-106	5.14	2.6×10^{-3}	6.35	3.2×10^{-3}
Zr-95	1.76	1.8×10^{-4}	3.52	3.5×10^{-4}

Table 9

Radioactivity in Air

 $(10^{-12} \mu\text{Ci/ml})$

	<u>Number of Samples</u>	<u>Beta</u>	<u>% CG</u>	<u>Alpha</u>	<u>% CG</u>
ALRR--Site 1A	242				
Average		0.057	0.06	0.0016	8.0
High		0.304		0.0101	
Low		0.005		NDA	
Spedding Hall-- Site 2A	180				
Average		0.073	0.07	0.0024	12.0
High		0.301		0.0136	
Low		0.009		NDA	

Precipitation Samples

Precipitation samples are collected on an "as it happens basis" near the weather observation tower on the ALRR Site. The samples are evaporated to dryness and counted for gross alpha and beta activity. A 5 ml sample is used for tritium analysis. Gamma analysis is performed on a quarterly composite. The monthly and quarterly data are presented in Appendix B, Tables B21 and B22, and summarized in Table 10. The total number of samples for 1975 was 27.

Table 10
Radioactivity in Precipitation
($\mu\text{Ci/ml}$)

	<u>Average</u>	<u>% CG</u>
Beta,	27.21×10^{-9}	0.9
Alpha,	2.16×10^{-9}	7.2
Be-7,	4.30×10^{-9}	2.2×10^{-4}
Ce-144,	2.29×10^{-9}	2.3×10^{-2}
Co-60,	0.06×10^{-9}	2.0×10^{-4}
Cs-137,	0.39×10^{-9}	4.0×10^{-3}
H-3,	2.17×10^{-6}	7.2×10^{-2}

River Water Samples

River water samples are collected weekly and analyzed for tritium activity and gross alpha and beta activity. Samples are obtained from each river or creek (Onion Creek Gulch → Onion Creek → Squaw Creek → Skunk River) in the flow route of the ALRR drainage system. In addition, two samples (Clear Creek and Des Moines River) are obtained from streams outside the ALRR flow route. These constitute control samples and are numbered nine and ten in the data. Samples are obtained whenever possible. Some of 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. Gamma analysis is performed on quarterly composites of the weekly samples. The sample results are summarized in Table 11.

Table 11
Radioactivity in River Water
($\mu\text{Ci/ml}$)

	<u>Number of</u> <u>Samples</u>	<u>Beta</u> <u>10^{-9}</u>	<u>% CG</u>	<u>Alpha</u> <u>10^{-9}</u>	<u>% CG</u>	<u>Number of</u> <u>Samples</u>	<u>Tritium</u> <u>10^{-6}</u>	<u>% CG</u>
<u>Downstream</u>								
<u>Sites 4R, 6R, 8R</u>								
Soluble	120					94		
Ave		6.07	0.20	0.59	2.0		2.08	0.069
High		28.1		1.74			5.32	
Low		2.84		NDA			0.31	
Insoluble	7							
Ave		18.1		1.53				
High		36.6		2.40				
Low		7.30		0.84				
<u>Upstream</u>								
<u>Sites 1R, 3R, 5R, 7R</u>								
Soluble	179					130		
Ave		5.73	0.19	0.59	2.0		2.27	0.076
High		23.65		2.10			7.45	
Low		0.99		NDA			0.13	
Insoluble	9							
Ave		18.35		2.11				
High		34.41		5.16				
Low		8.92		0.84				
<u>Control</u>								
<u>Sites 9R, 10R</u>								
Soluble	98					64		
Ave		6.36	0.21	0.50	1.7		2.22	0.074
High		19.14		1.86			4.84	
Low		1.49		NDA			0.43	
Insoluble	3							
Ave		12.37		5.26				
High		13.78		12.67				
Low		10.00		1.38				

Gamma analysis for River Sites 1R,3R,4R,8R,10R yielded one detectable isotope, Cs-137 in second quarter composite Site 10R, $0.26 \times 10^{-9} \mu\text{Ci/ml}$, and fourth quarter composite Site 8R, $0.21 \times 10^{-9} \mu\text{Ci/ml}$.

Soil Samples

Soil samples are collected once each year. Circles surrounding the ALRR site were divided into quadrants on the basis of wind frequencies. The annuli were chosen on the basis of simplicity for defining sampling areas. One sample was taken in each sector of each annulus (see Figures 1-4).

Reference samples were collected at Fort Dodge, Iowa. The number-letter designations on the data sheets are our codes for sample locations. One-quart samples are collected from the 0-2 inches of top soil. The samples are completely dried in a 100°C drying oven and mixed thoroughly, with large stones and roots being removed. A 3-4 gram counting sample is made from the dried soil, placed in a 3-inch aluminum planchet and counted directly in the Sharp System for gross alpha and beta activity.

Table 12

Radioactivity in Soil Samples

($10^{-6} \mu\text{Ci/g}$)

	Number of Samples	Beta			Alpha		
		Ave	High	Low	Ave	High	Low
Sites 1S-12S	12	10.33	12.03	7.68	0.66	1.14	0.36
Sites 13S-24S	12	10.09	11.50	8.07	0.78	1.04	0.38
Fort Dodge	2	11.42	11.51	11.33	0.85	0.89	0.81

Gamma analysis on Soil Sites 1S-12S yielded an average Cs-137 activity of $3.6 \times 10^{-7} \mu\text{Ci/g}$ with no detectable Co-60 activity. The Fort Dodge control sites had a Cs-137 activity of $2.65 \times 10^{-7} \mu\text{Ci/g}$ with no detectable Co-60 activity. Gamma analyses were not performed on Site 13S-24S.

Vegetation

Vegetation samples are collected once each year. Samples are obtained at soil sample locations which are designated SV (see Figures 1-3) and Fort Dodge (Figure 4). Date of collection is correlated to the maximum growth period which is July to August for this area. Samples are not collected directly after precipitation of any kind to minimize surface contamination. Generally, the vegetation is confined to grasses with none of the root system included in the sample. Corn samples were obtained at Soil Sites 2S, 8S, 10SV, 12SV (Figure 2) and Fort Dodge (Figure 4).

For each sample, one portion is used to determine moisture content and gross alpha and beta activity. These samples are dried, ground to a fine powder, and weighed into 0.8 gram counting samples on 3-inch aluminum planchets. Samples are counted for gross alpha and beta activity in the Sharp System. The other portion is frozen for freeze-drying at a later time. The tritium concentration is determined by liquid scintillation counting on the water obtained in the freeze-drying operation. The tritium concentration determined by this method represents only the tritium which is in the plant in the form of molecular water. The vegetation sampling results are summarized in Table 13.

Table 13
Radioactivity in Vegetation
(10^{-6} $\mu\text{Ci/g}$)

	<u>Number of Samples</u>	<u>Beta</u>	<u>Alpha</u>	<u>Tritium</u>
<u>General Vegetation</u>				
Sites 3SV,9SV,10SV,11SV,12SV	5			
Ave		22.83	0.42	1.82
High		30.24	1.28	2.08
Low		17.06	NDA	1.61
Sites 13SV,15SV,17SV,19SV	7			
Ave		23.13	0.43	1.69
High		27.65	0.90	2.14
Low		14.53	0.08	1.15
Fort Dodge	2			
Ave		19.60	0.30	1.66
High		21.57	0.45	1.72
Low		17.62	0.15	1.59
<u>Corn</u>				
Sites 2S,8S,10SV,12SV	4			
Ave		17.10	0.21	2.05
High		28.10	0.38	3.00
Low		11.88	NDA	1.59
Fort Dodge	1	7.15	NDA	1.32

Pond Water

Pond water samples are collected monthly from three sites: The George Todd site four miles northeast of the ALRR; the Izaak Walton League site three miles east of the ALRR; and the Kelley site six miles south of the ALRR. The sample size is one liter and is handled in the same manner as the river water samples. Gamma analysis on yearly composites, 12 samples, yielded 0.17×10^{-9} $\mu\text{Ci/ml}$ of Cs-137 (8.5×10^{-4} % CG) in the Izaak Walton League pond water.

Table 14
Radioactivity in Pond Water
($\mu\text{Ci/ml}$)

	<u>Number of Samples</u>	<u>Beta 10^{-9}</u>	<u>% CG</u>	<u>Alpha 10^{-9}</u>	<u>% CG</u>	<u>Tritium 10^{-6}</u>	<u>% CG</u>
Ave	36	8.36	0.28	0.47	1.6	2.52	0.084
High		24.55		1.86		9.01	
Low		2.30		NDA		0.56	

Well Water Samples

Well water samples are obtained monthly from City of Ames wells, Iowa State University (I.S.U.) campus wells, and from a personal farm well (Martin) at a location two miles north of the ALRR. A control well water sample is obtained yearly from the Fort Dodge city wells. The sample size is one liter and is handled in the same manner as the river water samples. No gamma activity was observed on the yearly composites of the well samples.

Table 15
Radioactivity in Well Water Samples
($\mu\text{Ci/ml}$)

	<u>Number of Samples</u>	<u>Beta 10^{-9}</u>	<u>% CG</u>	<u>Alpha 10^{-9}</u>	<u>% CG</u>	<u>Tritium 10^{-6}</u>	<u>% CG</u>
Ave	36	4.94	0.16	0.37	1.2	2.49	0.083
High		6.89		0.84		10.48	
Low		2.97		NDA		1.13	
Ft. Dodge	1	13.96	0.47	1.80	6.0	1.74	0.058

Bottom Sediment

Bottom Sediment samples are obtained at or near the river water and pond water sites on a quarterly basis. Samples are analyzed for gross alpha and beta activity. A one-quart sample is obtained from the top 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 1975 are shown in Table 16 and Table B23.

Table 16
Radioactivity in Bottom Sediments
(10^{-6} $\mu\text{Ci/g}$)

	<u>Number of Samples</u>	<u>Ave</u>	<u>Beta High</u>	<u>Low</u>	<u>Ave</u>	<u>Alpha High</u>	<u>Low</u>
Ponds	12	9.14	13.40	5.90	0.47	0.93	0.20
Downstream sites 2R, 4R, 6R, 8R	16	7.78	10.61	5.19	0.34	0.83	0.04
Upstream sites 1R, 3R, 5R, 7R	16	7.86	9.66	6.56	0.27	0.47	0.03
Control sites 9R, 10R	8	7.84	11.58	6.08	0.46	1.01	0.10

Gamma analysis on the bottom sediment samples (200-600 grams) yielded detectable amounts of Co-60 and Cs-137. The Co-60 was present only in Site 2R, immediately below the ALRR outfall. The average Co-60 concentration was 1.23×10^{-7} $\mu\text{Ci/g}$. The presence of Co-60 is probably due to ALRR operations. It was not found in samples from any other bottom sediment site. The Cs-137 activity concentration averaged 16.9×10^{-9} $\mu\text{Ci/g}$ in three upstream sites, 38.2×10^{-9} $\mu\text{Ci/g}$ in three downstream sites, 178×10^{-9} $\mu\text{Ci/g}$ in Control Site 10R and 370×10^{-9} $\mu\text{Ci/g}$ in the ponds. It is evident from a comparison of the upstream, control site and pond results to the downstream results that the presence of Cs-137 is not due to ALRR operations.

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 argon, Ar-41, and 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 (5) the estimates have been made for the radiation dose at the exclusion fence. The man-Rem dose for the population within a 50 mile radius of the reactor has been estimated using a cylindrical diffusion volume with a 50 mile radius and a height of 1,000 feet. The height used in the 1974 report was 2,000 feet.

Average Individual Dose at Fence Line for 1975

	Millirem
Ar-41	3.4
H-3 (tritium)	<u>0.06</u>
TOTAL	3.46

The 50 mile Man-Rem Dose for 1975 (590,500 population)

	Man-Rem
Ar-41	2.8
H-3 (tritium)	<u>178.</u>
TOTAL	180.8

The concentration guide value for an average dose taken as 0.5 Rem/3 = 0.17 Rem yielded 100,385 man-Rem for the population within 50 miles. Thus the man-Rem dose due to Ames Laboratory operation was .0018 or 0.18% of the CG.

Using the concentration guide value of 500 mrem for an individual at the exclusion fence, the ratio was 0.007, 0.7% of the CG.

The apparent reversal in the Ar-41 and H-3 doses under the two conditions above was due to the decay of Ar-41 during the diffusion time to distribute the Ar-41. The models for the fence line case and the 50 mile radius case were also different. The doses were based on the relationship of the concentration guide level exposure to the radiation protection standard in ERDA Manual Chapter 0524.

There are no realistic models for the exposure due to the concentrations of radionuclides in the streams. Based on the H-3 released as waste during 1975 in the outfall, Table 6, before stream dilution, the average individual dose was 2.2% of the dose derived from the concentration guide. After mixing in the receiving stream the potential dose was not more than 0.06% of that derived from the concentration guide. H-3 has the highest percentage of the concentration guide, by a factor of 10, of any of the radioactive waste constituents shown in Table 6.

V. Non-Radiological Monitoring Program

A. Effluents

Effluent water samples are collected twice daily at the ALRR outfall. A Beckman pH Meter is used to determine the pH of each sample. The effluent temperature is determined daily with a standard mercury centigrade thermometer when the first sample is obtained. This thermometer, -20°C to 110°C in 1°C increments, has been checked for accuracy against a 0°C to 50°C in 0.1°C increments laboratory thermometer. The flow rate is determined daily by measuring the time needed to fill a container of known volume.

Weekly effluent samples are collected for chloride, hexavalent chromium, zinc and turbidity measurements. The hexavalent chromium and zinc determinations are made as soon after sampling as time permits usually within one to two days. The hexavalent chromium and zinc analyses are performed with a Hach DR Colorimeter using Hach's procedures and chemicals. Hach's hexavalent chromium analysis is based on the 1,5-Diphenylcarbohydrazine method (7). The zinc analysis is based on the Zincon method (7). The chloride and turbidity determinations are performed after a number of samples have been collected. The turbidity is determined using a Hach Turbidimeter. The chloride determination is a Hach Chemical Company procedure based on the mercuric nitrate method (7).

The 5 day biochemical oxygen demand (BOD) and fecal coliform analysis are performed monthly. The BOD sample is a flow weighted mixture of several samples taken throughout the day. The procedures in Standard Methods (3) are followed for the BOD determination. The fecal coliform sample is a grab sample taken in a sterile glass bottle. The membrane

filter technique employing grided membrane filter paper and sterile M-FC broth ampoules from Millipore is used for the fecal coliform determination.

A summary of the non-radiological effluent data is shown in Table 17.

A monthly breakdown of these results appears in Appendix C.

Table 17
Non-Radiological Effluent Results
1975

	<u>Number of Samples</u>	<u>Average</u>	<u>High</u>	<u>Low</u>
Chlorides	51	564 mg/l	3095 mg/l	40 mg/l
Chromium (hexavalent)	51	0.57 mg/l	1.90 mg/l	0.01 mg/l
Zinc	51	0.18 mg/l	1.00 mg/l	0.00 mg/l
Turbidity	51	4.6	58	0.40
pH	497	7.6	10.2	6.2
Temperature	241	22°C	33°C	2°C
Flow	177	58 l/min	333 l/min	4 l/min
Biochemical Oxygen Demand (5-day)	7	1.9 mg/l	5.8 mg/l	0.1 mg/l
Fecal Coliform	9	48 /100 ml	130 /100 ml	1 /100 ml

B. Environmental (Non-Radiological)

The hexavalent chromium concentration and pH were determined for samples from Sites 3R (Upstream) and 4R (Downstream) (Figure 2). The sampling and analytical procedures are as described previously. Site 4R was dry from September to December, therefore, no analysis could be performed. The summary for 1975 is shown in Table 18 with a monthly breakdown in Appendix C.

Table 18

Non-Radiological Environmental Results

	<u>Number of Samples</u>	<u>Average</u>	<u>High</u>	<u>Low</u>
Site 3R--Upstream				
Chromium (hexavalent)	34	0.01 mg/l	0.025 mg/l	0.0 mg/l
pH	31	8.0	9.0	7.6
Site 4R--Downstream				
Chromium (hexavalent)	34	0.02 mg/l	0.025 mg/l	0.00 mg/l
pH	31	8.0	8.8	7.4

C. Impact (Non-Radiological)

The upstream and downstream averages for hexavalent chromium were 0.01 mg/l and 0.02 mg/l, respectively, indicating a small contribution of hexavalent chromium to Onion Creek by ALRR operations. The downstream value, 0.02 mg/l, is 40% of Class C Standards. The upstream and downstream pH averages were equal indicating no significant pH contribution.

All ALRR effluent samples were within the NPDES interim effluent limits with the exception of two. One of 497 pH samples read 10.2, 0.2 higher than the limit of 10.0. The daily quantity limit for zinc discharged was exceeded in one of 51 determinations. The daily quantity limit, 0.12 Kg/day, was exceeded by 10 grams, 0.13 Kg/day. The zinc concentration never exceeded the daily maximum of 2.0 mg/l. The pH averaged 7.6 and the zinc averaged 0.18 mg/l, 18% of the NPDES daily average concentration, with the daily quantity averaging 0.012 Kg/day, 20% of the NPDES daily average quantity. The highest outfall temperature recorded was 33°C, 2°C lower than the NPDES maximum of 35°C. The BOD averaged 1.9 mg/l, 6% of the NPDES average concentration. The daily BOD quantity averaged 0.14 Kg/day, 23% of the NPDES value, with the maximum quantity being 0.28 Kg/day, 35% of the NPDES value. The fecal coliform count averaged 48 organisms/100 ml with the highest being 130 organisms/100 ml. These were 24% and 32% of their respective NPDES limits.

The chloride, hexavalent chromium and turbidity results can be viewed relative to Iowa's water quality standards. However, it must be remembered that Iowa's standards are instream values and not effluent standards. The turbidity averaged 4.6 in the outfall, which is 18% of Iowa's allowed increase in stream turbidity. The hexavalent chromium which averaged 0.57 mg/l in the ALRR effluent averaged only 0.02 mg/l in samples taken in Onion Creek downstream from the drainage ditch confluence point. The instream value is 40% of Iowa's standards. The chloride content averaged 546 mg/l, 226% of Iowa's instream standards. However, if a minimum Onion Creek dilution factor of three is applied, the chloride

concentration is 75% of Class C standards. The actual Onion Creek dilution factor is estimated to be 40.

The non-radiological impact of ALRR operations on Onion Creek and subsequent streams is negligible. Of the 805 analysis performed relative to NPDES effluent limitations only two were above maximum values. In terms of the Iowa standards, considering that Onion Creek is a non-classified stream and that the standards applied were instream, Class C sources of potable water, the ALRR site is not detrimental in any way to Onion Creek and subsequent streams.

Figure 2; Environmental Sampling Sites Within Two Miles of ALRR. Map drawn to scale.

Figure 4: State of Iowa including control site, Fort Dodge. Map drawn to scale.

AIR

<u>Figure Reference</u>	<u>Symbol</u>	
1	1A	The on-site monitoring station is located approximately 400 feet south of the reactor.
2	2A	The off-site monitoring station is located on the Spedding Hall roof approximately 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.
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 1000 feet downstream from confluence point in Onion Creek.
2	5R	5-Sq-U	Site is in Squaw Creek upstream from the confluence with Onion Creek.
2	6R	6-Sq-D	Site is in Squaw Creek downstream from the Onion Creek confluence.
3	7R	7-Sk-U	Site is in the Skunk River upstream from the Squaw Creek confluence.
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	10R	10-DM	This control site is located approximately 15 miles west of the reactor in the Des Moines River.
3	11R	11-Sk-S	This is a sample of the Ames Water Pollution Control Plant effluent.

SOIL & VEGETATION

The 24 soil and vegetation sampling sites consists of six groups. Each succeeding group is further away from the ALRR, Group 1 being the nearest to the reactor. Four sites, each in a different direction (northwest, northeast, southwest, southeast) make up each group.

	<u>Figure Reference</u>	<u>Map Symbol</u>	<u>Table Symbol</u>	
Group 1:	1,2	1S	1S-SE1	Soil site, southeast
	2	2S	2S-SW1	Soil site, southwest
	1	3S	3SV-NW1	Soil and vegetation site, northwest
	1	4S	4S-NE1	Soil site, northeast
Group 2:	2	5S	5S-SE2	Soil site, southeast
	2	6S	6S-SW2	Soil site, southwest
	2	7S	7S-NW2	Soil site, northwest
	2	8S	8S-NE2	Soil site, northeast
Group 3:	2	9SV	9SV-SE3	Soil and vegetation site, southeast
	2	10SV	10SV-SW3	Soil and vegetation site, southwest
	2	11SV	11SV-NW3	Soil and vegetation site, northwest
	2	12SV	12SV-NE3	Soil and vegetation site, northeast
Group 4:	2	13SV	13SV-SE4	Soil and vegetation site, southeast
	2	14S	14S-SW4	Soil site, southwest
	2	15SV	15SV-NW4	Soil and vegetation site, northwest
	2	16S	16S-NE4	Soil site, northeast
Group 5:	3	17SV	17SV-SE5	Soil and vegetation site, southeast
	3	18S	18S-SW5	Soil site, southwest
	3	19SV	19SV-NW5	Soil and vegetation site, northwest
	3	20S	20S-NE5	Soil site, northeast

	<u>Figure Reference</u>	<u>Map Symbol</u>	<u>Table Symbol</u>	
Group 6:	3	21SV	21SV-SE6	Soil and vegetation site, southeast
	3	22SV	22SV-SW6	Soil and vegetation site, southwest
	3	23S	23S-NW6	Soil site, northwest
	3	24SV	24SV-NE6	Soil and vegetation site, northeast

PONDS AND WELLS

<u>Figure Reference</u>	<u>Map Symbol</u>	<u>Table Symbol</u>	
3	1P	Todd	The George Todd pond site is located four miles northeast of the ALRR.
3	2P	Walton	The Izaak Walton League pond site is located three miles east of the ALRR.
3	3P	Kelley	The Kelley pond site is located six miles south of the ALRR.
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 personal farm well located two miles north of the ALRR.

VI. References

1. ERDAM 0524, "Standards for Radiation Protection".
2. Iowa Departmental Rules, "Water Quality Standards," Chapter 16, Feb. 12, 1974.
3. "Standard Methods for the Examination of Water and Wastewaters", 13th Edition, 1971 American Public Health Association, New York, New York 10019.
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VIII. Acknowledgements

We wish to thank the following organizations and individuals for their cooperation, advice and assistance.

City of Ames - Water Department & Pollution Control Plant

Iowa State University - Physical Plant

Dr. A. F. Voigt, Ames Laboratory

Dr. M. D. Dougal, Director, Iowa State Water Resources Research
Institute

Dr. D. N. Yarger, Associate Professor of Climatology and
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IX. Distribution

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APPENDIX A. Applicable Standards

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

Table A1
Concentration Guides (CG's)

	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
Ag-110m	30,000	300
Ar-41	--	40,000
Be-7	2,000,000	40,000
Cc-141	90,000	5,000
Ce-144	10,000	200
Co-60	30,000	300
Cs-134	9,000	400
Cs-137	20,000	500
H-3	3,000,000	200,000
Na-22	30,000	300
Nb-95	100,000	3,000
Ru-103	80,000	3,000
Ru-106	10,000	200
Zn-65	100,000	2,000
Zr-95	60,000	1,000

Ames Laboratory has received authorization to discharge into the drainage ditch, a tributary of Onion Creek, under the National Pollutant Discharge Elimination System (NPDES). The interim NPDES effluent limitations applicable for 1975 are specified in Table A2.

Table A2
NPDES Interim Effluent Limitations

	Concentration		Quantity	
	Daily Avg.	Daily Max.	Daily Avg.	Daily Max.
Temperature	---	35°C	---	---
Biochemical Oxygen Demand (5 day)	30 mg/l	45 mg/l	0.6 Kg/day	0.8 Kg/day
Fecal Coliform (organisms/100 ml)	200	400	---	---
Zinc	1 mg/l	2 mg/l	0.06 Kg/day	0.12 Kg/day
pH	not less than 6.0 nor greater than 10.0			

Chapter 16 of the Iowa Department of Environmental Quality Rules, "Water Quality Standards" adopted February 12, 1974, provides instream guidelines for chlorides, hexavalent chromium, and turbidity. Chlorides and hexavalent chromium for Class C water, raw water source of potable water, should not exceed 250 mg/l and 0.05 mg/l, respectively, in the stream at the point of withdrawal. The turbidity of any receiving stream should not be increased by more than 25 Jackson turbidity units.

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	21	0.072	0.0013
Feb	19	0.089	0.0018
Mar	17	0.089	0.0017
Apr	22	0.109	0.0033
May	20	0.091	0.0020
Jun	21	0.051	0.0008
Jul	21	0.057	0.0012
Aug	20	0.026	0.0008
Sep	20	0.021	0.0012
Oct	23	0.025	0.0013
Nov	18	0.026	0.0018
Dec	20	0.034	0.0016
Total	242		
Average		0.057	0.0016
High		0.304	0.0101
Low		0.005	NDA

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

Quarter	Be-7	Ce-144	Cs-137	Nb-95	Ru-103	Ru-106	Zr-95
1	49.79	15.82	2.18	15.74	1.25	5.64	4.78
2	73.97	25.33	4.11	9.99	0.33	14.93	2.27
3	69.31	6.05	0.77	0.68	NDA	NDA	NDA
4	49.09	NDA	1.05	NDA	NDA	NDA	NDA
Average	60.54	11.80	2.03	6.60	0.40	5.14	1.76

Table B3
Air Site, 2A, Off-Site Station
(10⁻¹² μ Ci/ml)

	Number of Samples	Beta	Alpha
Jan	12	0.098	0.0027
Feb	11	0.116	0.0030
Mar	10	0.123	0.0040
Apr	15	0.150	0.0051
May	14	0.114	0.0034
Jun	15	0.068	0.0020
Jul	20	0.080	0.0018
Aug	18	0.036	0.0008
Sep	16	0.029	0.0016
Oct	18	0.035	0.0023
Nov	13	0.032	0.0018
Dec	18	0.043	0.0019
Total	180		
Average		0.073	0.0024
High		0.301	0.0136
Low		0.009	NDA

Table B4
Gamma Analysis Air Site 2A
(10⁻¹⁵ μ Ci/ml)

Quarter	Be-7	Ce-141	Ce-144	Cs-137	Nb-95	Ru-103	Ru-106	Zr-95
1	70.86	1.06	21.14	2.15	19.89	1.03	12.91	7.97
2	100.78	NDA	28.20	4.43	11.82	0.91	12.47	6.12
3	78.36	NDA	9.01	1.03	1.55	NDA	NDA	NDA
4	66.55	NDA	1.17	0.68	NDA	NDA	NDA	NDA
Average	79.14	0.27	14.88	2.07	8.32	0.49	6.35	3.52

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

	Number of Samples	Beta	Alpha
Jan	22	0.060	0.0020
Feb	19	0.069	0.0018
Mar	20	0.064	0.0020
Apr	22	0.091	0.0037
May	18	0.074	0.0023
Jun	21	0.054	0.0016
Jul	21	0.052	0.0018
Aug	18	0.049	0.0016
Sep	21	0.041	0.0026
Oct	23	0.024	0.0019
Nov	18	0.018	0.0012
Dec	20	0.026	0.0020
Total	243		
Average		0.052	0.0021
High		0.173	0.0237
Low		NDA	NDA

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

Quarter	Be-7	Ce-144	Cs-137	Nb-95	Zr-95
1	41.38	10.59	0.91	NDA	14.51
2	45.18	13.09	3.14	5.07	1.92
3	47.23	0.70	1.04	NDA	NDA
4	17.64	NDA	0.25	NDA	NDA
Average	37.86	6.10	1.34	1.27	4.11

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

		Number of Samples	Beta 10^{-9}	Alpha 10^{-9}	Co-60 10^{-9}	Cs-137 10^{-9}	Number of Samples	Tritium 10^{-6}
Jan	AM	22	7.80	0.07	3.72	0.93	21	5.88
	PM	22	7.69	0.02	2.17	0.52	21	6.38
Feb	AM	20	7.80	0.21	3.48	NDA	20	6.20
	PM	20	8.94	0.22	1.64	0.79	20	7.71
Mar	AM	20	7.73	0.14	NDA	NDA	18	5.33
	PM	17	8.48	0.18	NDA	NDA	15	9.71
Apr	AM	22	7.73	0.04	0.49	NDA	22	7.30
	PM	22	8.34	0.02	NDA	NDA	22	7.63
May	AM	21	7.46	0.04	0.88	NDA	21	14.0
	PM	21	8.49	0.03	NDA	NDA	21	11.0
Jun	AM	21	7.31	0.08	1.90	NDA	21	11.2
	PM	21	7.68	0.09	1.29	NDA	21	7.93
Jul	AM	22	7.37	0.05	NDA	NDA	22	66.9
	PM	21	5.64	0.05	NDA	NDA	21	6.04
Aug	AM	21	7.97	0.28	0.44	1.22	21	78.0
	PM	20	6.81	0.13	NDA	NDA	20	6.78
Sep	AM	21	6.45	0.42	0.30	0.30	21	8.11
	PM	21	7.73	0.15	0.26	0.44	21	12.1
Oct	AM	23	5.58	0.23	0.31	0.34	23	4.85
	PM	23	7.03	0.23	0.33	0.33	23	3.72
Nov	AM	18	7.18	0.06	0.34	0.69	18	4.89
	PM	18	5.90	0.09	NDA	NDA	18	4.05
Dec	AM	20	6.58	0.14	NDA	0.46	20	9.25
	PM	22	6.58	0.18	NDA	NDA	22	9.02
Total		499					493	
Average			7.34	0.13	0.73	0.25		13.3
High			22.48	2.82	3.72	1.22		1440.
Low			1.26	NDA	NDA	NDA		1.19

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

Soluble Portion

	Number of Samples	Beta, 10^{-9}	Alpha, 10^{-9}	Number of Samples	Tritium, 10^{-6}
Jan	3	2.12	0.08	1	2.23
Feb	0	Site Dry		0	
Mar	2	3.06	0.33	0	
Apr	4	1.48	0.02	1	7.45
May	5	2.52	0.22	1	3.44
Jun	4	2.15	0.23	3	4.89
Jul	3	2.27	0.24	3	4.20
Aug	0	Site Dry		0	
Sep	0	Site Dry		0	
Oct	0	Site Dry		0	
Nov	0	Site Dry		0	
Dec	0	Site Dry		0	
Total	21			9	
Average		2.21	0.17		4.49
High		4.91	0.72		7.45
Low		0.99	NDA		2.23

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

Soluble Portion

	Number of Samples	Beta, 10 ⁻⁹	Alpha, 10 ⁻⁹	Number of Samples	Tritium, 10 ⁻⁶
Jan	5	3.20	0.28	5	1.17
Feb	4	4.31	0.71	4	1.71
Mar	4	7.72	0.92	3	1.67
Apr	4	5.57	0.38	4	4.24
May	5	3.87	0.69	5	1.71
Jun	4	5.50	0.59	4	1.78
Jul	5	4.09	0.57	5	1.54
Aug	4	6.23	0.65	4	2.42
Sep	3	3.87	0.34	3	2.47
Oct	5	5.69	0.43	5	3.21
Nov	4	6.06	0.53	4	2.41
Dec	5	9.03	0.64	5	1.71
Total	52			51	
Average		5.43	0.56		2.14
High		21.49	1.62		5.92
Low		2.21	NDA		0.78

Insoluble Portion

May	1	14.32	1.68
Jun	2	9.66	1.20
Total	3		
Average		11.22	1.36
High		14.32	1.68
Low		8.96	0.84

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

Soluble Portion

	Number of Samples	Beta, 10^{-9}	Alpha, 10^{-9}	Number of Samples	Tritium, 10^{-6}
Jan	5	3.23	0.23	5	1.23
Feb	4	3.43	0.74	4	1.41
Mar	4	7.86	0.62	3	2.50
Apr	4	5.08	0.62	4	4.01
May	5	4.23	0.57	5	1.83
Jun	4	5.30	0.78	4	2.37
Jul	5	4.66	0.24	5	1.39
Aug	3	6.26	0.62	3	2.93
Sep	0	Site Dry		0	
Oct	0	Site Dry		0	
Nov	0	Site Dry		0	
Dec	0	Site Dry		0	
Total	34			33	
Average		4.89	0.52		2.11
High		17.84	1.32		5.32
Low		0.63	NDA		0.82

Insoluble Portion

May	1	19.64	1.32
Jun	2	7.46	0.87
Total	3		
Average		11.52	1.02
High		19.64	1.32
Low		7.30	0.84

Table B11
 River Site 5R
 Upstream, Squaw Creek (5-Sq-U)
 ($\mu\text{Ci/ml}$)

Soluble Portion

	Number of Samples	Beta, 10^{-9}	Alpha, 10^{-9}	Number of Samples	Tritium, 10^{-6}
Jan	5	7.49	0.24	1	0.98
Feb	4	4.85	0.75	1	1.68
Mar	4	9.58	0.92	1	1.76
Apr	4	6.22	0.81	1	4.63
May	5	4.42	0.79	1	1.93
Jun	4	9.65	1.02	3	0.72
Jul	5	6.67	0.61	5	1.31
Aug	4	6.06	0.81	4	1.70
Sep	4	4.38	0.32	4	2.68
Oct	5	6.50	0.64	5	2.79
Nov	4	5.44	0.39	4	2.14
Dec	5	6.11	0.54	5	1.88
Total	53			35	
Average		6.43	0.65		1.98
High		23.65	1.50		4.63
Low		2.34	NDA		0.13

Insoluble Portion

May	1	19.50	2.46
Jun	2	19.55	1.89
Total	3		
Average		19.53	2.08
High		30.18	2.46
Low		8.92	1.74

Table B12
 River Site 6R
 Downstream, Squaw Creek (6-Sq-D)
 ($\mu\text{Ci/ml}$)

Soluble Portion

	Number of Samples	Beta, 10^{-9}	Alpha, 10^{-9}	Number of Samples	Tritium, 10^{-6}
Jan	5	3.77	0.30	1	1.76
Feb	4	4.85	0.62	1	1.62
Mar	4	9.14	1.16	1	2.00
Apr	4	7.24	0.62	1	4.98
May	5	4.23	0.38	1	1.42
Jun	4	9.42	0.89	3	1.45
Jul	5	6.08	0.41	5	1.18
Aug	4	7.40	0.68	4	2.73
Sep	4	4.43	0.27	4	2.63
Oct	5	5.04	0.42	5	2.58
Nov	4	9.72	0.44	4	2.69
Dec	5	9.43	0.91	5	1.79
Total	53			35	
Average		6.63	0.58		2.17
High		28.06	1.74		4.98
Low		2.84	NDA		0.86

Insoluble Portion

May	1	24.32	1.44
Jun	2	25.21	2.07
Total	3		
Average		24.91	1.86
High		36.58	2.40
Low		13.83	1.44

Table B13
 River Site 7R
 Upstream, Skunk River (7-Sk-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	5	6.36	0.55	1	0.98
Feb	4	4.84	0.87	1	1.53
Mar	4	8.69	1.14	1	1.64
Apr	4	8.49	0.78	1	4.72
May	5	5.61	0.72	1	2.40
Jun	4	8.20	0.74	3	1.15
Jul	5	6.58	0.57	5	1.21
Aug	4	8.20	0.95	4	2.87
Sep	4	5.92	0.62	4	3.05
Oct	5	6.69	0.84	5	2.86
Nov	4	5.23	0.42	4	2.33
Dec	5	6.21	0.60	5	1.67
Total	53			35	
Average		6.70	0.72		2.18
High		16.31	2.10		4.72
Low		3.29	NDA		0.60

<u>Insoluble Portion</u>			
Jun	3	24.29	2.88
Total	3		
Average		24.29	2.88
High		34.41	5.17
Low		18.69	1.32

Table B14
 River Site 8R
 Downstream, Skunk River (8-Sk-D)
 ($\mu\text{Ci/ml}$)

Soluble Portion

	Number of Samples	Beta, 10^{-9}	Alpha, 10^{-9}	Number of Samples	Tritium, 10^{-6}
Jan	1	3.29	0.30	1	0.31
Feb	1	2.75	0.84	1	2.92
Mar	2	5.07	0.90	1	1.67
Apr	3	7.28	0.94	1	4.29
May	4	4.90	0.75	1	1.63
Jun	3	8.29	0.86	2	1.28
Jul	5	7.50	0.78	5	1.38
Aug	4	5.17	0.74	4	1.98
Sep	3	5.11	0.42	3	2.05
Oct	3	6.52	0.14	3	2.22
Nov	2	6.40	0.24	2	2.55
Dec	2	11.04	0.99	2	1.79
Total	33			26	
Average		6.38	0.68		1.91
High		13.29	1.38		4.29
Low		2.75	NDA		0.31

Insoluble Portion

Jun	1	17.39	2.04
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Table B15
 River Site 9R
 Control, Clear Creek (9-CC)
 ($\mu\text{Ci/ml}$)

Insoluble Portion

	Number of Samples	Beta, 10^{-9}	Alpha, 10^{-9}	Number of Samples	Tritium, 10^{-6}
Jan	5	2.78	0.10	1	0.55
Feb	4	3.51	0.51	1	1.42
Mar	4	5.61	0.83	1	2.00
Apr	4	3.53	0.35	1	4.42
May	5	4.14	0.32	1	0.81
Jun	4	5.78	0.65	3	1.28
Jul	5	3.78	0.49	5	1.44
Aug	3	7.09	0.78	3	2.06
Sep	4	6.46	0.38	4	2.86
Oct	5	7.23	0.38	5	3.51
Nov	4	4.59	0.24	4	2.98
Dec	5	5.48	0.20	5	1.77
Total	52			34	
Average		4.93	0.42		2.24
High		11.71	1.32		4.84
Low		1.49	NDA		0.55

Insoluble Portion

Jun	1	13.78	1.38
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Table B16
 River Site 10R
 Control, Des Moines River (10-DM)
 ($\mu\text{Ci/ml}$)

Soluble Portion

	Number of Samples	Beta, 10 ⁻⁹	Alpha, 10 ⁻⁹	Number of Samples	Tritium, 10 ⁻⁶
Jan	4	6.33	0.08	0	
Feb	4	6.24	0.32	1	0.99
Mar	3	13.59	1.18	1	1.42
Apr	3	10.14	0.96	0	
May	4	10.08	0.96	1	1.24
Jun	4	8.99	1.11	3	1.02
Jul	5	7.53	0.26	5	1.95
Aug	3	7.12	0.48	3	2.65
Sep	4	6.60	0.47	4	3.17
Oct	5	7.00	0.65	5	2.81
Nov	2	6.85	0.42	2	2.48
Dec	5	7.04	0.42	5	2.01
Total	46			30	
Average		7.98	0.59		2.21
High		19.14	1.86		4.51
Low		5.27	NDA		0.43

Insoluble Portion

Jun	2	11.67	7.21
Total	2		
Average		11.67	7.21
High		13.33	12.67
Low		10.00	1.74

Table B17
River Site 11R
Ames Water Pollution Control Plant Effluent (11-Sk-S)
($\mu\text{Ci/ml}$)

<u>Soluble Portion</u>					
	Number of Samples	Beta, 10 ⁻⁹	Alpha, 10 ⁻⁹	Number of Samples	Tritium, 10 ⁻⁶
Jan	5	12.00	0.07	1	2.04
Feb	4	12.99	0.30	1	1.51
Mar	4	12.24	0.32	1	1.93
Apr	4	9.68	0.06	1	4.93
May	5	8.69	0.11	1	1.76
Jun	4	8.67	0.35	3	0.95
Jul	5	7.87	0.31	5	1.42
Aug	4	11.48	0.33	4	2.43
Sep	4	13.42	0.26	4	2.48
Oct	5	13.58	0.24	5	2.78
Nov	4	14.07	0.08	4	2.86
Dec	5	14.76	0.30	5	2.80
Total	53			35	
Average		11.60	0.22		2.32
High		18.78	1.08		4.93
Low		4.19	NDA		0.29

Table B18
Cs-137* Activity in River Sites
(10⁻⁹ $\mu\text{Ci/ml}$)

Quarter	Site 1	Site 3	Site 4	Site 8	Site 10
1	NDA	NDA	NDA	NDA	NDA
2	NDA	NDA	NDA	NDA	0.26
3	NDA	NDA	NDA	NDA	NDA
4	Dry	NDA	Dry	0.21	NDA
Average	NDA	NDA	NDA	0.05	0.06

*Only detectable gamma activity

Table B19
Radioactivity in Wells
($\mu\text{Ci/ml}$)

Site	Number of Samples	Beta, 10^{-9}	Alpha, 10^{-9}	Tritium, 10^{-6}
City	12	4.65	0.36	2.64
Martin	12	5.82	0.28	2.52
I.S.U.	12	4.36	0.46	2.30
Total	36			
Average		4.94	0.37	2.49
High		6.89	0.84	10.48
Low		2.97	NDA	1.13
Fort Dodge	1	13.96	1.80	1.74

No detectable gamma activity.

Table B20
Radioactivity in Ponds
($\mu\text{Ci/ml}$)

Site	Number of Samples	Beta, 10^{-9}	Alpha, 10^{-9}	Tritium, 10^{-6}	Cs-137, 10^{-9}
Kelly	12	4.18	0.40	2.02	NDA
Todd	12	6.22	0.64	2.66	NDA
Walton	12	14.67	0.38	2.89	0.17
Total	36				
Average		8.36	0.47	2.52	0.06
High		24.55	1.86	9.01	
Low		2.30	NDA	0.56	

Table B21
Radioactivity in Precipitation
($\mu\text{Ci/ml}$)

	Number of Samples	Beta, 10^{-9}	Alpha, 10^{-9}	Number of Samples	Tritium, 10^{-6}
Jan	2	67.58	6.94	2	5.64
Feb	1	58.87	3.35	1	4.51
Mar	0			0	
Apr	4	43.18	1.12	1	2.81
May	3	18.09	0.83	3	1.96
Jun	8	10.90	0.18	8	1.02
Jul	0			0	
Aug	4	4.28	0.35	4	2.29
Sep	2	3.62	1.42	2	1.73
Oct	0			0	
Nov	1	47.70	5.35	0	
Dec	2	77.22	10.27	2	1.74
Total	27			25	
Average		27.21	2.16		2.17
High		80.84	10.63		8.77
Low		1.46	NDA		0.26

Table B22
Gamma Analysis of Precipitation
($10^{-9} \mu\text{Ci/ml}$)

Quarter	Volume (liters)	Be-7	Ce-144	Co-60	Cs-137
1	1.69	NDA	NDA	NDA	NDA
2	15.5	NDA	1.01	0.25	0.61
3	3.96	NDA	NDA	NDA	NDA
4	2.48	17.2	8.14	NDA	0.95
Average		4.30	2.29	0.06	0.39

Table B23
Radioactivity in Bottom Sediment
($\mu\text{Ci/g}$)

Site	Number of Samples	Beta 10^{-6}	Alpha 10^{-6}	Co-60 10^{-9}	Cs-137 10^{-9}
<u>Upstream</u>					
1-DD-U	4	7.65	0.21	NDA	21.4
3-On-U	4	7.47	0.23	NDA	4.5
5-Sq-U	4	8.23	0.30	NDA	24.8
7-Sk-U	4	8.08	0.35	*	*
Total	16				
Average		7.86	0.27	NDA	16.9
High		9.66	0.47		89.3
Low		6.56	0.03		NDA
<u>Downstream</u>					
Outfall	4	7.98	0.28	122.6	56.6
4-On-D	4	7.46	0.22	NDA	12.0
6-Sq-D	4	7.74	0.33	NDA	46.0
8-Sk-D	4	7.94	0.53	*	*
Total	16				
Average		7.78	0.34	40.9	38.2
High		10.61	0.83	451.	225.
Low		5.19	0.04	NDA	NDA
<u>Control</u>					
9-CC	4	6.42	0.23	*	*
10-DM	4	9.26	0.69	NDA	178.
Total	8				
Average		7.84	0.46	NDA	178.
High		11.58	1.01		517.
Low		6.08	0.10		37.1
<u>Ponds</u>					
Kelly	4	8.15	0.47	NDA	474.
Todd	4	10.89	0.67	NDA	437.
Walton	4	8.37	0.29	NDA	198.
Total	12				
Average		9.14	0.47		370.
High		13.40	0.93		1500.
Low		5.90	0.20		49.1

*Gamma analysis was not performed on these samples.

Table B24
Radioactivity in Vegetation
1975
(10^{-6} μ Ci/g)

Site	Beta	Alpha	Tritium	Per Cent Moisture
3SV-NW1	17.06	1.28	1.71	59
9SV-SE3	30.24	0.22	1.74	81
10SV-SW3	22.97	0.30	2.08	73
11SV-NW3	23.48	0.30	1.61	71
12SV-NE3	20.38	0.00	1.96	73
13SV-SE4	27.65	0.60	2.14	79
15SV-NW4	14.53	0.22	1.15	59
17SV-SE5	27.03	0.53	2.00	80
19SV-NW5	22.07	0.08	1.79	69
21SV-SE6	25.17	0.38	1.59	75
22SV-SW6	21.73	0.30	1.94	76
24SV-NE6	23.70	0.90	1.24	75
Average	23.00	0.43	1.75	72
High	30.24	1.28	2.14	81
Low	14.53	NDA	1.24	59
Fort Dodge 1	21.57	0.45	1.59	72
Fort Dodge 2	17.62	0.15	1.72	70

Table B25
Radioactivity in Corn
1975
(10^{-6} μ Ci/g)

Site	Beta	Alpha	Tritium	Per Cent Moisture
2S-SW1	28.10	0.00	3.00	79
8S-NE2	11.88	0.38	1.96	69
10SV-SW3	13.57	0.38	1.59	78
12SV-NE3	14.86	0.08	1.64	66
Average	17.10	0.21	2.05	73
High	28.10	0.38	3.00	79
Low	11.88	0.00	1.59	66
Fort Dodge	7.15	NDA	1.32	68

Table B26
Radioactivity in Soil
8-25-75
(10^{-6} μ Ci/g)

Site	Beta	Alpha	Cs-137
1S-SE1	10.98	0.80	0.54
2S-SW1	9.69	0.53	0.40
3SV-NW1	11.22	0.65	0.23
4S-NE1	10.56	0.50	0.21
5S-SE2	11.24	0.47	0.66
6S-SW2	10.30	1.14	NDA
7S-NW2	10.39	0.63	0.44
8S-NE2	12.03	0.89	0.41
9SV-SE3	10.16	0.66	0.26
10SV-SW3	9.75	0.74	0.38
11SV-NW3	7.68	0.60	0.16
12SV-NE3	9.93	0.36	0.63
13SV-SE4	11.15	0.78	*
14S-SW4	8.07	0.59	
15SV-NW4	10.05	0.66	
16S-NE4	10.18	0.93	
17SV-SE5	9.58	0.89	
18S-SW5	10.99	0.77	
19SV-NW5	10.15	0.80	
20S-NE5	11.50	0.78	
21SV-SE6	10.69	0.38	
22SV-SW6	9.70	1.04	
23SV-NW6	10.15	0.77	
24SV-NE6	8.90	0.92	
Total			
Average	10.21	0.72	0.36
High	12.03	1.14	6.60
Low	7.68	0.36	NDA
Ft. Dodge 1	11.33	0.81	0.23
Ft. Dodge 2	11.51	0.89	0.30

*Gamma analysis was not performed on Sites 13-24.

APPENDIX C. Non-Radiological Results for Specific Sites

Table C1
Chemical Analysis
ALRR Outfall (Map Site 2R)

	Number of Samples	Average mg/l			Average Turbidity
		Cl ⁻	Cr ⁺⁶	Zn ⁺²	
Jan	5	379	1.41	0.02	3.1
Feb	4	900	0.78	0.25	3.7
Mar	4	539	0.11	0.08	6.4
Apr	4	454	0.19	0.28	4.7
May	5	633	0.47	0.20	7.4
Jun	4	774	0.04	0.33	17.2
Jul	4	473	0.06	0.10	1.9
Aug	3	311	0.47	0.10	1.4
Sep	4	241	1.19	0.10	1.5
Oct	5	132	0.74	0.15	2.6
Nov	4	1536	0.48	0.45	4.7
Dec	5	488	0.66	0.05	0.72
Total	51				
Average		564	0.57	0.18	4.6
High		3095	1.90	1.00	58
Low		40	0.01	0.00	0.40

Table C2
pH and Temperature
ALRR Outfall (Map Site 2R)

	Number	pH			Number	Temperature, °C		
		Ave	High	Low		Ave	High	Low
Jan	44	7.7	8.5	6.2	22	14	22	2
Feb	40	7.7	9.1	7.1	20	16	24	10
Mar	37	7.8	8.5	6.8	18	20	25	10
Apr	43	7.6	8.2	6.5	21	20	24	13
May	42	7.4	8.2	6.6	20	22	25	10
Jun	42	7.5	8.4	6.8	21	26	28	23
Jul	43	7.5	8.4	6.8	22	28	29	25
Aug	41	7.5	8.4	6.7	21	29	33	27
Sep	42	7.5	8.2	6.7	19	28	31	23
Oct	46	7.8	10.2	6.5	22	24	27	21
Nov	36	7.8	8.9	6.8	17	24	27	20
Dec	41	7.9	8.9	7.2	18	18	25	10
Total	497				241			
Average		7.6				22		
High		10.2				33		
Low		6.2				2		

Table C3
Flow, Biochemical Oxygen Demand and Fecal Coliform Count
ALRR Outfall (Map Site 2R)

	Flow, l/min				BOD		Fecal Coliform	
	Number	Ave	High	Low	Number	mg/l	Number	Counts/100 ml
Jan	20	34	207	7				
Feb	15	22	115	5				
Mar	17	54	324	6				
Apr	17	49	83	16			1	130
May	17	59	333	17	1	1.7	1	97
Jun	12	138	300	40			1	3
Jul	19	70	273	21	1	1.1	1	1
Aug	12	101	231	27	1	1.1	1	5
Sep	15	55	158	9	1	2.2	1	128
Oct	15	65	188	13	1	1.2	1	22
Nov	8	39	80	5	1	0.1	1	21
Dec	10	17	48	4	1	5.8	1	28
Total	177				7		9	
Average		58				1.9		48
High		333				5.8		130
Low		4				0.1		1

Table C4
pH and Cr⁺⁶ Concentrations
Onion Creek, Upstream (3R) and Downstream (4R)

	pH			Cr ⁺⁶ , mg/l		
	Number of Samples	Upstream Site 3R	Downstream Site 4R	Number of Samples	Upstream Site 3R	Downstream Site 4R
Jan	5	7.8	7.8	5	0.02	0.02
Feb	3	7.9	7.9	4	0.01	0.02
Mar	3	7.8	7.8	4	0.01	0.01
Apr	3	8.0	7.8	4	0.01	0.01
May	5	7.9	7.9	5	0.01	0.02
Jun	4	8.2	8.2	4	0.01	0.02
Jul	5	8.1	8.2	5	0.01	0.01
Aug	3	7.9	7.9	3	0.01	0.01
Sep		Site 4R Dry*				
Oct		Site 4R Dry*				
Nov		Site 4R Dry*				
Dec		Site 4R Dry*				
Total	31			34		
Average		8.0	8.0		0.01	0.02
High		9.0	8.8		0.025	0.025
Low		7.6	7.4		0.0	0.0

*During this period Site 3R normally had stagnant water. Since the purpose of this study was a comparison of upstream versus downstream samples, no chromate or pH determinations were made on the samples of stagnant water collected at Site 3R.