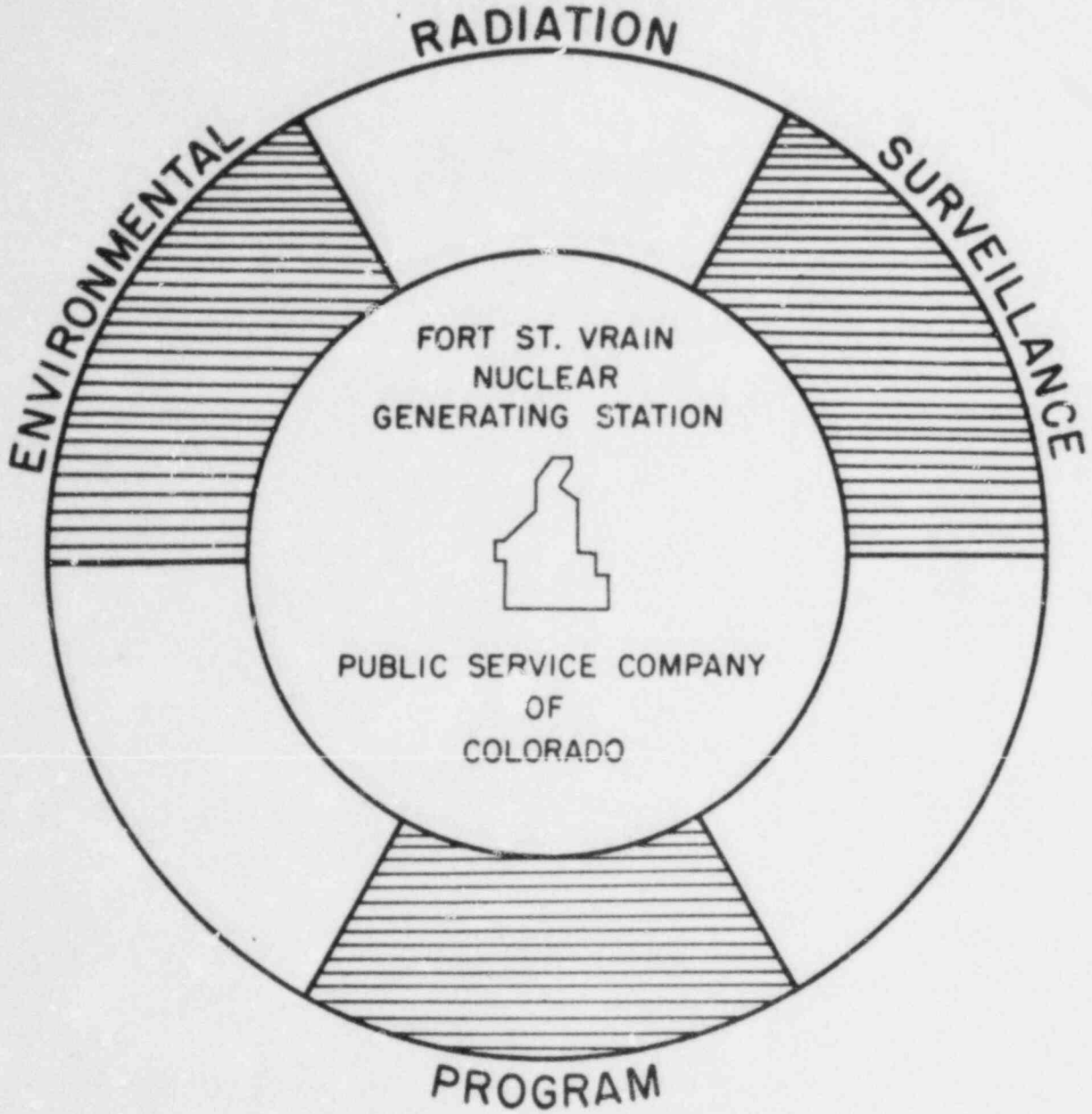

SUMMARY REPORT

THIRD AND FOURTH QUARTERS

1983

PURCHASE ORDER No. 21362

COLORADO STATE UNIVERSITY

FORT COLLINS, COLORADO 80521

ERSP SUMMARY REPORT COVER SHEET

ENVIRONMENTAL RADIATION SURVEILLANCE PROGRAM

Summary Report
for the period
July through December, 1983

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Acknowledgements

Many persons have contributed to this project during 1983 and it is important to acknowledge their effort. We also wish to thank the citizens from whose farms, homes, and ranches we collect the environmental samples. Without their cooperation the project would not be possible.

The persons working directly on the project have been:

William Carl, Jr.

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I. Introduction to Radiation Surveillance Data for the Second Half of 1983.

During the second half of 1983 the Fort St. Vrain Nuclear Generating Station produced electrical energy as follows:

Month	Dates with Electrical Generation	# of Days Without Generation	Gross Electrical Energy Generation (MWH)
July	16-31	15	34,331
August	1-31	0	140,498
September	1-30	0	144,116
October	1-29	2	135,325
November	8-30	7	100,999
December	1-8, 11-31	2	130,463

The total energy generated was 4.9 times that generated during the first half of 1983, the previous reporting period. The radioactivity released in reactor effluents, however, did not increase by that proportion. The effluent release of tritium, the major radionuclide released that is measured in this project, actually was less during the last half of 1983 than during the first half of 1983. This is due to several reasons, but principally a result of the plant shutdown during April, May, and June of 1983. A complete and detailed listing of radioactivity released by all effluent routes may be found in the Public Service Company of Colorado semi-annual Effluent Release Report to the U.S. Nuclear Regulatory Commission. When possible in this report any

correlation of radioactivity in environmental samples with the effluent release data is discussed. This analysis is found in each sample type section and in the summary section, II.H.

This report covers the last period of operation under the original environmental technical specifications. Since January 1, 1984 a revised set of technical specifications (8.0) has been in effect. Although the intent and major components of the new specifications are very similar to the previous set, there are some changes in sample numbers, types and collection frequencies. As a result this will be the last report in this identical format and that can be compared directly to previous reporting periods. Therefore, in this report, some analysis of pre-and post-operational data is provided for the major sample types.

Tropospheric fallout was a minor, but not a negligible contributor to radionuclide activities measured during this period. The most recent Chinese atmospheric nuclear weapon test was conducted in December of 1980. Air concentrations were at pretest background levels, but the resulting surface deposition of the fallout from that test was still observed. Significant tropospheric fallout from Chinese weapon tests has been observed during the entire preoperational and operational period of the reactor. The fallout measured has been extremely variable and does not allow direct comparison of preoperational and post operational data. Fallout deposition and more importantly natural background must be subtracted before any such comparisons are made.

The environmental sampling and analysis program was essentially identical to that used in the most recent reporting periods. No changes occurred during the last half of 1983.

The radioactivity concentrations measured in this project are very close to baseline concentrations and, more importantly, near the minimum detectable concentration (MDC) levels for each radionuclide and sample type. It has been well documented that even independent of the above reasons, environmental data exhibit great inherent variability. This is due to sampling and analysis variability, but principally due to true environmental or biological variability. As a result, the overall variability of the surveillance data is quite large, and it is necessary to use mean values from a large sample size to make any conclusions about the absolute radioactivity concentrations in any environmental pathway.

The resulting frequency distributions of the environmental radiation surveillance data is generally non-normal. Usually the data can be satisfactorily treated using log-normal statistics. However, when the number of observations is small, i.e., less than 10, log-normal treatment is tentative.

When a high percentage of data points is less than MDC, (the minimum detectable concentrations of activity in that sample type), calculation of true arithmetic mean values is impossible. Therefore in these reports we have chosen not to include mean values with each data table. At the end of this report in Section II.H., Conclusions and Summary, we have listed the calculated arithmetic means and confidence intervals

for the reporting period as well as for the last 12 months. We also list the geometric means and geometric standard deviations for the last year of data reporting. If any data points measured resulted in negative values, these values were used in calculating the true mean values in Table II.H.1. (negative values are possible due to the statistical nature of radioactivity counting, i.e. the observed gross sample count rate can be statistically less than the observed background count rate). This is the current accepted practice by the U.S. National Bureau of Standards. It should be noted that we have not used any footnote for values less than MDC. Rather we list the measured value as less than the actual MDC value. Because the MDC is dependent upon variables such as the sample and the background count time and sample size, the value will be different for each sample type and even within sample type.

Many sets of data were compared in this report. The statistical test used was either a "t-test" or a paired "t-test". If data sets are noted to be significantly different or not significantly different, the confidence for the statement is at the 95% level ($\alpha = 0.05$).

In this report we have added to appropriate tables the maximum permissible concentration applicable to that radionuclide. We have chosen to list the maximum permissible concentrations as found in Appendix B, Table II of 10 CFR 20. This is the concentration of any radionuclide which if ingested or inhaled continuously, would singularly produce the maximum permissible dose rate to a member of the general public. That value is 170 millirem/year, but must include the dose from all sources and routes, but excludes background radiation dose and medical radiation doses. The MPC values are given only for comparison of the

measured environmental values. As stated in 10 CFR 20 these are the maximum concentrations above natural background that a licensee may release to an unrestricted area. It is generally assumed that no direct ingestion or inhalation of effluent concentration can occur right at the restricted area boundary and that dilution and dispersion decreases the concentration before it reaches nearby residents. This is certainly the case for the Fort St. Vrain environs.

There is no specified maximum permissible dose rate or dose commitment for residents near the Fort St. Vrain reactor. Such limits for water cooled reactors are found in 10 CFR 50 Appendix I. These are judged the "As Low as Reasonably Achievable" dose rates from such reactor types and although not directly applicable to the Fort St. Vrain gas cooled reactor, can be used for comparison purposes.

A limit that does apply is the independent maximum permissible dose commitment rate set by the E.P.A. (40 CFR 190) for any specified member of the general public from any part of the nuclear fuel cycle. This value is 25 mrem/year as the dose to the whole body from all contributing radionuclides. As will be noted in this report, dose commitments are calculated for any mean concentrations noted in unrestricted areas that are significantly above control mean values.

The following is the footnote system used in this report.

a. Sample lost prior to analysis.

b. Sample missing at site.

c. Instrument malfunction.

d. Sample lost during analysis.

e. Insufficient weight or volume for analysis.

r. Sample unavailable.

g. Analysis in progress.

h. Sample not collected (actual reason given).

i. Analytical error (actual reason given).

N.A. Not applicable.

II. Surveillance Data for July through December 1983 and Interpretation Of Results.

A. External Gamma-ray Exposure Rates

The average measured gamma-ray exposure rates expressed in mR/day are given in Table II.A.1. The values were determined by CaF_2:Dy (TLD-200) dosimeters at each of 37 locations (see Tables III.B.1, III.B.2, III.B.3). Two TLD chips per package are installed at each site and the mean value is reported for that site. The mean calculated total exposure is then divided by the number of days that elapsed between pre-exposure and post-exposure annealing to obtain the average daily exposure rate. The TLD devices are changed monthly at each location.

The TLD data indicate that the arithmetic mean measured exposure rate in the Facility area for the last half of 1983 was 0.45 mR/day. The mean exposure rate was 0.45 mR/day for the Adjacent area and 0.42 mR/day for the Reference area. There were no significant differences between the values for the Facility, Adjacent and Reference areas. There was also no significant difference from the values measured during the first half of 1983. The exposure rate measured for October 1983 at A-35 is concluded to be a true value. The two TLD chips in the packet indicated nearly identical readout values. See past reports for discussion of anomalies at A-35.

The exposure rate measured at all sites is due to a combination of exposure from cosmic rays, from natural gamma-ray emitters in the earth's crust and from ground surface deposition of fission products from previous world-wide fallout. The variation in measured values is due

to true variation of the above sources plus the variation due to the measurement method. The purpose of the TLD ring around the reactor is not to measure gamma-rays generated from the reactor facility itself, but to document the presence or absence of gamma-ray emitters deposited upon the ground from the reactor effluents. Since the inception of power production by the reactor there has been no detectable increase in the external exposure rate due to reactor releases.

The TLD system is calibrated by exposing chips to a scattered gamma-ray flux in a cavity surrounded by Uranium mill tailings. This produces a gamma-ray spectrum nearly identical to that measured in the reactor environs.

Table II. A.1 Gamma Exposure Rates Measured by the TLD Technique (mR/day). Second Half, 1983.

Facility Area Locations	Average Daily Gamma Exposure Rates					
	July	August	September	October	November	December
F 1	0.44	0.42	0.45	0.50	0.42	0.39
F 3	0.42	0.41	0.41	0.50	0.47	0.39
F 4	0.41	0.43	0.42	0.46	0.48	0.39
F 7	0.42	0.42	0.40	0.47	0.44	0.40
F 8	0.46	0.44	0.48	0.50	0.50	0.42
F 9	0.44	0.47	0.46	0.52	0.54	0.43
F 11	0.43	0.41	0.42	0.50	0.50	0.38
F 12	0.46	0.42	0.48	0.51	0.48	0.42
F 13	0.45	0.47	0.46	0.49	0.50	0.41
F 14	0.40	0.43	0.45	0.48	0.47	0.34
F 46	0.47	0.46	0.46	0.51	0.52	0.42
F 47	0.42	0.45	0.44	0.49	0.44	0.39
F 51	0.47	0.48	0.50	0.52	0.49	0.41
X	0.44	0.44	0.45	0.50	0.48	0.40
Adjacent Area Locations						
A 5	0.45	0.46	0.47	0.52	0.45	0.40
6	0.40	0.41	0.41	0.48	0.40	0.38
A 27	0.42	0.42	0.43	0.46	0.41	0.34
A 28	e	0.41	0.40	0.45	0.39	0.35
A 29	0.42	0.45	0.41	0.49	0.43	0.32
A 30	0.45	0.46	0.45	0.53	0.45	0.41
A 31	0.38	0.40	0.42	0.47	0.40	0.38
A 32	0.41	0.42	0.43	0.48	0.41	0.36
A 33	0.41	0.44	0.40	0.51	0.42	0.40
A 34	0.47	0.46	0.46	0.53	0.46	0.41
A 35	e	0.44	0.46	1.72	0.49	0.39
A 36	0.40	0.42	0.45	0.51	0.44	0.39
X	0.42	0.43	0.43	0.60	0.43	0.38
Reference Area Locations						
R 15	0.32	0.44	0.37	0.46	0.41	0.36
R 16	0.44	0.48	0.49	0.50	0.44	0.42
R 17	0.36	0.35	0.33	0.43	0.38	0.33
R 18	0.39	0.40	0.36	0.45	0.39	0.34
R 19	0.40	0.41	0.40	0.43	0.39	0.35
R 20	0.44	0.44	0.45	0.49	0.46	0.36
R 21	0.42	0.43	0.42	0.49	0.40	0.36
R 22	0.42	0.43	0.44	0.51	0.43	0.37
R 23	0.41	0.42	0.40	0.47	0.44	0.35
R 24	0.51	0.46	0.50	0.58	0.47	0.40
R 25	0.46	0.43	0.44	0.48	0.43	0.38
R 26	0.43	0.40	0.43	0.47	0.43	0.37
X	0.43	0.42	0.42	0.48	0.42	0.37

e Sample missing at site.

II.B. Air Sampling Data

1. Gross alpha and beta activity.

The measured air concentrations of particulate gross alpha and gross beta activity for the Facility and Adjacent sampling sites are listed in Tables II.B.1 and II.B.2. The concentrations are listed in units of femtocuries per cubic meter of air, although the activity is due to a mixture of radionuclides.

The arithmetic mean of the values of gross alpha activity for all the Facility stations was statistically the same as the mean for the values measured at the Adjacent stations for both the third and fourth quarters.

The gross alpha mean was greater during the fourth quarter than during the third quarter and this difference was statistically significant. A slight peak in gross alpha concentrations can be noted for the two week period ending 11/5/83. There was a corresponding peak in gross beta concentrations during the same period. There was an earlier additional peak in gross beta concentrations for the week ending 7/2/83. No corresponding gross alpha peak was apparent. The gross beta means for the fourth quarter were also slightly, but significantly, greater than during the third quarter.

There was no significant difference between Facility stations and Adjacent stations during the entire sampling period. There has never been a significant difference observed between the Facility and Adjacent sites. Thus it can be concluded that stack effluents of particulate fission products or activation products is not a pathway of concern for the Fort St. Vrain reactor environs.

Station F-2 is in the flood plain of the Platte river and during

July and August the late snow run-off in the mountains caused local flooding of the site and electricity was not available. On 10 of the 189 air filter samples collected during the period, excessive dust loading occurred and gross alpha measurement was unreliable. These occurrences were only at stations A-5 and A-35, both of which are dusty locations, particularly during fall and early winter months.

Table II. B.1
Concentrations of Long-Lived Gross Alpha Activity in Airborne Particles (fCi/m^3).
a. Third Quarter, 1983.

Date Collected	Facility Areas				Adjacent Areas		
	1	2	3	4	5	6	35
7-2-83	2.3 (0.6)*	2.9 (0.6)	4.4 (1.0)	4.1 (0.8)	2.3 (0.7)	1.4 (0.5)	3.7 (0.8)
7-9-83	7.0 (1.2)	C_1	6.1 (1.1)	7.5 (1.2)	8.4 (1.6)	3.7 (1.2)	4.4 (0.9)
7-16-83	2.7 (0.5)	C_1	3.1 (0.6)	4.7 (1.0)	6.7 (1.2)	4.5 (1.1)	3.1 (1.5)
7-23-83	2.4 (0.5)	2.0 (0.4)	1.9 (0.5)	2.2 (0.5)	5.2 (1.0)	C_2	C_2
7-30-83	5.3 (1.0)	4.1 (0.7)	5.9 (1.1)	7.1 (1.2)	3.8 (0.7)	C_3	3.6 (0.6)
8-7-83	7.7 (1.3)	C_2	7.0 (1.2)	2.7 (0.5)	5.9 (1.1)	3.7 (0.5)	11.6 (2.0)
8-12-83	7.7 (1.8)	C_2	7.5 (1.5)	5.0 (1.4)	6.2 (1.6)	6.5 (1.4)	6.3 (1.2)
8-20-83	C_2	C_3	6.4 (1.1)	0.6 (0.4)	6.7 (1.4)	3.6 (0.8)	8.0 (1.2)
8-27-83	C_2	7.2 (1.5)	6.8 (1.3)	8.6 (1.7)	7.9 (1.5)	10.7 (1.8)	8.9 (1.6)
9-3-83	8.9 (1.7)	7.9 (1.4)	11.0 (2.1)	8.1 (1.7)	**	9.3 (1.8)	11.6 (2.0)
9-10-83	4.9 (1.1)	4.5 (1.2)	7.0 (1.6)	5.6 (1.3)	6.8 (1.9)	6.8 (1.4)	**
9-17-83	8.5 (1.7)	8.2 (1.4)	10.2 (1.8)	9.8 (1.9)	**	8.9 (1.6)	**
9-24-83	9.3 (1.7)	7.7 (1.4)	7.9 (1.6)	10.7 (1.8)	9.6 (2.0)	7.5 (1.5)	11.7 (2.2)
Average	6.1 (1.1)	5.6 (1.1)	6.1 (1.3)	5.9 (1.2)	6.3 (1.3)	6.1 (1.2)	7.3 (1.4)
Quarterly (45 Samples)	0.6 -minimum 11.0 -maximum 6.1 - $\bar{X}$				Quarterly (32 Samples)	3.6 -minimum 11.6 -maximum 6.4 - $\bar{X}$	

All concentrations are expressed in femtocuries per cubic meter of air: $1fCi/m^3 = 10^{-15}$ $\mu Ci/ml$.
* Uncertainties (in parentheses) are for the 95% confidence interval (± 1.96 S.D.)
** Excessive dust load on filter prevented valid alpha counting.
C1 Electricity out at site due to flood.
C2 Pump stopped, fuse blown.
C3 Pump in for repair.

Table II. B.1
Concentrations of Long-Lived Gross Alpha Activity in Airborne Particles (fCi/m^3).

b. Fourth Quarter, 1983.

Date Collected	Facility Areas				Adjacent Areas		
	1	2	3	4	5	6	35
10-1-83	11.2 (1.9)*	6.5 (1.1)	11.4 (1.9)	11.1 (2.0)	**	8.3 (1.7)	**
10-8-83	6.8 (1.3)	9.0 (1.5)	7.0 (1.5)	11.2 (2.0)	8.3 (1.9)	8.4 (1.4)	8.2 (1.6)
10-15-83	7.8 (1.3)	6.8 (1.2)	5.8 (1.0)	7.3 (1.3)	9.3 (1.8)	4.5 (0.9)	8.8 (1.5)
10-22-83	9.0 (1.2)	16.9 (1.9)	15.6 (2.0)	17.8 (2.2)	14.9 (2.3)	16.1 (2.2)	11.0 (1.5)
10-29-83	18.6 (2.5)	16.0 (2.2)	16.3 (2.2)	19.7 (2.6)	**	13.1 (2.0)	22.7 (3.1)
11-5-83	21.5 (2.9)	22.0 (2.6)	20.4 (2.8)	22.9 (3.3)	**	21.3 (3.2)	**
11-12-83	10.9 (1.8)	14.4 (1.9)	8.5 (1.7)	11.4 (1.8)	14.2 (2.2)	8.5 (1.6)	16.5 (2.4)
11-19-83	1.7 (0.4)	4.8 (1.0)	5.6 (1.2)	5.5 (1.2)	7.7 (1.7)	7.5 (1.5)	**
11-26-83	3.6 (0.9)	3.5 (0.8)	C_1	2.2 (0.7)	3.8 (1.0)	1.2 (0.4)	4.6 (1.2)
12-3-83	6.3 (1.5)	6.5 (1.3)	C1	17.9 (2.6)	C_2	9.0 (1.6)	C_2
12-10-83	6.9 (1.4)	2.0 (0.6)	5.2 (1.3)	6.8 (1.0)	C1	3.0 (0.9)	C_1
12-17-83	4.0 (1.0)	4.1 (0.8)	3.7 (0.8)	3.6 (0.9)	3.2 (0.8)	3.9 (0.8)	C_1
12-23-83	12.1 (1.8)	11.3 (1.4)	12.0 (1.5)	13.4 (1.8)	15.3 (1.8)	6.5 (1.1)	15.5 (0.7)
12-31-83	14.3 (2.2)	5.1 (1.0)	8.9 (1.7)	8.0 (1.5)	8.0 (1.3)	5.2 (1.0)	2.6 (0.7)
Average	9.6	9.2	10.0	11.3	9.4	8.3	11.3
Quarterly (54 Samples)	1.7-minimum 22.0-maximum 10.0- $\bar{X}$				Quarterly (31 Samples)	1.2 -minimum 22.7 -maximum 9.4 - $\bar{X}$	

All concentrations are expressed in femtocuries per cubic meter of air: $1 fCi/m^3 = 10^{-15}$ µCi/ml.

* Uncertainties (in parentheses) are for the 95% confidence interval (± 1.96 S.D.)

** Excessive dust load on filter prevented valid alpha counting.

C_1 Pump in for repair.

C_2 Electricity out at pump.

Table II.B.2
Concentrations of Long-lived Gross Beta Activity in Airborne Particles (fCi/m^3).
a. Third Quarter, 1983.

Date Collected	Facility Areas				Adjacent Areas		
	1	2	3	4	5	6	35
7-2-83	51 (3)*	24 (1)	37 (2)	28 (2)	21 (1)	32 (2)	33 (2)
7-9-83	17 (1)	C_1	14 (1)	12 (1)	19 (2)	16 (2)	11 (1)
7-16-83	13 (1)	C_1	12 (1)	13 (1)	8 (1)	7 (1)	9 (3)
7-23-83	13 (1)	12 (1)	9 (1)	11 (1)	15 (1)	C_2	C_2
7-30-83	13 (1)	12 (1)	14 (1)	14 (1)	10 (1)	C_3	10 (1)
8-7-83	17 (1)	C_2	14 (1)	10 (1)	18 (1)	5 (1)	14 (2)
8-12-83	19 (2)	C_2	17 (2)	19 (2)	20 (2)	14 (1)	14 (1)
8-20-83	C_2	C_3	19 (1)	4 (1)	25 (2)	8 (1)	17 (1)
8-27-83	C_2	20 (2)	17 (1)	22 (2)	17 (2)	21 (2)	19 (2)
9-3-83	23 (2)	19 (2)	27 (2)	14 (2)	37 (3)	32 (2)	14 (2)
9-10-83	17 (1)	20 (2)	19 (2)	16 (1)	21 (2)	17 (2)	23 (2)
9-17-83	23 (2)	20 (2)	24 (2)	23 (2)	35 (3)	12 (1)	42 (3)
9-24-83	19 (2)	18 (2)	16 (2)	15 (2)	24 (2)	15 (1)	16 (2)
Average	20 (1)	18 (2)	18 (2)	15 (2)	21 (2)	16 (1)	19 (2)
Quarterly (45 samples)	4.0 -minimum 51.0 -maximum 17.6 - $\overline{X}$				Quarterly (35 samples)	3.0 -minimum 42.0 -maximum 18.6 - $\overline{X}$	

All concentrations are expressed in femtocuries per cubic meter of air: $1 fCi/m^3 = 10^{-15}$ µCi/ml.
* Uncertainties (in parentheses) are for the 95% confidence interval (± 1.96 S.D.)

C1 Electricity out at site due to flood.
C2 Pump stopped, fuse blown.
C3 Pump in for repair.

Table II.B.2
Concentrations of Long-lived Gross Beta Activity in Airborne Particles (fCi/m^3).
b. Fourth Quarter, 1983.

Date Collected	Facility Areas				Adjacent Areas		
	1	2	3	4	5	6	35
10-1-83	22 (2)*	16 (1)	17 (2)	19 (2)	31 (2)	13 (2)	31 (2)
10-8-83	14 (1)	15 (1)	14 (2)	15 (2)	19 (2)	15 (1)	15 (2)
10-15-83	16 (1)	18 (2)	16 (1)	17 (2)	19 (2)	10 (1)	17 (1)
10-22-83	27 (2)	22 (2)	17 (2)	18 (2)	44 (3)	44 (2)	17 (1)
10-29-83	25 (2)	23 (2)	19 (2)	21 (2)	53 (4)	14 (2)	26 (2)
11-5-83	35 (3)	36 (2)	30 (2)	45 (3)	64 (4)	44 (3)	46 (3)
11-12-83	28 (2)	25 (2)	23 (2)	28 (2)	32 (2)	17 (2)	33 (2)
11-19-83	9 (1)	18 (2)	16 (1)	13 (2)	31 (3)	14 (2)	22 (2)
11-26-83	12 (1)	14 (1)	C_1	12 (1)	18 (2)	10 (1)	16 (2)
12-3-83	23 (2)	25 (2)	C_1	29 (3)	C_2	12 (2)	C_2
12-10-83	24 (2)	9 (1)	18 (2)	22 (2)	C_1	12 (1)	C_1
12-17-83	15 (2)	7 (1)	15 (1)	14 (1)	14 (1)	15 (1)	C_1
12-23-83	29 (2)	21 (2)	20 (2)	28 (2)	18 (2)	25 (2)	22 (2)
12-31-83	44 (2)	22 (2)	29 (2)	28 (2)	25 (2)	24 (2)	8 (1)
Average	23	19	20	22	31	19	23
Quarterly (54 samples)	7.0 -minimum 45.0 -maximum 20.9 - $\bar{X}$				Quarterly (37 samples)	8.0 -minimum 64.0 -maximum 24.1 - $\bar{X}$	

All concentrations are expressed in femtocuries per cubic meter of air: $1fCi/m^3 = 10^{-15}$ $\mu Ci/ml$.
* Uncertainties (in parentheses) are for the 95% confidence interval (± 1.96 S.D.)
C_1 Pump in for repair.
C_2 Electricity out at pump.

2. Tritium Activity.

Tropospheric water vapor samples are collected continuously by passive absorption on silica gel at all seven air sampling stations (four in the Facility area and three in the Adjacent area). The specific activity of tritium in water extracted from these weekly samples is listed in Table II.B.3. From measured relative humidity at F-4, the corresponding air concentration of tritium is calculated for all samples and these values are given in Table II.B.3a.

The principle release mode of tritium from the reactor is batch liquid releases from holding tanks. The tank water is first analyzed and then released with sufficient dilution in order to not exceed 10 CFR 20 concentration limits. The summary of tritium released by all modes is given in Table II.B.3b. Approximately 72% of all tritium released by the batch technique occurred during the month of August. Inspection of Table II.B.3 reveals an increase in observed tritium concentrations at F-1 and F-2 during August and the week ending 9/3/83. F-1 and F-2 stations are along the principal water effluent route and respond to tritium contaminated water evaporating from the effluent ditch. The high values at F-4 for the week ending 7/9/83 and at F-2 for the week ending 10/15/83 cannot be explained at this time.

Inspection of Table II.H.1 reveals that the mean concentration for all Facility sites was greater than the mean of the Adjacent sites. This difference however, was not statistically significant.

A hygrothermograph is located at site F-4 only. During an intense cold spell in December the instrument malfunctioned and humidity and temperature data was collected from the FSV meteorological station.

An additional hygrothermograph has recently been purchased and will be installed at the F-1 station. Using the temperature and relative humidity data from the hygrothermograph it is possible to convert specific activity of tritiated water collected on silica gel (pCi/liter) to activity per unit volume of air (pCi/m^3). This is used if calculation of immersion dose from tritiated water vapor were ever necessary.

Two equations are used in the conversion of pCi/liter of water to pCi/m^3 of air. The first equation is used to determine the vapor pressure of water (1):

$\log_{10} P = A-B/(C+t)$, where: P = vapor pressure (mm Hg)
t = temperature (C)
A = 9.10765
B = 1750.286
C = 235.0

The temperature used is the integrated weekly value taken from the hygrothermograph. The conversion is completed in the second equation which is the "Ideal Gas Equation":

$PV = nRT$, where: P = vapor pressure (atmosphere)
V = volume (liters)
n = number of moles of gas
R = 0.08206 liter-atmospheres/mole-K
T = temperature in K

The number of grams of water per cubic meter of air is then determined.

The value of "n" obtained is for saturated air. The relative humidity is therefore integrated over the week and this percentage of the saturated air value is taken. The final value is reported in pCi/m^3. This procedure has been applied to data collected for the second half of 1983 and listed in Table II.B.3a. The weekly integrated relative

humidity at the F-4 site is relatively constant, and the correlation of measured tritium specific activity in atmospheric water vapor and air concentration is very high. For this reason inspection of Table II.B.3a shows the same site dependence on reactor effluent discussed above.

Table II. B.3
Tritium Concentrations in Atmospheric Water Vapor (pCi/l).

a) Third Quarter, 1983.

Date Collected	Facility Areas				Adjacent Areas		
	1	2	3	4	5	6	35
7-2-83	< 300	< 300	< 300	< 300	< 300	< 300	< 300
7-9-83	< 300	< 300	< 300	5,770 * (353)	< 300	< 300	< 300
7-16-83	< 297	< 297	< 297	< 297	< 297	< 297	< 297
7-23-83	< 297	620 (304)	382 (301)	< 302	< 302	< 302	< 302
7-30-83	355 (318)	< 324	< 324	< 324	< 324	< 324	< 324
8-7-83	620 (321)	458 (319)	< 324	< 324	328 (318)	< 324	< 324
8-12-83	< 304	< 304	< 304	< 304	< 304	< 304	< 304
8-20-83	454 (300)	735 (303)	< 304	< 304	< 304	< 304	< 304
8-27-83	420 (299)	816 (304)	< 304	< 304	411 (299)	321 (298)	< 304
9-3-83	< 328	1,850 (309)	< 328	< 328	< 328	< 328	< 328
9-10-83	< 328	< 328	< 328	< 328	< 328	< 328	< 328
9-17-83	< 328	< 328	< 328	< 328	< 328	< 328	< 328
9-24-83	< 295	< 295	< 295	< 295	< 295	< 295	319 (289)

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).

Table II. B.3
Tritium Concentrations in Atmospheric Water Vapor (pCi/l).
b. Fourth Quarter, 1983.

Date Collected	Facility Areas				Adjacent Areas		
	1	2	3	4	5	6	35
10-1-83	449 (291)*	456 (291)	< 295	398 (290)	375 (290)	< 295	575 (292)
10-8-83	432 (301)	< 312	< 312	< 312	< 312	< 312	< 312
10-15-83	375 (303)	5,750 (359)	e	< 312	< 312	< 312	371 (303)
10-22-83	568 (305)	461 (305)	< 314	< 314	436 (306)	321 (305)	< 314
10-29-83	721 (294)	< 295	< 295	490 (292)	< 295	< 295	< 295
11-5-83	< 299	573 (296)	< 299	< 299	< 299	< 299	< 299
11-12-83	< 299	< 299	< 299	< 299	< 299	< 299	< 299
11-19-83	< 299	< 299	< 299	< 299	< 299	324 (293)	< 299
11-26-83	< 299	< 299	< 299	< 299	< 299	< 299	< 299
12-3-83	< 299	< 299	< 299	< 299	< 299	< 299	< 299
12-10-83	< 299	< 299	< 299	< 299	< 299	< 299	< 299
12-17-83	575 (283)	503 (282)	692 (285)	508 (282)	834 (286)	< 285	894 (287)
12-23-83	< 305	< 305	< 305	< 305	< 305	369 (297)	< 305
12-31-83	< 303	< 303	< 303	< 303	< 303	< 303	< 303

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).
e Insufficient weight or volume for analysis.

Table II.B.3a
Tritium Concentrations in Air (pCi/m^3)

a) Third Quarter, 1983

Date Collected	Facility Areas				Adjacent Areas		
	1	2	3	4	5	6	35
7-2-83	< 3.26	< 3.26	< 3.26	< 3.26	< 3.26	< 3.26	< 3.26
7-9-83	< 3.25	< 3.25	< 3.25	62.5	< 3.25	< 3.25	< 3.25
7-16-83	< 3.31	< 3.31	< 3.31	< 3.31	< 3.31	< 3.31	< 3.31
7-23-83	< 4.31	11.7	8.24	6.66	< 4.38	5.25	6.56
7-30-83	4.30	< 3.93	< 3.93	< 3.93	< 3.93	< 3.93	< 3.93
8-7-83	8.46	6.25	< 4.48	< 4.48	< 4.54	< 4.48	< 4.48
8-12-83	2.77	< 3.74	< 3.74	< 3.74	< 3.74	< 3.74	< 3.74
8-20-83	3.14	5.09	< 2.10	< 2.10	< 2.10	< 2.10	< 2.10
8-27-83	5.21	10.1	< 3.77	< 3.77	5.10	3.98	< 3.77
9-3-83	< 4.71	26.6	< 4.71	< 4.71	< 4.71	< 4.71	< 4.71
9-10-83	< 1.95	< 1.95	< 1.95	< 1.95	< 1.95	< 1.95	< 1.95
9-17-83	< 2.79	< 2.79	< 2.79	< 2.79	< 2.79	< 2.79	< 2.79
9-24-83	< 2.40	< 2.40	< 2.40	< 2.40	< 2.40	< 2.40	2.89

^3H $MPC_a = 2 \times 10^5$ pCi/m^3. (10CFR20, Appendix B, Table II).

Table II.B.3a
Tritium Concentrations in Air (pCi/m^3)

b) Fourth Quarter, 1983

Date Collected	Facility Areas				Adjacent Areas		
	1	2	3	4	5	6	35
10-1-83	3.83	3.89	< 2.52	3.40	3.20	< 2.52	4.91
10-7-83	2.71	< 1.96	< 1.96	< 1.96	< 1.96	< 1.96	< 1.96
10-15-83	2.14	32.9	e	< 1.78	< 1.78	< 1.78	2.12
10-22-83	2.15	1.75	< 1.19	< 1.19	1.65	1.22	< 1.19
10-29-83	3.28	< 1.34	< 1.34	< 2.23	< 1.34	< 1.34	1.34
11-5-83	< 0.835	1.58	< 0.835	< 0.835	< 0.835	< 0.835	< 0.835
11-12-83	< 1.01	< 1.01	< 1.01	< 1.01	< 1.01	< 1.01	< 1.01
11-19-83	< 0.957	< 0.957	< 0.957	< 0.957	< 0.957	1.04	< 0.957
11-26-83	< 0.701	< 0.701	< 0.701	< 0.701	< 0.701	< 0.701	< 0.701
12-3-83	< 0.796	< 0.796	< 0.796	< 0.796	< 0.796	< 0.796	< 0.796
12-10-83	< 1.25	< 1.25	< 1.25	< 1.25	< 1.25	< 1.25	< 1.25
12-17-83	1.74	1.52	2.09	1.53	2.52	< 0.861	2.70
12-23-83	< 0.366	< 0.366	< 0.366	< 0.366	< 0.366	0.443	< 0.366
12-31-83	< 1.75	< 1.75	< 1.75	< 1.75	< 1.75	< 1.75	< 1.75

^3H $MPC_a = 2 \times 10^5$ pCi/m^3. (10CFR20, Appendix B, Table II).

e Insufficient sample volume for analysis.

Table II.B.3b Tritium Released (Ci) in Reactor Effluents, 1983

Mode	July	Aug	Sept	Oct	Nov	Dec	Total
Continucus (Turbine building sump and reactor building sump)	0.2	0.5	0.4	0.4	1.9	0.9	4.3
Batch Liquid	2.1	13.9	0.7	0.1	0.3	2.1	19.2
Gaseous Stack	0.2	0.2	0.2	0.2	0.1	0.1	1.0
TOTAL	2.5	14.6	1.3	0.7	2.3	3.1	24.5

3. Activity of gamma-ray emitting radionuclides in air.

Table II.B.4 lists the concentrations of I-131 observed in air by activated charcoal sampling and gamma-ray spectrum analysis. The sample counted is a composite from all seven air sampling stations. All charcoal samples are counted for at least 1000 minutes on the Ge(Li) detector essentially immediately after collection to minimize decay of I-131. All radon and thoron daughters are trapped on the particulate filter and radon daughter ingrowth on the charcoal can be corrected by Ge(Li) high resolution spectrometry. Background is determined from counts of unused charcoal. The I-131 concentrations presented are the result of decay correction back to the midpoint of the sampling period. Decay correction to the midpoint of the sampling period is appropriate as any I-131 in air would not arrive at the sampling station at a constant rate, but rather in pulses of short duration compared to the collection period. This is the case whether the I-131 source term would be weapons testing fallout or reactor stack effluent.

The composite air concentrations of I-131 measured during the second half of 1983 were all less than the lower limit of detection. The mean value for this reporting period was 0.069 fCi/m^3 but not significantly different from zero. The Effluent Release Report data indicated negligible reactor release of I-131 during the period.

Table II.B.5 lists the results of the gamma-ray spectrum analysis of weekly composites of the membrane air filters from each of the seven samplers. The mean values for Ru-106, Cs-137 and

Zr-Nb-95 were essentially identical to those measured during the first half of 1983. All fission product mean concentrations were lower than during 1981 when fission product debris from the most recent Chinese weapon test was readily apparent.

All samples are counted after decay of Radon and Thoron daughters, several of which are gamma-ray emitters.

The radioruthenium data is listed in the tables as Ru-106. However, it is true that the activity measured can be a mixture of Ru-103 and Ru-106. Both isotopes have gamma-rays at essentially the same energy, and they cannot be separated by NaI(Tl) spectral analysis. No separation by half-life determination was attempted on the data. Since the half-life of Ru-103 is 40 days and that of Ru-106 is one year, in periods soon after an atmospheric weapon test, a high proportion is expected to be Ru-103, and at later times predominately Ru-106. Since the element Ruthenium and its compounds have negligible biological availability, neither isotope have any consequence in calculation of population dose, and efforts to separate them are not warranted. The naturally occurring radionuclide Be-7, which is produced in the atmosphere by cosmic rays also has a gamma-ray very close to the two Ruthenium isotopes. Air concentrations of Be-7 are apparently very constant over the U.S. The mean concentration recently measured from air filters collected on the project was 87 fCi/m^3. (1)

We correct for Be-7 in our spectrum stripping program, but likely small errors due to gain shift, etc., often produce significant variation in the Ru-106 estimate.

(1) Personal Communication, Dr. Owen Hoffman, Oak Ridge National Laboratory.

Table II. B.4
Iodine-131 Concentrations in Air (Taken From Composites of Activated Charcoal at all Air Sampling Stations and Determined by Gamma Spectrometry).

Sample Ending Dates	^{131}I (fCi/m^3)
7-2-83	< 6.18
7-9-83	< 5.96
7-16-83	< 5.94
7-23-83	< 6.52
7-30-83	< 5.45
8-7-83	< 4.33
8-12-83	< 7.38
8-20-83	< 6.16
8-27-83	< 6.24
9-3-83	< 6.01
9-10-83	< 5.74
9-17-83	< 5.76
9-24-83	< 5.73
10-1-83	< 5.77
10-8-83	< 5.52
10-15-83	< 5.62
10-22-83	< 5.34
10-29-83	< 6.26
11-5-83	< 6.99
11-12-83	< 7.05
11-19-83	< 7.03
11-26-83	< 7.12
12-3-83	< 14.3
12-10-83	< 9.74
12-17-83	C
12-23-83	< 6.40
12-30-83	< 6.50

All concentrations are expressed in femtocuries per cubic meter of air: 1 fCi/m^3 = 10^{-15} µCi/ml.

^{131}I MPC_a = 10^5 fCi/m^3. (10CFR20, Appendix B, Table II)
C. Instrument malfunction.

Table II. B.5
Gamma-ray Emitting Radionuclide Concentrations in Air (Taken from Composites of all Air Sampling Stations) (fCi/m^3).

Sample Ending Dates	^{106}Ru	^{137}Cs	^{95}Zr & Nb
7-2-83	< 2.05	< 1.43	< 0.618
7-9-83	< 5.52	2.99 (1.07)*	1.06 (0.722)
7-16-83	11.2 (7.78)	2.45 (1.22)	1.44 (0.759)
7-23-83	18.9 (8.49)	4.61 (1.37)	1.90 (0.782)
7-30-83	< 5.64	< 1.26	1.10 (0.613)
8-7-83	6.18 (5.36)	1.37 (0.879)	0.770 (0.440)
8-12-83	12.2 (9.19)	< 1.71	1.56 (0.716)
8-20-83	< 6.37	4.96 (1.29)	1.61 (0.562)
8-27-83	< 2.00	< 0.452	0.504 (0.278)
9-3-83	< 6.13	< 1.38	< 0.598
9-10-83	< 5.86	< 1.32	< 0.572
9-17-83	< 1.87	1.09 (0.421)	1.33 (0.281)
9-24-83	< 5.84	< 1.32	1.02 (0.649)
10-1-83	11.0 (3.02)	1.67 (0.464)	1.24 (0.345)
10-8-83	< 5.66	2.15 (1.12)	1.12 (0.815)
10-15-83	4.72 (2.88)	1.66 (0.455)	< 0.185
10-22-83	< 5.53	< 1.24	1.19 (1.07)
10-29-83	< 6 12	< 1.38	< 0.598
11-5-83	< 7.24	3.41 (1.45)	1.35 (1.07)
11-12-83	< 7.25	< 1.63	< 0.708
11-19-83	< 7.23	< 1.63	1.58 (0.896)
11-26-83	< 2.44	0.861 (0.571)	< 0.238
12-3-83	< 14.8	< 3.33	2.96 (1.84)
12-10-83	< 10.0	< 2.26	< 0.979
12-17-83	< 6.60	< 1.49	< 0.645
12-23-83	< 6.69	< 1.51	< 0.654
12-31-83	12.6 (8.48)	5.31 (1.43)	3.47 (0.672)

All concentrations are expressed in femtocuries per cubic meter of air: 1 $fCi/m^3 = 10^{-15}$ $\mu Ci/ml$.

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

^{106}Ru $MPC_a = 3 \times 10^6$ fCi/m^3. ^{137}Cs $MPC_a = 2 \times 10^6$ fCi/m^3. ^{95}Zr $MPC_a = 4 \times 10^6$ fCi/m^3.

(10CFR20, Appendix B, Table II)

II.C.1 Radionuclide Concentrations in Surface Water.

Table II.C.1 lists the gross beta activity in surface water and potable water supplies in the study area.

Values of gross beta concentrations in surface water fluctuated at upstream, effluent and downstream sites by approximately a factor of 4, but the mean values were very close to those measured in the last reporting period. The mean upstream value was 7.8 pCi/L, the mean effluent value was 11.5 pCi/L and the mean downstream value was 8.3 pCi/L. The mean value for the two potable water stations was 6.9 pCi/L. The mean for the effluent samples was significantly greater than the other three mean values. None of the others were statistically different from each other. The gross beta concentrations in the two potable water sources were lower but nearly as variable as surface water. The concentrations in potable water should be lower due to water purification which removes suspended solids. Any variation is probably due to mixing of different reservoir or well water sources which vary due to different runoff areas or aquifers.

Weekly samples were collected at E-38, at the farm pond on the effluent pathway. This is the principal route for liquid discharge from the reactor, and a monthly sample is not adequate to reflect discharges of tritium. It must be noted, however, that tritium is lost during the evaporation step for gross beta activity determination, and therefore the gross beta value does not include tritium. Gross beta concentrations in these samples are shown in Table II.C.1a. Note that these values include the monthly samples shown in Table II.C.1. The values observed presumably only reflect leaching and runoff

from fallout deposition as well as naturally occurring radioactivity.

Table II.C.2 lists tritium in surface water and potable water supplies for each monthly collection for the second half of 1983. In several cases, the downstream tritium concentration exceeded the upstream value. The upstream mean value during the period was 266 pCi/L and the downstream arithmetic mean value was 279 pCi/L. Both of them are less than the lower limit of detection. These mean values are not significantly different, even though downstream values, particularly at D-40 and D-45, were high during the peak tritium discharge periods (see Table II.B.3b). A record high spring runoff this year occurred late in the spring and early summer and overall produced greater than normal dilution of the tritium effluent. Significantly more tritium was released in the liquid effluent routes from the reactor during the first half of 1983 as compared to this reporting period and the mean downstream tritium concentration was less during the last half of 1983.

No radiation dose commitment calculations are warranted as the mean concentrations in possible drinking water sources were not statistically greater than upstream concentrations.

The mean effluent tritium concentrations (which include the weekly values shown in Table II.C.4a) was 1,450 pCi/L. This is significantly greater than upstream, downstream and potable mean values. These values correspond reasonably well with the effluent release of tritium, but grab samples even on a weekly basis have obvious limitations to document a changing release pattern. Beginning

1/1/84 a continuous water sampler was installed at the outlet of the Goosequill Pond to the Platte River.

The tritium concentrations in the potable water supplies were more constant than in previous reporting periods.

On a few occasions in the past, elevated tritium concentrations were noted in the sample collected from the Gilcrest city water well (D-39). Since this is a shallow well into an aquifer recharged by tributary water, there was some possibility that the elevated tritium concentrations were the result of FSV effluent. Early in 1983 weekly water samples were collected at D-39 and this collection schedule was continued throughout the year. A correlation study was conducted between paired weekly values measured at D-39, the Gilcrest city water well, at E-38, the input of the water effluent route to the Goosequill pond, and at the two upstream locations, U-42 and U-43. The resulting correlation coefficients for essentially all of 1983 are as follows:

Locations Compared	R
D-39 vs E-38	- 0.083
D-39 vs U 43	0.11
D-39 vs U-42	0.13
U-42 vs U-43	0.51

The above data indicate that the correlation of the down gradient well water tritium concentrations (D-39) have a very low correlation coefficient with the effluent release concentrations. In fact the correlation coefficient was negative. The correlation of D-39 with the upstream values was also low but positive and as would be expected

the correlation between the two upstream locations was respectable. Since the distance from E-38 to D-39 is considerable and the volume of the underground aquifer, while unknown, must be very large, it seems logical to expect sufficient dilution that the tritium released at the Goosequill pond outlet should not be observed at D-39. The statistical analysis of this data during 1983 confirms this conclusion. Beginning January 1, 1984 a shallow well used for drinking water at the farm near F-1 has been included in the normal sampling program. Since this well is at one of the closest residences to the reactor it will be an excellent site to document any effluent tritium seepage into ground water. The Gilcrest city water well will continue to be monitored, but at the 1984 technical specification frequency. Weekly samples are composited and analyzed every two weeks.

Table II.C.3 and II.C.4 list Sr-90 and Sr-89 concentrations in surface water at the same sampling locations. These values were all close to the MDC values and mean values for each category were not significantly different. Table II.C.4a lists the same radionuclides as well as tritium in reactor effluent water samples collected weekly at E-38.

The concentrations of Ru-106, Cs-137, and Zr-Nb-95 in surface and potable water are given in Table II.C.5. The same radionuclides were measured in the weekly samples collected at E-38. This data is shown in Table II.C.5. The concentrations of all of the fission products measured in water are similar to those previously measured.

Table II.C.1

Gross Beta Activity in Surface Water (pCi/L)

Sampling Locations	Monthly Collection Dates					
	7-16-83	8-20-83	9-10-83	10-8-83	11-12-83	12-10-83
Effluent						
E 38: Farm Pond (Goosequill)	8.07 (2.15)*	5.92 (2.09)	9.53 (2.21)	18.1 (2.44)	8.57 (2.13)	9.56 (2.19)
E 41: Goosequill Ditch	6.98 (2.12)	18.5 (2.50)	14.0 (2.40)	15.6 (2.38)	12.0 (2.27)	8.85 (1.40)
Downstream						
D 37: Lower Latham Reservoir	9.70 (4.32)	8.77 (2.19)	8.24 (2.18)	10.4 (2.20)	16.2 (2.38)	10.8 (2.22)
D 40: S. Platte River Below Confluence	5.79 (2.07)	7.47 (2.13)	4.47 (2.05)	9.26 (2.15)	9.42 (2.15)	8.90 (2.38)
D 45: St. Vrain Creek	5.15 (2.06)	4.98 (2.06)	7.56 (2.18)	8.00 (2.11)	7.62 (2.10)	7.05 (2.76)
Upstream						
U 42: St. Vrain Creek	8.13 (2.16)	6.34 (1.22)	6.23 (2.11)	7.64 (2.09)	12.9 (2.26)	6.27 (2.05)
U 43: S. Platte River	4.90 (2.04)	5.77 (2.06)	8.94 (2.17)	8.62 (2.11)	8.83 (2.12)	8.98 (2.12)
Potable						
F 49: Visitor's Center	6.48 (4.31)	5.23 (4.28)	3.62 (4.23)	4.91 (4.26)	4.94 (4.26)	4.22 (4.24)
D 39: Gilcrest City Water	8.32 (4.38)	11.0 (4.51)	8.17 (4.44)	8.42 (4.43)	11.9 (4.50)	5.33 (4.30)

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

MPC_w = 30 pCi/L Table II, Appendix B limit 10 CFR20 for an unidentified mixture of radionuclides in water 'if either the identity or the concentration of any radionuclide is not known.'

Table II. C.1.A.

Gross Beta Activity in Effluent Water, Goosequill Pond, E-38. (pCi/L)

Collection Date	Total Water Concentrations
7-2-83	i
7-9-83	i
7-16-83	8.07 (2.15)*
7-23-83	5.50 (2.07)
7-30-83	8.18 (2.15)
8-7-83	10.7 (2.23)
8-12-83	14.5 (2.34)
8-20-83	5.92 (2.09)
8-27-83	6.68 (2.12)
9-3-83	6.95 (2.13)
9-10-83	9.53 (2.21)
9-17-83	12.3 (10.7)
9-24-83	7.80 (2.11)
10-1-83	11.7 (2.24)
10-8-83	18.1 (2.44)
10-15-83	14.8 (2.34)
10-22-83	10.8 (2.20)
10-29-83	12.0 (2.26)
11-5-83	9.40 (2.16)
11-12-83	8.57 (2.13)
11-19-83	18.8 (2.46)
11-26-83	14.6 (2.32)
12-3-83	16.0 (2.37)
12-10-83	9.56 (2.19)
12-17-83	12.1 (2.40)
12-23-83	18.1 (2.46)
12-31-83	11.8 (2.26)

MPC_W = 30 pCi/L Table II, Appendix B limit 10 CFR20 for an unidentified mixture of radionuclides in water 'if either the identity or the concentration of any radionuclide is not known.'

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

i Sample data unreliable due to cross contamination.

Table II. C.2
Tritium Concentrations in Surface Waters (pCi/l).

Sampling Locations	Monthly Collection Dates					
	7-9-83	8-20-83	9-17-83	10-8-83	11-12-83	12-10-83
Effluent						
E 38: Farm Pond (Goosequill)	634 (287)*	1,840 (309)	324 (296)	3,270 (330)	1,300 (301)	667 (300)
E 41: Coosequill Ditch	407 (285)	2,750 (319)	668 (298)	1,540 (309)	1,900 (308)	668 (300)
Downstream						
D 37: Lower Latham Reservoir	< 289	< 297	< 299	< 301	321 (295)	< 301
D 40: S. Platte River Below Confluence	< 289	953 (299)	429 (295)	463 (297)	< 301	< 301
D 45: St. Vrain Creek	402 (285)	< 297	339 (294)	519 (297)	503 (292)	< 301
Upstream						
U 42: St. Vrain Creek	< 289	< 297	395 (294)	< 301	323 (290)	303 (294)
U 43: S. Platte River	463 (285)	< 297	< 299	< 301	< 301	505 (296)
Potable						
F 49: Visitor's Center	465 (285)	< 297	< 302	339 (295)	< 301	569 (297)
D 39: Gilcrest City Water	< 289	< 297	< 302	< 301	613 (293)	604 (297)

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

^{3}H $MPC_w = 3 \times 10^{6}$ pCi/L (10CFR20, Appendix B, Table II)

Table II. C.3
Strontium 90 Concentrations in Surface Waters (pCi/l).

Sampling Locations	Monthly Collection Dates					
	7-16-83	8-20-83	9-17-83	10-8-83	11-12-83	12-10-83
Effluent						
E 38: Farm Pond (Goosequill)	< 0.927	< 1.35	< 1.01	< 1.25	1.39 (1.16)	< 1.25
E 41: Goosequill Ditch	< 0.940	1.29 (1.07)*	< 1.00	2.25 (2.00)	1.45 (0.699)	1.23 (1.16)
Downstream						
D 37: Lower Latham Reservoir	< 1.11	< 0.770	3.77 (1.44)	1.49 (1.47)	< 0.740	< 1.43
D 40: S. Platte River Below Confluence	< 1.15	< 0.751	< 1.44	< 0.936	< 0.801	1.44 (1.04)
D 45: St. Vrain Creek	1.14 (1.25)	< 1.03	1.54 (1.06)	< 1.19	0.828 (0.899)	< 1.31
Upstream						
U 42: St. Vrain Creek	< 1.21	< 1.50	< 1.40	1.84 (1.82)	< 0.896	< 1.73
U 43: S. Platte River	< 1.34	< 1.38	< 1.10	< 0.969	< 0.794	< 1.88
Potable						
F 49: Visitor's Center	< 1.14	< 0.872	< 0.829	< 2.06	< 0.585	1.00 (1.14)
D 39: Gilcrest City Water	< 0.860	< 0.988	0.987 (0.988)	< 1.68	0.936 (1.04)	< 1.17

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

^{90}Sr MPC_w = 300 pCi/L. (10CFR20, Appendix B, Table II).

Table II. C.4
Strontium 89 Concentrations in Surface Waters (pCi/l).

Sampling Locations	Monthly Collection Dates					
	7-16-83	8-20-83	9-17-83	10-8-83	11-12-83	12-10-83
Effluent						
E 38: Farm Pond (Goosequill)	< 1.10	< 1.17	3.12 * (1.56)	< 0.816	< 0.852	< 1.08
E 41: Goosequill Ditch	< 1.12	< 0.716	< 0.805	< 1.57	< 0.558	< 0.833
Downstream						
D 37: Lower Latham Reservoir	< 1.31	< 0.735	< 1.03	< 0.845	< 0.642	< 1.23
D 40: S. Platte River Below Confluence	< 1.36	< 0.656	< 1.22	< 0.936	< 0.636	< 0.757
D 45: St. Vrain Creek	< 1.26	< 0.965	< 0.743	< 0.990	< 0.691	< 1.08
Upstream						
U 42: St. Vrain Creek	< 1.43	< 1.30	< 1.16	< 1.19	< 0.805	< 1.43
U 43: S. Platte River	< 1.57	< 1.17	< 0.946	< 0.815	< 0.650	< 1.51
Potable						
F 49: Visitor's Center	1.45 (3.14)	< 0.810	< 0.687	< 1.61	< 0.550	< 0.725
D 39: Gilcrest City Water	< 1.03	< 0.936	< 0.799	< 1.68	< 0.701	< 1.00

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

^{89}Sr $MPC_w = 3 \times 10^3$ pCi/L . (10CFR20, Appendix B, Table II).

Table II.C.4.A
Tritium, Strontium 89, and Strontium 90 Concentrations in Effluent Water, Goosequill Pond, E-38.
a. Third Quarter, 1983.

Collection Date	Tritium (pCi/l)	Strontium 89 (pCi/l)	Strontium 90 (pCi/l)
7-2-83	< 300	< 0.708	0.994 (0.946)*
7-9-83	634 (287)	< 1.21	< 1.04
7-16-83	< 319	< 1.10	< 0.927
7-23-83	11,200 (394)	< 1.71	< 1.45
7-30-83	818 (290)	< 2.23	< 1.90
8-7-83	470 (285)	< 1.29	< 1.09
8-12-83	695 (285)	< 1.41	< 1.18
8-20-83	1,840 (309)	< 1.17	< 1.35
8-27-83	< 302	< 0.905	1.15 (1.69)
9-3-83	< 302	< 0.842	< 0.962
9-10-83	333 (296)	< 1.15	1.53 (1.69)
9-17-83	324 (296)	3.12 (1.56)	< 1.01
9-24-83	584 (301)	< 0.836	1.95 (1.38)

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

^{3}H $MPC_w = 3 \times 10^{6}$ pCi/L (10 CFR 20, Appendix B, Table II).

^{89}Sr $MPC_w = 3 \times 10^{3}$ pCi/L (10 CFR 20, Appendix B, Table II).

^{90}Sr $MPC_w = 300$ pCi/L (10 CFR 20, Appendix B, Table II).

Table II.C.4.A
Tritium, Strontium 89, and Strontium 90 Concentrations in Effluent Water, Goosequill Pond, E-38.
b. Fourth Quarter, 1983.

Collection Date	Tritium (pCi/l)	Strontium 89 (pCi/l)	Strontium 90 (pCi/l)
10-1-83	1,040 (306)*	< 0.803	< 1.08
10-8-83	3,270 (330)	< 0.816	< 1.25
10-15-83	1,230 (308)	< 0.851	< 0.975
10-22-83	< 302	< 0.764	< 0.919
10-29-83	823 (302)	< 0.715	< 0.832
11-5-83	< 300	< 1.31	2.35 (2.22)
11-12-83	1,300 (301)	< 0.852	1.39 (1.16)
11-19-83	2,560 (319)	< 0.900	2.68 (1.13)
11-26-83	2,330 (317)	< 0.931	2.67 (2.00)
12-3-83	1,730 (311)	< 0.754	1.63 (0.971)
12-10-83	667 (300)	< 1.08	< 1.25
12-17-83	3,170 (319)	< 1.01	1.64 (1.30)
12-23-83	1,670 (314)	< 0.693	< 0.846
12-31-83	3,690 (336)	5.28 (6.86)	< 1.57

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

^{3}H $MPC_w = 3 \times 10^{6}$ pCi/L (10 CFR 20, Appendix B, Table II).

^{89}Sr $MPC_w = 3 \times 10^{3}$ pCi/L (10 CFR 20, Appendix B, Table II).

^{90}Sr MPC = 300 pCi/L (10 CFR 20, Appendix B, Table II).

Table II. C.5.

Gamma-ray Emitting Radionuclide Concentrations in Surface Water. (pCi/L)

Collected July 16, 1983.

Sample Location		^{106}Ru	^{137}Cs	^{95}Zr & Nb
	Effluent			
E 38:	Farm Pond (Goosequill)	< 2.15	1.78 (0.832)*	1.76 (0.762)
E 41:	Goosequill Ditch	< 2.15	< 0.671	0.926 (0.700)
	Downstream			
D 37:	Lower Latham ** Reservoir	< 2.17	< 0.677	< 0.289
D 40:	S. Platte River Below Confluence	1.82 (2.31)	< 0.248	0.869 (0.464)
D 45:	St. Vrain Creek	< 2.19	0.685 (0.837)	1.31 (0.738)
	Upstream			
U 42:	St. Vrain Creek	3.29 (3.55)	< 0.674	0.774 (0.735)
U 43:	S. Platte River	< 2.15	< 0.671	< 0.286
	Potable			
F 49:	Visitor's Center	4.84 (2.79)	< 0.799	0.617 (0.588)
D 39:	Gilcrest City Water	< 2.58	< 0.803	< 0.342

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

^{106}Ru $MPC_w = 1 \times 10^4$ pCi/L

^{137}Cs $MPC_w = 2 \times 10^4$ pCi/L

^{95}Zr-Nb $MPC_w = 6 \times 10^4$ pCi/L

(10CFR20, Appendix B, Table II)

** Analysis on dissolved solids only.

Table II. C.5.

Gamma-ray Emitting Radionuclide Concentrations in Surface Water. (pCi/L)

Collected August 20, 1983.

Sample Location		^{106}Ru	^{137}Cs	^{95}Zr & Nb
	Effluent			
E 38:	Farm Pond (Goosequill)	7.25 * (2.31)	0.771 (0.572)	1.43 (0.368)
E 4 :	Goosequill Ditch	7.06 (3.36)	< 0.674	0.584 (0.545)
	Downstream			
D 37:	Lower Latham Reservoir	5.20 (3.29)	1.27 (0.830)	1.50 (0.500)
D 40:	S. Platte River Below Confluence	5.36 (3.30)	< 0.674	0.810 (0.479)
D 45:	St. Vrain Creek	8.27 (3.32)	< 0.674	< 0.288
	Upstream			
U 42:	St. Vrain Creek	5.07 (2.42)	< 0.232	0.248 (0.365)
U 43:	S. Platte River	6.79 (2.41)	< 0.224	0.089 (0.340)
	Potable			
F 49:	Visitor's Center	3.42 (2.47)	< 0.799	< 0.341
D 39:	Gilcrest City Water	< 2.54	< 0.799	0.556 (0.399)

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

^{106}Ru $MPC_w = 1 \times 10^4$ pCi/L

^{137}Cs $MPC_w = 2 \times 10^4$ pCi/L

^{95}Zr-Nb $MPC_w = 6 \times 10^4$ pCi/L

(10CFR20, Appendix B, Table II)

Table II. C.5.

Gamma-ray Emitting Radionuclide Concentrations in Surface Water. (pCi/L)

Collected September 17, 1983.

Sample Location	^{106}Ru	^{137}Cs	^{95}Zr & Nb
Effluent			
E 38: Farm Pond (Goosequill)	11.1 * (2.34)	7.79 (0.658)	1.58 (0.303)
E 41: Goosequill Ditch	< 2.14	< 0.674	0.379 (0.407)
Downstream			
D 37: Lower Latham Reservoir	< 2.14	< 0.674	0.416 (0.388)
D 40: S. Platte River Below Confluence	2.80 (3.17)	< 0.674	< 0.288
D 45: St. Vrain Creek	6.23 (2.11)	4.40 (0.578)	1.20 (0.381)
Upstream			
U 42: St. Vrain Creek	7.10 (3.20)	2.41 (0.840)	0.599 (0.412)
U 43: S. Platte River	4.25 (1.28)	0.343 (0.332)	0.776 (0.165)
Potable			
F 49: Visitor's Center	2.76 (2.69)	1.16 (0.697)	0.892 (0.363)
D 39: Gilcrest City Water	9.77 (2.56)	< 0.790	0.561 (0.331)

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

^{106}Ru $MPC_w = 1 \times 10^4$ pCi/L

^{137}Cs $MPC_w = 2 \times 10^4$ pCi/L

^{95}Zr-Nb $MPC_w = 6 \times 10^4$ pCi/L

(10CFR20, Appendix B, Table II)

Table II. C.5.

Gamma-ray Emitting Radionuclide Concentrations in Surface Water. (pCi/L)

Collected October 8, 1983.

Sample Location		^{106}Ru	^{137}Cs	^{95}Zr & Nb
	Effluenc			
E 38:	Farm Pond (Goosequill)	6.69 (3.42)*	6.13 (0.862)	1.80 (0.600)
E 41:	Goosequill Ditch	5.52 (3.37)	3.32 (0.838)	1.36 (0.571)
	Downstream			
D 37:	Lower Latham Reservoir	11.2 (3.40)	5.39 (0.994)	1.33 (0.556)
D 40:	S. Platte River Below Confluence	5.73 (3.24)	0.866 (0.825)	0.711 (0.423)
D 45:	St. Vrain Creek	3.74 (2.21)	0.340 (0.561)	0.633 (0.319)
	Upstream			
U 42:	St. Vrain Creek	8.99 (3.64)	3.35 (0.868)	2.67 (0.851)
U 43:	S. Platte River	7.94 (3.37)	3.07 (0.837)	1.29 (0.665)
	Potable			
F 49:	Visitor's Center	8.91 (2.97)	5.15 (0.734)	1.17 (0.590)
D 39:	Gilcrest City Water	6.88 (1.08)	2.31 (0.257)	0.732 (0.214)

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

^{106}Ru $MPC_w = 1 \times 10^4$ pCi/L

^{137}Cs $MPC_w = 2 \times 10^4$ pCi/L

^{95}Zr-Nb $MPC_w = 6 \times 10^4$ pCi/L

(10CFR20, Appendix B, Table II)

Table II. C.5.

Gamma-ray Emitting Radionuclide Concentrations in Surface Water. (pCi/L)

Collected November 12, 1983.

Sample Location		^{106}Ru	^{137}Cs	^{95}Zr & Nb
	Effluent			
E 38:	Farm Pond (Goosequill)	< 0.823	< 0.258	< 0.111
E 41:	Goosequill Ditch	< 2.15	2.39 (0.825)	0.811 (0.496)
	Downstream			
D 37:	Lower Latham Reservoir	12.9 (3.34)	4.32 (0.848)	1.03 (0.503)
D 40:	S. Platte River Below Confluence	9.67 (2.19)	4.18 (0.560)	1.07 (0.317)
D 45:	St. Vrain Creek	7.77 (2.17)	3.61 (0.557)	0.636 (0.315)
	Upstream			
U 42:	St. Vrain Creek	< 0.822	3.00 (0.889)	0.188 (0.742)
U 43:	S. Platte River	8.23 (3.23)	4.80 (0.853)	1.56 (0.428)
	Potable			
F 49:	Visitor's Center	< 2.77	1.27 (0.685)	< 0.373
D 39:	Gilcrest City Water	7.09 (2.78)	3.22 (0.712)	0.559 (0.408)

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

^{106}Ru $MPC_w = 1 \times 10^4$ pCi/L

^{137}Cs $MPC_w = 2 \times 10^4$ pCi/L

^{95}Zr-Nb $MPC_w = 6 \times 10^4$ pCi/L

(10CFR20, Appendix B, Table II)

Table II. C.5.

Gamma-ray Emitting Radionuclide Concentrations in Surface Water. (pCi/L)

Collected December 10, 1983.

Sample Location	^{106}Ru	^{137}Cs	^{95}Zr & Nb
Effluent			
E 38: Farm Pond (Goosequill)	< 0.685	1.21 (0.313)*	0.114 (0.172)
E 41: Goosequill Ditch	< 2.58	1.17 (0.596)	0.764 (0.348)
Downstream			
D 37: Lower Latham Reservoir	< 2.17	1.50 (0.825)	< 0.292
D 40: S. Platte River Below Confluence	< 2.17	1.22 (0.816)	< 0.292
D 45: St. Vrain Creek	2.11 (1.11)	3.14 (0.288)	0.229 (0.060)
Upstream			
U 42: St. Vrain Creek	< 2.17	< 0.683	< 0.292
U 43: S. Platte River	< 2.17	< 0.683	< 0.292
Potable			
P 49: Visitor's Center	< 2.77	2.32 (0.698)	0.568 (0.334)
D 39: Gilcrest City Water	< 2.58	0.809	0.353 (0.372)

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

^{106}Ru $MPC_w = 1 \times 10^4$ pCi/L

^{137}Cs $MPC_w = 2 \times 10^4$ pCi/L

^{95}Zr-Nb $MPC_w = 6 \times 10^4$ pCi/L

(10CFR20, Appendix B, Table II)

Table II.C.5.A.
Gamma-ray Emitting Radionuclide Concentrations in Effluent Water, Goosequill Pond, L-38. (pCi/L)

Collection Date	^{106}Ru	^{137}Cs	^{95}Zr & Nb
7-2-83	< 2.19	< 0.686	3.67 (0.885)*
7-9-83	< 2.19	< 0.686	< 0.293
7-16-83	< 2.15	1.78 (0.832)	1.76 (0.700)
7-23-33	4.41 (3.35)	2.27 (0.831)	1.46 (0.768)
7-30-83	< 2.17	2.77 (0.835)	1.47 (0.470)
8-3-83	3.77 (3.37)	2.37 (0.832)	1.20 (0.530)
8-12-83	2.54 (3.32)	0.831 (0.825)	0.821 (0.526)
8-20-83	7.25 (2.31)	0.771 (0.572)	1.43 (0.368)
8-27-83	< 0.823	< 0.259	< 0.110
9-3-83	1.91 (2.18)	< 0.674	0.544 (0.496)
9-10-83	3.18 (2.31)	< 0.212	0.469 (0.298)
9-17-83	11.1 (2.34)	7.79 (0.658)	1.58 (0.303)
9-24-83	8.26 (2.64)	3.69 (0.600)	1.15 (0.634)
10-1-83	8.59 (3.19)	3.53 (0.856)	1.81 (0.392)
10-8-83	6.69 (3.42)	6.13 (0.862)	1.80 (0.600)
10-15-83	5.21 (2.17)	1.44 (0.552)	0.664 (0.317)
10-22-83	< 2.15	2.43 (0.822)	0.600 (0.646)
10-29-83	< 2.15	1.80 (0.821)	1.34 (0.612)
11-5-83	< 2.16	1.93 (0.822)	0.833 (0.615)
11-12-83	< 0.823	< 0.258	< 0.111
11-19-83	< 2.10	2.16 (0.823)	0.765 (0.534)
11-26-83	< 0.680	0.715 (0.582)	0.707 (0.358)
12-3-83	< 2.56	3.87 (0.893)	0.670 (0.532)
12-10-83	< 0.685	1.21 (0.313)	0.114 (0.172)
12-17-83	< 2.16	0.846 (0.811)	< 0.290
12-23-83	< 0.941	1.91 (0.631)	0.279 (0.323)
12-31-83	< 2.17	1.78 (0.827)	0.396 (0.390)

^{106}Ru $MPC_w = 1 \times 10^{4}$ pCi/L ^{137}Cs $MPC_w = 2 \times 10^{4}$ pCi/L ^{95}Zr-Nb $MPC_w = 6 \times 10^{4}$ pCi/L

(10CFR20, Appendix B, TableII).
* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

II.C.2 Radionuclide Concentrations in Sediment

Sediment is the major compartment for radionuclide contaminants in a fresh water ecosystem due to the high concentration factors for fission products in the sediment mineral matrices. Although the samples are always collected at the same point, it is impossible to collect a sample with a known surface area to volume ratio as can be done for soils. Therefore, activity is reported as concentration values in pCi/kg rather than as deposition as is done for soil. The values cannot be used to predict environmental transport of activity and serve only as monitoring information. The sample itself is a result of sediment transport downstream and is therefore a function of water flowrate which fluctuates greatly during the year.

Table II.C.6 lists gross beta activity in sediment samples from the sampling sites in the water courses for the second half of 1983. The mean values for effluent, upstream, and downstream samples were, as always, nearly identical. They were not significantly different from each other (see Table II.H.1) and indicate that the sediment samples are very homogeneous. The gross beta activity is predominately from naturally occurring radionuclides in the uranium and thorium decay series, and K-40.

Table II.C.7 and II.C.8 list the Sr-90 and Sr-89 concentrations in the same sediment samples respectively. The mean concentrations of both radionuclides were not significantly different between the three sampling areas, e.g., effluent, downstream and upstream, although there were occasional high values. Table II.C.9 shows the concentration in sediment of the fission products Ru-106, Cs-137, and Zr-Nb-95.

Although again occasional high values appear, the mean values for these sample types (Table II.H.1) indicate no significant difference for any of the fission products in each of the sampling locations. Sediment samples are subject to leaching. Solubility differences between the three radionuclides should be expected.

It should be noted that the sand fraction of the sediment samples is removed and only the silt plus the clay mineral fraction is analyzed. These two particle size fractions should contain essentially all of the radioactivity, both natural and any due to reactor effluents. Tritium of course is lost in the heat drying of the sample.

The high minimum detectable concentrations are due to the fact that sediment samples are counted by Ge(Li) gamma-ray spectrometry. High resolution gamma-ray spectrum analysis is necessary due to the presence of members of the Ra-226 and Th-232 decay series.

Table II. C.6
Gross Beta Activity Concentrations in Bottom Sediment (pCi/kg).

Sampling Locations	Monthly Collection Dates					
	7-16-83	8-20-83	9-10-83	10-8-83	11-12-83	12-10-33
Effluent						
E 38: Farm Pond (Goosequill)	36,100 (1,920)*	40,000 (1,890)	33,300 (1,470)	34,000 (1,460)	32,600 (1,410)	33,200 (1,410)
E 41: Goosequill Ditch	29,900 (1,730)	31,600 (1,650)	31,400 (1,480)	30,400 (1,420)	30,000 (1,400)	32,500 (1,450)
Downstream						
D 37: Lower Latham Reservoir	29,100 (1,470)	29,000 (1,650)	29,400 (1,380)	26,300 (1,320)	27,500 (1,300)	26,800 (1,300)
D 40: S. Platte River Below Confluence	34,800 (1,690)	35,200 (1,730)	34,000 (1,430)	32,200 (1,460)	31,400 (1,430)	32,400 (1,410)
D 45: St. Vrain Creek	31,600 (1,660)	28,500 (1,300)	34,100 (1,640)	29,100 (1,360)	28,600 (1,370)	28,800 (1,340)
Upstream						
U 42: St. Vrain Creek	29,500 (1,570)	29,300 (1,520)	31,500 (1,710)	48,000 (1,750)	27,300 (1,340)	28,200 (1,490)
U 43: S. Platte River	35,300 (2,090)	36,200 (1,680)	34,100 (1,640)	35,100 (1,480)	36,100 (1,630)	35,100 (1,470)

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

Table II. C.7
Strontium 90 Activity Concentrations in Bottom Sediment (pCi/kg).

	Sampling Locations	Monthly Collection Dates					
		7-16-83	8-20-83	9-10-83	10-8-83	11-12-83	12-10-83
	Effluent						
E 38:	Farm Pond (Goosequill)	< 177	298 (292) *	< 200	<198	533 (429)	< 211
E 41:	Goosequill Ditch	< 169	< 183	< 189	462 (265)	< 161	216 (229)
	Downstream						
D 37:	Lower Latham Reservoir	181 (159)	< 258	< 191	< 180	259 (239)	163 (136)
D 40:	S. Platte River Below Confluence	< 176	< 211	237 (210)	271 (200)	477 (718)	270 (325)
D 45:	St. Vrain Creek	< 316	< 169	< 198	< 435	< 171	376 (347)
	Upstream						
U 42:	St. Vrain Creek	< 160	< 245	< 165	354 (341)	253 (381)	328 (274)
U 43:	S. Platte River	< 182	< 257	< 215	< 305	368 (420)	< 171

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

Table II. C.8
Strontium 89 Activity Concentrations in Bottom Sediment (pCi/kg).

Sampling Locations		Monthly Collection Dates					
		7-16-83	8-20-83	9-10-83	10-8-83	11-12-83	12-10-83
	Effluent						
E 38:	Farm Pond (Goosequill)	337 (316)*	< 205	< 170	< 165	< 244	< 172
E 41:	Goosequill Ditch	892 (361)	603 (481)	< 171	< 198	< 139	< 148
	Downstream						
D 37:	Lower Latham Reservoir	281 (278)	< 225	131 (384)	< 146	< 149	< 119
D 40:	S.Platte River Below Confluence	< 153	513 (505)	< 157	< 146	< 280	< 210
D 45:	St. Vrain Creek	< 369	170 (273)	< 171	< 348	< 150	< 260
	Upstream						
U 42:	St. Vrain Creek	< 139	< 211	494 (340)	< 266	< 151	< 165
U 43:	S. Platte River	250 (368)	< 219	< 179	< 246	< 179	< 149

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

Table II. C.9
Gamma-ray Emitting Radionuclide Concentrations in Bottom Sediment (pCi/kg)
for Samples Collected July 16, 1983.

	Sampling Locations	^{106}Ru	^{137}Cs	^{95}Zr & Nb
	Effluent			
E 38:	Farm Pond (Goosequill)	< 3,640	< 632	< 227
E 41:	Goosequill Ditch	< 10,400	< 1,810	2,510 (1,330)*
	Downstream			
D 37:	Lower Latham Reservoir	< 5,140	< 888	< 320
D 40:	S. Platte River Below Confluence	< 9,870	< 1,720	< 619
D 45:	St. Vrain Creek	< 8,690	< 1,500	< 540
	Upstream			
U 42:	St. Vrain Creek	< 3,740	< 650	< 234
U 43:	S. Platte River	< 3,690	< 640	< 230

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

Table II. C.9
Gamma-ray Emitting Radionuclide Concentrations in Bottom Sediment (pCi/kg)
for Samples Collected August 20, 1983.

Sampling Locations	^{106}Ru	^{137}Cs	^{95}Zr & Nb
Effluent			
E 38: Farm Pond (Goosequill)	8,430 * (8,160)	< 1,070	< 385
E 41: Goosequill Ditch	< 2,440	< 423	< 152
Downstream			
D 37: Lower Latham Reservoir	< 4,360	< 742	< 269
D 40: S. Platte River Below Confluence	< 3,680	< 639	< 230
D 45: St. Vrain Creek	< 5,770	< 997	< 360
Upstream			
U 42: St. Vrain Creek	< 3,710	< 645	250 (379)
U 43: S. Platte River	< 5,070	< 881	728 (445)

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

Table II. C.9
Gamma-ray Emitting Radionuclide Concentrations in Bottom Sediment (pCi/kg)
for Samples Collected September 10, 1983 .

	Sampling Locations	^{106}Ru	^{137}Cs	^{95}Zr & Nb
	Effluent			
E 38:	Farm Pond (Coosequill)	< 3,630	< 630	< 226
E 41:	Goosequill Ditch	< 3,570	< 620	< 223
	Downstream			
D 37:	Lower Latham Reservoir	< 3,850	< 669	< 241
D 40:	S. Platte River Below Confluence	< 6,980	< 1,220	< 438
D 45:	St. Vrain Creek	< 3,210	< 557	< 200
	Upstream			
U 42:	St. Vrain Creek	< 433	< 75.2	< 27.0
U 43:	S. Platte River	< 3,670	< 637	< 229

Table II. C.9
Gamma-ray Emitting Radionuclide Concentrations in Bottom Sediment (pCi/kg)
for Samples Collected October 8, 1983 .

Sampling Locations	^{106}Ru	^{137}Cs	^{95}Zr & Nb
Effluent			
E 38: Farm Pond (Goosequill)	< 3,020	< 523	< 188
E 41: Goosequill Ditch	< 2,830	< 491	< 176
Downstream			
D 37: Lower Latham Reservoir	< 3,320	< 570	367 (510)*
D 40: S. Platte River Below Confluence	3,560 (5,430)	< 502	< 180
D 45: St. Vrain Creek	< 6,430	< 1,120	< 402
Upstream			
U 42: St. Vrain Creek	< 6,180	< 1,070	1,090 (1,350)
U 43: S. Platte River	< 5,540	< 964	< 346

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

Table II. C.9
Gamma-ray Emitting Radionuclide Concentrations in Bottom Sediment (pCi/kg)
for Samples Collected November 12, 1983 .

Sampling Locations	^{106}Ru	^{137}Cs	^{95}Zr & Nb
Effluent			
E 38: Farm Pond (Goosequill)	< 5,350	< 930	444 (589)*
E 41: Goosequill Ditch	< 2,620	< 454	< 163
Downstream			
D 37: Lower Latham Reservoir	< 6,130	< 1,070	< 383
D 40: S. Platte River Below Confluence	< 2,900	< 503	< 180
D 45: St. Vrain Creek	< 3,790	< 658	347 (475)
Upstream			
U 42: St. Vrain Creek	< 3,690	< 641	< 230
U 43: S. Platte River	< 3,070	< 533	< 191

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

Table II. C.9
Gamma-ray Emitting Radionuclide Concentrations in Bottom Sediment (pCi/kg)
for Samples Collected December 10, 1983.

Sampling Locations	^{106}Ru	^{137}Cs	^{95}Zr & Nb
Effluent			
E 38: Farm Pond (Goosequill)	< 3,080	657 * (666)	< 192
E 41: Goosequill Ditch	< 5,920	< 1,030	< 370
Downstream			
D 37: Lower Latham Reservoir	< 5,140	< 888	< 320
D 40: S. Platte River Below Confluence	< 5,770	< 1,000	< 361
D 45: St. Vrain Creek	< 6,820	< 1,190	< 427
Upstream			
U 42: St. Vrain Creek	< 2,340	< 405	< 145
U 43: S. Platte River	< 3,670	< 637	< 229

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

II.C.3 Precipitation

Gross beta deposition from precipitation and the tritium concentration in precipitation is given in Table II.C.10. Large funnel collectors (diameter = 2.4m) are located at locations F-1 and F-4. These large funnels produce a significant sample per month for analysis. The gross beta deposition measured (expressed as pCi/m^2) is actually the sum of dry and precipitation deposition as the funnels are washed down at sample collection or after a large rain or snowfall event. Values expressed as deposition can be used to predict food chain transport. Studies of world wide fallout in the 1960's have produced models that predict forage and subsequent meat or milk concentrations from deposition values.

From Table II.C.10 and Table II.H.1 it can be observed that there is essentially no difference in gross beta deposition at the two collection sites. The mean gross beta deposition at F-1 was 22.7 pCi/m^2 and 30.9 pCi/m^2 at F-4. These mean values have large standard deviations and are not statistically different from each other.

Tritium activity in precipitation is listed in Table II.C.10 as the concentration in the water collected by the funnel. Correction is made for the wash water volume and the background tritium in the wash water.

The monthly observed concentrations of tritium were all less than MDC. Tritium concentrations at F-1 have never been significantly greater than at F-4 even though F-1 is nearer the principal effluent surface water pathway. These collection sites are at opposite directions from the reactor and in the predominant wind directions.

Tables II.C.11 and II.C.12 list the precipitation deposition of Ru-106, Cs-137 and Zr-Nb-95. The only source of these radionuclides has been world wide fallout. The mean values at F-1 and F-4 were not significantly different due to the high standard deviation values. Cs-137 values should be higher than the other radionuclides measured because it has a much longer half-life and it is held strongly by ion exchange to the clay minerals in soil. Therefore the Cs-137 deposition is trapped on the surface of the soil. These surface soil particles are resuspended by wind and deposited in the collection funnel and are evidenced in the suspended solids fraction.

Table II.C.13 lists the deposition of the strontium radioisotopes. These as well have their origin in world wide fallout. The values are extremely variable. Due to the large water volume collected, small uncertainties in the concentrations produce large variations in the total deposition estimate. Sr-90 penetrates deeper into the soil profile than Cs-137 and therefore the values due to soil resuspension are somewhat lower. Sr-89 has a short half-life and it cannot be detected above counter background.

Table II. C.10
Gross Beta and Tritium Deposition from Precipitation at Locations F1 and F4.

Sample Ending Dates	Cumulative Volume (liters)		Total Gross Beta Deposition (pCi/m^2)		Tritium in Collected Precipitation (pCi/L)	
	F1	F4	F1	F4	F1	F4
7-30-83	50	50	48.5 (13.0)**	63.4 (12.7)	< 303	< 303
8-27-83	80	75	40.4 (22.5)	32.5 (19.8)	< 297	< 297
9-24-83	61	43	45.0 (25.7)	56.9 (20.8)	< 292	< 292
10-1-83	12	12	6.44 (3.42)	20.7 (3.13)	< 301	< 301
10-15-83	12	24	14.2 (5.79)	22.7 (7.39)	< 295	< 295
10-29-83	12	12	7.38 (2.91)	7.86 (2.75)	< 295	< 295
11-26-83	40	45	23.8 (9.62)	21.8 (10.2)	< 295	< 295
12-10-83	16	41	5.57 (3.74)	7.14 (8.77)	< 303	< 303
12-31-83	30	50	13.0 (7.06)	45.5 (11.8)	< 303	< 303

** Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

Table II. C.11

Gamma-ray Emitting Radionuclide Deposition from Precipitation at Location F1.

Sample Ending Date	Total Volume (Liters)	Total Deposition (pCi/m^2)		
		^{106}Ru	^{137}Cs	^{95}Zr & Nb
7-30-83	50	< 24.4	17.4 (9.87)*	16.6 (6.53)
8-27-83	80	< 45.0	< 14.2	6.06 (11.2)
9-24-83	61	86.9 (82.5)	67.8 (22.0)	37.2 (10.0)
10-1-83	12	39.4 (5.82)	15.5 (3.28)	3.56 (3.08)
10-15-83	12	< 3.75	13.0 (1.92)	4.79 (1.76)
10-29-83	12	15.3 (6.29)	9.75 (1.52)	3.82 (1.14)
11-26-83	40	13.0 (12.1)	12.8 (3.01)	4.24 (1.80)
12-10-83	16	< 3.37	20.9 (3.32)	< 2.00
12-31-83	30	18.1 (22.7)	22.8 (6.01)	3.16 (2.86)

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).

Table II. C.12

Gamma-ray Emitting Radionuclide Deposition from Precipitation at Location F4.

Sample Ending Date	Total Volume (Liters)	Total Deposition (pCi/m^2)		
		^{106}Ru	^{137}Cs	^{95}Zr & Nb
7-30-83	50	< 29.5	43.52 (9.46)*	3.30 (6.12)
8-27-83	75	22.0 (41.5)	13.4 (10.5)	11.9 (6.16)
9-24-83	43	338 (55.1)	54.5 (15.8)	7.70 (9.59)
10-1-83	17	29.3 (6.47)	13.5 (1.51)	6.74 (1.46)
10-15-83	24	49.9 (25.4)	26.9 (6.02)	11.7 (5.22)
10-29-83	12	29.0 (6.10)	17.2 (1.49)	6.53 (1.11)
11-26-83	45	< 4.72	14.9 (5.90)	7.26 (3.57)
12-10-83	41	< 19.1	30.2 (7.70)	8.00 (4.60)
12-31-83	50	< 7.49	20.2 (3.66)	2.07 (1.77)

** Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

Table II. C.13
Radiostrontium Deposition from Precipitation at Locations F1 and F4 (pCi/m^2).

Sample Ending Dates	Cumulative Volume (liters)		Strontium 89		Strontium 90	
	F1	F4	F1	F4	F1	F4
7-30-83	50	50	< 14.3	< 14.4	< 12.2	< 12.3
8-27-83	80	75	< 14.9	< 14.0	< 17.4	< 16.4
9-24-83	61	43	< 20.9	< 19.3	25.5 (29.6)*	28.7 (30.0)
10-1-83	12	12	< 1.97	< 1.73	< 2.33	< 2.07
10-15-83	12	24	< 5.18	< 5.42	7.76 (7.01)	< 6.07
10-29-83	12	12	< 1.83	< 1.66	2.16 (2.35)	2.36 (2.18)
11-26-83	40	45	< 7.08	< 7.39	< 8.47	< 8.70
12-10-83	16	41	< 3.18	< 7.08	< 4.03	< 9.17
12-31-83	30	50	< 9.55	< 13.6	< 12.3	54.4 (54.2)

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).

II.D. Food Chain Data

1. Milk. Milk is the most important radiation dose commitment pathway for H-3, I-131, Cs-137 and Sr-89,90. Tritium concentrations in milk are summarized in Table II.D.1. There was no significant difference in mean tritium values in water extracted from milk at the only dairy in the Facility area (F-44), and the Adjacent Composite and the Reference Composite mean values for the second half of 1983 (see Table II.H.1) The arithmetic means were not significantly different from MDC. This was the case for all of 1983. This implies the tritium from reactor effluents is not contributing any radiation dose to humans via the milk pathway.

Tritium concentrations in milk should respond rapidly to changes in tritium concentrations of the forage water intake or drinking water intake to the cow. This is due to the short biological half-life for water in the cow (about three days for the lactating cow).

As noted in previous reports, tritium activity per liter reflects the tritium in water extracted from the milk and not the activity per liter of milk. Whole milk is approximately 87% water (± 3-4 %, depending on the cow breed, pasture, and feed).

Skim milk accordingly has a higher water content. It may be assumed though that the remaining solids in milk (proteins, carbohydrates, and lipids) also contain some tritium due to exchange of tritium with hydrogen on these large molecular sturctures. This tritium concentration will be very much lower than in the water fraction and is not significant for dose considerations.

Tables II.D.2 and II.D.3 list the Sr-90 and Sr-89 concentrations

in milk. The arithmetic mean for the Facility milk samples was not significantly different than the means for the other two areas. Variations noted during this reporting period are typical of past periods and attributed to differences in feeding practices and methodological variation, but not to reactor effluents. The mean values for Sr-89 appear to be greater for the Reference samples, but were not statistically different.

The concentrations of I-131, Cs-137 and K-nat in milk are given in Table II.D.4. The arithmetic mean values of I-131 and Cs-137 for the Facility area (Table II.G.1) for the reporting period were not significantly different from the means of the Adjacent and Reference areas. The means were less than MDC. The occasional I-131 concentrations in milk reported above MDC are assumed to be due to methodological variability. No I-131 peak was observed on the gamma-ray spectra of these samples and the variation is probably due to variation in Be-7 concentrations and therefore unexpected Compton counts in the I-131 absorption peak region. No I-131 was released from the reactor during the last half of 1983 and no other source of I-131 can be postulated. Inspection of Table II.B.4 shows that no I-131 was detectable in air samples during the period.

K-natural, as measured by K-40 is very constant in milk. The mean literature value is 1.5 g/L. K concentrations are homeostatically controlled and independent of K intake. K-nat is measured and reported therefore, only as a quality control measure of Cs-137 and I-131 determined in the same sample by gamma-ray spectrometry.

A close relationship between forage deposition and milk

concentrations should be expected for tritium, the strontium radioisotopes, for Cs-137 and for I-131 only if the cows are on pasture or fed green cut forage. This, unfortunately, is not the general feeding practice at the dairies around the reactor. Nearly all cattle feed is hay harvested locally or brought in from Nebraska or from the North Park region of Colorado. At times it can even be cuttings from the previous year. This makes correlation of milk concentrations with air concentrations very difficult. On the other hand, if elevated I-131 or tritium concentrations in milk are noted, the surface depositions must have been reasonably related in time and location due to the short effective half lives of these radionuclides in the dairy ecosystems.

Table II. D.1
Tritium Concentrations in Water Extracted from Milk (pCi/l).

Sample Ending Dates	Facility Area 44	Adjacent Composite *	Reference Composite *
Pasture Season			
7-2-83	395 (313)**	< 300	< 300
7-9-83	< 300	< 300	< 300
7-16-83	510 (303)	< 303	< 303
7-23-83 ***	< 303	< 303	< 303
7-30-83	< 303	317 (297)	< 303
8-7-83	< 303	492 (299)	< 303
8-12-83	< 324	< 324	< 324
8-20-83	< 324	< 324	< 324
8-27-83	< 328	< 328	< 328
9-3-83	< 328	< 328	< 328
9-10-83	< 328	< 328	< 328
9-17-83	459 (323)	< 328	< 328
9-24-83	566 (305)	< 308	< 308
Post Pasture Season			
10-8-83	314 (302)	479 (304)	< 308
11-12-83	< 302	< 302	< 302
12-10-83	< 300	< 300	< 300

* Adjacent Composite Locations: A6, A28, A31, A50, A 36, A48.
Reference Composite Locations: R16, R17, R20, R22, R23, R25.
** Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)

*** F-44 Collected 7-27-83.

Table II. D.2
Strontium 90 Activity in Milk (pCi/l).

Sample Ending Dates	Facility Area 44	Adjacent Composite *	Reference Composite *
Pasture Season			
7-1-83	1.94 (1.68) **	1.98 (1.56)	1.64 (1.29)
7-9-83	3.00 (1.40)	1.36 (1.50)	< 1.77
7-16-83	1.84 (1.22)	1.86 (1.95)	< 0.344
7-23-83 ***	2.76 (1.47)	< 5.41	< 8.63
7-30-83	2.07 (1.60)	3.43 (1.65)	4.85 (5.59)
8-7-83	< 1.03	1.39 (1.33)	< 3.65
8-12-83	2.17 (2.17)	< 7.79	2.23 (1.59)
8-20-83	2.00 (1.60)	< 1.89	< 1.43
8-27-83	1.64 (1.28)	< 1.59	< 1.17
9-3-83	1.31 (1.07)	< 4.58	3.04 (1.87)
9-10-83	2.75 (1.39)	< 6.57	3.45 (2.66)
9-17-83	5.05 (2.37)	10.8 (6.00)	< 6.39
9-26-83	3.02 (2.65)	5.39 (2.79)	< 2.14
Post Pasture Season			
10-8-83	4.38 (2.68)	5.15 (3.07)	5.26 (2.91)
11-12-83	< 2.58	< 3.58	3.68 (4.44)
12-10-83	< 3.60	< 1.71	2.28 (2.16)

* Adjacent Composite Locations: A6, A28, A31, A50, A36, A48.
Reference Composite Locations: R16, R17, R20, R22, R23, R25.
** Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).

*** F-44 collected 7-27-83.

Table II. D.3
Strontium 89 Activity in Milk (pCi/l).

Sample Ending Dates	Facility Area 44	Adjacent Composite *	Reference Composite *
Pasture Season			
7-1-83	< 2.00	< 1.78	< 1.57
7-9-83	< 1.57	< 1.70	< 2.31
7-16-83	< 1.35	< 1.98	< 0.311
7-23-83***	3.44 (2.21) **	40.9 (12.5)	59.2 (20.0)
7-30-83	9.35 (2.32)	10.4 (2.44)	37.0 (8.94)
8-7-83	2.51 (1.92)	< 1.43	4.57 (7.31)
8-12-83	2.76 (3.02	9.35 (17.4)	4.88 (2.26)
8-20-83	< 1.52	< 1.90	< 1.45
8-27-83	< 1.20	< 1.65	< 1.27
9-3-83	< 0.792	< 4.16	< 1.57
9-10-83	< 1.10	13.9 (8.33)	< 1.89
9-17-83	6.13 (3.34)	< 5.99	10.4 (8.58)
9-26-83	< 1.95	< 2.38	< 1.97
Post Pasture Season			
10-8-83	< 2.13	< 2.50	< 1.99
11-12-83	< 2.22	< 3.20	< 3.34
12-10-83	< 3.83	< 2.27	< 2.28

* Adjacent Composite Locations: A6, A28, A31, A50, A36, A48.
Reference Composite Locations: R16, R17, R20, R22, R23, R25.
** Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.)
*** F-44 collected 7-27-83.

Table II. D.4
Gamma-ray Emitting Radionuclide Concentrations in Composite Milk Samples.

Samples Collected	Area *	^{131}I (pCi/1)	^{137}Cs (pCi/1)	Nat. K (g/1)
7-2-83	Facility	< 0.186	< 0.194	1.78 (0.0180)**
	Adjacent	< 0.181	< 0.189	1.60 (0.0173)
	Reference	< 0.193	< 0.201	1.45 (0.0177)
7-9-83	Facility	< 0.190	< 0.198	1.67 (0.0181)
	Adjacent	< 0.161	< 0.168	1.38 (0.0184)
	Reference	< 0.189	< 0.197	1.63 (0.0179)
7-16-83	Facility	2.08 (1.02)	< 0.182	1.63 (0.0169)
	Adjacent	1.92 (1.28)	< 0.197	1.48 (0.0181)
	Reference	1.37 (1.63)	< 0.285	1.53 (0.0239)
7-23-83 ***	Facility	< 0.190	< 0.197	1.49 (0.0181)
	Adjacent	1.81 (1.96)	< 0.197	1.50 (0.0181)
	Reference	6.88 (1.66)	< 0.197	1.47 (0.0180)
7-30-83	Facility	< 0.210	< 0.218	1.48 (0.0194)
	Adjacent	< 0.200	< 0.207	1.58 (0.0190)
	Reference	< 0.191	< 0.197	1.27 (0.0153)
8-7-83	Facility	< 0.199	< 0.206	1.41 (0.0163)
	Adjacent	2.18 (0.213)	< 0.221	1.45 (0.0195)
	Reference	< 0.206	< 0.213	1.53 (0.0192)
8-12-83	Facility	3.44 (1.55)	< 0.208	1.49 (0.0182)
	Adjacent	1.62 (1.84)	< 0.205	1.44 (0.0185)
	Reference	0.779 (2.44)	< 0.287	1.39 (0.0236)
8-20-83	Facility	< 0.300	< 0.312	1.47 (0.0255)
	Adjacent	3.30 (2.09)	< 0.256	1.51 (0.0220)
	Reference	4.69 (0.128)	< 0.132	1.37 (0.0113)
8-27-83	Facility	4.51 (1.68)	< 0.202	1.54 (0.0181)
	Adjacent	5.65 (2.03)	< 0.207	1.55 (0.0189)
	Reference	2.44 (1.99)	< 0.203	1.28 (0.0179)

* Adjacent Composite Locations: A6, A28, A31, A50, A36, A48.
Reference Composite Locations: R16, R17, R20, R22, R23, R25.
** Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).
*** Collected 7-27-83

Table II. D.4
Gamma-ray Emitting Radionuclide Concentrations in Composite Milk Samples.

Samples Collected	Area *	^{131}I (pCi/l)	^{137}Cs (pCi/l)	Nat. K (g/l)
9-3-83	Facility	2.79 (1.44)**	< 0.174	1.51 (0.0167)
	Adjacent	5.51 (1.77)	< 0.190	1.41 (0.0175)
	Reference	7.86 (1.93)	< 0.186	1.43 (0.0173)
9-10-83	Facility	4.03 (1.20)	< 0.210	1.54 (0.0170)
	Adjacent	4.93 (1.57)	< 0.214	1.46 (0.0170)
	Reference	< 0.199	< 0.207	1.47 (0.0181)
9-17-83	Facility	1.85 (2.18)	0.248 (1.08)	1.61 (0.0128)
	Adjacent	< 0.116	< 0.120	1.61 (0.0128)
	Reference	< 0.252	< 0.262	1.53 (0.0221)
9-24-83	Facility	< 0.195	< 0.202	1.65 (0.0182)
	Adjacent	< 0.205	< 0.213	1.57 (0.0188)
	Reference	< 0.197	< 0.205	1.57 (0.0182)
10-8-83	Facility	< 0.141	< 0.146	1.37 (0.0122)
	Adjacent	2.06 (2.19)	< 0.206	1.66 (0.0185)
	Reference	< 0.195	< 0.203	1.67 (0.0184)
11-12-83	Facility	< 0.140	2.17 (0.992)	1.79 (0.0155)
	Adjacent	< 0.186	< 0.193	1.44 (0.0172)
	Reference	< 0.141	< 0.145	1.55 (0.0125)
12-10-83	Facility	< 0.225	< 0.234	1.54 (0.0202)
	Adjacent	< 0.183	< 0.193	1.52 (0.0172)
	Reference	< 0.198	< 0.205	1.55 (0.0166)

* Adjacent Composite Locations: A6, A28, A31, A50, A36, A48.
Reference Composite Locations: R16, R17, R20, R22, R23, R25.
** Uncertainties (in parentheses) are for the 95% confidence interval, (= 1.96 S.D.).

II.D. Food Chain Data

2. Forage. Table II.D.5 lists the tritium specific activity in water extracted from forage samples as well as Sr-89 and Sr-90 concentrations in the forage dry matter. Tritium mean values were less than the minimum detectable for the entire period.

In an effort to sample the feed given to the local dairy herds, most of the forage collected was hay fed to these dry-lot herds. In most of these samples the water content was too low to extract sufficient water for tritium analysis. In the water from those samples that could be extracted, the tritium concentrations were all less than MDC.

Strontium-89 and Sr-90 concentrations were not significantly different for the three sampling zones. The Facility area mean for Sr-89 was higher than that for the other two areas, but due to the high standard deviation the mean values were not statistically different.

Table II.D.6 lists Ru-106, Cs-137 and Zr-Nb-95 activities in forage samples for the second half of 1983. No significant differences were observed.

Gross beta concentrations in soil and forage collected at the same locations are given in Table II.D.7. No statistically significant differences were observed. The forage concentrations are, of course, lower than soil as all of the radionuclides in the soil are not biologically available for plant uptake. However, it should be noted that a significant fraction of the forage activity is due to soil

particles trapped on the plant surface from resuspension. The high gross beta concentration measured in the sample collected at A-6 on September 17, 1983 is an example of this point. The sample count rate was nearly the average of the group, but the ash/dry ratio was approximately 2.5 times greater. This indicates considerable soil contamination and inflates the resulting concentration which is on a dry weight basis.

A cattle forage sample, i.e. fresh cut grass or alfalfa hay, is the sample of choice for several reasons. Forage integrates atmospheric wet and dry deposition over a large surface area per unit weight and also is a direct link in the dairy and beef food chain transport of H-3, Cs-137, and the strontium radioisotopes. Such samples are collected when possible. However, due to feeding practices, vagaries of weather and other factors, often silage or cut samples must be collected. These samples may or may not be harvested locally and may represent different fallout periods as well as different soil areas.

Table II. D.5
Tritium, Strontium 89, and Strontium 90 Concentrations in Forage for Samples Collected July 9, 1983.

Areas	Tritium (pCi/l)	Strontium 89 (pCi/kg)	Strontium 90 (pCi/kg)
Facility			
4**	e	< 7.70	90.3 (14.1)*
44	< 299	24.6 (66.4)	44.0 (28.6)
Adjacent			
6	e	18.2 (42.1)	81.0 (22.1)
28	< 299	< 17.8	82.1 (17.5)
31	< 299	< 13.4	93.8 (16.2)
36	< 299	< 19.8	59.8 (18.2)
48	< 299	< 32.9	178 (47.5)
50	e	< 13.5	74.7 (17.8)
Reference			
16	e	< 24.6	99.1 (23.2)
17	e	< 49.8	94.7 (52.2)
20	e	< 21.7	134 (21.5)
22	e	< 31.4	144 (34.0)
23	e	< 28.7	72.2 (21.4)
25	e	< 22.9	103 (37.6)

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).

e Insufficient water in forage sample for analysis.

** Sample collected 7-16-83.

Table II. D.5
Tritium, Strontium 89, and Strontium 90 Concentrations in Forage for Samples Collected August 27, 1983.

Areas	Tritium (pCi/l)	Strontium 89 (pCi/kg)	Strontium 90 (pCi/kg)
Facility			
4	< 328	< 52.1	147 (54.8)*
44	e	< 8.01	94.8 (11.9)
Adjacent			
6	e	< 3.61	28.8 (7.05)
28	< 328	40.9 (33.3)	< 17.3
31	< 328	< 16.4	87.3 (28.8)
36	e	20.0 (51.1)	71.0 (13.0)
48	e	< 11.1	160 (19.9)
50	e	< 14.2	62.2 (13.9)
Reference			
16	e	< 19.1	60.9 (16.1)
17	e	15.6 (14.5)	54.0 (8.88)
20	e	22.0 (35.2)	295 (23.9)
22	-	< 11.3	37.7 (11.0)
23	e	< 16.8	78.7 (21.8)
25	e	22.9 (33.5)	80.8 (20.6)

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).

e Insufficient water in forage sample for analysis.

Table II. D.5
Tritium, Strontium 89, and Strontium 90 Concentrations in Forage for Samples Collected September 17, 1983 .

Areas	Tritium (pCi/l)	Strontium 89 (pCi/kg)	Strontium 90 (pCi/kg)
Facility			
4	< 299	26.5 (23.2)*	40.2 (15.6)
44	e	11.6 (17.1)	72.8 (12.8)
Adjacent			
6	e	< 27.6	245 (35.4)
28	e	< 11.9	56.8 (15.2)
31	< 299	< 15.7	98.1 (24.5)
36	e	86.0 (20.6)	< 4.94
48	e	< 8.47	122 (12.4)
50	e	< 11.3	63.9 (16.1)
Reference			
16	e	< 9.44	101 (16.6)
17	e	< 24.7	175 (25.7)
20	e	35.8 (36.8)	138 (28.3)
22	e	< 15.3	48.7 (15.4)
23	< 299	< 21.5	53.5 (22.0)
25	e	19.8 (46.6)	91.7 (18.0)

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).
e Insufficient water in forage sample for analysis.

Table II. D.6
Gamma-ray Emitting Radionuclide Concentrations in Forage (pCi/kg) for Samples Collected July 9, 1983.

Areas	^{106}Ru	^{137}Cs	^{95}Zr & Nb
Facility			
4***	219 (135)*	196 (33.2)	147 (23.4)
44	< 72.7	107 (19.3)	63.0 (14.1)
Adjacent			
6	< 80.9	62.7 (21.7)	56.2 (15.5)
28	< 75.3	87.6 (20.7)	57.4 (15.1)
31	83.2 (83.4)	49.1 (19.8)	30.7 (14.4)
36	128 (73.5)	51.4 (17.3)	44.5 (13.0)
48	117 (76.7)	125 (19.3)	85.2 (14.0)
50	68.6 (76.4)	72.7 (18.7)	71.7 (14.0)
Reference			
16	< 73.7	123 (20.1)	64.9 (14.0)
17**	< 787	< 137	< 49.1
20	< 88.3	54.0 (23.3)	37.1 (17.0)
22	83.7 (80.1)	73.4 (19.8)	56.7 (14.7)
23	163 (160)	97.3 (38.6)	52.0 (28.6)
25	103 (80.5)	75.5 (19.4)	73.8 (14.8)

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).

** Counted on Ge(Li) detector.

*** Sample collected 7-16-83.

Table II. D.6
Gamma-ray Emitting Radionuclide Concentrations in Forage (pCi/kg) for Samples Collected August 27, 1983.

Areas	^{106}Ru	^{137}Cs	^{95}Zr & Nb
Facility			
4	172 (77.6)*	74.2 (19.8)	86.4 (13.8)
44	83.1 (53.6)	32.0 (12.7)	68.4 (11.1)
Adjacent			
6	71.4 (57.8)	15.5 (14.3)	23.8 (9.86)
28	43.5 (48.4)	28.6 (11.1)	29.3 (12.1)
31	< 190	151 (49.7)	84.8 (59.1)
36	68.3 (54.7)	34.5 (14.8)	39.6 (11.3)
48	< 62.6	43.2 (17.4)	91.5 (21.4)
50	85.0 (72.4)	41.4 (17.1)	34.8 (15.8)
Reference			
16	129 (85.4)	43.5 (20.2)	100 (19.3)
17	< 47.6	< 15.0	30.2 (9.17)
20	84.2 (71.4)	44.6 (17.9)	51.9 (12.3)
22	< 59.9	50.2 (16.7)	43.5 (11.4)
23	193 (27.4)	58.0 (6.13)	41.4 (6.95)
25	146 (67.6)	40.5 (16.0)	73.2 (15.1)

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).

Table II. D.6
Gamma-ray Emitting Radionuclide Concentrations in Forage (pCi/kg) for Samples Collected September 17, 1983.

Sampling Location	^{106}Ru	^{137}Cs	^{95}Zr & Nb
Facility			
4	65.0 (26.0)*	41.2 (6.19)	54.9 (5.42)
44	48.8 (20.2)	55.0 (5.12)	< 2.05
Adjacent			
6	164 (128)	97.9 (30.5)	105 (26.7)
28	56.0 (59.1)	41.9 (14.0)	26.4 (11.9)
31	146 (29.0)	84.8 (7.10)	85.9 (6.10)
36	105 (68.0)	39.1 (16.2)	40.9 (14.0)
48	48.1 (25.7)	78.4 (13.9)	64.9 (12.2)
50	117 (94.3)	33.3 (19.7)	28.5 (32.4)
Reference			
16	66.5 (22.8)	147 (5.42)	72.3 (4.96)
17	136 (40.4)	56.7 (9.51)	51.4 (8.58)
20	< 66.5	46.3 (17.7)	36.6 (15.5)
22	90.4 (24.6)	56.0 (5.90)	61.6 (5.10)
23	< 83.7	74.3 (22.3)	47.9 (19.5)
25	26.1 (36.5)	42.1 (7.79)	102 (13.1)

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).

Table II. D.7
Gross Beta Concentrations in Soil and Forage (pCi/kg) for Samples Collected Third Quarter, 1983.

Sampling Location	July 9, 1983		August 12, 1983		September 17, 1983	
	Soil	Forage	Soil	Forage	Soil	Forage
Facility						
4	31,000 * (1,760)	6,480** (166)	27,500 (1,390)	31,300 (530)	25,600 (1,200)	20,900 (333)
44	31,300 (1,670)	15,800 (794)	18,100 (1,160)	22,600 (349)	30,700 (1,410)	19,300 (330)
Adjacent						
6	26,800 (1,730)	20,400 (602)	26,100 (1,220)	7,730 (165)	22,700 (1,230)	48,700 (796)
28	22,000 (1,430)	19,700 (977)	22,000 (1,240)	11,800 (258)	16,500 (1,120)	15,300 (235)
31	27,500 (1,690)	16,900 (755)	25,900 (1,300)	25,000 (440)	25,400 (1,270)	18,500 (475)
36	25,700 (1,610)	16,700 (804)	25,300 (1,300)	14,300 (226)	22,900 (1,240)	14,700 (230)
48	31,500 (1,870)	2,510 (84)	26,100 (1,320)	21,300 (291)	26,700 (1,280)	20,300 (328)
50	24,100 (1,490)	23,400 (765)	26,800 (1,350)	13,800 (263)	26,600 (1,330)	7,990 (179)
Reference						
16	30,800 (1,710)	14,600 (549)	27,800 (1,380)	21,200 (333)	25,200 (1,300)	18,300 (289)
17	22,700 (1,540)	13,300 (556)	26,900 (1,350)	12,200 (192)	21,800 (1,120)	17,800 (287)
20	28,000 (1,760)	20,900 (734)	26,700 (1,370)	20,000 (393)	23,900 (1,260)	20,600 (344)
22	25,200 (1,630)	18,800 (286)	27,100 (1,380)	14,200 (224)	29,300 (1,350)	18,100 (308)
23	19,900 (1,400)	22,500 (1,060)	21,600 (1,140)	4,470 (114)	26,400 (1,320)	14,900 (267)
25	29,700 (1,880)	22,500 (746)	27,400 (1,370)	18,200 (368)	23,500 (1,300)	25,400 (486)

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).

** Collected 7/16/83.

II.D. Food Chain Data

3. Soil. Soil samples are collected at the same time and location as forage samples. A core borer is used to collect the sample. The sample depth is 10.3 cm and the area is 102 cm^2. Bulk soil density is approximately 1 g/cm^3. Table II.D.8 presents gross beta activity of soil per unit surface area for the second half of 1983. This parameter is calculated from the gross beta concentration in soil (Table II.D.7) multiplied by the mass per unit surface area of the sample core. Since reactor airborne effluents or fallout will result in deposition on the soil surface, activity per unit surface area is the parameter of choice to document environmental contamination. The mean value for the Facility area was not significantly greater than that measured for the Adjacent or Reference areas (Table II.H.1). Any small variations are due to different concentrations of the natural Uranium and Thorium decay series and natural K-40. The difference is not due to fission product activity.

Table II.D.9 and the calculated mean values indicate that there is no significant difference for Ru-106, Cs-137 or Zr-Nb-95 between the Facility, Adjacent or Reference sampling zones.

Tritium, Sr-89, and Sr-90 in soil are shown in Table II.D.10. Tritium specific activity in soil water is statistically the same as that in other environmental samples, e.g. water, forage and milk. The activity per unit surface area of the strontium radioisotopes was again quite variable. Due to the large standard deviations there was no statistical difference in the mean values between the three

sampling zones. It should be noted that the Sr-90 values are considerably less than measured for Cs-137. This is because the weapon's fallout Cs-137 is trapped near the soil surface by ion exchange and the Sr-90 is leached down the soil profile to depths greater than that collected by our coring method.

Table II. D.8
Gross Beta Activity in Soil per Unit Surface Area ($\mu Ci/m^2$) for Samples Collected Third Quarter, 1983.

Sampling Locations	July 9, 1983	August 12, 1983	September 17, 1983
Facility			
4	3.99 (0.227)*	3.55 (0.179)	3.31 (0.155)
44	4.04 (0.215)	2.33 (0.150)	3.96 (0.182)
Adjacent			
6	3.46 (0.223)	3.37 (0.157)	2.93 (0.159)
28	2.84 (0.185)	2.84 (0.160)	2.12 (0.145)
31	3.54 (0.218)	3.34 (0.167)	3.28 (0.164)
36	3.32 (0.207)	3.26 (0.168)	2.96 (0.160)
48	4.06 (0.241)	3.37 (0.170)	3.45 (0.165)
50	3.11 (0.192)	3.46 (0.174)	3.43 (0.172)
Reference			
16	3.97 (0.221)	3.59 (0.178)	3.25 (0.167)
17	2.92 (0.198)	3.48 (0.175)	2.81 (0.145)
20	3.61 (0.227)	3.45 (0.177)	3.09 (0.163)
22	3.25 (0.210)	3.50 (0.178)	3.78 (0.174)
23	2.56 (0.181)	2.79 (0.148)	3.41 (0.171)
25	3.82 (0.243)	3.54 (0.176)	3.03 (0.167)

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).

Table II. D.9
Gamma-ray Emitting Radionuclide Activity per Unit Surface Area of Soil (nCi/m^2) for Samples Collected July 9, 1983.

Sampling Location	^{106}Ru	^{137}Cs	^{95}Zr & Nb
Facility			
4	< 350	< 60.8	< 21.8
44	< 257	< 44.7	69.9 (93.4)*
Adjacent			
6	< 314	< 54.6	< 19.6
28	< 315	< 54.8	< 19.6
31	< 227	< 39.2	< 14.1
36	< 489	< 85.2	42.2 (140)
48	< 314	89.4 (67.2)	48.5 (37.4)
50	< 439	< 76.5	60.6 (45.3)
Reference			
16	< 314	< 54.6	36.9 (72.0)
17	< 276	< 48.0	< 17.2
20	< 370	< 64.3	< 23.1
22	< 738	< 129	< 46.4
23	< 359	< 62.5	30.4 (41.8)
25	< 444	< 77.3	47.9 (39.5)

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).

Table II. D.9
Gamma-ray Emitting Radionuclide Activity per Unit Surface Area of Soil (nCi/m^2) for Samples Collected August 12, 1983.

Sampling Location	^{106}Ru	^{137}Cs	^{95}Zr & Nb
Facility			
4	< 337	< 58.6	< 21.1
44	< 313	< 54.4	< 19.6
Adjacent			
6	< 342	< 59.4	< 342
28	< 302	61.2 (62.3) *	< 18.9
31	< 452	< 78.7	29.0 (52.2)
36	< 268	< 46.5	< 16.7
48	< 503	< 87.5	< 31.5
50	< 435	< 75.7	38.1 (57.8)
Reference			
16	< 283	< 48.7	< 17.6
17	< 321	< 55.7	< 20.0
20	< 278	< 48.3	< 17.4
22	< 303	< 52.6	< 18.9
23	< 284	< 49.3	< 17.7
25	< 320	< 55.5	< 20.0

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).

Table II. D.9
Gamma-ray Emitting Radionuclide Activity per Unit Surface Area of Soil (nCi/m^2) for Samples Collected September 10, 1983.

Sampling Location	^{106}Ru	^{137}Cs	^{95}Zr & Nb
Facility			
4	< 303	62.3 (63.0)*	< 18.9
44	< 332	< 57.7	< 20.8
Adjacent			
6	< 505	< 87.9	< 31.5
28	< 287	< 49.9	< 17.9
31	< 481	< 83.7	< 30.1
36	< 505	< 88.0	< 31.6
48	< 192	< 33.2	< 11.9
50	< 220	< 38.2	< 13.7
Reference			
16	< 265	< 46.0	< 16.5
17	< 555	< 96.6	< 34.8
20	< 313	< 54.3	< 19.5
22	< 415	< 72.1	< 26.0
23	< 252	< 43.7	20.6 (49.9)
25	< 584	< 102	< 36.7

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).

Table II. D.10
Tritium, concentration in soil water and Strontium 89, Strontium 90 Activity per unit surface of Soil for Samples Collected July 9, 1983.

Sampling Location	Tritium (pCi/l)	Strontium 89 (pCi/m^2)	Strontium 90 (pCi/m^2)
Facility			
4	< 319	17.7 (32.0)*	< 14.4
44	< 299	< 28.1	209 (49.9)
Adjacent			
6	< 319	< 56.8	316 (83.9)
28	< 319	< 27.4	170 (44.8)
31	< 299	< 20.5	120 (33.9)
36	< 299	< 18.0	137 (30.4)
48	< 299	< 18.0	< 15.5
50	< 299	< 29.2	186 (53.0)
Reference			
16	431 (314)	< 31.5	164 (46.4)
17	< 319	< 14.8	22.0 (13.6)
20	< 319	< 20.7	< 17.4
22	386 (313)	< 34.8	263 (56.7)
23	< 319	< 44.9	230 (69.5)
25	441 (296)	< 27.6	< 23.8

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).

Table II. D.10
Tritium, concentration in soil water and Strontium 89, Strontium 90 Activity per unit surface of Soil for Samples Collected August 12, 1983.

Sampling Location	Tritium (pCi/l)	Strontium 89 (pCi/m^2)	Strontium 90 (pCi/m^2)
Facility			
4	< 304	< 9.83	15.2 (11.7) *
44	< 304	11.3 (28.3)	< 11.9
Adjacent			
6	< 304	< 9.54	19.6 (11.4)
28	< 304	20.5 (40.9)	29.3 (18.6)
31	< 304	87.4 (46.7)	25.4 (17.3)
36	< 304	< 9.94	26.4 (13.3)
48	< 304	< 11.3	28.1 (16.8)
50	< 304	< 12.8	22.6 (19.5)
Reference			
16	< 297	< 10.7	31.8 (13.6)
17	< 300	< 9.97	12.4 (12.2)
20	< 297	< 11.1	< 12.7
22	< 297	< 14.4	18.0 (17.7)
23	< 297	< 9.87	28.3 (13.9)
25	< 297	< 12.3	30.3 (17.1)

* Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).

Table II. D.10
Tritium, concentration in soil water and Strontium 89, Strontium 90 Activity per unit surface of Soil for Samples Collected September 17, 1983.

Sampling Location	Tritium (pCi/l)	Strontium 89 (pCi/m^2)	Strontium 90 (pCi/m^2)
Facility			
4	< 300	< 8.02	53.3 (16.7)*
44	< 300	< 7.82	13.6 (14.8)
Adjacent			
6	< 300	< 10.8	17.3 (13.0)
28	< 300	< 9.78	14.7 (12.3)
31	< 300	< 8.65	< 10.9
36	< 300	< 9.15	28.2 (16.8)
43	< 300	< 12.8	39.2 (25.3)
50	< 300	< 10.0	< 11.8
Reference			
16	< 299	10.1 (30.6)	10.1 (11.9)
17	< 299	< 8.72	22.5 (10.8)
20	< 299	< 8.89	12.0 (11.1)
22	< 299	< 8.16	10.7 (9.89)
23	< 299	< 10.8	13.5 (13.6)
25	< 299	< 8.60	21.4 (15.1)

* Uncertainties (in parentheses) are for the 95% confidence interval, ($\pm$ 1.96 S.D.).

II.E. Aquatic Biota

Table II.E.1 shows gross beta and strontium concentrations observed in aquatic biota collected during the second half of 1983. Gross beta concentrations in the sample types are higher than any particular fallout fission product because of the presence of the naturally occurring radionuclide, K-40. For all of the sample types, the downstream gross beta concentrations were statistically the same as upstream. This was true for the radiostrontium isotopes as well. The number of samples analyzed over the last 6 months was small, but observation of the data over all of 1983 shows large variation in all the radionuclides in all of the sample types. (From Table II.H.1 it can be observed that the geometric standard deviations are very great).

Table II.E.2 lists Ru-106, Cs-137, and Zn-Nb-95 concentrations measured in the same samples. These concentrations appear to be similar to those measured during the first half of 1983. The activity of fallout radionuclides deposited previously from the 1980 Chinese Nuclear Weapon Test is apparently only gradually decreasing. There was no significant difference between upstream and downstream sample types.

The high MDC values for seston are due to the fact that such samples are counted by a rather low efficiency Ge(Li) spectrometer system rather than the NaI used for most other sample types. This is because seston, which is principally algae, collects and concentrates particulate radioactivity, and high resolution is necessary for radionuclide measurement of fission product activity in the presence of Ra-226 and Th-232 natural radioactivity. Seston radionuclide concentrations are generally higher

than for the other sample types. A much larger Ge(Li) system is on order and will be used in 1984 for most sample types.

The presence of Corbicula Fluminea, a species of freshwater clam, is being monitored at several sites around the Fort St. Vrain Nuclear Generating Station in Platteville. Corbicula have been introduced to North America from Asia. The freshwater clams are now found in large river systems in the U.S. from coast to coast. The Colorado Division of Wildlife has stated that Corbicula have been found in Northern Colorado, Boyd Lake, some 30 miles from the Fort St. Vrain Nuclear Generating Station. However, to this date, our samplings have indicated no evidence of Corbicula in any of the sampling sites immediately upstream of the reactor.

Table II. E.1

Analysis of Composite* Aquatic Biota
For Samples collected July 1983.

Sampling locations	Gross Beta pCi/Kg	Strontium 89 pCi/Kg	Strontium 90 pCi/Kg
Fish			
Upstream 7-23-83	9,570 (262)**	< 14.5	25.6 (16.0)
Downstream 7-23-83	10,200 (277)	< 28.9	35.4 (36.0)
Effluent 7-23-83	14,100 (405)	< 25.4	36.4 (30.1)
Benthic Organisms			
Upstream 7-23-83	11,100 (524)	< 48.5	198 (44.5)
Downstream 7-23-83	11.400 (533)	< 261	198 (180)
Effluent 7-23-83	13,300 (534)	< 126	87.4 (119)
Vascular Plants			
Upstream 7-16-83	19,700 (349)	< 26.1	120 (23.4)
Downstream 7-16-83	28,500 (443)	< 27.1	127 (27.2)
Effluent 7-16-83	9,090 (169)	< 15.9	69.8 (18.3)
Seston			
Upstream 7-23-83	24,300 (717)	< 26.1	120 (23.4)
Downstream 7-23-83	26,400 (533)	< 27.1	127 (27.2)
Effluent 7-23-83	23,300 (523)	< 15.9	69.8 (18.3)

* Upstream Composite: U 42, U 43.
Downstream Composite: D 40, D 45.

** Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).

Table II. E.1 Analysis of Composite* Aquatic Biota
For Samples collected August 1983.

Sampling locations	Gross Beta pCi/Kg	Strontium 89 pCi/Kg	Strontium 90 pCi/Kg
Fish			
Upstream 8-10-83	11,400 (414)**	< 46.2	62.3 (40.0)
Downstream 8-10-83	10,500 (402)	< 24.9	35.4 (29.8)
Effluent 8-10-83	10,000 (437)	< 60.6	< 55.7
Benthic Organisms			
Upstream 8-10-83	7,950 (459)	< 380	327 (346)
Downstream 8-10-83	23,300 (689)	< 228	< 216
Effluent 8-10-83	18,400 (706)	< 162	226 (242)
Vascular Plants			
Upstream 8-27-83	27,100 (515)	< 30.5	119 (54.0)
Downstream 8-27-83	29,300 (493)	< 26.9	99.7 (39.1)
Effluent 8-27-83	22,900 (419)	46.6 (42.0)	38.5 (18.5)
Seston			
Upstream 8-10-83	18,100 (566)	78.9 (130)	181 (91.2)
Downstream 8-10-83	24,800 (657)	< 51.7	219 (53.1)
Effluent 8-10-83	21,400 (600)	< 66.8	139 (84.3)

* Upstream Composite: U 42, U 43.
Downstream Composite: D 40, D 45.

** Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).

Table II. E.1 Analysis of Composite* Aquatic Biota
For Samples collected September, 1983

Sampling locations	Gross Beta pCi/Kg	Strontium 89 pCi/Kg	Strontium 90 pCi/Kg
Fish			
Upstream 9-28-83	9,380 (308) **	< 64.3	< 53.5
Downstream 9-28-83	2,370 (165)	< 78.8	61.6 (65.5)
Effluent 9-28-83	10,700 (323)	< 50.5	34.6 (35.9)
Benthic Organisms			
Upstream 9-28-83	5,330 (184)	d	d
Downstream 9-28-83	3,240 (121)	< 10.6	19.2 (11.1)
Effluent 9-28-83	5,020 (160)	< 37.9	< 27.1
Vascular Plants			
Upstream 9-10-83	23,300 (410)	< 86.0	121 (155)
Downstream 9-10-83	17,600 (314)	< 16.5	61.9 (19.7)
Effluent 9-10-83	18,700 (402)	< 14.4	44.3 (18.1)
Seston			
Upstream 9-28-83	73,500 (1,850)	< 25.0	< 19.3
Downstream 9-28-83	11,500 (492)	< 24.8	35.5 (25.8)
Effluent 9-28-83	29,900 (854)	< 3.28	7.34 (3.92)

* Upstream Composite: U 42, U 43.
Downstream Composite: D 40, D 45.

** Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).

d Sample lost during analysis.

Table II. E.1 Analysis of Composite* Aquatic Biota
For Samples collected 4th Quarter, 1983 .

Sampling locations	Cross Beta pCi/Kg	Strontium 89 pCi/Kg	Strontium 90 pCi/Kg
Fish			
Upstream 12-2-83	2,440 (169)**	< 53.9	< 36.7
Downstream 12-2-83	2,910 (196)	< 109	82.3 (91.9)
Effluent	f	f	f
Benthic Organisms			
Upstream	f	f	f
Downstream	f	f	f
Effluent	f	f	f
Vascular Plants			
Upstream 10-8-83	14,900 (346)	179 (122)	164 (55.9)
Downstream 10-8-83	20,400 (406)	< 15.7	39.3 (19.4)
Effluent 10-8-83	12,900 (224)	44.6 (84.4)	206 (37.3)
Seston			
Upstream	f	f	f
Downstream	f	f	f
Effluent	f	f	f

* Upstream Composite: U 42, U 43.
Downstream Composite: D 40, D 45.

** Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).

f Sample unavailable due to weather conditions.

Table II. E.2
Gamma-ray Emitting Radionuclide Concentrations in Aquatic Biota Samples
(pCi/kg) for Samples Collected July, 1983.

Sampling Locations *	^{106}Ru	^{137}Cs	^{95}Zr & Nb
Fish			
Upstream 7-23-83	< 250	177 (62.2)**	< 33.2
Downstream 7-23-83	273 (257)	202 (63.1)	122 (44.1)
Effluent 7-23-83	< 250	355 (64.8)	150 (45.0)
Benthic Organisms			
Upstream 7-23-83	< 298	309 (75.3)	102 (45.1)
Downstream 7-23-83	< 250	284 (64.2)	192 (41.4)
Effluent 7-23-83	238 (88.2)	285 (22.0)	138 (13.5)
Vascular Plants			
Upstream 7-16-83	< 481	460 (122)	218 (91.0)
Downstream 7-16-83	901 (528)	< 159	< 67.6
Effluent 7-16-83	< 568	449 (141)	< 75.5
Seston ***			
Upstream 7-23-83	1,280 (352)	503 (84.6)	355 (56.6)
Downstream 7-23-83	1,640 (619)	300 (147)	205 (98.4)
Effluent 7-23-83	e	e	e

* Upstream Composite: U 42, U 43.
Downstream Composite: D 40, D 45.
Effluent: E 38.

** Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).

*** Counted on Ge(Li) detector.

e Insufficient sample weight for analysis.

Table II. E.2
Gamma-ray Emitting Radionuclide Concentrations in Aquatic Biota Samples
(pCi/kg) for Samples Collected August, 1983.

Sampling Locations *	^{106}Ru	^{137}Cs	^{95}Zr & Nb
Fish			
Upstream 8-10-83	285 (242)**	248 (63.5)	55.8 (30.7)
Downstream 8-10-83	< 250	130 (61.7)	35.3 (30.0)
Effluent 8-10-83	< 250	244 (63.2)	46.8 (30.5)
Benthic Organisms			
Upstream 8-10-83	< 312	465 (80.9)	174 (37.2)
Downstream 8-10-83	< 250	434 (66.6)	198 (28.9)
Effluent 8-10-83	< 304	515 (79.7)	169 (34.6)
Vascular Plants			
Upstream 8-27-83	< 385	234 (99.8)	166 (67.3)
Downstream 8-27-83	< 432	328 (113)	227 (76.4)
Effluent 8-27-83	510 (444)	162 (109)	178 (75.0)
Seston			
Upstream 8-10-83	461 (380)	565 (101)	206 (44.2)
Downstream 8-10-83	< 556	419 (138)	180 (61.2)
Effluent 8-10-83	e	e	e

* Upstream Composite: U 42, U 43.
Downstream Composite: D 40, D 45.
Effluent: E 38.

** Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).

e. Insufficient weight for analysis.

Table II. E.2
Gamma-ray Emitting Radionuclide Concentrations in Aquatic Biota Samples
(pCi/kg) for Samples Collected September, 1983.

Sampling Locations *	^{106}Ru	^{137}Cs	^{95}Zr & Nb
Fish			
Upstream 9-28-83	195 (139) **	108 (32.8)	76.9 (29.7)
Downstream 9-28-83	122 (57.5)	66.5 (13.4)	47.0 (11.9)
Effluent 9-28-83	< 120	71.9 (30.6)	47.4 (27.0)
Benthic Organisms			
Upstream 9-28-83	228 (132)	240 (30.9)	194 (26.7)
Downstream 9-28-83	538 (283)	250 (66.6)	173 (58.2)
Effluent 9-28-83	1,340 (390)	875 (94.2)	426 (72.4)
Vascular Plants			
Upstream 9-10-83	722 (465)	235 (104)	183 (113)
Downstream 9-10-83	659 (183)	202 (41.7)	177 (40.9)
Effluent 9-10-83	799 (448)	302 (102)	205 (99.3)
Seston ***			
Upstream 9-28-83	< 6,130	< 1,060	455 (382)
Downstream 9-28-83	< 25,800	< 4,490	< 1,610
Effluent 9-28-83	< 22,800	< 3,950	< 1,420

* Upstream Composite: U 42, U 43.
Downstream Composite: D 40, D 45.
Effluent: E 38.

** Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).

*** Counted on Ge(Li) detector.

Table II. E.2
Gamma-ray Emitting Radionuclide Concentrations in Aquatic Biota Samples
(pCi/kg) for Samples Collected 4th Quarter, 1983.

Sampling Locations *	^{106}Ru	^{137}Cs	^{95}Zr & Nb
Fish			
Upstream 12-2-83	< 232	106 (57.8)**	< 31.2
Downstream 12-2-83	< 74.6	61 (23.1)	29.0 (14.0)
Effluent	f	f	f
Benthic Organisms			
Upstream	f	f	f
Downstream	f	f	f
Effluent	f	f	f
Vascular Plants			
Upstream 10-8-83	612 (448)	243 (106)	155 (86.2)
Downstream 10-8-83	678 (538)	321 (127)	184 (104)
Effluent 10-8-83	1,980 (412)	715 (100)	355 (69.6)
Seston			
Upstream	f	f	f
Downstream	f	f	f
Effluent	f	f	f

* Upstream Composite: U 42, U 43.
Downstream Composite: D 40, D 45.
Effluent: E 38.

** Uncertainties (in parentheses) are for the 95% confidence interval, (± 1.96 S.D.).

f Sample unavailable due to weather conditions.

II.F. Beef Cattle. Two head of beef cattle from the herd that grazes the facility area are counted each quarter in the CSU whole-body-counter. The animals are washed carefully and counted for 20 minutes each. This method is far more sensitive than counting meat samples and is the method of choice for detecting Cs-137 in the meat food chain of humans. If thyroid I-131 contamination were significant this would be detected from the whole body count. Detectable I-131 activity has never been observed.

Table II.F.1 gives values for whole body counting of beef cattle for the second half of 1983. The animals are selected at random; however, the animal number is recorded and the animal may be retrieved and recounted if necessary. The Cs-137 body burdens are greatly different between third quarter and fourth quarter. This only reflects a different cutting and/or source of hay and pasture for the animals. The values are still within the range of past data.

The Cs-137 concentration is expressed as pCi per gram of K in the whole animal. This is done to more easily compare the counts between different size animals. K and Cs are both intracellular cations and by normalizing the Cs-137 activity to K, differences due to fat percentage in the animals are eliminated because the K concentration of fat free muscle is very constant.

Table II.F.2 lists the Cs-137, tritium, K and radiostrontium concentrations in one beef animal from the local herd which was slaughtered at the end of the pasture season. The radionuclide of concern for FSV effluents would be tritium, but the observed concentration was less than MDC.

Table II.F.1. Radionuclides in Facility Area Beef Cattle

In-vivo Gamma-ray activity in Fort St. Vrain Area beef cattle.

		Third Quarter Values
9-22-83	^{131}I	^{137}Cs pCi/g K
Cow 1	none detected	< 2.21
Cow 2	none detected	< 2.21
12-21-83		Fourth Quarter Values
Cow 1	none detected	48.6
Cow 2	none detected	33.5

Table II.F.2.

Radionuclides in Beef Sample from Local Herd.
Animal Slaughtered, Fourth Quarter, 1983 *

Hamburger

^{137}Cs pCi/Kg	K g/kg	Tritium pCi/l
0.171	0.610	< 299

Bone

^{89}Sr pCi/Kg	^{90}Sr pCi/Kg
< 320	367 (337)*

* Uncertainties (shown in parentheses) are for the 95% confidence interval (± 1.96 S.D.).

II.G.1 Sample Cross Check Data.

To assure the precision and accuracy of the environmental data obtained from the radiation surveillance program provided for the Fort St. Vrain reactor, Colorado State University participates in the U.S. Environmental Protection Agency (EPA) sponsored laboratory intercomparison studies program. This involves the analysis of a variety of environmental media containing various levels of radioactivity. The media, type of analysis and frequency of analysis are summarized below.

The media, type of analysis and frequency of analysis

Medium	Analysis (radionuclide)	Frequency
Water	^{3}H	bimonthly
Water	gross α, gross β	bimonthly
Water	^{51}Cr, ^{60}Co, ^{65}Zn, ^{106}Ru, ^{134}Cs, ^{137}Cs	triannually
Water	^{89}Sr, ^{90}Sr	triannually
Water	^{131}I	triannually
Air particulate filters	^{90}Sr, ^{137}Cs, gross α, gross β	triannually
Milk	^{89}Sr, ^{90}Sr, ^{131}I, ^{137}Cs, ^{40}K	triannually

For each radionuclide analysis of a particular medium, three independent measurements are performed and the mean value is then calculated. The percentage deviation of our determined mean value from the EPA specified value is also calculated.

Table II.G.1 gives the EPA cross check data for the last half of 1983. The EPA has chosen to use the term Estimated Laboratory Precision (ELP), calculated as $3\sigma/N$, as the control parameter, where N = the number of analyses. Whenever our mean value falls outside this limit, the sample calculations are rechecked and the sample reanalyzed if possible. Of the cross check results reported for this period, most were within the ELP. These values have a superscript notation (n) in Table II.G.1. The recheck process and conclusion is given below for each of these individual samples.

(1) through (6) The analysis of each radionuclide in this sample exceeded the ELP. The sample results given were determined independently by NaI(Tl) and Ge(Li) spectrometry. Although there still is uncertainty regarding the Cr-51, Co-60 and Zn-65 calibrations, we have confidence in the calibration of the other three radionuclides and generally had good cross check results. No reason for this discrepancy can be given at this time. The analysis was repeated and the results were essentially unchanged. A new calibration for all 6 radionuclides is currently underway.

(7), (8) A repeat analysis of this sample also gave the original values which are outside of the ELP. The Ru-106 value did prove to be correct after reanalysis.

(9) The Sr-90 analysis was repeated but no reason for the discrepancy can be given.

(10) This I-131 analysis could not be repeated due to the decay of the radionuclide in the EPA sample. We plan to check all milk samples in the future by high efficiency Ge(Li) counting using a

Marinelli beaker.

Table II.G.2 shows the results of independent analyses of the same water sample by CSU, the Colorado Department of Health, and Public Service Company of Colorado. The samples are from two effluent locations and one upstream location. The results for gross beta analyses have been reviewed and the following corrective actions have been adopted.

1. Samples will be counted at approximately the same time after collection to correct for possible S-35 activity in the sample.
2. The same sample volume (100 ml) will be used by each group so that sample self-absorption will be identical.
3. All samples will be homogenized and treated with acid identically.

The tritium results were acceptable.

Table II.G.1. EPA Cross-Check Data Summary

Date	Radio nuclide	CSU Value	EPA Value	Standard Deviation, σ	Estimated Laboratory Precision*	% deviation from known
			Water, Tritium pCi/l			
8-12-83	^{3}H	1,483	1,836	342	593	- 19.2
10-14-83	^{3}H	1,210	1,099	329	570	+ 18.3
12-9-83	^{3}H	2,480	2,389	351	608	+ 3.8
			Water, Alpha and Beta pCi/l			
7-15-83	gross α	7	7	5	8.7	0
	gross β	22	22	5	8.7	0
9-16-83	gross α	4	5	5	8.7	- 20.0
	gross β	6	9	5	8.7	- 33.3
			Water, Strontium 89 & 90 pCi/l			
9-2-83	^{89}Sr	12	15	5	8.7	- 23.1
	^{90}Sr	11	10	1.5	2.6	+ 10.0
			Water, Iodine pCi/l			
8-5-83	^{131}I	9	14	6	10.4	- 35.7

* $3\sigma/\sqrt{n}$

Table II.G.1. EPA Cross-Check Data Summary, (cont.)

Date	Radio nuclide	CSU Value	EPA Value	Standard Deviation, σ	Estimated Laboratory Precision*	% deviation from known
			Air, pCi/Filter			
8-26-83	gross α	11	13	5	8.7	- 15.4
	gross β	38	36	5	8.7	+ 5.6
	^{90}Sr	11	10	1.5	2.6	+ 10.0
	^{137}Cs	15	15	5	8.7	0
			Water, Gamma pCi/l			
6-3-83	^{51}Cr (1)	21	60	5	8.7	- 65
	^{60}Co (2)	2.3	13	5	8.7	- 82
	^{65}Zn (3)	9.3	36	5	8.7	- 74
	^{106}Ru (4)	11	40	5	8.7	- 73
	^{134}Cs (5)	74	47	5	8.7	+ 57
	^{137}Cs (6)	37	26	5	8.7	+ 42
10-7-83	^{51}Cr (7)	16	51	5	8.7	- 68.6
	^{60}Co	20	19	5	8.7	+ 5.3
	^{65}Zn (8)	26	40	5	8.7	- 35.0
	^{106}Ru	54**	52	5	8.7	+ 3.8
	^{134}Cs	22	15	5	8.7	+ 46.7
	^{137}Cs	30	30	5	8.7	0
			Gamma, Milk pCi/l			
6-10-83	^{89}Sr	17	25	5	8.7	- 32.0
	^{90}Sr (9)	20	16	1.5	2.6	+ 25.0
	^{131}I	28	30	6	10.4	- 6.7
	^{137}Cs	50	47	5	8.7	+ 6.4
	K	1,557	1,486	75	129	+ 4.8
10-28-83	^{89}Sr	10	15	5	8.7	- 33.3
	^{90}Sr	15	14	1.5	2.6	+ 7.1
	^{131}I (10)	20	40	4.8	8.4	- 50.0
	^{137}Cs	32	33	5	8.7	- 3.0
	K	1,637	1,5[illegible]	78	135	+ 5.6

* $3\sigma/\sqrt{n}$

** Result of reanalysis.

Table II.G.2 Crosscheck Analyses on Split Water Samples Determined by Colorado State University, Colorado Department of Health and Public Service Company of Colorado.

Collection Date	Sample Location	Gross Beta pCi/L			Tritium pCi/L		
		CSU	CDH	PSC	CSU	CDH	PSC
7-15-83	E38	7.6	12	< 78.2	1,110	1,030	< 651
	E41	7.6	9	< 78.2	1,440	1,120	936
	U42	4.7	28	< 78.2	297	350	< 651
8-12-83	E38	7.7	22	< 73.7	4,170	4,190	5,490
	E41	9.4	20	< 73.7	805	993	873
	U42	5.7	15	< 73.7	< 303	< 350	1,140
9-16-83	E38	9.3	17	21.0	1,230	1,404	1,280
	E41	13.4	23	17.1	744	1,759	< 695
	U42	6.6	12	11.2	< 297	469	< 695
10-14-83	E38	12.2	17	23.2	1,840	1,377	2,080
	E41	12.3	21	27.6	861	911	1,660
	U42	7.1	10	26.4	1,170	855	1,010
11-25-83	E38	11.0	18	< 69.8	3,420	4,554	3,760
	E41	12.2	19	< 70.1	3,750	4,629	3,770
	U42	7.3	11	< 69.8	< 302	571	< 482
12-8-83	E38	10.7	16	13.8	1,350	1,359	1,350
	E41	16.7	18	24.5	1,220	1,033	948
	U42	5.7	12	14.3	< 302	< 350	< 477

II.H. Summary and Conclusions

Table II.H.1 presents the primary summary and analysis of data collected during the second half of 1983. The tabular data may be used for comparison to previous reactor operational periods and for comparison to other operating power reactors. The number of samples analyzed in the reporting period and the maximum and minimum values for each sample type are given. From log-normal analysis of each data set for the last 12 month period the geometric mean and geometric standard deviations are presented. The arithmetic mean is also calculated back for the entire year and for the reporting period. It should be noted that the tabular data presented in the body of this report contain only positive calculated values. Any calculated values less than zero or less than the minimum detectable concentration (MDC) are listed as less than the actual MDC for that sample analysis. However, the actual result in all cases was used in the calculation for the arithmetic mean values for the period. Therefore all values, negative as well as positive, were included. This procedure is now generally accepted and gives a better estimate of the true mean value. Because of this procedure, however, the values listed in Table II.H.1 cannot be calculated directly from the tabular values in the report. It must be emphasized that while it is true that no sample can contain less than zero radioactivity, due to the random nature of radioactive decay, it is statistically possible to obtain sample count rates less than background and hence a negative result. The minimum value listed in Table II.H.1 is the lowest positive value observed in the data set, even if this value is below the MDC value which is recorded in the text table. On a few occasions, due to small data sets all values are negative and the minimum value listed in Table

II.H.1 is the MDC value corresponding to the lowest negative value.

The log-normal probability treatment is to plot all data for each sample type over the last full year on log-probit coordinates. The samples are ranked by increasing activity concentration and the cumulative percentage of rankings are plotted on the probit abcissa versus the activity concentration on the log ordinate. The geometric mean value $\bar{x}_g$ is determined directly from the 50th percentile point. The geometric standard deviation is simply the slope of the line which can be calculated from the ratio between 84.1 percentile and the 50th percentile. In a normal distribution the arithmetic standard deviation is an additive parameter to the arithmetic mean; i.e., $(\bar{x} \pm \sigma)$, whereas in the log-normal distribution the geometric standard deviation σ_g is a multiplicative parameter to the geometric mean $(\bar{x} \times \sigma_g)$. The area between $\bar{x}_g$ divided by σ_g, and $\bar{x}_g$ multiplied by σ_g should contain 68% of the frequency values. The log-normal statistical treatment is tentative when the number of samples in the group is small. For this reason only the last full year of data points is treated by this method. With the log-normal analysis, no bias results from using either actual values or less than MDC values.

From the values presented in Table II.H.1 and the tabular data of the report, the following observations and conclusions may be drawn:

1. Tritium was the only radionuclide that was detected in any of the effluent pathways that can be attributed to reactor operation. Since the tritium is released as tritiated water, the dilution by the surrounding hydrosphere is great. Although on several occasions elevated concentrations of tritiated water could be detected downstream

of the reactor, the average over the six month period was not statistically greater than upstream concentrations. The tritium concentrations measured in animals that graze near the reactor in the Facility area and the milk produced by the nearest dairy herd were all less than MDC. Thus no dose commitment can be calculated for the effluent tritium for any pathway.

2. The fallout from the October 17, 1980 Chinese Nuclear Weapon test was not detectable in air samples during this reporting period. Only the previous deposition as observed in soil and food chain samples was still observed. Nuclear weapon test fallout, however, has since the inception of the project been noted to be the predominant contribution to background. It is the variation in fallout deposition that requires so many environmental samples to detect any possible increase due to reactor effluents. A simple comparison of preoperational and postoperational values is of little value for most sample types because the fallout deposition was considerably greater during the preoperational period. Figure II.H.1 shows the half-yearly mean values of gross beta concentrations in air for the Facility and Adjacent air sampling sites. Although by using half yearly means some of the fine structure is lost, the overall conclusion is that from 1974-1983 there was no difference in gross beta air concentrations between Facility and Adjacent sites. The large peaks correspond to weapons testing fallout produced by Mainland China. Table II.H.2 gives dates of announced atmospheric nuclear weapon tests and the dates of the reactor start-up and operation. The mean for the Adjacent stations was greater than for the Facility station.

This difference was not statistically significant. It is clear from the plot that if fallout produces variations of such magnitude (a factor approximately 25) then small increments from reactor effluents even if detectable would not be significant and difficult to document.

3. Figure II.H.2 is a plot of tritium measured in water samples over the period 1974-1983. During the entire period the overall pattern is that of fallout deposition. There is some delay period in the peaks due to the mean residence time of tritium in the hydrosphere and input from other areas. Beginning in 1981 there can be observed an increase in the downstream locations relative to upstream. This small increase is statistically significant, but has not produced any increase in tritium concentration in potable water or any food products measured.

4. The most significant pathway for environmental tritium dose to humans is via milk. Figure II.H.3 shows tritium concentrations in milk measured during 1974-1983. Although between 1974 and 1977 there is an apparent difference in the concentrations between the three sampling zones, during the periods of significant reactor operation, no differences are discernible.

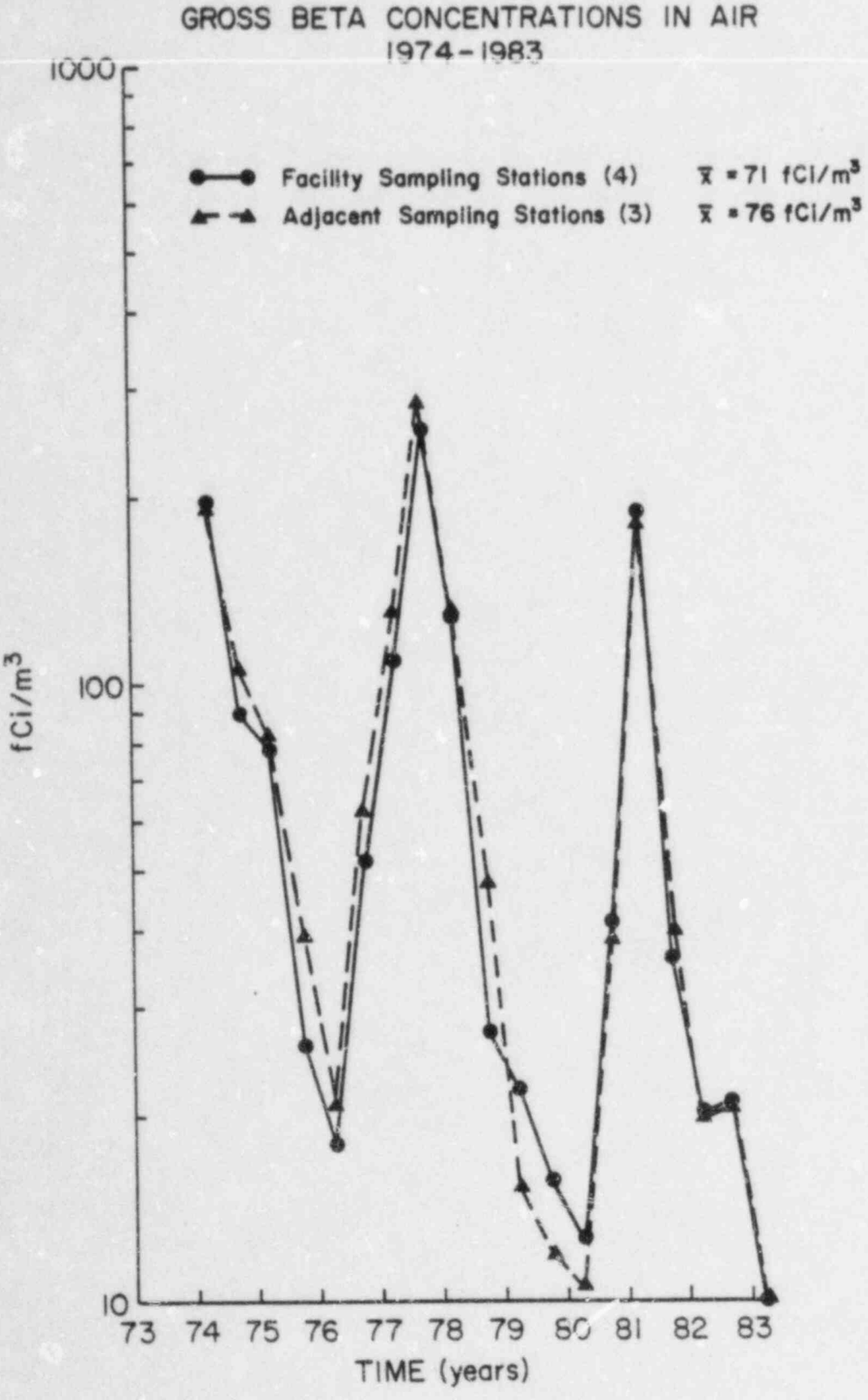
5. The log-normal treatment of all the data revealed that for most of the data such analysis is appropriate. However, sigmoid distributions were quite often observed. Sigmoid distributions can be resolved into bimodal or even trimodal log-normal distributions. This is generally interpreted to mean that there is more than one significant activity source term. For all of the data analyzed over the past year by the log-normal treatment, those sample types that

are reservoirs or sinks for activity, e.g., soil, sediment and TLD, tended to be described by a single distribution. Those sample types which are less stable and fluctuate due to outside sources, e.g., air and precipitation, tended to be bimodal or trimodally distributed, particularly when weapon test fallout is present.

6. As in every previous report, it was again apparent that for most sample types the variability observed around the mean values was great. This variability is due to counting statistics and methodological error, but principally due to true environmental variation. It must be recognized and accounted for in analysis of any set of environmental data before meaningful conclusions can be drawn.

7. It can be concluded again that the radiation dose commitments calculated for the closest inhabitants or other parts of the nearby ecosystems from current reactor effluents are negligible compared to natural background radiation dose rate and the dose commitment from atmospheric weapon testing fallout.

Figure II.H.1


GROSS BETA CONCENTRATIONS IN AIR
1974-1983
Facility Sampling Stations (4) x̄ = 71 fCi/m³
Adjacent Sampling Stations (3) x̄ = 76 fCi/m³
1000
100
10
fCi/m³
73 74 75 76 77 78 79 80 81 82 83
TIME (years)

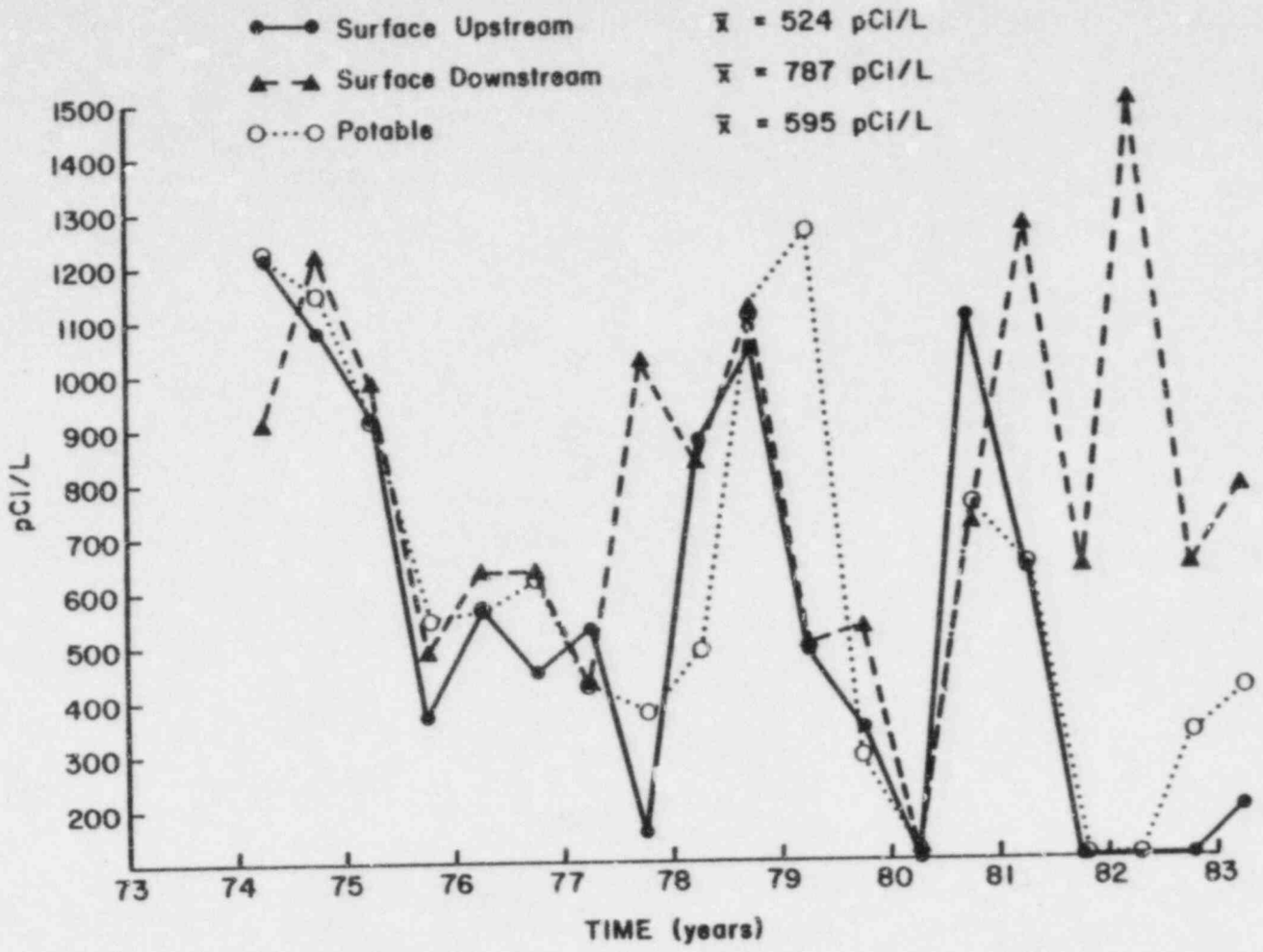

TRITIUM CONCENTRATIONS IN WATER, 197 1983
Surface Upstream
Surface Downstream
Potable
x̄ = 524 pCi/L
x̄ = 787 pCi/L
x̄ = 595 pCi/L
pCi/L
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
73
74
75
76
77
78
79
80
81
82
83
TIME (years)

Figure II.H.2.

Figure II. H. 3.

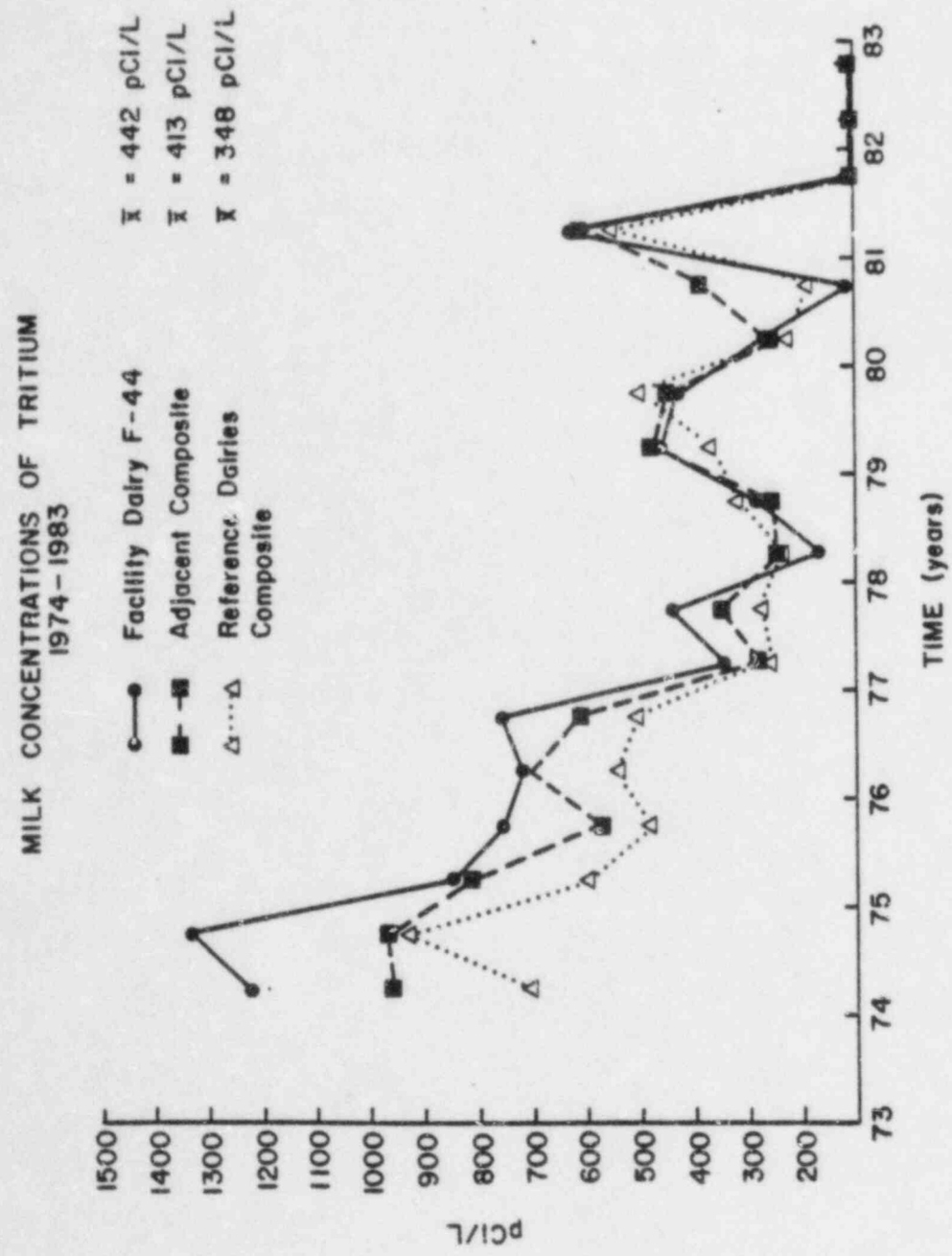

MILK CONCENTRATIONS OF TRITIUM
1974-1983
Facility Dairy F-44
Adjacent Composite
Reference Dairies Composite
x̄ = 442 pCi/L
x̄ = 413 pCi/L
x̄ = 348 pCi/L
pCi/L
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
73
74
75
76
77
78
79
80
81
82
83
TIME (years)

Table II.H.1. Mean Values for all Sample Types.

Sample Type	Area	Number of Samples Analyzed 6 Months	Minimum Value Observed 6 Months	Maximum Value Observed 6 Months	$\tilde{x}_g$ 1 Year	σ_g 1 Year	$\bar{x}$ 1 Year	$\bar{x}$ 6 Months
TLD External (mR/day)	Facility	78	0.34	0.52	0.44	1.08	0.44	0.45
	Adjacent	70	0.32	1.72	0.42	1.16	0.43	0.45
	Reference	70	0.33	0.58	0.41	1.12	0.41	0.42
Air Gross α (fCi/m^3)	Facility	99	0.60	22.9	4.21	2.43	5.93	8.24
	Adjacent	73	3.60	22.7	4.16	2.49	5.91	7.89
Air Gross β (fCi/m^3)	Facility	99	4.0	51.0	13.6	1.81	15.8	19.7
	Adjacent	73	3.0	64.0	13.1	1.94	16.1	24.4
Air Tritium (pCi/l)	Facility	107	< 297	5,770	249	2.52	137	185
	Adjacent	81	< 295	894	208	2.46	52.6	13.1
Air ^{131}I (fCi/m^3)	Composite	26	< 5.45	< 5.45	0.307	9.19	< 5.45	< 5.45
Air ^{106}Ru (fCi/m^3)	Composite	26	< 2.00	18.0	6.47	2.37	2.65	0.632

Table II.H.1. Mean Values for all Sample Types.(Cont'd.)

Sample Type	Area	Number of Samples Analyzed 6 Months	Minimum Value Observed 6 Months	Maximum Value Observed 6 Months	$\bar{x}_g$ 1 Year	σ_g 1 Year	$\bar{x}$ 1 Year	$\bar{x}$ 6 Months
Air ^{137}Cs (fCi/m^3)	Composite	27	< 1.26	5.31	1.37	2.68	1.61	1.67
Air ^{95}Zr (fCi/m^3)	Composite	27	< 0.185	3.47	0.834	2.16	0.469	0.698
Water Gross β (pCi/l)	Effluent	31	5.50	18.8	9.98	1.42	10.6	11.5
	Downstream	18	4.47	16.2	7.48	1.54	8.12	8.32
	Upstream	12	4.90	12.9	7.44	7.64	7.87	7.80
	Potable	12	3.62	11.9	6.43	1.46	6.23	6.88
Water Tritium (pCi/l)	Effluent	33	< 300	11,200	563	4.54	4,620	1,450
	Downstream	18	< 289	953	319	3.37	528	279
	Upstream	12	< 289	505	254	2.01	229	266
	Potable	12	< 297	613	354	1.90	311	214
Water ^{90}Sr (pCi/l)	Effluent	33	< 0.927	2.25	0.804	2.41	0.327	0.888
	Downstream	18	< 0.740	3.77	0.785	2.06	0.341	0.888
	Upstream	12	< 0.896	1.84	0.764	2.38	< 0.896	0.305
	Potable	12	< 0.860	1.00	0.657	2.15	< 0.872	0.374

Table II.H.1. Mean Values for all Sample Types. (Cont'd.)

Sample Type	Area	Number of Samples Analyzed 6 Months	Minimum Value Observed 6 Months	Maximum Value Observed 6 Months	$\bar{x}_g$ 1 Year	σ_g	$\bar{x}$ 1 Year	$\bar{x}$ 6 Months
Water ^{89}Sr (pCi/l)	Effluent	33	< 0.558	5.28	0.642	3.02	< 0.558	< 0.558
	Downstream	18	< 0.636	0.134	0.883	1.72	< 0.642	< 0.642
	Upstream	12	< 0.650	0.292	0.746	3.14	< 0.650	< 0.650
	Potable	12	< 0.550	1.45	0.663	2.05	< 0.550	< 0.550
Water ^{106}Ru (pCi/l)	Effluent	33	< 0.685	11.1	2.36	2.17	< 0.680	1.49
	Downstream	18	< 1.82	12.9	2.35	3.11	< 2.17	4.54
	Upstream	12	< 0.822	8.99	2.58	2.32	0.889	4.39
	Potable	12	< 2.54	9.77	2.83	2.21	1.75	3.63
Water ^{137}Cs (pCi/l)	Effluent	33	< 0.258	7.79	1.58	2.34	0.631	< 0.258
	Downstream	18	< 0.248	5.39	1.44	2.66	2.03	1.75
	Upstream	12	< 0.224	4.80	1.02	3.27	0.976	1.38
	Potable	12	< 0.799	5.15	0.898	3.13	1.27	1.44
Water ^{95}Zr (pCi/l)	Effluent	33	< 0.110	3.67	0.850	2.63	1.09	0.780
	Downstream	18	< 0.288	1.50	0.618	3.04	0.947	0.711
	Upstream	12	< 0.188	2.67	0.693	2.54	0.953	0.780
	Potable	12	< 0.341	1.17	0.573	1.95	0.629	0.546
Sediment Gross β (pCi/kg)	Effluent	12	29,900	40,000	31,900	1.10	32,000	32,900
	Downstream	18	26,300	35,200	30,800	1.11	30,900	30,500
	Upstream	12	27,300	48,000	31,700	1.14	32,000	33,800

Table II.H.1. Mean Values for all Sample Types (Cont'd.)

Sample Type	Area	Number of Samples Analyzed 6 Months	Minimum Value Observed 6 Months	Maximum Value Observed 6 Months	$\bar{x}_g$ 1 Year	σ_g 1 Year	$\bar{x}$ 1 Year	$\bar{x}$ 6 Months
Sediment ^{90}Sr (pCi/kg)	Effluent	12	< 161	533	105	3.41	54.1	158
	Downstream	18	< 163	477	135	3.01	83.2	172
	Upstream	12	< 160	420	146	2.45	53.1	164
Sediment ^{89}Sr (pCi/kg)	Effluent	12	< 148	892	131	2.35	67.4	103
	Downstream	18	< 119	513	202	1.92	< 119	< 119
	Upstream	12	< 149	494	117	2.81	< 149	< 149
Sediment ^{106}Ru (pCi/kg)	Effluent	12	< 2,440	8,430	2,160	2.99	< 2,440	< 2,440
	Downstream	18	< 2,900	8,390	2,510	2.19	< 2,900	< 2,900
	Upstream	12	< 2,340	2,650	2,800	2.03	< 2,340	< 2,340
Sediment ^{137}Cs (pCi/kg)	Effluent	12	< 423	2,090	391	2.59	185	273
	Downstream	18	< 502	844	328	3.08	< 557	< 557
	Upstream	12	< 405	777	379	3.48	216	187
Sediment ^{95}Zr (pCi/kg)	Effluent	12	< 152	2,510	194	2.40	145	262
	Downstream	18	< 180	367	175	2.34	< 180	< 180
	Upstream	12	< 27.0	1,090	140	3.71	152	177
Precipitation Gross β (pCi/m^2)	F-1	9	< 5.57	48.5	20.1	2.63	34.1	22.7
	F-4	9	< 7.14	63.4	21.6	2.79	33.8	30.9

Table II.H.1. Mean Values for all Sample Types.(Cont'd.)

Sample Type	Area	Number of Samples Analyzed 6 Months	Minimum Value Observed 6 Months	Maximum Value Observed 6 Months	$\bar{x}_g$ 1 Year	σ_g 1 Year	$\bar{x}$ 1 Year	$\bar{x}$ 6 Months
Precipitation Tritium (pCi/m^2)	F-1	9	< 292	< 303	215	2.80	< 295	< 295
	F-4	9	< 292	< 295	245	1.68	< 295	< 295
Precipitation ^{106}Ru (pCi/m^2)	F-1	9	< 3.37	86.9	13.0	2.52	< 3.37	15.9
	F-4	9	< 4.72	338	18.1	3.95	26.0	48.5
Precipitation ^{137}Cs (pCi/m^2)	F-1	9	< 14.2	67.8	4.82	2.28	4.53	5.43
	F-4	9	13.4	54.5	16.4	1.95	18.6	26.0
Precipitation ^{95}Zr (pCi/m^2)	F-1	9	< 2.00	37.2	3.91	2.03	1.21	< 2.00
	F-4	9	2.07	11.9	5.87	1.95	7.08	7.24
Precipitation ^{90}Sr (pCi/m^2)	F-1	9	< 2.33	7.76	2.53	3.77	< 2.33	1.21
	F-4	9	< 2.07	54.4	6.68	2.99	6.86	12.3
Precipitation ^{89}Sr (pCi/m^2)	F-1	9	< 1.83	2.50	4.99	2.20	< 1.83	< 1.83
	F-4	9	< 1.66	25.5	6.52	2.38	< 1.66	< 1.66
Milk Tritium (pCi/l)	Facility	16	< 300	566	301	1.64	< 300	< 300
	Adjacent	16	< 300	492	183	2.84	< 300	< 300
	Reference	16	< 300	< 328	257	1.72	< 300	< 300

Table II.H.1. Mean Values for all Sample Types.(Cont'd.)

Sample Type	Area	Number of Samples Analyzed 6 Months	Minimum Value Observed 6 Months	Maximum Value Observed 6 Months	$\bar{x}_g$ 1 Year	σ_g	$\bar{x}$ 1 Year	$\bar{x}$ 6 Months
Milk	Facility	16	0.843	5.05	2.13	1.72	2.33	2.50
^{90}Sr	Adjacent	16	< 1.36	10.8	1.65	2.97	1.42	2.20
(pCi/l)	Reference	16	< 0.344	5.26	1.67	2.62	1.57	2.14
Milk	Facility	16	< 0.792	9.35	1.37	4.07	0.864	0.841
^{89}Sr	Adjacent	16	< 1.43	40.9	2.33	3.05	2.59	4.03
(pCi/l)	Reference	16	< 0.311	59.2	1.53	5.30	3.44	6.50
Milk	Facility	16	< 0.140	4.51	0.466	3.90	< 0.140	< 0.140
^{131}I	Adjacent	16	< 0.116	5.65	0.626	4.49	< 0.116	< 0.116
(pCi/l)	Reference	16	< 0.141	7.86	0.528	4.40	< 0.141	< 0.141
Milk	Facility	16	< 0.146	2.17	0.258	2.06	< 0.146	< 0.146
^{137}Cs	Adjacent	16	< 0.120	< 0.256	0.251	2.33	< 0.720	< 0.120
(pCi/l)	Reference	16	< 0.132	< 0.287	0.204	1.64	< 0.132	< 0.132
Milk	Facility	16	1.37	1.79	1.51	1.08	1.51	1.56
Nat. K	Adjacent	16	1.38	1.66	1.47	1.06	1.47	1.51
(g/l)	Reference	16	1.28	1.67	1.44	1.08	1.45	1.48
Forage	Facility	3	< 299	< 328	278	1.24	< 299	< 299
Tritium	Adjacent	7	< 299	< 328	190	1.99	< 299	< 299
(pCi/l)	Reference	1	< 299	< 299	179	2.30	< 299	< 297

Table II.H.1. Mean Values for all Sample Types.(Cont'd.)

Sample Type	Area	Number of Samples Analyzed 6 Months	Minimum Value Observed 6 Months	Maximum Value Observed 6 Months	$\bar{x}_g$ 1 Year	σ_g 1 Year	$\bar{x}$ 1 Year	$\bar{x}$ 6 Months
Forage	Facility	6	< 7.70	26.5	19.9	2.26	3.39	5.54
^{89}Sr	Adjacent	18	< 3.61	86.0	12.4	2.67	< 3.61	< 3.61
(pCi/kg)	Reference	18	< 9.44	35.8	16.9	2.04	< 9.44	< 9.44
Forage	Facility	6	40.2	147	49.6	3.74	80.8	81.5
^{90}Sr	Adjacent	18	< 4.94	245	66.7	2.19	83.7	87.7
(pCi/kg)	Reference	18	37.7	295	91.9	1.56	102	103
Forage	Facility	6	48.8	219	69.5	1.91	39.4	106
^{106}Ru	Adjacent	18	43.5	164	60.4	2.03	< 62.6	78.4
(pCi/kg)	Reference	18	< 66.5	1379	75.9	2.10	59.5	123
Forage	Facility	6	32.0	196	54.3	2.03	68.3	84.2
^{137}Cs	Adjacent	18	15.5	151	60.8	1.88	78.0	63.2
(pCi/kg)	Reference	18	40.5	147	51.0	1.93	59.3	61.5
Forage	Facility	6	< 2.05	147	30.6	4.25	28.0	23.6
^{95}Zr	Adjacent	18	23.8	105	55.4	1.56	60.9	55.6
(pCi/kg)	Reference	18	30.2	102	51.3	1.37	53.9	58.0
Forage	Facility	6	6,480	31,300	18,200	1.50	19,300	19,400
Gross β	Adjacent	18	2,510	48,700	16,000	1.63	17,600	17,700
(pCi/kg)	Reference	18	4,470	25,400	16,700	1.44	17,600	17,700

Table II.H.1. Mean Values for all Sample Types.(Cont'd.)

Sample Type	Area	Number of Samples Analyzed 6 Months	Minimum Value Observed 6 Months	Maximum Value Observed 6 Months	$\bar{x}_g$ 1 Year	σ_g	$\bar{x}$ 1 Year	$\bar{x}$ 6 Months
Soil Gross β (pCi/kg)	Facility	6	18,100	31,300	27,100	1.17	27,400	27,400
	Adjacent	18	16,500	31,500	24,600	1.14	24,800	25,000
	Reference	18	19,900	30,800	24,600	1.16	24,900	25,800
Soil Gross β ($\mu Ci/m^2$)	Facility	6	2.33	4.04	3.50	1.17	3.54	3.53
	Adjacent	18	2.12	4.06	3.17	1.14	3.19	3.23
	Reference	18	2.56	3.97	3.18	1.16	3.21	3.33
Soil ^{106}Ru (nCi/m^2)	Facility	6	< 257	63.0	241	2.26	< 257	< 257
	Adjacent	18	< 192	357	278	1.88	< 192	< 192
	Reference	18	< 252	303	248	2.38	< 265	< 265
Soil ^{137}Cs (nCi/m^2)	Facility	6	< 44.7	62.3	30.7	2.24	10.9	25.6
	Adjacent	18	< 33.2	89.4	34.1	2.37	18.2	19.3
	Reference	18	< 43.7	89.6	26.9	3.50	28.4	20.7
Soil ^{95}Zr (nCi/m^2)	Facility	6	< 18.9	69.9	23.3	1.90	20.0	12.1
	Adjacent	18	< 11.9	60.6	18.2	3.08	6.40	1.68
	Reference	18	< 16.5	47.9	16.9	4.63	24.6	11.1
Soil Tritium (pCi/l)	Facility	6	< 319	< 319	265	1.27	< 299	< 299
	Adjacent	18	< 299	55.9	274	1.40	< 299	< 299
	Reference	18	< 297	441	197	2.36	< 297	< 29

Table II.H.1. Mean Values for all Sample Types.(Cont'd.)

Sample Type	Area	Number of Samples Analyzed 6 Months	Minimum Value Observed 6 Months	Maximum Value Observed 6 Months	$\bar{x}_g$ 1 Year	σ_g	$\bar{x}$ 1 Year	$\bar{x}$ 6 Months
Soil	Facility	6	< 7.82	17.7	13.0	1.47	< 7.82	< 7.82
^{89}Sr	Adjacent	18	< 8.65	87.4	14.3	1.75	< 8.65	< 8.65
(pCi/m^2)	Reference	18	< 8.60	12.6	8.55	4.22	< 8.60	< 8.60
Soil	Facility	6	< 11.9	209	18.7	2.71	32.0	48.2
^{90}Sr	Adjacent	18	< 11.8	316	22.6	3.31	46.2	66.2
(pCi/m^2)	Reference	18	10.1	263	13.6	3.53	33.3	50.3
Aquatic Biota	Upstream	4	2,440	11,400	8,350	1.73	9,160	8,200
Fish	Downstream	4	2,370	10,500	6,430	1.87	7,380	6,500
Gross β	Effluent	3	10,000	14,100	12,200	1.33	12,600	11,600
(pCi/kg)								
Aquatic Biota	Upstream	3	5,330	11,100	8,300	1.39	8,620	8,130
Benthic	Downstream	3	3,240	23,300	9,510	2.72	12,600	12,600
Gross β	Effluent	3	5,020	18,400	6,740	2.84	9,360	12,200
(pCi/kg)								
Aquatic Biota	Upstream	4	14,900	27,100	12,300	2.44	16,000	22,200
Vascular Plants	Downstream	4	20,400	29,300	13,000	3.24	19,300	26,900
Gross β	Effluent	4	9,900	22,900	10,100	2.13	12.400	16,900
(pCi/kg)								
Aquatic Biota	Upstream	3	18,100	73,500	28,100	1.73	32,500	38,600
Seston	Downstream	3	11,500	26,400	21,400	1.42	22,300	20,900
Gross β	Effluent	3	21,400	29,900	20,200	1.34	21,000	24,900
(pCi/kg)								

Table II.H.1. Mean Values for all Sample Types.(Cont'd.)

Sample Type	Area	Number of Samples Analyzed 6 Months	Minimum Value Observed 6 Months	Maximum Value Observed 6 Months	$\bar{x}_g$ 1 Year	σ_g 1 Year	$\bar{x}$ 1 Year	$\bar{x}$ 6 Months
Aquatic Biota	Upstream	4	< 14.5	< 64.3	28.1	2.99	< 14.5	< 14.5
Fish	Downstream	4	< 24.9	12.0	26.4	3.69	< 78.8	< 78.8
^{89}Sr	Effluent	3	< 25.4	24.8	12.9	6.42	< 50.5	< 50.5
(pCi/kg)								
Aquatic Biota	Upstream	2	< 48.5	< 48.5	212	3.63	< 48.5	< 48.5
Benthic	Downstream	3	< 10.6	< 10.6	85.8	6.12	< 10.6	< 10.6
^{89}Sr	Effluent	3	< 37.9	< 37.9	107	2.02	< 37.9	< 37.9
(pCi/kg)								
Aquatic Biota	Upstream	4	< 26.1	179	65.4	5.01	114	28.3
Vascular Plants	Downstream	4	< 15.7	20.0	21.1	1.60	< 15.7	< 15.7
^{89}Sr	Effluent	4	< 14.4	46.6	16.4	2.22	< 14.4	< 14.4
(pCi/kg)								
Aquatic Biota	Upstream	3	< 25.0	78.9	68.0	2.82	< 25.0	2.03
Seston	Downstream	3	< 24.8	10.9	39.1	3.31	< 24.8	< 24.8
^{89}Sr	Effluent	3	< 3.28	2.27	11.2	4.16	< 3.28	< 3.28
(pCi/kg)								
Aquatic Biota	Upstream	4	17.6	62.3	28.2	2.27	35.5	39.8
Fish	Downstream	4	35.4	82.3	32.3	3.70	48.1	53.7
^{90}Sr	Effluent	3	34.6	36.4	29.2	1.83	33.3	29.1
(pCi/kg)								
Aquatic Biota	Upstream	2	198	327	97.9	5.33	180	263
Benthic	Downstream	3	19.2	216	93.6	3.95	144	144
^{90}Sr	Effluent	3	4.3	226	56.0	5.80	108	106
(pCi/kg)								
Aquatic Biota	Upstream	4	119	164	88.1	1.74	99.0	131
Vascular Plants	Downstream	4	39.3	127	96.9	1.91	118	82.0
^{90}Sr	Effluent	4	38.5	206	51.7	1.93	66.0	89.7
(pCi/kg)								

Table II.H.1. Mean Values for all Sample Types (Cont'd.)

Sample Type	Area	Number of Samples Analyzed 6 Months	Minimum Value Observed 6 Months	Maximum Value Observed 6 Months	$\bar{x}_g$ 1 Year	σ_g 1 Year	$\bar{x}$ 1 Year	$\bar{x}$ 6 Months
Aquatic Biota	Upstream	3	0.556	181	39.8	11.2	85.0	101
Seston	Downstream	3	35.5	219	134	2.79	201	127
^{90}Sr	Effluent	3	7.34	139	47.9	3.08	46.5	72.0
(pCi/kg)								
Aquatic Biota	Upstream	4	289	289	143	2.34	3.76	179
Fish	Downstream	4	43.4	273	92.8	3.27	< 24.9	133
^{106}Ru	Effluent	3	56.3	163	115	2.10	34.2	101
(pCi/kg)								
Aquatic Biota	Upstream	3	2.58	228	76.8	11.8	75.9	101
Benthic	Downstream	3	92.4	538	214	2.42	276	276
^{106}Ru	Effluent	3	28.9	1,340	390	7.38	< 37.8	536
(pCi/kg)								
Aquatic Biota	Upstream	4	274	722	401	2.18	215	492
Vascular Plant	Downstream	4	371	901	509	1.53	144	653
^{106}Ru	Effluent	4	510	1,980	773	2.06	608	893
(pCi/kg)								
Aquatic Biota	Upstream	3	461	1,280	1,030	2.29	< 25.0	1,030
Seston	Downstream	3	< 556	1,640	930	1.53	< 556	590
^{106}Ru	Effluent	1	< 2,870	<22,800	3,570	5.76	<2,870	< 2,870
(pCi/kg)								
Aquatic Biota	Upstream	4	106	248	132	1.58	128	160
Fish	Downstream	4	61.0	202	153	2.36	88.9	115
^{137}Cs	Effluent	3	71.9	355	151	1.90	179	224
(pCi/kg)								
Aquatic Biota	Upstream	3	240	465	279	1.51	298	338
Benthic	Downstream	3	250	434	313	1.33	323	323
^{137}Cs	Effluent	3	285	875	562	1.66	418	558
(pCi/kg)								

Table II.H.1. Mean Values for all Sample Types.(Cont'd.)

Sample Type	Area	Number of Samples Analyzed 6 Months	Minimum Value Observed 6 Months	Maximum Value Observed 6 Months	$\bar{x}_g$ 1 Year	σ_g 1 Year	$\bar{x}$ 1 Year	$\bar{x}$ 6 Months
Aquatic Biota Vascular Plant ^{137}Cs (pCi/kg)	Upstream	4	234	460	237	1.95	277	293
	Downstream	4	< 202	328	199	1.58	183	233
	Effluent	4	162	715	369	2.02	416	407
Aquatic Biota Seston ^{137}Cs (pCi/kg)	Upstream	3	< 1,060	503	561	1.52	159	178
	Downstream	3	300	419	294	1.44	309	356
	Effluent	1	< 3,950	< 3,950	1,724	1.76	< 3,950	< 3,950
Aquatic Biota Fish ^{95}Zr (pCi/kg)	Upstream	4	0.978	76.9	19.7	4.38	27.4	36.1
	Downstream	4	29.0	122	80.5	3.15	65.9	58.3
	Effluent	3	46.8	150	67.9	1.72	77.6	81.4
Aquatic Biota Benthic ^{95}Zr (pCi/kg)	Upstream	3	102	194	139	1.39	114	157
	Downstream	3	173	198	187	2.19	188	188
	Effluent	3	138	205	198	1.44	103	171
Aquatic Biota Vascular Plants ^{95}Zr (pCi/kg)	Upstream	4	155	218	143	2.29	168	181
	Downstream	4	67.6	227	105	4.69	106	162
	Effluent	4	75.5	355	187	2.67	272	199
Aquatic Biota Seston ^{95}Zr (pCi/kg)	Upstream	3	206	455	238	1.66	264	339
	Downstream	3	180	205	240	3.00	40.8	< 1,610
	Effluent	1	< 1,420	< 1,420	437	2.57	156	< 1,420
Beef ^{137}Cs pCi/g Nat K	F-44	4	< 2.21	48.6	5.84	4.13	9.58	13.9

Table II.H.2 Dates of Announced Atmospheric Nuclear Weapon Tests and FSV Reactor Operation.

Date	Event
January 1974	FSV reactor start-up
June 1974	1 Mton test by Mainland China
July, August, and September, 1974	Six tests by Mainland China of unknown yield
January, 1976	20 kton test by Mainland China
December, 1976	Initiation of significant operation of FSV reactor
September, 1976	200 kton test by Mainland China
November, 1976	4 Mton test by Mainland China
September, 1977	20 kton test by Mainland China
March, 1978	20 kton test by Mainland China
October, 1980	Test of unknown yield by Mainland China

III. ENVIRONMENTAL RADIATION SURVEILLANCE PROGRAM SCHEDULE

III.A. Environmental Radiation Surveillance Schedule

Table III.A.1 outlines the collection and analysis of environmental samples within an area extending to a twenty-mile radius from the reactor site. A concentrated area of sampling within a one mile radius is designated the "Facility" zone; the area from one to ten miles, the "Adjacent" zone; while the "Reference" zone extends from ten to twenty miles. The data obtained from the Facility zone are statistically compared to those from the Adjacent and Reference zones to test for any significant differences in values. A similar rationale is used for surface waters and sediments. These are partitioned into "Effluent" (Farm Pond and Slough), "Downstream", and "Upstream" locations for statistical analysis.

The sampling locations are shown in Figures III.B.1 and III.B.2. Tables III.B.1, III.B.2 and III.B.3 give some detail of the sampling sites in the Facility, Adjacent and Reference zones respectively. There were no changes in the sampling sites during the second half of 1983.

TABLE III. A.1. ENVIRONMENTAL RADIATION SURVEILLANCE PROGRAM SCHEDULE *

Exposure Routes or Media & Sample Types (No. of Locations/zone)[1]	SAMPLING FREQUENCIES AND ANALYSES - by Action Levels, based upon actual emissions as percentages of release rates authorized by 10 CFR 20		
	Action Level 1: Less than 3%	Action Level 2: 3% to 10%	Action Level 3: Greater than 10%
EXTERNAL EXPOSURE TLD Chips (F-13, A-12, R-12)	Average mR/day determined by QUARTERLY cumulative exposures; collection and analysis in rotation of 1/3 of all TLDs MONTHLY.		Average mR/day determined by MONTHLY analysis of all TLDs.
ATMOSPHERE Membrane filters for particulates; charcoal cartridges for iodine. (F-4, A-3)	Gross beta, every filter, WEEKLY; gamma spectrum of filter and cartridge composites, MONTHLY.	Same as for Level 1, plus gross alpha on one weekly set of filters, MONTHLY.	Gross alpha and beta, every filter; gamma spectrum of filter and cartridge composites, all WEEKLY.
Tritium oxide (F-2)	Specific activity of tritium in atmospheric water vapor by passive absorption and liquid scintillation counting. QUARTERLY	MONTHLY	WEEKLY
WATER Potable water (F-1, A-1)	Gross beta, tritium and gamma spectrum analyses; Facility area and nearest off-site supply (shallow wells at town of Gilcrest, 6 miles northeast). QUARTERLY	MONTHLY	MONTHLY, plus Sr 89 & 90 analyses
Precipitation (F-2)	No collection or analyses of precipitation at Level 1.	Gross beta, MONTHLY	Gross beta, tritium and Sr 89 & 90, MONTHLY; gamma spectrum of composite, QUARTERLY.
Surface water & silt (F-3, A-4)	Gross beta, tritium[2] and gamma spectrum, QUARTERLY.	Same as for Level 1, but MONTHLY.	Same as for Level 2, plus Sr 89 & 90 analyses, MONTHLY.
FOOD CHAINS Soil, forage & crops (F-2, A-6, R-6)	Tritium and gamma spectrum analyses of forage and crops in the most probable routes to man. QUARTERLY, as available (i.e., spring, summer and fall).	MONTHLY during growing season (i.e., approx. April to October).	Same as Level 2, plus Sr 89 & 90, plus concurrent soil samples analyzed for the same nuclides, MONTHLY during growing season.
Beef cattle (F-1)	No analysis of beef at Level 1.	Gamma spectrum, tritium and Sr 89 & 90 analyses on one meat sample from beef raised in Facility Area; ANNUALLY, at end of grazing season (i.e., late fall).	Same as for Level 2, plus total body count of 2 to 4 animals from Facility Area, QUARTERLY.
Milk (F-2, A-6, R-6)	Tritium, gamma spectrum and Sr 89 & 90 analyses on composite: Facility Area only, QUARTERLY.	Facility, Adjacent and Reference Areas; MONTHLY during pasture season, otherwise QUARTERLY.	Same as for Level 2, but WEEKLY during pasture season, otherwise, MONTHLY.
AQUATIC BIOTA (2 streams, above and below discharge points) (F-2, A-2)	Gross beta and gamma spectrum analyses of composites of each of 4 categories: (1) suspended organisms, (2) benthic organisms, (3) vascular plants and (4) fish. QUARTERLY, as available.	MONTHLY during summer; otherwise QUARTERLY, as available.	Same as for Level 2, plus Sr 89 & 90 analyses.

*Table 5.9-1 in *Technical Specifications*.

1. Legend:
   F — Facility Zone
   A — Adjacent Zone
   R — Reference Zone
2. Tritium Analysis of Surface Water Only

Table III.B.1. Facility area and effluent sampling locations for environmental media.

Loc. No.	Media Sampled at Location						Location and Description (see Fig. II.B.1) Distance and Direction from Reactor; Comments.	
	TLD	AIR	M	S	H_2O	AQB		
F 1	*	**					0.8 mi. N:	potato cellar; TLD on pole at NE corner of barn; precipitation on hill E of barn.
F 2		*					1.1 mi. NNE;	cabin.
F 3	*	*					0.7 mi. SE;	Farm on corner next to machine shop. TLD on pole 250 ft. N of Drive.
F 4	*	**		*			0.8 mi. S:	first shed along drive; precipitation in corral; forage and soil S of shed.
F 7	*						0.8 mi. NNE;	pole by gate at corner of Goosequill Rd.
F 8	*						0.6 mi. NE;	2nd pole S of cattle-guard on hill.
F 9	*						0.8 mi. SSE;	2nd pole W of pump house.
F 11	*						0.9 mi. SSW;	0.3 mi. W of intersection of 19½ and 34.
F 12	*						0.8 mi. SW;	7th pole N of intersection.
F 13	*						0.6 mi. WSW;	pole nearest intersection.
F 14	*						1.0 mi. NW;	pole nearest corner.
F 44			*	*			1.1 mi. E;	Leroy Odenbaugh dairy.
F 51	*						0.3 mi. N;	Ted Horst farm, pole SW of house.
F 46	*						1.0 mi. SW;	2nd pole N of intersection, near Aristocrat Angus office.
F 47	*						0.4 mi. E;	pole near driveway to pump house.
F 49					*		0.1 mi. W;	tap outside Visitors Center.
E 38					*	*	1.3 mi. NNE;	Goosequill pond.
E 41					*		0.2 mi. NW;	Concrete slough above and below point of entry of plant water.

Codes: F = Facility area (within one mile). S = Soil and Forage sampling locations.
E = Effluent surface streams.
TLD = Thermoluminescent Dosimeter for measuring external gamma exposure.
AIR = Air sampling location; ** = atmospheric precipitation collected.
H^2O = Water sampling locations; silt also sampled from surface sources.
AQB = Aquatic biota sampling locations

Table III.B.2 Adjacent area sampling locations for environmental media.

Loc. No.	Media Sampled at Location						Location Description (See Figs. II.B.1 and II.B.2) Distance and Direction from Reactor; Comments	
	TLD	AIR	M	S	H_2O	AQB		
A 5	*	*					4.5 mi. NNE;	Lloyd Rumsey farm; 2 mi. N, 1.5 mi. W of Peckham.
A 6	*	*	*	*			5.5 mi. S;	Clifton Wissler farm; 2 mi. W, 2.5 mi. S of Platteville; TLD on pole 30 ft N of parlor.
A 27	*						5.0 mi. NW;	1 mi. S of Colo. 56, 1 mi. E of I-25, pole on NE corner.
A 28	*		*	*			6.0 mi. NW;	Virgil Podtburg dairy; Colo. 60, 2 mi. W of Johnstown; TLD on last pole on NE corner.
A 29	*						3.5 mi. NNW;	3 mi. S; 1.6 mi. E of Johnstown, TLD on pole by the stand of trees.
A 30	*						3.5 mi. NE;	1 mi. S of Colo. 256 on Colo. 60, pole on NE corner.
A 31	*		*	*			6.0 mi. ENE;	1.5 mi. E of Peckham; TLD on pole in front of house.
A 32	*						4.0 mi. E;	3 mi. N of Platteville; 1.2 mi. E of US 85; NW pole.
A 33	*						5.0 mi. SE;	Niles Miller Dairy; 0.2 mi. S, 0.5 mi. E of Platteville.
A 34	*						6.5 mi. SW;	1 mi. E of I-25 at Colo. 254; pole on SW corner.
A 35	*	*					2.5 mi. SSW;	.5 mi. N of Colo. 66 on RD 19, Curtis Strong feedlot.
A 36	*		*	*			8.0 mi. W;	Dave Gruber dairy; 2 mi W of I-25 on Colo. 56, then 1.5 mi. S. TLD 0.5 mi. W.
A 48			*	*			9.5 mi. NW;	Bill Ray dairy; 2 mi. E and 1 mi. N of Peckham.
A 50			*	*			5.0 mi. SE;	0.8 mi. E of Platteville.
D 37					*		12.5 mi. ENE;	Lower Latham Res.; 2.5 mi. E of LaSalle.
D 39					*		5.0 mi. ENE;	Gilcrest water from U.S. Post Office.
D 40					*	*	5.5 mi. ENE;	South Platte River at Colo. 60.
D 45					*	*	1.0 mi. N;	St. Vrain Creek at Jct. Rd. 19½, 0.2 mi. from discharge.

Codes: A = Adjacent area (one to ten miles from reactor).
D = Downstream potable or surface waters.

All other symbols same as for Table III.B.1.

Table III.B.3. Reference area and upstream sampling locations for environmental media

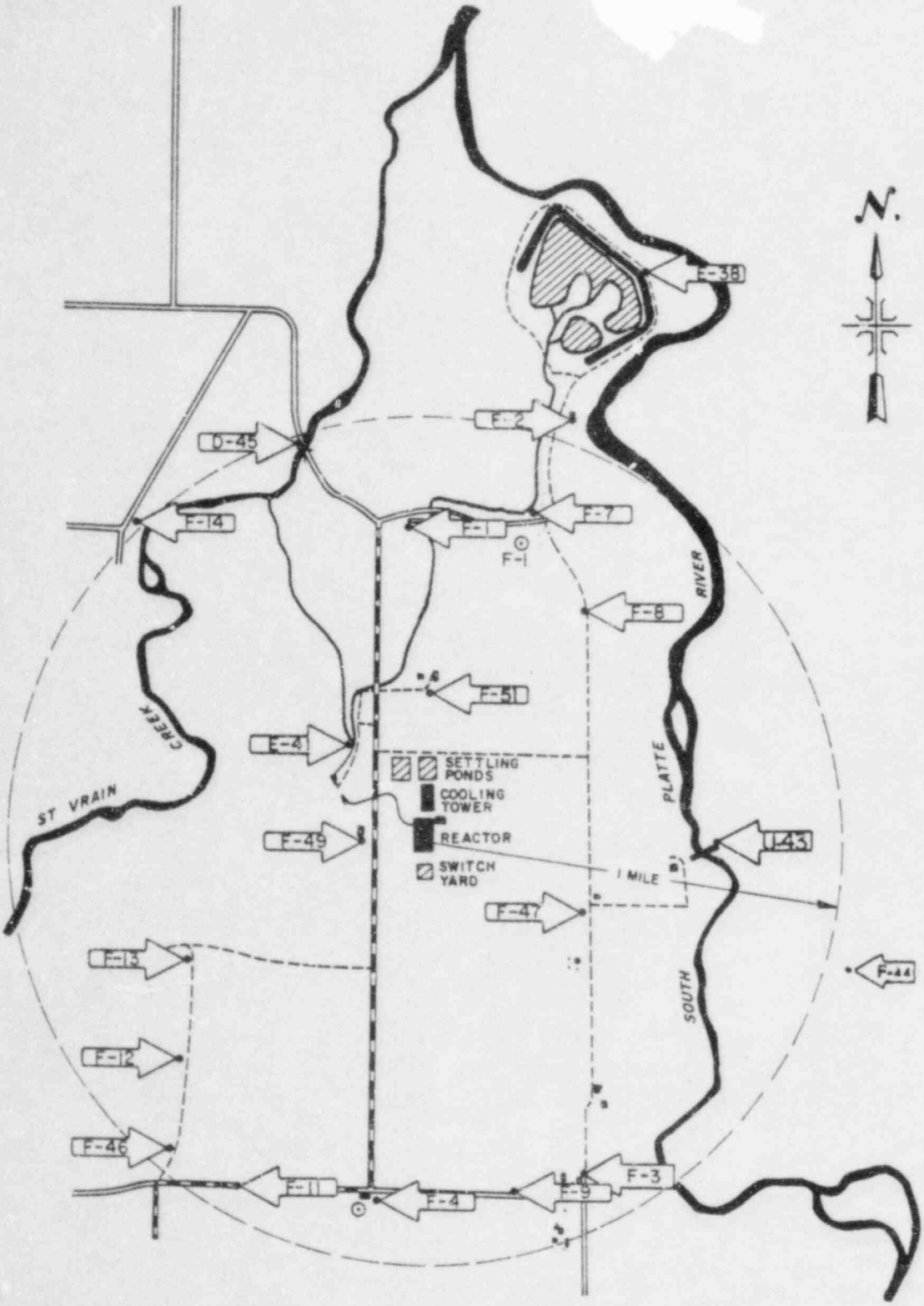
Loc. No.	Media Sampled at Location						Location Description (see Figs. II.B.1. and II. B.2.) Distance and Direction from Reactor; Comments.	
	TLD	AIR	M	S	H_2O	AQB		
R 15	*						11.5 mi. NW;	4.2 mi. W of I-25 on Colo. 60; TLD on pole W of farm driveway.
R 16	*		*	*			11.8 mi. NNW;	Mountain View Farms; N side of Colo. 402 W of I-25.
R 17	*		*	*			11.8 mi. NNE;	Bob Schneider Dairy; 1 mi. S of US 34 on RD 25; on pole 0.5 mi. N of parlor on RD 25.
R 18	*						10.0 mi. NNE;	on pole on SE corner of intersection of 65th Ave. and 37th Street (Greeley)
R 19	*						13.3 mi. NNE;	US 34 at 47th Ave. (Greeley); pole on SW corner, opposite golf course.
R 20	*		*	*			11.1 mi. ENE;	Dick Stroh dairy; 2 mi. E;, 1.6 mi. S of Lasalle; TLD on pole W of parlor
R 21	*						11.9 mi. E;	5 mi. E of US 85 on Colo. 265; then 1 mi. S; TLD on pole on SW corner.
R 22	*		*	*			11.1 mi. SE;	Hagans Bros. Dairy; 4.2 mi. S of Platteville; 4.2 mi. E of US 85 TLD on 1st pole E of drive.
R 23	*		*	*			11.5 mi. S;	Dick Silver; 3.5 mi W of Ft. Lupton, TLD on 1st pole W on drive.
R 24	*						12.2 mi. SSW;	I-25 at Colo. 52; pole W of the frontage road; NW corner.
R 25	*		*	*			13.3 mi. SW;	5665 Weld County RD 3.
R 26	*						12.2 mi. WNW;	On US 287, 2.5 mi on Colo. 56, 2nd pole S on RD 2E.
U 42					*	*	1.5 mi. WSW;	St. Vrain Creek at bridge, RD 34.
U 43					*	*	0.6 mi. E;	South Platte River, at dam and inlet ponds.

Codes: R = Reference area (greater than 10 miles from reactor).

U = Upstream from effluent discharge points.

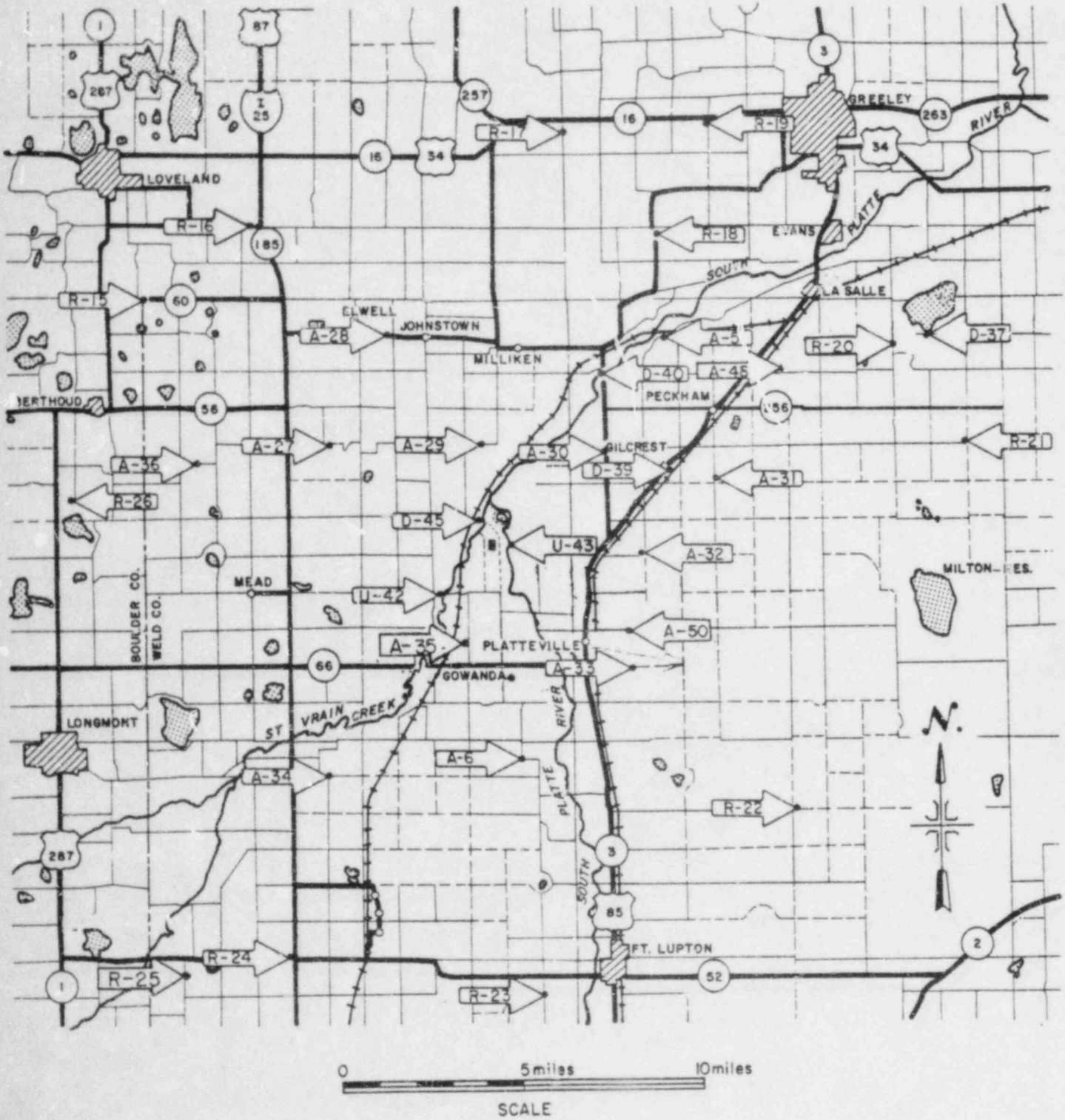
All other symbols as in Table III B.1.

Figure III.B.1. On-site Sampling Locations



On-site and close-in sampling locations.
F = facility area, E = effluent stream,
U = upstream, D = downstream.

Figure III.B.II. Off-site Sampling Locations

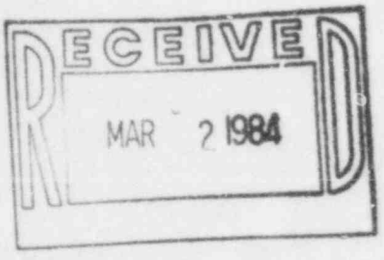


Public Service Company of Colorado

2420 W. 26th Avenue, Suite 100D Denver, CO 80211

February 29, 1984
Fort St. Vrain
Unit No. 1
P-84061

Mr. John T. Collins,
Regional Administrator
Nuclear Regulatory Commission
Region IV
Office of Inspection and Enforcement
611 Ryan Plaza Drive
Arlington, Texas 76012



SUBJECT: Environmental Radiation
Surveillance Program -
Summary Report

Dear Mr. Collins:

Please find enclosed two copies of the Summary Report for the Environmental Radiation Surveillance Program being conducted by Colorado State University for the Fort St. Vrain Nuclear Generating Station for the period July 1, 1983 through December 31, 1983. This document is submitted to report the results of environmental radiological monitoring performed in accordance with the requirements of Technical Specification SR 5.9.1 of Appendix A to operating license DPR-34 which was in effect throughout 1983.

If you should have any questions regarding these reports, please feel free to contact us.

Very truly yours,

Lawrence Brey

H. L. Brey, Manager
Nuclear Engineering Division

HLB/JLP:pa

Enclosure

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