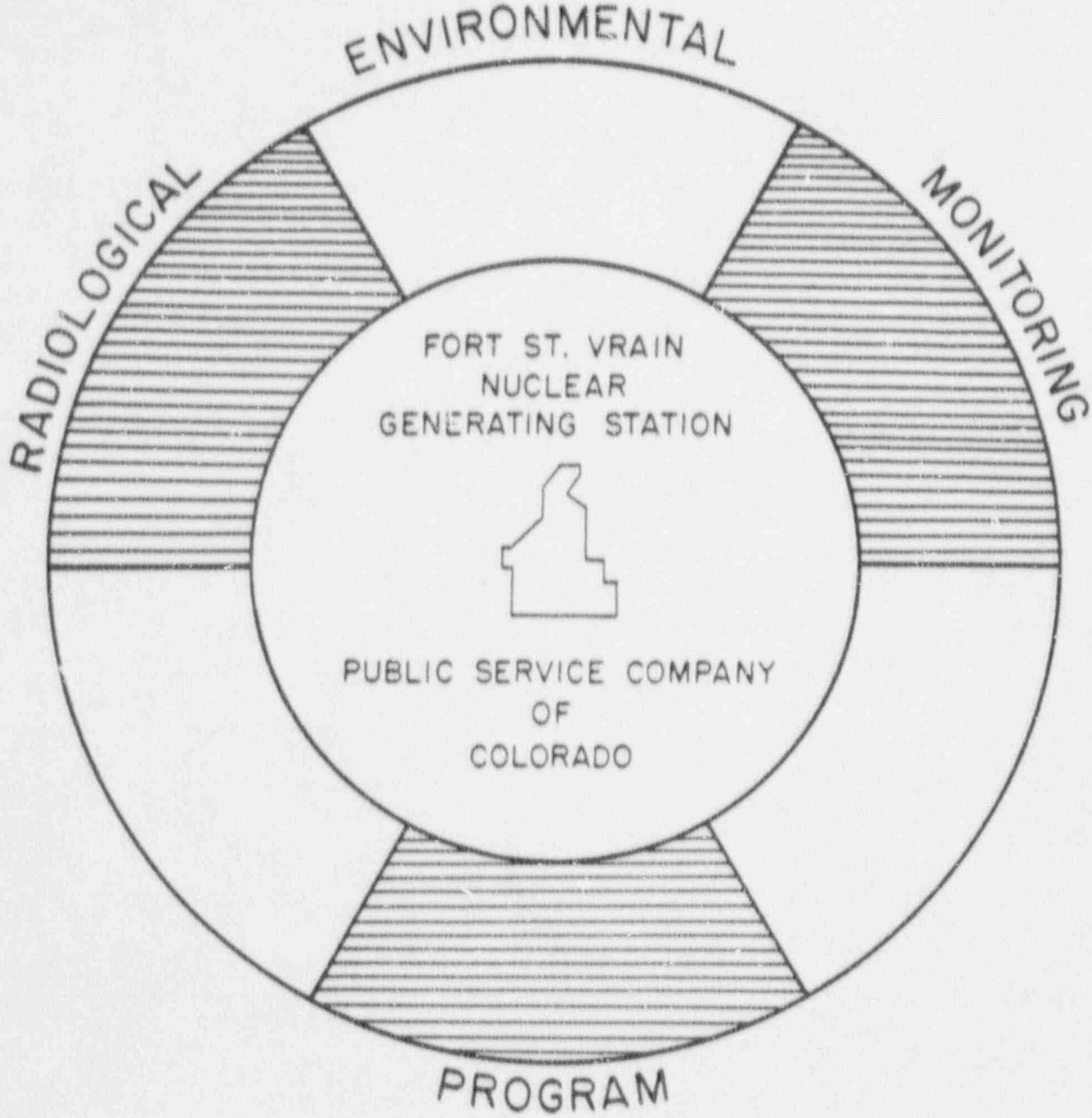

SUMMARY REPORT

1990

COLORADO STATE UNIVERSITY
FORT COLLINS, COLORADO 80523

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

for the Fort St. Vrain Nuclear Generating Station
Operated by the Public Service Co. of Colorado

Summary Report
for the Period
January 1, 1990 - December 31, 1990

Prepared by: James Johnson — 3/28/91
James E. Johnson, Professor, Colorado State University — Date

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Radiochemistry Supervisor — Date

Approved by: Frederick von Borst — 4/8/91
Nuclear Training and Support Manager — Date

Acknowledgements

Many persons have contributed to this project during 1990, 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.

We also wish to acknowledge and thank the Colorado Division of Wildlife, Fort Collins regional office for assisting with the fish collection. Without their cooperation, equipment and expertise the collection would not be possible.

In particular I wish to acknowledge the efforts of Sharon J. Clow. She was the laboratory coordinator during the entire period of the present technical specifications and contributed greatly to the operation and success of the project. She is currently employed at the Department of Energy, Albuquerque operations office.

The persons working directly on the project have been:

Faye Bruno	Chief Laboratory Technician
Thomas Miller	Student Employee
Steven Ziliak	Student Employee
Charles Sampier	Chief Electronic Technician
Paul J. Valentinelli	Graduate Student Employee
Christopher Roelle	Student Employee

James E. Johnson
Professor and Project Director

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I. Introduction to Radiological Environmental Monitoring Data for the Period January 1, 1990 - December 31, 1990.

During 1990 the Fort St. Vrain Nuclear Generating Station did not operate and is presently in a defueling phase. The operational phase of the reactor ended on July 18, 1989.

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 Reports for 1990 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. These discussions are presented in the appropriate sample type section and in the summary section, II.H.

Table III.A.2 lists the LLD values achievable by the counting systems used during 1990 on project samples. These values are given for typical sample sizes, counting times and decay times. The LLD is, therefore, an a priori parameter to indicate the capability of the detection system used. The LLD values in Table III.A.2 were calculated as suggested in NUREG-0472.

Throughout the report, however, when a sample result is listed as less than a specified value, that value is the calculated MDC (minimum detectable concentration). This approach is analogous to that of Currie (NUREG/CR-4007): the

MDC is the same as S_c, the critical signal, and the LLD is equal to S_D, the detectable signal. The MDC value applies to the actual sample size, counting time and decay time applicable to that individual sample. It is calculated as:

$$MDC = 2.33\ \sigma_B/E\ Y\ V\ E^{-\lambda t}$$

Where: σ_B = Standard deviation of background count rate

E = Counting efficiency, c s^{-1} pCi^{-1}

Y = Chemical yield

V = Sample volume (or mass)

λ = 0.693/Half-life

t = Decay time between sample collection and analysis

This calculation method assumes that E and Y are constants and makes no allowance for systematic error.

It should be noted that we have not used the notation "<MDC" for values less than MDC. Rather, we report the result as less than the actual MDC value. Because the MDC is dependent upon variables such as the background count time and sample size, the value will be different for each sample type and even within sample type.

Essentially all radioactivity values measured on this project are near background levels and, more importantly, near the MDC values for each radionuclide and sample type. It has been well-documented that environmental radioactivity values exhibit great inherent variability. This is partly due to

sampling and analytical variability, but most importantly 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 rather large sample population size to make any conclusions about the absolute radioactivity concentrations in any environmental pathway.

The arithmetic mean for each sample set is listed in Table II.H.2. All measured values, both positive and negative, are used in the calculations of the arithmetic mean. This is the suggested practice by Gilbert (Health Physics 40:377, 1984) and the NRC (NUREG/CR-4007).

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 footnoted appropriate tables with the maximum permissible concentration applicable to each radionuclide. We have chosen to list the maximum permissible concentrations as found in Appendix B Table II of 10CFR20. This is the concentration in water or air of each radionuclide which if ingested or inhaled continuously would singularly produce the maximum permissible radiation dose rate to a specified individual member of the general public. That value is 500 mrem/year, but must include the dose from all possible sources, and, therefore, cannot be solely due to reactor

effluent. As stated in 10CFR20 these are the maximum concentrations above natural background that a licensee may release to an unrestricted area. It is assumed that no direct ingestion or inhalation of effluents can occur 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 from the reactor effluents. Such limits for water cooled reactors are found in 10CFR50 Appendix I. These are judged as "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. (40CFR190) for any specified member of the general public from any part of the nuclear fuel cycle. This value is 25 mrem/year, the dose rate to the whole body from all contributing radionuclides excluding background and medical radiation dose rate.

Dose commitments are calculated for hypothetical individuals 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.

f. 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 January Through December 1990 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 41 locations (see Table III.B.1). 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 quarterly at each location. Fading during field exposure is minimized by the post-annealing readout procedure.

The TLD data indicate that the arithmetic mean measured exposure rate in the facility area for all of 1990 was 0.40 mR/day. The mean exposure rate was 0.39 mR/day for the adjacent area and 0.39 mR/day for the reference area. These mean values were not significantly different from each other.

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 due to 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 having two TLD rings 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 effluent. Since the inception of power production by the reactor, there has been no detectable increase in the external exposure rate due to reactor releases. Fallout deposition, both from the Chinese nuclear weapon tests and from the Chernobyl accident, was detected in the past.

The TLD system is calibrated by exposing chips to a scattered gamma-ray flux produced in a cavity surrounded by uranium mill tailings. This produces a gamma-ray spectrum nearly identical to that from natural background measured in the reactor environs. The quality control program includes calibration before readout of each quarterly batch of TLD devices.

For comparison purposes, the EPA in EPA 520/5-89-034 Report #58 lists 0.37 ± 0.27 mR/day for the background external exposure rate in Denver during the period April to June 1990. This is excellent agreement with the results fr this program.

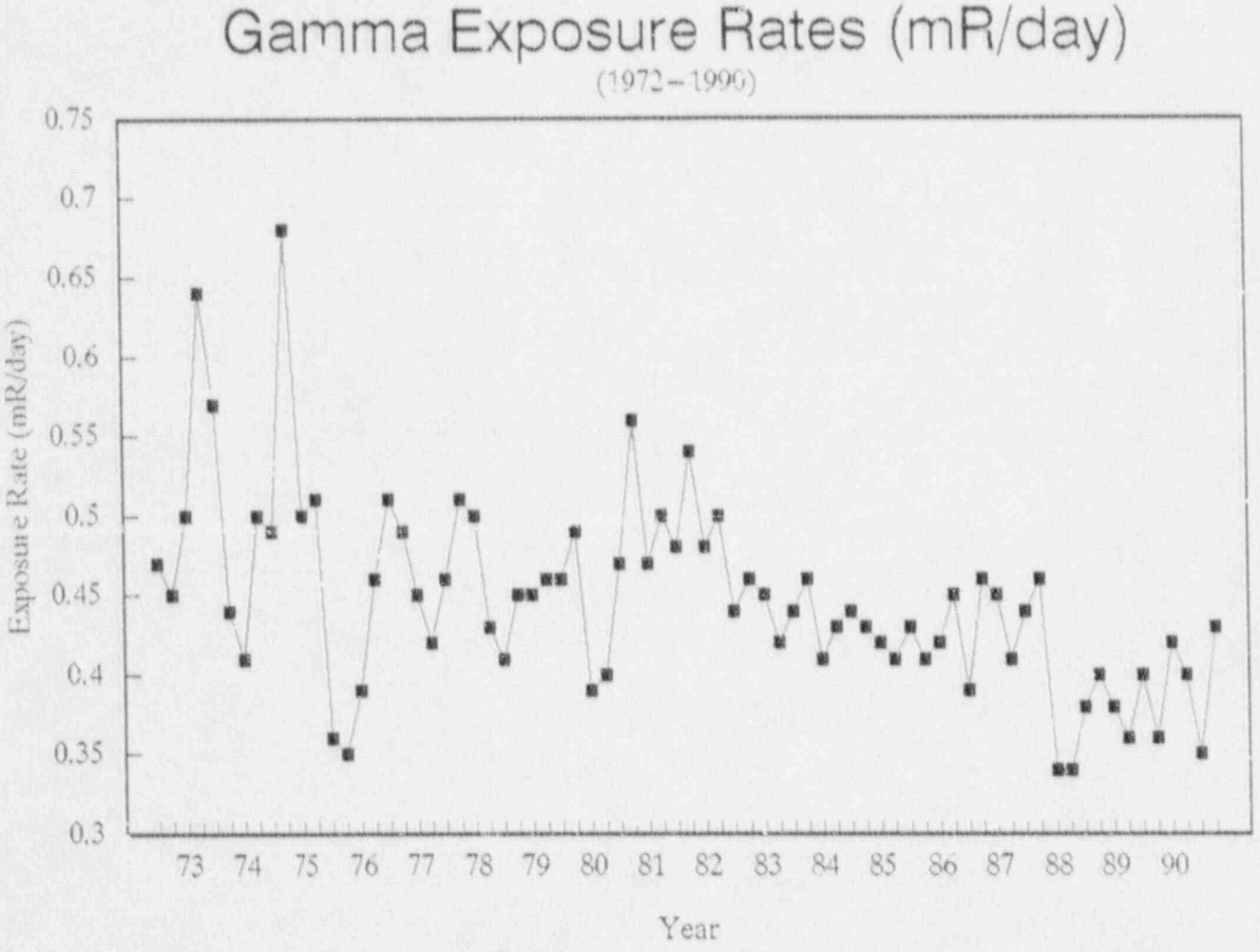
Figure II.A.1 shows the measured mean exposure rate in the Facility Area since the inception of the program. The steady decrease in exposure rate over the period is due to the decay and weathering of fission product deposition from previous atmospheric weapon tests.

Table II.A.1 Gammma Exposure Rates. (mR/day) 1990

Facility Area	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
F-1	.39	.44	.34	.43
F-2	.39	.42	.32	.43
F-3	.45	.35	.31	.41
F-4	.45	.37	.44	.41
F-5	.40	.40	.31	.47
F-6	.40	.35	b	.41
F-7	.42	.45	.33	.47
F-8	.44	.41	b	.47
F-9	.42	.37	.35	.45
F-10	.43	.40	.36	.41
F-11	.47	.46	.48	.45
F-12	.39	.42	.37	.41
F-13	.40	.38	.32	.39
F-14	.42	.41	.28	.41
F-15	.40	.42	.34	.40
F-16	.42	.43	.32	.37
F-17	.40	.36	.35	.42
F-18	.45	.38	.42	.47
$\bar{x}$ (1.96σ)	.42(0.048)	.40(0.066)	.35(0.103)	.43(0.059)
Adjacent Area				
A-1	.46	.38	.37	.46
A-2	.45	.41	.42	b
A-3	.42	.40	.38	.46
A-4	.37	.36	.38	.43
A-5	b	.37	b	.36
A-6	.36	.35	.37	.37
A-7	.40	.38	.37	.40
A-8	.42	.42	.36	.43
A-9	.42	.41	.38	.37
A-10	.48	.43	.38	.45
A-11	.39	.35	.38	.39
A-12	.39	.34	.40	.43
A-13	.34	.34	.35	.34
A-14	.36	.39	.35	.39
A-15	.36	.36	.34	.39
A-16	.44	.38	.35	.40
A-17	.44	.40	.38	.42
A-20	.43	.44	.38	.40
$\bar{x}$ (1.96σ)	.41(0.079)	.38(0.060)	.37(0.040)	.41(0.069)
Reference Area				
R-2	.41	b	b	.42
R-3	.46	.39	.40	.37
R-4	.37	b	.32	.40
R-5	.45	.41	.34	.43
R-7	.39	b	.35	.39
$\bar{x}$ (1.96σ)	.42(0.075)	.40(0.028)	.35(0.067)	.40(0.047)

b - sample missing at site

Figure II.A.1


Gamma Exposure Rates (mR/day)
(1972-1990)
Exposure Rate (mR/day)
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90
Year

II.B. Ambient Air Concentrations

1. Gross Beta Activity

The air concentrations of long lived particulate gross beta activity measured at the facility and reference sampling sites are listed in Tables II.B.1a-1d for each quarter of 1990. A-19, while technically in the adjacent zone, is only a few meters from the facility boundary and logically should be considered a facility site. It has been termed a facility site since the inception of the monitoring program. The reference sites R-3, R-4, and R-11 are all new locations as of January 1, 1984 and sufficiently distant to be considered reference (control) locations. (See Table III.B.1).

The reported concentrations are listed in units of femtocuries per cubic meter of ambient air, although the measured activity is due to a combination of radionuclides almost all of which are naturally occurring. It should be noted that the current technical specifications no longer require measurement of gross alpha activity. All filters, however, are saved indefinitely for later alpha activity analysis if needed.

The mean gross beta concentration in air for all facility stations for all of 1990 was 23 fCi/m^3. For 1989 the mean value was 26 fCi/m^3. The mean concentration for 1990 for all reference stations was also 23 fCi/m^3. These measured mean

values were obviously not statistically significant at the 95% confidence level.

The gross beta data for 1990 have been added to the plot of air concentrations observed since 1973 (Figure II.B.1). In this figure the half-yearly mean values for the facility sites are plotted with the values from the reference sites. The contribution from Chernobyl is clearly evident in 1986. It can be observed that overall mean values are not significantly different and that world-wide fallout, principally due to past Chinese atmospheric nuclear weapon tests, is the predominant contributor to the measured values over the period shown.

There has never been a significant difference observed between facility and reference sites. Thus, it can be concluded that reactor air effluents of particulate fission products or activation products during operation were not a source of dose commitment for the Fort St. Vrain environs population. This is expected to be true as well during the defueling and decommissioning phase.

Table II.B.1 Concentrations of Long-lived Gross Beta Particulate Activity in Air. (fCi/m^3)

a) First Quarter, 1990

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
1/6/90	20(1.2)*	23(1.9)	21(1.3)	23(1.2)	20(1.4)	21(1.5)	24(1.6)
1/13/90	20(1.1)	19(1.3)	19(1.4)	18(2.0)	20(1.6)	16(1.0)	19(1.5)
1/20/90	17(1.2)	24(1.9)	23(1.4)	27(1.3)	24(1.5)	23(1.5)	31(1.9)
1/27/90	27(1.2)	26(1.4)	23(1.5)	37(3.7)	21(1.7)	21(1.1)	25(1.6)
2/3/90	13(1.2)	17(1.6)	18(1.2)	2[illegible](1.3)	20(1.4)	17(1.2)	20(1.5)
2/10/90	29(1.3)	28(1.5)	23(1.6)	21(1.9)	25(1.8)	20(1.1)	26(1.7)
2/17/90	26(1.3)	26(2.0)	25(1.4)	33(1.5)	26(1.7)	25(1.5)	27(1.7)
2/24/90	20(1.0)	21(1.4)	18(1.3)	13(1.8)	19(1.6)	18(1.1)	19(1.5)
3/3/90	31(1.7)	e	29(1.5)	31(1.2)	27(1.7)	26(1.4)	27(1.7)
3/10/90	21(1.1)	16(0.91)	17(1.3)	20(2.0)	18(1.7)	16(0.93)	21(1.5)
3/17/90	12(1.0)	12(1.1)	13(1.1)	15(0.90)	14(1.3)	14(1.1)	15(1.4)
3/24/90	18(0.97)	17(0.97)	16(1.3)	13(1.9)	18(2.3)	17(1.0)	17(1.4)
3/31/90	19(1.2)	20(1.3)	20(1.3)	19(1.0)	18(1.3)	17(1.1)	21(1.5)
---	---	---	---	---	---	---	---
$\bar{x}$	21	21	20	22	21	19	22
1.96 σ	11	9.4	8.3	15	7.3	7.3	9.0
MAX: 37	$\bar{x}$(1.96 σ):	21(11)			MAX: 31	$\bar{x}$(1.96 σ):	21(8.1)
MIN: 12	n:	51			MIN: 14	n:	39

* 1.96 σ (Due to Counting Statistics.)
e - insufficient weight or volume for analysis

Table II.B.1 Concentrations of Long-lived Gross Beta Particulate Activity in Air. (fCi/m^3)

b) Second Quarter, 1990

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
4/7/90	21(1.[illegible])*	21(1.1)	18(1.3)	18(2.0)	22(1.8)	22(1.1)	22(1.6)
4/14/90	19(1.0)	20(1.0)	13(1.8)	19(1.1)	c	20(1.1)	19(1.6)
4/21/90	23(1.3)	25(1.2)	22(1.5)	22(1.1)	14(1.0)	20(1.1)	16(1.5)
4/28/90	19(1.2)	15(1.0)	19(1.4)	18(1.1)	17(1.1)	17(1.0)	19(1.5)
5/5/90	19(1.2)	18(1.0)	17(1.3)	17(1.0)	17(1.1)	17(0.95)	18(1.4)
5/12/90	16(1.2)	15(1.0)	16(1.3)	16(1.0)	18(1.4)	17(1.0)	17(1.4)
5/19/90	25(1.5)	19(1.1)	24(1.5)	21(1.4)	15(1.1)	18(1.0)	23(1.7)
5/26/90	23(1.4)	24(1.2)	21(1.4)	21(1.1)	25(1.3)	23(1.2)	23(1.6)
6/2/90	5.5(1.0)	14(1.0)	12(1.2)	13(0.93)	12(0.91)	14(0.93)	15(1.3)
6/9/90	19(1.4)	20([illegible]	19(1.3)	19(1.1)	20(1.2)	29(1.7)	18(1.4)
6/16/90	17(1.4)	16(1.1)	17(1.3)	15(1.0)	17(1.1)	16(1.0)	18(1.4)
6/23/90	25(1.5)	21(1.1)	19(1.4)	19(1.1)	21(1.2)	21(1.1)	21(1.5)
6/30/90	42(1.8)	30(1.4)	32(1.8)	28(1.4)	28(1.4)	25(1.3)	28(1.8)
$\bar{x}$	21	20	19	19	19	20	20
1.96 σ	16	8.9	10	7.3	9.0	8.0	6.9
MAX: 42 MIN: 5.5		$\bar{x}$(1.96 σ): 20(11) n: 52			MAX: 29 MIN: 12		$\bar{x}$(1.96 σ): 20(7.9) n: 38

* 1.96 σ (Due to Counting Statistics)

c - instrument malfunction

Table II.B.1 Concentrations of Long-lived Gross Beta Particulate Activity in Air. (fCi/m^3)

c) Third Quarter, 1990

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
07/07/90	33 (1.7)*	23 (1.3)	24 (1.5)	24 (1.6)	6.6 (1.8)	22 (1.2)	24 (1.8)
07/14/90	25 (1.5)	18 (1.2)	19 (1.4)	25 (1.4)	17 (1.0)	20 (1.0)	20 (1.6)
07/21/90	22 (1.5)	19 (1.3)	21 (1.4)	29 (1.4)	21 (1.2)	21 (1.1)	23 (1.6)
07/28/90	18 (1.4)	18 (1.2)	16 (1.4)	16 (1.0)	17 (1.1)	18 (1.1)	18 (1.6)
08/04/90	28 (1.6)	25 (1.2)	24 (1.6)	24 (1.1)	20 (1.4)	26 (1.2)	24 (1.7)
08/11/90	29 (1.7)	24 (1.7)	28 (1.8)	28 (1.2)	15 (1.2)	27 (1.3)	29 (1.9)
08/18/90	20 (1.5)	h	18 (1.6)	19 (1.0)	17 (1.2)	20 (1.1)	21 (1.7)
08/25/90	21 (1.5)	21 (2.7)	22 (1.9)	21 (1.1)	21 (1.4)	22 (1.2)	22 (1.9)
09/01/90	25 (1.7)	23 (2.2)	11 (1.6)	22 (1.2)	15 (1.1)	20 (1.1)	23 (2.1)
09/08/90	29 (1.7)	27 (1.6)	26 (1.5)	27 (1.2)	28 (1.2)	28 (1.3)	24 (2.4)
09/15/90	35 (1.9)	34 (1.9)	33 (1.8)	30 (1.3)	24 (1.2)	31 (1.4)	33 (2.8)
09/22/90	29 (1.7)	28 (1.7)	29 (1.7)	23 (1.2)	29 (1.5)	50 (2.3)	27 (1.5)
09/29/90	28 (1.6)	26 (1.7)	27 (1.6)	29 (1.2)	25 (1.2)	29 (1.3)	29 (1.8)
---	---	---	---	---	---	---	---
$\bar{x}$	26	24	23	24	20	26	24
1.96 σ	9.8	9.1	12	8.3	12	16	8.1
MAX: 35 MIN: 11		$\bar{x}$ (1.96 σ): 24(10) n: 51			MAX: 50 MIN: 6.6	$\bar{x}$ (1.96 σ): 23(13) n: 39	

* 1.96 σ (Due to counting Statistics.)

h - sample not collected (air pump not functioning)

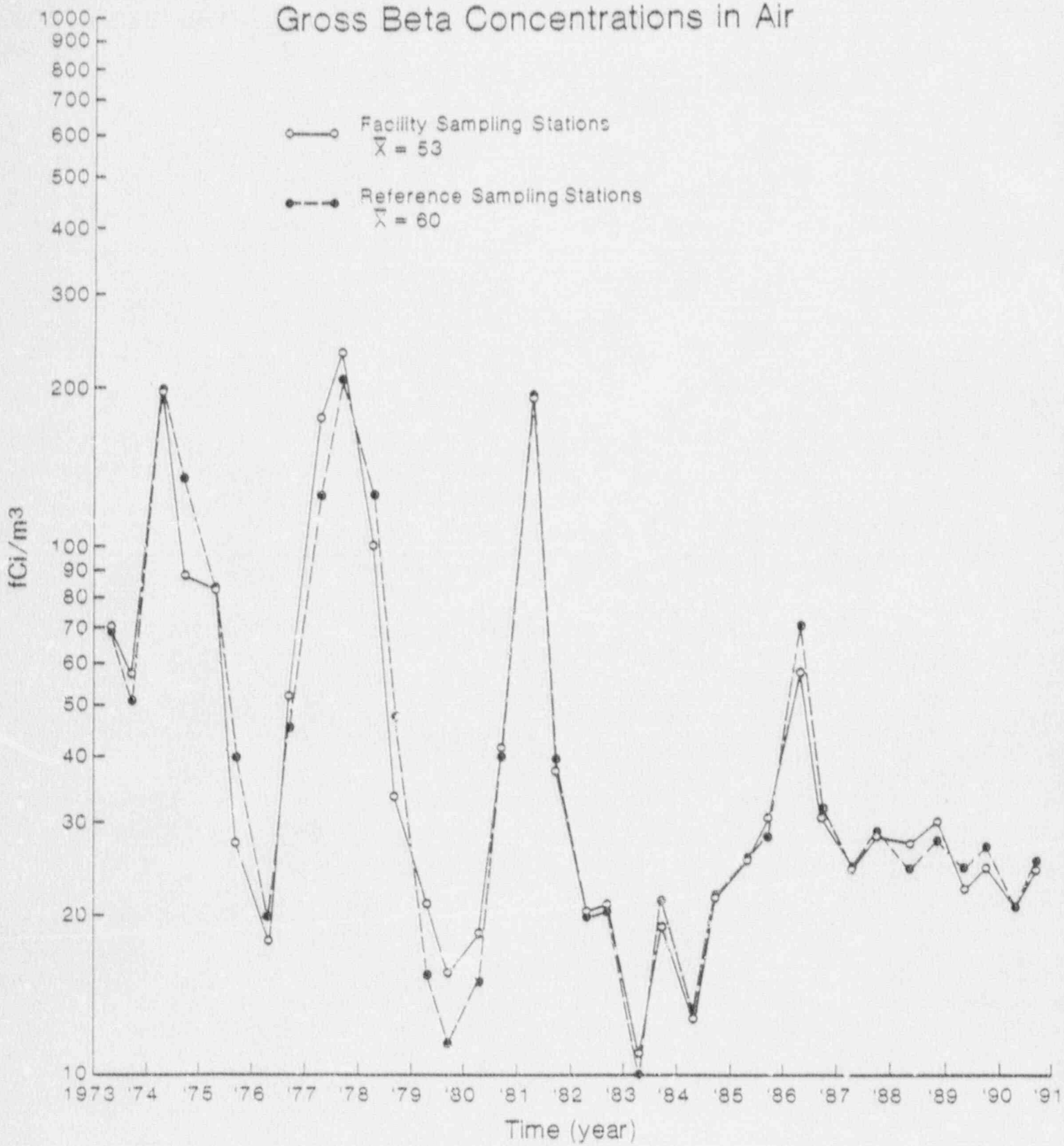
Table II.B.1 Concentrations of Long-lived Gross Beta Particulate Activity in Air. (fCi/m^3)

d) Fourth Quarter, 1990

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
10/06/90	23 (1.6)*	24 (2.0)	24 (1.7)	24 (1.2)	24 (1.2)	24 (1.3)	24 (1.4)
10/13/90	20 (1.5)	22 (2.6)	20 (1.5)	17 (0.95)	22 (1.2)	21 (1.2)	21 (1.3)
10/20/90	24 (1.7)	25 (2.8)	23 (2.0)	19 (1.1)	22 (1.2)	22 (1.2)	23 (1.5)
10/27/90	30 (1.7)	26 (1.2)	30 (1.4)	30 (1.3)	27 (1.2)	26 (1.3)	29 (1.6)
11/03/90	34 (1.9)	31 (1.4)	32 (1.5)	31 (1.4)	31 (1.5)	29 (1.4)	10 (1.4)
11/10/90	28 (1.7)	30 (1.3)	25 (1.3)	29 (1.3)	25 (1.2)	33 (1.7)	22 (1.1)
11/17/90	30 (1.7)	28 (1.3)	30 (1.5)	29 (1.3)	28 (1.7)	20 (1.3)	24 (1.4)
11/24/90	42 (2.0)	29 (1.4)	30 (1.4)	25 (1.2)	24 (1.3)	40 (1.8)	56 (2.3)
12/01/90	23 (1.6)	22 (1.2)	26 (1.4)	18 (1.1)	27 (1.4)	22 (1.3)	43 (2.6)
12/08/90	9.7 (1.3)	14 (1.0)	21 (1.3)	18 (1.1)	54 (3.1)	17 (1.2)	16 (1.1)
12/15/90	29 (1.6)	25 (1.2)	29 (1.4)	28 (1.2)	21 (1.2)	22 (1.3)	26 (1.3
12/22/90	52 (2.5)	37 (1.5)	37 (1.6)	36 (1.4)	33 (1.6)	35 (1.7)	36 (1.7)
12/29/90	49 (2.4)	33 (1.6)	42 (2.0)	43 (1.8)	12 (1.1)	33 (1.8)	34 (1.6)
---	---	---	---	---	---	---	---
$\bar{x}$	30	27	28	27	27	26	28
1.96σ	23	11	12	15	19	14	23
MAX: 52 MIN: 9.7		$\bar{x}$(1.96σ): 28(17) n: 52			MAX: 56 MIN: 10	$\bar{x}$(1.96σ): 27(20) n: 39	

* 1.96σ (Due to Counting Statistics.)

Figure II.B.1


Gross Beta Concentrations in Air
Facility Sampling Stations
X̄ = 53
Reference Sampling Stations
X̄ = 60
fCi/m3
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
10
1973 '74 '75 '76 '77 '78 '79 '80 '81 '82 '83 '84 '85 '86 '87 '88 '89 '90 '91
Time (year)

2. Tritium Activity

Atmospheric 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 reference area). The specific activity of tritium in water extracted from these weekly samples for 1990 is listed in Tables II.B.2a-2d. The corresponding tritium concentration in air (pCi/m^3) is calculated from the specific activity data using weekly mean temperatures and dew points measured at the FSV meteorological tower. The measuring point is at a height of 2 m from the surface. The tritium air concentrations are shown in Table II.B.3a-3d.

The principle release mode of tritium from the reactor was batch liquid releases from holding tanks (system 62). The tank water is first analyzed and then released with sufficient additional dilution, if necessary, to meet 10CFR20 concentration limits. The summary of tritium release by all modes is shown in Table II.B.4. The summary indicates that the total tritium released in 1990 was 70 percent of that released in 1989 by all routes. This effluent release was not detected at F-16 and A-19, two air sampling sites close to the Goosequill ditch effluent path.

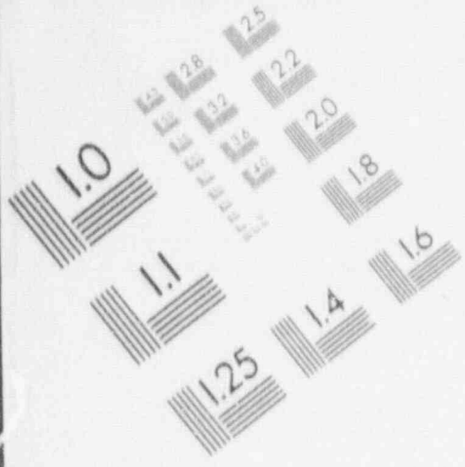
The mean values for sites F-16 and A-19 were statistically the same as for all other sites during the year. In any case, inhalation is not a significant pathway for dose to humans. The milk and food product pathway is the only significant source of radiation dose to humans from

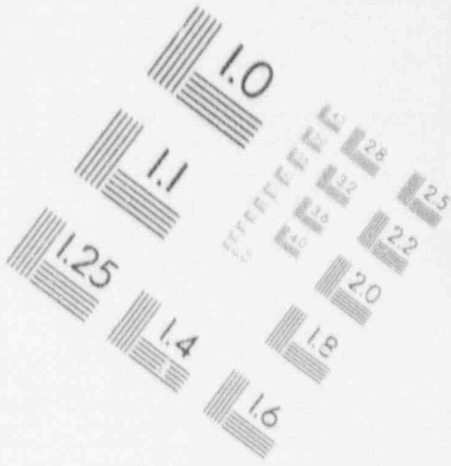
environmental tritium. See results for these pathways in sections II.D and II.E.

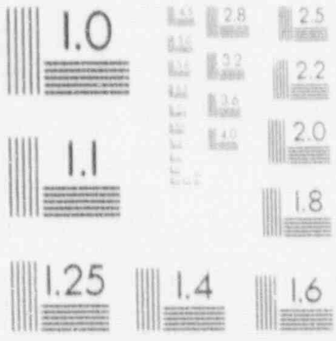
Since the same weekly relative humidity is assumed for all sites, Table II.B.3 would show the same site dependence on reactor effluent as Table II.B.2. Only the units used to measure tritium in surface air are different.

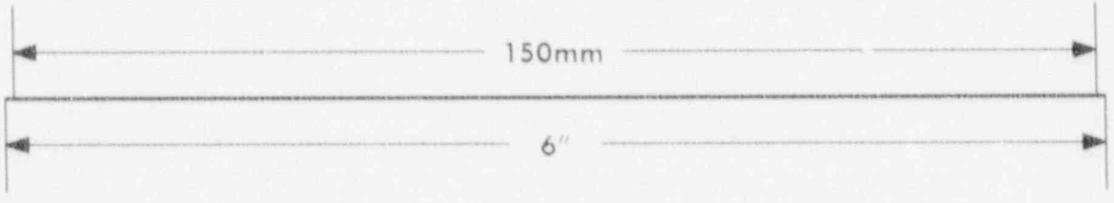
1

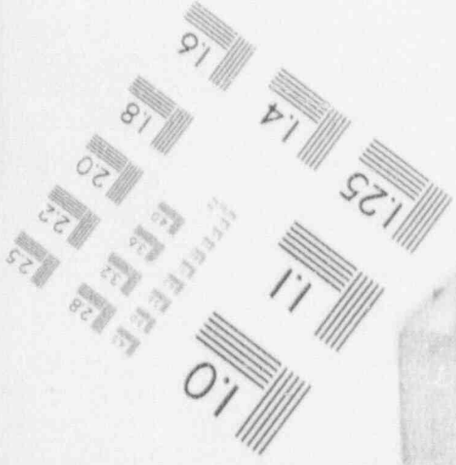
IMAGE EVALUATION TEST TARGET (MT-3)











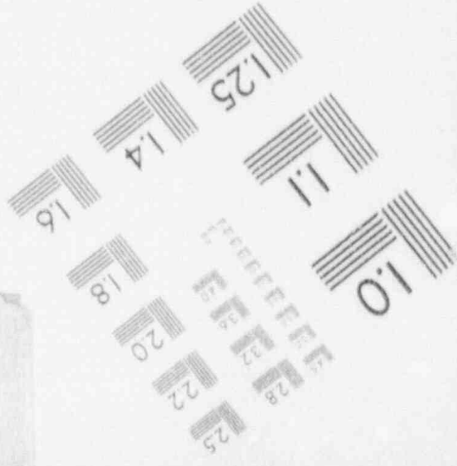


Table II.B.2 Tritium Concentrations in Atmospheric Water Vapor. (pCi/L)

a) First Quarter, 1990

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
1/6/90	< 420	< 420	< 420	< 420	< 420	e	e
1/13/90	< 420	< 420	< 420	< 420	< 420	e	< 420
1/20/90	< 420	< 420	< 420	< 420	< 420	< 420	< 420
1/27/90	e	< 420	< 420	< 420	< 420	< 420	< 420
2/3/90	< 420	< 420	< 420	< 420	< 420	< 420	< 420
2/10/90	< 420	< 420	< 420	< 420	< 420	< 420	< 420
2/17/90	< 420	< 420	< 420	< 420	e	< 420	< 420
2/24/90	e	< 420	e	e	< 420	e	e
3/3/90	< 420	< 420	e	< 420	e	< 420	< 420
3/10/90	< 420	< 420	< 420	< 420	< 420	< 420	< 420
3/17/90	< 420	< 420	< 420	< 420	< 420	< 420	< 420
3/24/90	< 420	< 420	< 420	< 420	< 420	< 420	< 420
3/31/90	< 420	< 420	< 420	< 420	< 420	< 420	e

e - insufficient weight or volume for analysis.

Table II.B.2 Tritium Concentrations in Atmospheric Water Vapor. (pCi/L)

b) Second Quarter, 1990

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
4/7/90	<420	<420	<420	<420	<420	<420	<420
4/14/90	<420	<420	<420	<420	<420	<420	a
4/21/90	<420	<420	<420	<420	<420	<420	<420
4/28/90	<420	<420	<420	<420	<420	<420	<420
5/5/90	<430	<430	<430	<430	<430	<430	<430
5/12/90	<390	<390	<390	<390	<390	<390	<390
5/19/90	<420	<420	<420	<420	<420	<420	<420
5/26/90	<400	<400	<400	<400	<400	<400	<400
6/2/90	<390	<400	<400	<390	<400	<400	<400
6/9/90	<390	<390	<390	<390	<390	<390	<390
6/16/90	<390	<390	<390	<390	<390	<390	<390
6/23/90	<390	<390	<390	<390	<390	<390	<390
6/30/90	<390	<390	<400	<390	<400	<400	<390
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*1.96σ (Due to Counting Statistics)

a-sample lost prior to analysis

Table II.B.2 Tritium Concentrations in Atmospheric Water Vapor. (pCi/L)

c) Third Quarter, 1990

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
07/07/90	< 390	< 390	< 390	< 390	< 390	< 390	< 390
07/14/90	< 400	< 400	< 400	< 400	< 400	< 400	< 400
07/21/90	< 390	< 390	< 390	< 390	< 390	< 390	< 390
07/28/90	< 390	< 390	< 390	< 390	< 390	< 390	< 390
08/04/90	< 390	< 390	< 390	< 390	< 390	< 390	< 390
08/11/90	< 390	< 390	< 390	< 390	< 390	< 390	< 390
08/18/90	< 390	< 390	< 390	< 390	< 390	< 390	< 390
08/25/90	< 390	< 390	< 390	e	< 390	< 390	< 390
09/01/90	< 390	< 390	< 390	< 390	< 390	< 390	< 390
09/08/90	< 400	< 400	< 400	< 400	< 400	< 400	< 400
09/15/90	< 390	< 390	< 390	< 390	< 390	< 390	< 390
09/22/90	< 400	< 400	< 400	< 400	< 400	< 400	< 400
09/29/90	< 390	< 390	< 390	< 390	< 390	< 390	< 390
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e - insufficient weight or volume for analysis

Table II.B.2 Tritium Concentrations in Atmospheric Water Vapor. (pCi/L)

d) Fourth Quarter, 1990

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
10/06/90	< 400	< 400	< 400	< 400	< 400	< 400	< 400
10/13/90	< 400	< 400	< 400	< 400	< 400	< 400	< 400
10/20/90	< 400	< 400	< 400	< 400	< 400	< 400	< 400
10/27/90	< 390	< 390	< 390	< 390	< 390	< 390	< 390
11/03/90	< 400	< 400	< 400	< 400	< 400	< 400	< 400
11/10/90	< 390	< 390	< 390	< 390	< 390	< 390	< 390
11/17/90	420(410)*	< 400	< 400	< 400	< 400	< 400	< 400
11/24/90	< 400	< 400	< 400	< 400	< 400	< 400	< 400
12/01/90	< 400	< 400	< 400	< 400	< 400	< 400	< 400
12/08/90	< 390	< 390	< 390	< 390	< 390	< 390	< 390
12/15/90	< 410	< 410	< 410	< 410	< 410	< 410	< 410
12/22/90	< 400	< 400	< 400	< 400	< 400	< 400	< 400
12/29/90	< 400	< 400	< 400	< 400	< 400	< 400	< 400
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* 1.96 σ (Due to Counting Statistics.)

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

a) First Quarter, 1990

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
01/06	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	e	e
01/13	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	e	< 1.4
01/20	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4
01/27	e	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
02/03	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2
02/10	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4
02/17	< 1.1	< 1.1	< 1.1	< 1.1	e	< 1.1	< 1.1
02/24	e	< 1.6	e	e	< 1.6	e	e
03/03	< 1.7	< 1.7	e	< 1.7	e	< 1.7	< 1.7
03/10	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
03/17	< 1.6	< 1.6	< 1.6	< 1.6	< 1.6	< 1.6	< 1.6
03/24	< 1.7	< 1.7	< 1.7	< 1.7	< 1.7	< 1.7	< 1.7
03/31	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	e

e - insufficient volume for analysis

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

b) Second Quarter, 1990

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
04/07	< 2.1	< 2.1	< 2.1	< 2.1	< 2.1	< 2.1	< 2.1
04/14	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2	a
04/21	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5
04/28	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3
05/05	< 1.7	< 1.7	< 1.7	< 1.7	< 1.7	< 1.7	< 1.7
05/12	< 1.8	< 1.8	< 1.8	< 1.8	< 1.8	< 1.8	< 1.8
05/19	< 1.9	< 1.9	< 1.9	< 1.9	< 1.9	< 1.9	< 1.9
05/26	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3	< 2.3
06/02	< 2.4	< 2.5	< 2.5	< 2.4	< 2.5	< 2.5	< 2.5
06/09	< 2.7	< 2.7	< 2.7	< 2.7	< 2.7	< 2.7	< 2.7
06/16	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5
06/23	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2	< 2.2
06/30	< 2.8	< 2.8	< 2.9	< 2.8	< 2.9	< 2.9	< 2.8

a - Sample lost prior to analysis

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

c) Third Quarter, 1990

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
07/07	< 2.9	< 2.9	< 2.9	< 2.9	< 2.9	< 2.9	< 2.9
07/14	< 2.8	< 2.8	< 2.8	< 2.8	< 2.8	< 2.8	< 2.8
07/21	< 2.6	< 2.6	< 2.6	< 2.6	< 2.6	< 2.6	< 2.6
07/28	< 2.7	< 2.7	< 2.7	< 2.7	< 2.7	< 2.7	< 2.7
08/04	< 2.6	< 2.6	< 2.6	< 2.6	< 2.6	< 2.6	< 2.6
08/11	< 2.7	< 2.7	< 2.7	< 2.7	< 2.7	< 2.7	< 2.7
08/18	< 2.9	< 2.9	< 2.9	< 2.9	< 2.9	< 2.9	< 2.9
08/25	< 2.0	< 2.0	< 2.0	e	< 2.0	< 2.0	< 2.0
09/01	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
09/08	< 3.3	< 3.3	< 3.3	< 3.3	< 3.3	< 3.3	< 3.3
09/15	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4	< 2.4
09/22	< 2.6	< 2.6	< 2.6	< 2.6	< 2.6	< 2.6	< 2.6
09/29	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5	< 2.5

e - insufficient volume for analysis

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

d) Fourth Quarter, 1990

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
10/06	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
10/13	< 1.6	< 1.6	< 1.6	< 1.6	< 1.6	< 1.6	< 1.6
10/20	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4
10/27	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
11/03	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
11/10	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2
11/17	1.6(1.5)*	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5	< 1.5
11/24	1.3	< 1.3	< 1.3	< 1.3	< 1.3	< 1.3	< 1.3
12/01	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
12/08	< 0.95	< 0.95	< 0.95	< 0.95	< 0.95	< 0.95	< 0.95
12/15	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2	< 1.2
12/22	< 0.49	< 0.49	< 0.49	< 0.49	< 0.49	< 0.49	< 0.49
12/29	< 0.52	< 0.52	< 0.52	< 0.52	< 0.52	< 0.52	< 0.52

*1.96σ (Due to Counting Statistics)

Table II.B.4 Tritium Released (mCi) in Reactor Effluents, 1990

MODE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Continuous (Turbine Building Sump)	13	4.9	18	0.72	0.31	0.94	3.9	4.7	1.1	0.65	0.91	1.4	50
Batch Release (Reactor Building Sump)	14	28	19	3.4	1.9	28	2.5	2.4	1.4	0.71	2.5	2.2	105
Batch Release (System 62)	198	170	51	8.5	55	1.6	51	503	135	44	427	492	2135
Gaseous Stack	28	7.6	543	40	34	11	11	14	11	7.6	12	8.7	728
TOTAL	253	211	630	52	91	42	68	524	148	53	443	504	3018

3. Concentrations of Gamma-ray Emitting Radionuclides in Ambient Air

Tables II.B.5a-5d list the concentrations of I-131 in air as measured by activated charcoal sampling and Ge(Li) gamma-ray spectrum analysis during 1990. Each sample from the seven air sampling stations is counted within 96 hours after collection. A 100 minute count and a sample volume of 800 m^3 is required to achieve an MDC of 33 fCi/m^3. Radon daughters and Thoron daughters are trapped on the particulate filter ahead of the charcoal trap. Radon-222 daughter in-growth on the charcoal does not provide interference to the region of interest for I-131 using the Ge(Li) high resolution spectrometry system. Any positive I-131 activity is corrected for radioactive decay back to the midpoint of the collection period. Decay correction to the midpoint of the sampling period is appropriate as any I-131 in air would not arrive at the sampling stations at a constant rate, but rather randomly in pulses of short duration compared to the collection period. This is the case whether the I-131 source term would be a nuclear accident elsewhere, weapons testing fallout or reactor stack effluent.

There were only occasional positive values very near the MDC value and all are assumed to be false positives. I-131 concentrations due to reactor effluent have never been detected in any sample type in the Fort St. Vrain environs.

Table II.B.6 lists measured ambient air concentrations of Cs-134 and Cs-137. These values are from gamma-ray spectrum

analyses on weekly air filters composited quarterly from each of the seven air sampling stations. The occasional positive Cs-137 concentrations measured are likely due to resuspension of surface soil. The Cs-137 activity is due to Chernobyl or previous fallout which is bound by clay minerals on the surface of undisturbed soil. For the entire year, the mean of the facility stations was not different from the mean of the reference stations.

Although only Cs-134 and Cs-137 are reported, each gamma-ray spectrum is scanned for evidence of peaks from other fission products and activation products. Only gamma-ray activity due to the naturally occurring background radionuclides are observed. During the second quarter of 1986, however, many other fission product and activation product radionuclides were observed due to the Chernobyl accident. Of these only Cs-137 can still be detected, but at steadily decreasing concentrations.

Table II.B.5 Iodine-131 Concentrations in Air. (fCi/m^3)

a) First Quarter, 1990

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
1/03/90	< 14.0	< 33.0	< 11.0	< 29.0	< 32.0	< 26.0	< 12.0
1/10/90	< 22.0	< 22.0	< 33.0	< 11.0	37.0 (29.0)*	< 7.7	< 6.9
1/17/90	< 16.0	< 16.0	< 16.0	< 28.0	< 14.0	< 11.0	< 19.0
1/24/90	< 19.0	< 34.0	< 25.0	< 20.0	< 34.0	< 26.0	< 6.4
1/31/90	< 16.0	< 17.0	< 22.0	< 26.0	< 20.0	<17.0	< 18.0
2/7/90	< 16.0	< 20.0	< 30.0	< 26.0	< 8.9	< 9.0	< 16.0
2/14/90	< 7.1	< 18.0	< 7.0	< 13.0	< 17.0	< 9.7	< 14.0
2/21/90	< 5.4	< 13.0	< 20.0	< 32.0	< 13.0	< 16.0	< 33.0
2/28/90	< 24.0	< 20.0	< 18.0	< 7.6	< 7.3	< 5.5	< 17.0
3/7/90	< 13.0	< 11.0	< 11.0	< 14.0	< 8.8	< 13.0	< 25.0
3/14/90	< 23.0	31.0 (38.0)	< 22.0	< 15.0	< 16.0	< 16.0	< 14.0
3/21/90	< 9.6	< 7.4	< 11.0	< 17.0	< 16.0	30.0 (28.0)	< 7.1
3/28/90	< 31.0	< 8.9	< 21.0	< 8.2	< 15.0	< 16.0	< 13.0

*1.96σ (Due to Counting Statistics)

Table II.B.5 Iodine-131 Concentrations in Air. (fCi/m^3)

b) Second Quarter, 1990

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
4/04/90	< 20.0	< 8.4	< 8.6	19.0 (20.0)*	< 24.0	< 24.0	< 26.0
4/11/90	< 8.0	< 13.0	< 13.0	< 11.0	e	< 6.9	< 16.0
4/18/90	< 5.4	< 7.7	< 11.0	< 8.7	< 6.8	< 19.0	< 14.0
4/25/90	< 22.0	< 19.0	< 26.0	< 17.0	< 14.0	< 16.0	< 26.0
5/02/90	< 4.9	< 11.0	< 8.2	< 11.0	< 13.0	< 7.9	< 11.0
5/09/90	< 12.0	< 11.0	< 11.0	< 12.0	< 16.0	< 14.0	< 7.4
5/16/90	< 26.0	< 18.0	< 20.0	< 23.0	27.0 (31.0)	< 14.0	< 14.0
5/23/90	< 22.0	< 19.0	< 13.0	< 13.0	< 20.0	< 14.0	< 18.0
5/30/90	< 29.0	< 25.0	< 13.0	< 15.0	23.0 (23.0)	< 11.0	< 24.0
6/06/90	< 33.0	< 14.0	< 23.0	< 18.0	< 12.0	< 21.0	< 17.0
6/13/90	< 29.0	< 15.0	< 24.0	< 9.1	< 13.0	29.0 (26.0)	< 14.0
6/20/90	43.0 (43.0)	< 12.0	< 24.0	< 5.6	< 4.7	< 9.6	< 21.0
6/27/90	13.0 (13.0)	< 16.0	< 29.0	< 20.0	< 29.0	25.0 (24.0)	< 31.0

*1.96σ (Due to Counting Statistics)

e-insufficient weight or volume for analysis

Table II.B.5 Iodine-131 Concentrations in Air. (fCi/m^3)

d) Third Quarter, 1990

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
7/04/90	< 19.0	< 14.0	< 15.0	< 13.0	< 26.0	< 10.0	< 8.2
7/11/90	< 17.0	< 22.0	< 31.0	< 27.0	14.0 (14.0)*	< 15.0	< 30.0
7/18/90	< 20.0	< 17.0	< 21.0	< 14.0	< 21.0	< 23.0	< 24.0
7/25/90	< 17.0	< 32.0	31.0 (34.0)	< 7.3	< 19.0	< 15.0	< 22.0
8/01/90	< 31.0	< 12.0	< 11.0	< 18.0	< 27.0	< 13.0	< 31.0
8/08/90	< 25.0	< 26.0	< 19.0	< 13.0	< 22.0	< 9.3	< 32.0
8/15/90	< 20.0	h	< 15.0	< 12.0	< 9.0	< 20.0	< 20.0
8/22/90	< 23.0	< 14.0	< 21.0	< 12.0	< 13.0	< 19.0	< 9.6
8/29/90	< 24.0	< 17.0	< 22.0	29.0 (34.0)	< 30.0	< 21.0	< 20.0
9/05/90	< 15.0	< 14.0	< 17.0	< 20.0	< 25.0	< 4.4	26.0 (21.0)
9/12/90	< 35.0	< 17.0	< 9.4	< 5.3	< 4.5	< 16.0	< 35.0
9/19/90	< 24.0	< 7.1	< 27.0	< 13.0	< 29.0	< 18.0	< 8.6
9/26/90	< 7.5	< 27.0	< 19.0	< 18.0	< 9.4	< 16.0	< 33.0

*1.96σ (Due to Counting Statistics)
h - sample not collected (air pump not functioning)

Table II.B.5 Iodine-131 Concentrations in Air. (fCi/m^3)

d) Fourth Quarter, 1990

Collection Date	Facility Sites				Reference Sites		
	F-7	F-9	F-16	A-19	R-3	R-4	R-11
10/03/90	36.0 (35.0)*	< 23.0	< 13.0	< 34.0	< 34.0	< 29.0	< 34.0
10/10/90	< 17.0	< 27.0	< 23.0	17.0 (16.0)	< 22.0	< 33.0	< 5.7
10/17/90	< 17.0	< 15.0	< 18.0	< 4.4	< 34.0	< 22.0	< 18.0
10/24/90	< 13.0	< 19.0	< 11.0	< 24.0	18.0 (20.0)	< 21.0	< 24.0
10/31/90	< 34.0	< 21.0	< 5.6	< 19.0	< 20.0	< 13.0	< 23.0
11/07/90	< 25.0	< 8.3	< 15.0	< 9.5	< 4.4	< 8.0	< 15.0
11/14/90	< 11.0	< 35.0	< 17.0	< 18.0	< 29.0	< 16.0	28.0 (29.0)
11/21/90	< 11.0	< 11.0	< 14.0	< 9.1	< 18.0	< 19.0	49.0 (41.0)
11/28/90	< 26.0	< 18.0	< 22.0	< 14.0	< 20.0	< 24.0	< 24.0
12/05/90	< 27.0	30.0 (31.0)	< 26.0	33.0 (35.0)	< 19.0	< 16.0	< 31.0
12/12/90	< 19.0	< 25.0	< 20.0	< 7.1	< 16.0	< 30.0	< 33.0
12/19/90	< 27.0	< 22.0	< 19.0	< 14.0	< 21.0	< 24.0	< 23.0
12/26/90	< 30.0	< 23.0	52.0 (40.0)	< 18.0	< 30.0	< 15.0	< 30.0

*1.96σ (Due to Counting Statistics)

Table II.B.6 Radiocesium Concentrations in Ambient Air. (fCi/m^3)

1990 Collection Date	Radio-nuclide	Facility Sites F-7	F-9	F-16	A-19	Reference Sites R-3	R-4	R-11
1st	Cs-134	1.3 (1.3)*	< 1.1	< 1.1	< 1.4	< 2.0	< 1.2	< 1.3
Quarter	Cs-137	< 1.1	< 1.2	< 1.2	< 1.4	< 1.9	< 1.2	< 1.4
2nd	Cs-134	< 1.4	< 1.5	< 1.3	< 1.7	< 1.8	< 0.72	< 1.6
Quarter	Cs-137	< 1.4	< 1.5	1.7 (1.7)	< 1.8	< 1.7	< 0.76	< 1.8
3rd	Cs-134	< 1.7	< 2.3	2.7 (2.8)	< 1.2	< 1.6	< 0.86	< 2.1
Quarter	Cs-137	< 1.9	2.3 (2.6)	< 2.2	< 1.2	< 1.6	< 0.9	< 2.0
4th	Cs-134	< 1.2	< 1.2	< 1.3	< 1.3	< 0.5	< 1.2	< 1.7
Quarter	Cs-137	< 1.4	< 1.2	< 1.4	< 1.3	< 0.5	< 1.3	< 1.7

*1.96 σ (Due to Counting Statistics)

II.C. Radionuclide Concentration in Water

1. Drinking Water

Drinking water is sampled weekly and composited biweekly at two locations. Location R-6 is the well used for drinking water by the town of Gilcrest, Colorado and R-3 is a water tap located on the CSU dairy farm. The Gilcrest well is the nearest public water supply that could be affected by the reactor effluents. R-3 samples are from the Fort Collins drinking water supply and serve as a reference location since its source is run-off surface water from the Rocky Mountains to the West. However, water treatment systems for the two water supplies are very different.

Table II.C.1 shows gross beta concentrations measured in 1990 from each water supply. As in every past year, the mean for the Gilcrest site was significantly higher than the Reference site in Fort Collins. This is only due to the different water treatment practices and the different supply sources. The city of Gilcrest does not completely filter its water and natural radionuclide concentrations due to the suspended solids are responsible for the higher measured concentrations. As can be observed in Table II.H.2, the mean for the entire year for the Gilcrest site was similar to that observed in previous years.

Table II.C.2 lists measured tritium concentrations in these same two drinking water sources. No concentrations above MDC were detected in either source. The yearly arithmetic mean value for the Gilcrest location was less than

MDC. The mean yearly concentration measured in the Gilcrest supply was statistically the same as in the Fort Collins supply. The EPA limit for community drinking water systems is 20,000 pCi/L for tritium.

The two drinking water supplies are also analyzed for fission product and activation product concentrations. A sample of 18 liters is passed through Dowex 1-x8 anion exchange resin and the resin then counted by Ge(Li) spectrometry for I-131. A three liter aliquot of the original sample is counted directly for the other gamma-ray emitters.

Inspection of Table II-C.3 reveals occasional positive values of radionuclide concentration, but with the exception of Cs-137, these are interpreted to be random variations about the detection limit. The Cs-137 is the residue from the 1986 Chernobyl accident fallout as well as from past world-wide fallout from nuclear weapon testing.

Table II.C.1
Gross Beta Concentrations in Biweekly Composites of Drinking Water. (pCi/L)

Collection Date 90	Gilcrest City R-6	Fort Collins City R-3 (Reference)
12/30 1/06	4.2(2.3)*	0.88(0.55)
1/13 1/20	4.2(2.3)	1.2(0.57)
1/27 2/03	3.7(2.3)	1.0(0.55)
2/10 2/17	4.6(2.4)	1.1(0.57)
2/24 3/3	9.5(2.6)	0.69(0.55)
3/10 3/17	5.1(2.4)	0.70(0.56)
3/24 3/31	7.1(2.5)	0.94(0.57)
4/7 4/14	5.6(2.4)	0.97(0.57)
4/21 4/28	4.0(2.3)	1.2(0.58)
5/5 5/12	4.3(2.4)	0.62(0.55)
5/19 5/26	4.1(2.3)	0.34(0.53)
6/2 6/9	1.3(2.2)	0.75(0.56)
6/16 6/23	2.4(2.2)	0.34(0.53)
6/30 7/7	1.8(2.2)	0.51(0.54)
7/14 7/21	3.1(2.3)	0.68(0.55)
7/28 8/4	3.3(2.3)	0.74(0.56)
8/11 8/18	2.6(2.3)	0.53(0.54)
8/25 9/1	3.2(2.3)	0.58(0.54)
9/8 9/15	4.4(2.3)	0.71(0.55)
9/22 9/29	7.6(2.5)	0.76(0.55)
10/6 10/13	3.2(2.3)	0.73(0.55)
10/20 10/27	5.9(2.4)	0.64(0.56)
11/3 11/10	6.6(2.5)	1.1(0.57)
11/17 11/24	5.5(2.4)	1.3(0.59)
12/1 12/8	5.1(2.4)	2.3(0.62)
12/15 12/22	4.2(2.3)	0.94(0.56)

*1.96σ (Due to Counting Statistics)

Table II.C.2
Tritium Concentrations in Biweekly Composites of Drinking Water. (pCi/L)

Collection Date 90	Gilcrest City R-6	Fort Collins City R-3 (Reference)
12/30 1/06	<420	<420
1/13 1/20	<420	<420
1/27 2/3	<420	<420
2/10 2/17	<420	<420
2/24 3/3	<420	<420
3/10 3/17	<430	<430
3/24 3/31	<420	<420
4/7 4/14	<420	<420
4/21 4/28	<420	<420
5/5 5/12	<390	<390
5/19 5/26	<390	<390
6/2 6/9	<400	<400
6/16 6/23	<390	<390
6/30 7/7	<390	<390
7/14 7/21	<390	<390
7/28 8/4	<390	<390
8/11 8/18	<390	<390
8/25 9/1	<390	<390
9/8 9/15	<400	<400
9/22 9/29	<400	<400
10/6 10/13	<400	<400
10/20 10/27	<400	<400
11/3 11/10	<390	<390
11/17 11/24	<390	<390
12/1 12/8	<400	<400
12/15 12/22	<400	<400

Table II.C.3 Radionuclide Concentrations in Bi-weekly Composite of Drinking Water. (pCi/L)

Collection Date	for two weeks ending 1/3/90		for two weeks ending 1/17/90		for two weeks ending 1/31/90	
Radionuclide	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3
I-131	< 0.24	< 0.34	< 0.39	< 0.34	< 0.2	< 0.23
Cs-134	< 2.2	< 2.3	< 2.5	< 2.3	< 2.3	< 1.6
Cs-137	6.4 (4.0)*	< 3.3	< 3.1	3.6 (3.9)	6.0 (3.5)	< 1.7
Zr-95	< 5.6	< 5.2	< 5.8	< 5.2	< 4.9	< 3.3
Nb-95	< 2.0	< 2.1	< 2.4	< 2.1	< 2.5	1.5 (1.7)
Co-58	< 2.4	< 2.2	< 2.5	< 2.2	< 2.2	< 1.4
Mn-54	< 2.3	2.2 (2.6)	< 2.5	< 2.2	2.1 (2.7)	< 1.5
Zn-65	< 5.4	< 5.3	< 6.2	< 5.2	< 6.8	< 3.9
Fe-59	< 4.9	< 4.9	< 6.3	< 5.2	< 6.2	5.6 (5.2)
Co-60	< 2.3	< 2.2	< 2.8	< 2.3	3.7 (2.7)	< 1.4
Ba-140	< 3.2	< 4.5	< 4.1	< 3.4	< 4.1	< 3.9
La-140	< 3.7	< 5.2	< 4.7	< 3.9	< 4.7	< 4.5

*1.96 σ (Due to Counting Statistics)

Table II.C.3 Radionuclide Concentrations in Bi-weekly Composite of Drinking Water. (pCi/L)

Collection Date	for two weeks ending 2/14/90		for two weeks ending 2/28/90		for two weeks ending 3/14/90	
Radionuclide	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3
I-131	< 0.2	< 0.37	< 0.17	< 0.22	< 0.41	< 0.18
Cs-134	< 2.2	< 1.2	< 1.2	< 1.7	1.5 (1.4)	< 2.1
Cs-137	2.9 (3.2)*	< 1.4	1.6 (1.9)	< 1.8	1.7 (1.7)	< 3.0
Zr-95	< 5.5	< 2.5	< 2.7	< 3.5	< 2.6	< 4.6
Nb-95	< 2.1	1.6 (1.4)	< 1.3	< 1.5	< 1.3	< 1.8
Co-58	< 2.1	< 1.1	< 1.2	< 1.5	< 1.1	< 2.1
Mn-54	2.7 (2.7)	< 1.2	< 1.3	< 1.5	< 1.2	< 2.1
Zn-65	< 5.7	< 2.8	9.4 (4.1)	< 3.9	< 3.7	< 4.8
Fe-59	< 5.4	< 3.2	< 3.4	< 3.6	< 3.3	< 4.6
Co-60	< 2.4	< 1.1	1.2 (1.5)	< 1.4	< 1.2	< 2.2
Ba-140	< 3.6	< 2.0	< 2.2	< 3.2	< 2.1	< 4.2
La-140	< 4.1	< 2.3	< 2.5	< 3.7	< 2.4	< 4.9

*1.96 σ (Due to Counting Statistics)

Table II.C.3 Radionuclide Concentrations in Bi-weekly Composite of Drinking Water. (pCi/L)

Collection Date	for two weeks ending 3/28/90		for two weeks ending 4/11/90		for two weeks ending 4/25/90	
Radionuclide	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3
I-131	< 0.43	< 0.37	< 0.34	< 0.21	< 0.39	< 0.33
Cs-134	< 1.6	< 2.0	< 2.3	< 1.4	< 2.6	< 2.2
Cs-137	3.0 (2.3)	< 2.4	2.8 (3.3)	2.0 (1.9)	< 3.1	5.0 (3.3)
Zr-95	< 3.3	< 4.9	< 5.4	< 3.0	< 6.1	< 5.1
Nb-95	< 1.7	< 1.8	< 2.0	< 1.3	< 2.3	< 2.3
Co-58	< 1.5	< 1.8	< 2.1	< 1.3	< 2.4	< 2.1
Mn-54	< 1.6	2.4 (2.4)	< 2.2	< 1.3	< 2.5	< 2.2
Zn-65	< 6.7	< 5.3	< 6.4	< 3.8	< 7.0	< 7.5
Fe-59	< 4.0	< 4.6	< 5.2	< 3.5	< 6.2	< 5.0
Co-60	1.5 (1.8)	< 2.1	< 2.4	< 1.3	< 2.8	< 2.2
Ba-140	< 3.2	< 3.1	< 3.6	< 3.1	6.4 (6.2)	< 4.5
La-140	< 3.7	< 3.6	< 4.1	< 3.5	7.3 (7.2)	< 5.2

*1.96 σ (Due to Counting Statistics)

Table II.C.3 Radionuclide Concentrations in Bi-weekly Composite of Drinking Water. (pCi/L)

Collection Date	for two weeks ending 5/9/90		for two weeks ending 5/23/90		for two weeks ending 6/6/90	
Radionuclide	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3
I-131	< 0.3	< 0.17	<0.45	<0.26	0.18 (0.21)	< 0.13
Cs-134	< 2.1	< 2.2	< 1.9	< 1.8	< 1.4	< 2.1
Cs-137	< 2.4	< 2.5	2.9 (2.8)	< 2.4	< 1.7	2.6 (3.0)
Zr-95	< 4.7	< 4.8	< 4.1	< 4.6	< 3.2	< 4.6
Nb-95	< 2.1	< 1.9	2.6 (2.4)	2.9 (2.2)	1.5 (1.7)	< 2.0
Co-58	< 2.0	< 2.0	< 1.8	< 1.7	< 1.3	< 1.9
Mn-54	< 2.1	< 2.1	2.0 (2.4)	2.0 (2.4)	< 1.5	< 2.0
Zn-65	< 5.6	< 5.7	< 5.5	< 5.5	< 4.1	< 5.4
Fe-59	9.1 (6.9)	< 4.9	< 4.9	< 5.0	< 3.7	< 5.8
Co-60	< 2.0	< 2.1	< 1.9	< 1.8	1.3 (1.7)	< 2.0
Ba-140	< 3.7	< 3.3	< 3.4	< 3.6	< 2.5	< 3.6
La-140	< 4.3	< 3.8	< 3.9	< 4.2	< 2.8	< 4.2

*1.96 σ (Due to Counting Statistics)

Table II.C.3 Radionuclide Concentrations in Bi-weekly Composite of Drinking Water. (pCi/L)

Collection Date	for two weeks ending 06/20/90		for two weeks ending 07/04/90		for two weeks ending 07/18/90	
Radionuclide	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3
I-131	< 0.45	< 0.2	< 0.46	< 0.2	< 0.47	< 0.49
Cs-134	< 2.3	< 2.1	< 1.4	< 1.5	< 2.2	< 1.4
Cs-137	< 2.8	< 2.5	< 1.7	< 1.8	< 2.7	< 1.7
Zr-95	< 5.2	< 4.5	6.8 (4.1)*	< 3.4	< 4.5	< 3.1
Nb-95	< 2.5	< 1.9	< 1.6	< 1.4	6.1 (2.6)	< 1.4
Co-58	< 2.2	< 1.9	< 1.4	< 1.5	< 2.0	< 1.3
Mn-54	< 2.4	< 2.1	1.6 (1.7)	2.2 (1.8)	< 2.3	< 1.4
Zn-65	< 6.9	< 5.7	< 5.0	< 3.3	< 6.1	< 3.8
Fe-59	< 6.2	< 5.1	< 3.7	< 3.5	< 5.9	< 3.6
Co-60	< 2.3	< 2.0	< 1.4	2.1 (1.6)	< 2.1	< 1.3
Ba-140	< 5.9	< 3.2	< 2.4	< 2.5	5.1 (5.9)	< 2.5
La-140	< 6.8	< 3.7	< 2.8	< 2.3	5.9 (6.8)	< 2.9

*1.96 σ (Due to Counting Statistics)

Table II.C.3 Radionuclide Concentrations in Bi-weekly Composite of Drinking Water. (pCi/L)

Collection Date	for two weeks ending 08/01/90		for two weeks ending 08/15/90		for two weeks ending 08/29/90	
Radionuclide	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3
I-131	< 0.37	< 0.2	< 0.47	< 0.4	0.44 (0.38)*	0.44 (0.48)
Cs-134	< 2.2	< 1.4	< 2.7	< 1.4	< 2.1	< 1.4
Cs-137	< 2.8	< 1.6	3.9 (3.7)	2.0 (2.0)	4.0 (3.0)	< 1.8
Zr-95	< 5.0	3.4 (3.7)	< 5.6	< 3.3	< 4.7	< 3.0
Nb-95	< 2.4	< 1.2	< 2.5	< 1.4	< 2.0	< 1.3
Co-58	< 2.1	< 1.3	< 2.5	< 1.3	< 2.0	< 1.3
Mn-54	< 2.5	1.3 (1.6)	< 2.2	< 1.4	< 2.0	< 1.4
Zn-65	< 7.5	< 3.5	< 7.4	< 3.9	< 6.1	< 3.6
Fe-59	< 5.7	< 3.8	5.8 (7.3)	< 4.2	< 5.2	< 3.6
Co-60	< 2.7	< 1.3	< 2.5	< 1.3	< 2.2	< 1.3
Ba-140	< 5.4	< 3.2	< 6.3	< 2.4	< 3.3	< 3.3
La-140	< 6.2	< 3.7	< 7.2	< 2.8	< 3.8	< 3.8

*1.96 σ (Due to Counting Statistics)

Table II.C.3 Radionuclide Concentrations in Bi-weekly Composite of Drinking Water. (pCi/L)

Collection Date	for two weeks ending 09/12/90		for two weeks ending 09/26/90		for two weeks ending 10/10/90	
Radionuclide	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3
I-131	< 0.4	< 0.34	< 0.27	< 0.44	< 0.24	< 0.21
Cs-134	< 2.6	< 0.89	< 2.2	< 2.0	< 1.5	< 2.4
Cs-137	4.3 (3.6)*	2.7 (1.3)	< 2.6	< 2.5	< 1.9	< 2.8
Zr-95	< 5.6	< 2.0	< 5.2	< 4.8	< 3.9	< 5.0
Nb-95	3.5 (3.7)	1.3 (1.1)	< 2.0	2.7 (2.5)	< 1.8	< 2.2
Co-58	< 2.4	< 0.8	< 2.2	< 2.0	< 1.6	< 2.5
Mn-54	2.8 (3.1)	< 0.91	< 2.2	< 2.0	< 1.6	< 2.3
Zn-65	< 9.4	< 2.4	< 6.3	< 5.6	< 4.9	< 7.4
Fe-59	< 6.3	< 2.5	< 4.9	< 5.5	4.9 (5.3)	< 6.4
Co-60	< 2.5	< 0.87	2.1 (2.5)	< 2.0	< 1.5	3.2 (2.8)
Ba-140	< 4.5	< 2.4	< 3.3	< 3.7	< 2.5	< 3.8
La-140	< 5.1	< 2.8	< 3.8	< 4.2	< 2.9	< 4.4

*1.96 σ (Due to Counting Statistics)

Table II.C.3 Radionuclide Concentrations in Bi-weekly Composite of Drinking Water. (pCi/L)

Collection Date	for two weeks ending 10/24/90		for two weeks ending 11/07/90		for two weeks ending 11/21/90	
Radionuclide	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3
I-131	< 0.43	< 0.2	< 0.46	< 0.19	< 0.33	< 0.31
Cs-134	1.6 (1.8)*	< 2.2	< 2.0	< 2.8	< 2.3	< 2.0
Cs-137	< 1.9	3.7 (2.9)	< 2.4	< 3.2	< 2.9	< 2.5
Zr-95	< 3.6	< 4.5	< 4.2	< 5.8	< 5.6	< 4.7
Nb-95	1.9 (2.0)	< 2.1	< 1.8	< 2.3	< 2.3	< 1.8
Co-58	1.5 (1.8)	< 2.0	< 1.8	< 2.5	< 2.1	< 1.8
Mn-54	< 1.6	< 2.1	< 1.9	< 2.6	< 2.3	< 2.0
Zn-65	< 5.3	< 6.3	< 5.6	< 7.1	< 6.6	< 5.6
Fe-59	< 3.9	< 5.1	< 5.1	< 6.3	< 5.4	< 4.8
Co-60	< 1.3	< 1.9	2.0 (2.2)	< 2.6	< 2.6	< 1.9
Ba-140	4.0 (4.4)	< 5.1	< 3.1	< 4.1	< 3.9	< 3.1
La-140	4.6 (5.1)	< 5.9	< 3.6	< 4.8	< 4.5	< 3.5

*1.96 σ (Due to Counting Statistics)

Table II.C.3 Radionuclide Concentrations in Bi-weekly Composite of Drinking Water. (pCi/L)

Collection Date	for two weeks ending 12/05/90		for two weeks ending 12/19/90	
Radionuclide	Gilcrest R-6	Ft Collins R-3	Gilcrest R-6	Ft Collins R-3
I-131	< 0.5	< 0.39	< 0.49	< 0.13
Cs-134	2.2 (2.3)*	< 2.2	< 1.0	< 0.88
Cs-137	4.6 (2.7)	4.4 (3.2)	1.6 (1.5)	1.3 (1.3)
Zr-95	< 4.1	< 5.3	< 2.4	< 1.9
Nb-95	< 1.7	< 2.1	< 0.95	< 0.82
Co-58	< 1.7	< 2.2	< 0.96	< 0.87
Mn-54	< 1.8	2.4 (2.6)	1.2 (1.3)	< 0.88
Zn-65	< 5.4	< 6.1	< 2.8	< 2.5
Fe-59	< 4.9	< 5.0	< 2.7	< 2.0
Co-60	< 1.8	< 2.1	< 1.1	< 0.87
Ba-140	< 2.9	< 3.4	< 1.7	< 1.4
La-140	< 3.4	< 3.9	< 1.9	< 1.6

*1.96σ (Due to Counting Statistics)

2. Surface Water

Surface water is collected monthly from five sites. Since the reactor water effluent can be directed to either the St. Vrain Creek or the South Platte River, there are upstream and downstream sampling locations on both river courses.

Table II.C.4 shows tritium concentrations measured during 1990 at the four surface water sites. All of the values were less than MDC. The arithmetic mean value for the downstream locations in 1990 therefore was not significantly different from the two upstream locations (Table II.H.2). The EPA lists 300 ± 200 pCi/L for tritium measured in surface water samples from the South Platte River at Platteville during January to March 1990. This data is in good agreement with that measured in the REMP program.

Table II.C.5 shows measurements of fission product and activation product concentrations in surface water samples collected monthly. There were occasional positive values, but the mean of the downstream sites was not significantly different from the mean of the upstream sites during 1990 for any of the gamma-ray emitting radionuclides measured. This has been the case since the inception of reactor operations at the Fort St. Vrain site. The occasional positive values are either fallout Cs-137, which can be expected, or values close to the uncertainty limits and assumed to be false positives.

In addition to the monthly sampling of the South Platte River and St. Vrain Creek, a continuous water sample is

collected at station A-25. An aliquot of the farm pond outlet is sampled every 80 minutes and the composite collected weekly. The weekly composites are then combined and analyzed monthly. The results of these samples are also shown in Tables II.C.4 and II.C.5. For only January and December was there evidence of measurable tritium release (see Table II.C.4). Mean values for the other radionuclides were less than MDC except for Cs-137. The correlation of the tritium concentrations with the effluent release report is high.

Table II.C.4
Tritium Concentrations in Surface Water. (pCi/L)

	Downstream Sites		Upstream Sites		Effluent
Collection Date	St. Vrain F-20	S. Platte R-10	St. Vrain A-21	S. Platte F-19	Goosequill A-25
January	<420	<420	<420	<420	1600(460)*
February	<430	<430	<430	<430	<430
March	<430	<430	<430	<430	<430
April	<420	<420	<420	<420	<420
May	<400	<390	<400	<400	<390
June	<400	<400	<400	<400	<390
July	<400	<400	<400	<400	<400
August	<390	<390	<390	<390	<390
September	<400	<400	<400	<400	<400
October	<400	<400	<400	<400	<400
November	<390	<390	<390	<390	<390
December	<400	<400	<400	<400	1900(400)

*1.96σ (Due to Counting Statistics)

Table II.C.5 Radionuclide Concentrations In Surface Water. (pCi/L)

Collection Date: 1/13/90

Radio -nuclide	Downstream Sites		Upstream Sites		Effluent
	St. Vrain F-20	S. Platte R-10	St. Vrain A-21	S. Platte F-19	Goosequill A-25
Cs-134	< 2.0	< 3.0	< 2.3	< 2.6	< 1.2
Cs-137	< 3.1	7.1 (5.3)*	< 2.8	< 3.2	< 1.4
Zr-95	< 4.7	< 6.7	< 5.4	< 6.4	5.1(3.4)
Nb-95	< 1.8	< 2.8	< 2.1	< 2.3	< 1.2
Co-58	< 2.0	< 2.8	< 2.2	< 2.5	< 1.1
Mn-54	< 2.0	< 3.0	< 2.3	< 2.6	< 1.1
Zn-65	< 4.8	< 7.1	< 5.4	< 6.2	< 2.8
Fe-59	< 4.6	< 7.0	< 5.2	6.8 (8.0)	< 2.6
Co-60	< 2.0	< 3.1	< 2.5	< 2.7	< 1.2
Ba-140	< 4.2	< 4.4	< 3.7	< 6.5	< 3.7
La-140	< 4.8	< 5.0	< 4.2	< 7.5	< 4.3

*1.96σ (Due to Counting Statistics)

Table II.C.5 Radionuclide Concentrations In Surface Water. (pCi/L)

Collection Date: 2/10/90

Radio -nuclide	Downstream Sites		Upstream Sites		Effluent
	St. Vrain F-20	S. Platte R-10	St. Vrain A-21	S. Platte F-19	Goosequill A-25
Cs-134	< 2.5	2.0 (2.4)	< 1.6	< 2.3	< 1.6
Cs-137	4.4 (3.8)*	< 2.4	< 1.8	4.5 (4.1)	5.6(2.9)
Zr-95	< 6.0	< 4.4	< 3.5	< 5.3	< 4.2
Nb-95	< 2.4	< 1.9	< 1.6	< 2.3	< 1.5
Co-58	< 2.3	< 1.7	< 1.4	< 2.2	< 1.5
Mn-54	< 2.6	< 2.0	2.3 (1.8)	< 2.3	< 1.7
Zn-65	< 6.4	< 5.6	< 4.2	< 5.7	< 4.0
Fe-59	< 6.0	< 5.4	< 3.8	< 5.4	< 3.5
Co-60	< 2.7	< 2.0	< 1.5	< 2.4	< 1.7
Ba-140	< 4.5	< 3.4	< 2.7	< 3.7	< 2.4
La-140	< 5.1	< 3.9	< 3.1	< 4.3	< 2.7

*1.96σ (Due to Counting Statistics)

Table II.C.5 Radionuclide Concentrations In Surface Water. (pCi/L)

Collection Date: 3/10/90

Radio -nuclide	Downstream Sites		Upstream Sites		Effluent
	St. Vrain F-20	S. Platte R-10	St. Vrain A-21	S. Platte F-19	Goosequill A-25
Cs-134	< 2.2	< 2.0	< 1.2	< 2.1	< 2.2
Cs-137	3.2 (3.2)*	< 2.9	< 1.6	< 2.6	< 2.6
Zr-95	< 5.1	< 4.4	< 2.9	< 5.0	< 5.7
Nb-95	< 2.1	< 1.8	3.5 (1.5)	< 1.9	< 2.0
Co-58	< 2.0	< 1.9	< 1.2	< 1.9	< 2.0
Mn-54	< 2.2	< 1.9	1.4 (1.6)	2.4 (2.5)	< 2.2
Zn-65	< 5.1	< 4.8	7.7 (4.0)	< 5.0	< 5.8
Fe-59	< 5.1	< 4.5	< 3.7	< 5.1	< 5.0
Co-60	< 2.4	< 2.0	< 1.2	< 2.3	< 2.2
Ba-140	4.2 (4.5)	< 2.8	< 2.3	< 3.4	< 3.4
La-140	4.8 (5.2)	< 3.3	< 2.6	< 3.9	< 3.9

*1.96σ (Due to Counting Statistics)

Table II.C.5 Radionuclide Concentrations In Surface Water. (pCi/L)

Collection Date: 4/14/90

Radio -nuclide	Downstream Sites St. Vrain F-20	Downstream Sites S. Platte R-10	Upstream Sites St. Vrain A-21	Upstream Sites S. Platte F-19	Effluent Goosequill A-25
Cs-134	< 2.1	< 1.3	< 1.5	< 1.5	< 1.8
Cs-137	< 2.6	2.1 (1.8)*	1.9 (2.2)	2.7 (2.2)	< 2.1
Zr-95	< 4.5	< 2.7	< 3.3	4.3 (4.2)	< 3.7
Nb-95	< 2.2	< 1.2	< 1.6	< 1.4	< 1.5
Co-58	< 2.0	< 1.1	< 1.4	< 1.4	< 1.9
Mn-54	< 2.2	< 1.3	< 1.5	< 1.5	< 1.7
Zn-65	< 6.5	< 3.4	< 4.6	< 4.1	< 4.7
Fe-59	< 5.5	< 2.8	< 3.8	< 3.5	< 5.0
Co-60	< 2.1	< 1.2	< 1.5	< 1.6	< 1.7
Ba-140	< 4.1	< 2.0	< 3.0	< 2.4	< 2.8
La-140	< 4.8	< 2.3	< 3.5	< 2.8	< 3.2

*1.96σ (Due to Counting Statistics)

Table II.C.5 Radionuclide Concentrations In Surface Water. (pCi/L)

Collection Date: 5/12/90

Radio -nuclide	Downstream Sites		Upstream Sites		Effluent
	St. Vrain F-20	S. Platte R-10	St. Vrain A-21	S. Platte F-19	Goosequill A-25
Cs-134	< 2.5	< 1.3	< 2.4	< 2.2	<2.1
Cs-137	< 3.1	< 1.6	< 2.9	< 2.5	<2.6
Zr-95	< 5.9	< 2.9	< 5.7	< 4.7	<5.4
Nb-95	< 2.2	< 1.2	< 2.2	< 2.1	<2.2
Co-58	< 2.3	< 1.2	< 2.2	< 2.0	<1.9
Mn-54	< 2.5	< 1.3	< 2.4	< 2.1	<2.2
Zn-65	< 6.8	< 3.4	< 6.4	< 6.2	<5.6
Fe-59	< 5.9	< 3.3	< 5.6	< 4.9	<5.0
Co-60	< 2.8	< 1.3	< 2.6	< 2.1	<2.1
Ba-140	< 4.2	< 2.4	< 3.8	< 3.4	<3.4
La-140	< 4.8	< 2.7	< 4.4	< 3.9	<3.9

*1.96σ (Due to Counting Statistics)

Table II.C.5 Radionuclide Concentrations In Surface Water. (pCi/L)

Collection Date: 6/09/90

Radio -nuclide	Downstream Sites		Upstream Sites		Effluent
	St. Vrain F-20	S. Platte R-10	St. Vrain A-21	S. Platte F-19	Goosequill A-25
Cs-134	< 2.0	< 3.0	< 3.2	2.1 (2.4)	< 1.2
Cs-137	< 2.3	< 3.6	4.7 (4.9)	3.8 (3.0)	1.8 (1.8)
Zr-95	< 4.1	< 6.3	< 7.6	< 4.6	< 3.5
Nb-95	< 1.7	< 2.7	< 3.0	< 1.9	< 1.2
Co-58	< 1.9	< 2.9	< 3.1	2.4 (2.3)	< 1.4
Mn-54	< 1.9	< 2.8	< 3.4	< 2.0	< 1.2
Zn-65	< 5.1	< 8.3	< 8.9	< 5.7	< 3.9
Fe-59	< 5.1	< 6.8	< 7.7	< 4.9	7.3 (5.4)
Co-60	< 2.1	3.4 (3.5)	< 3.6	< 2.0	< 1.2
Ba-140	< 3.3	< 5.6	< 6.4	< 3.3	< 2.0
La-140	< 3.8	< 6.4	< 7.4	< 3.8	< 2.3

*1.96σ (Due to Counting Statistics)

Table II.C.5 Radionuclide Concentrations In Surface Water. (pCi/L)

Collection Date: 7/14/90

Radio -nuclide	Downstream Sites		Upstream Sites		Effluent
	St. Vrain F-20	S. Platte R-10	St. Vrain A-21	S. Platte F-19	Goosequill A-25
Cs-134	< 2.3	< 2.0	< 2.2	< 2.0	< 1.4
Cs-137	3.3 (3.4)*	4.2 (2.9)	2.9 (3.2)	< 2.3	< 1.7
Zr-95	< 5.5	5.2 (5.3)	< 5.3	< 4.2	4.2 (4.2)
Nb-95	< 2.1	< 1.8	< 2.0	< 1.9	1.8 (1.8)
Co-58	< 2.1	< 1.9	2.7 (2.5)	< 1.8	< 1.5
Mn-54	< 2.3	< 2.0	< 2.2	< 1.9	< 1.4
Zn-65	< 6.5	< 5.7	< 6.1	< 5.3	< 3.7
Fe-59	< 5.6	< 4.6	< 5.1	< 4.5	4.5 (5.5)
Co-60	< 2.6	< 2.1	< 2.4	< 1.9	< 1.3
Ba-140	< 3.8	< 3.2	< 4.0	< 3.4	< 2.4
La-140	< 4.4	< 3.7	< 4.6	< 3.9	< 2.7

*1.96σ (Due to Counting Statistics)

Table II.C.5 Radionuclide Concentrations In Surface Water. (pCi/L)

Collection Date: 8/11/90

Radio -nuclide	Downstream Sites		Upstream Sites		Effluent
	St. Vrain F-20	S. Platte R-10	St. Vrain A-21	S. Platte F-19	Goosequill A-25
Cs-134	< 2.4	< 2.0	< 2.4	< 2.2	< 1.2
Cs-137	< 2.9	4.6 (3.0)*	< 2.9	< 2.7	< 1.5
Zr-95	< 5.7	< 4.5	< 5.7	< 4.5	< 2.7
Nb-95	< 2.2	< 2.0	< 2.2	3.4 (2.7)	< 1.2
Co-58	< 2.2	< 1.9	< 2.2	< 2.0	< 1.1
Mn-54	2.5 (2.8)	< 2.0	< 2.4	2.5 (2.7)	1.7 (1.5)
Zn-65	< 6.5	< 5.7	< 6.9	< 6.7	< 3.6
Fe-59	< 5.8	< 4.7	< 5.5	< 5.5	< 3.2
Co-60	< 2.5	< 2.0	< 2.6	< 2.3	1.3 (1.4)
Ba-140	7.0 (5.3)	< 3.8	< 4.3	< 4.5	< 2.1
La-140	8.1 (6.1)	< 4.3	< 4.9	< 5.2	< 2.4

*1.96σ (Due to Counting Statistics)

Table II.C.5 Radionuclide Concentrations In Surface Water. (pCi/L)

Collection Date: 9/08/90

Radio -nuclide	Downstream Sites		Upstream Sites		Effluent
	St. Vrain F-20	S. Platte R-10	St. Vrain A-21	S. Platte F-19	Goosequill A-25
Cs-134	< 1.4	< 2.1	< 2.3	1.4 (1.7)*	< 3.4
Cs-137	3.1 (2.1)	< 2.6	< 2.5	< 1.8	< 4.2
Zr-95	< 3.2	< 5.1	< 4.7	< 3.1	< 8.0
Nb-95	2.1 (1.8)	< 2.1	< 2.0	< 1.5	< 3.2
Co-58	1.3 (1.6)	< 1.9	< 2.1	< 1.3	< 3.8
Mn-54	< 1.4	< 2.2	< 2.2	< 1.4	< 3.5
Zn-65	< 4.3	< 6.9	< 5.5	< 4.6	< 9.0
Fe-59	< 3.4	< 6.0	< 5.5	< 3.8	< 11.0
Co-60	< 1.4	< 2.4	< 2.1	< 1.4	< 3.8
Ba-140	< 2.5	< 4.7	7.2 (5.6)	3.5 (3.6)	< 5.7
La-140	< 2.8	< 5.4	8.3 (6.5)	4.0 (4.1)	< 6.5

*1.96σ (Due to Counting Statistics)

Table II.C.5 Radionuclide Concentrations In Surface Water. (pCi/L)

Collection Date: 10/13/90

Radio -nuclide	Downstream Sites St. Vrain F-20	Downstream Sites S. Platte R-10	Upstream Sites St. Vrain A-21	Upstream Sites S. Platte F-19	Effluent Goosequill A-25
Cs-134	< 3.5	< 3.3	< 2.3	< 2.0	< 2.4
Cs-137	< 4 2	< 3.9	< 2.6	< 2.6	3.0 (3.2)*
Zr-95	< 7.6	< 7.7	< 5.0	4.8 (5.8)	< 4.9
Nb-95	< 3.2	< 2.9	< 2.0	3.5 (2.6)	< 2.3
Co-58	< 3.2	< 3.0	< 2.1	< 1.9	< 2.1
Mn-54	< 3.5	< 3.3	< 2.2	< 2.0	< 2.2
Zn-65	< 10.0	< 8.9	< 6.2	< 6.3	< 7.0
Fe-59	< 9.0	< 8.4	7.0 (6.7)	< 5.6	< 6.7
Co-60	3.4 (4.0)	< 3.6	< 2.2	2.5 (2.3)	< 2.1
Ba-140	< 5.3	8.8 (8.6)	< 4.9	< 3.5	< 4.0
La-140	< 6.1	10.0 (9.9)	< 5.7	< 4.0	< 4.7

*1.96σ (Due to Counting Statistics)

Table II.C.5 Radionuclide Concentrations In Surface Water. (pCi/L)

Collection Date: 11/10/90

Radio -nuclide	Downstream Sites		Upstream Sites		Effluent
	St. Vrain F-20	S. Platte R-10	St. Vrain A-21	S. Platte F-19	Goosequill A-25
Cs-134	< 2.4	< 1.2	< 2.8	< 1.5	3.6 (2.7)
Cs-137	< 2.9	< 1.5	3.9 (4.1)*	3.9 (2.1)	< 2.7
Zr-95	< 5.9	< 2.9	< 6.5	< 3.4	< 5.2
Nb-95	< 2.2	< 1.2	< 2.6	< 1.3	< 2.0
Co-58	< 2.4	< 1.2	< 2.9	< 1.3	< 2.2
Mn-54	< 2.4	< 1.2	< 2.8	3.4 (1.8)	< 2.3
Zn-65	< 6.8	< 3.5	< 7.3	< 4.0	< 6.2
Fe-59	< 6.7	< 2.9	< 7.7	5.5 (4.5)	< 5.2
Co-60	< 2.2	< 1.2	< 3.0	< 1.6	< 2.4
Ba-140	< 3.7	< 1.9	< 4.6	< 2.4	< 6.5
La-140	< 4.3	< 2.2	< 5.3	< 2.8	< 7.5

*1.96σ (Due to Counting Statistics)

Table II.C.5 Radionuclide Concentrations In Surface Water. (pCi/L)

Collection Date: 12/08/90

Radio-nuclide	Downstream Sites		Upstream Sites		Effluent
	St. Vrain F-20	S. Platte R-10	St. Vrain A-21	S. Platte F-19	Goosequill A-25
Cs-134	< 3.0	< 2.6	< 2.6	< 2.6	< 2.1
Cs-137	< 3.7	< 3.1	4.5 (3.8)*	6.5 (3.8)	2.5 (3.0)
Zr-95	< 7.6	< 5.9	< 6.3	< 5.9	< 4.5
Nb-95	< 3.0	< 2.5	< 2.4	< 2.9	< 1.9
Co-58	3.8 (3.6)	< 2.3	< 2.6	< 2.6	< 1.9
Mn-54	< 3.0	< 2.6	< 2.6	< 2.6	< 2.1
Zn-65	< 8.8	< 6.9	< 7.0	< 9.0	< 5.8
Fe-59	< 6.9	< 5.9	< 6.9	< 6.1	< 4.8
Co-60	< 3.2	< 2.8	< 2.6	< 2.6	< 2.0
Ba-140	< 7.8	< 4.1	< 4.1	< 6.6	< 3.3
La-140	< 8.9	< 4.8	< 4.7	< 7.6	< 3.8

*1.96σ (Due to Counting Statistics)

3. Ground Water

Ground water is sampled quarterly at two locations. These are at F-16, a well on the farm immediately north and the closest to the reactor down the hydrological gradient, and at R-5, a well at a personal residence in the town of Milliken. Table II.C.6 lists the measured concentrations of fission products and activation products in ground water. The Cs-137 results are not surprising due to residue of Chernobyl fallout, and the other results above MDC are assumed to be statistically false positive values.

Table II.C.7 shows tritium concentrations in the same well water samples. The results indicate short-lived contamination of the aquifer supplying F-16 well. This well is not used for drinking water purposes and therefore dose commitment calculations are not warranted. Figure II.C.1 shows measured tritium concentrations in the F-16 well since 1984. To test the mean life time of tritium in the aquifer we have initiated weekly sampling of this site beginning early in 1991.

Table II.C.6 Radionuclide Concentrations in Ground Water. (pCi/L)

Radio-nuclide	1st Quarter 03/29		2nd Quarter 05/26		3rd Quarter 08/18		4th Quarter 11/17	
	F-16	R-5	F-16	R-5	F-16	R-5	F-16	R-5
Cs-134	< 2.4	< 2.7	< 1.6	< 2.6	< 2.3	< 1.8	< 1.4	< 1.2
Cs-137	5.9 (3.5)*	17.0 (4.0)	5.6 (2.4)	3.5 (3.8)	3.0 (3.4)	7.9 (2.6)	< 1.7	2.0 (1.7)
Zr-95	< 5.4	< 6.0	< 3.7	< 6.2	< 5.1	< 4.0	< 3.2	< 2.5
Nb-95	< 2.5	7.3 (4.0)	< 2.0	< 2.6	2.5 (2.8)	4.8 (2.8)	< 1.3	< 1.1
Co-58	2.9 (2.7)	< 2.5	< 1.5	< 2.3	< 2.1	< 1.7	< 1.3	< 1.0
Mn-54	< 2.4	5.9 (3.3)	2.0 (2.1)	2.7 (3.1)	< 2.3	< 1.9	1.4 (1.6)	< 1.1
Zn-65	< 8.7	< 13.0	< 6.7	< 8.2	< 7.6	< 9.1	< 3.8	< 3.4
Fe-59	< 5.7	< 6.2	< 4.2	< 6.4	< 5.9	< 4.3	< 3.4	< 2.7
Co-60	< 2.4	3.5 (3.1)	1.8 (1.8)	5.1 (3.2)	< 2.1	2.0 (2.0)	< 1.5	2.7 (1.3)
Ba-140	< 4.2	10.0 (5.5)	< 3.6	< 4.2	< 4.3	7.9 (4.2)	< 3.0	< 1.8
La-140	< 4.9	12.0 (6.4)	< 4.1	< 4.8	< 4.9	9.0 (4.9)	< 3.4	< 2.1

*1.96σ (Due to Counting Statistics)

Table II.C.7 Tritium in Ground Water 1990 . pCi/L

First Quarter Collected: 3/29		Second Quarter Collected: 5/26		Third Quarter Collected: 8/18		Fourth Quarter Collected: 11/17	
F-16	R-5	F-16	R-5	F-16	R-5	F-16	R-5
<430	<430	800(420)*	<390	3300(450)	<390	3400(400)	<400

* 1.96 σ (Due to counting statistics.)

Figure II.C.1

Tritium Concentrations at Location F-16

For 1984-1990

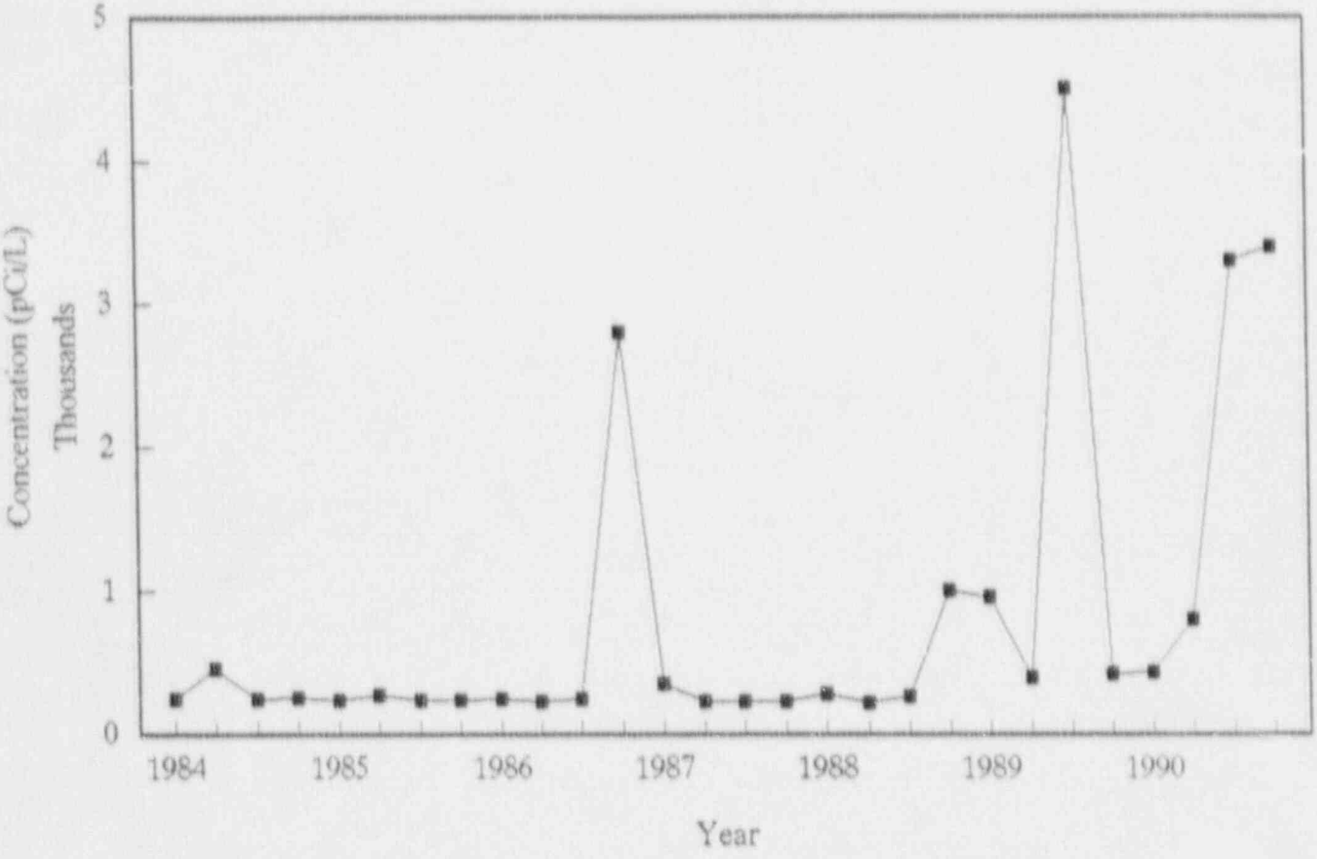


Table II.C.8 Maximum Permissible Concentrations in Drinking Water. (10CFR20, Appendix B, Table II)	
H-3	3×10^{6} pCi/L
I-131	3×10^{2} pCi/L
Cs-134	9×10^{3} pCi/L
Cs-137	2×10^{4} pCi/L
Zr-95	6×10^{4} pCi/L
Nb-95	1×10^{5} pCi/L
Co-58	1×10^{5} pCi/L
Mn-54	1×10^{5} pCi/L
Zn-65	1×10^{5} pCi/L
Fe-59	6×10^{4} pCi/L
Co-60	5×10^{4} pCi/L
Ba-140	3×10^{4} pCi/L
La-140	2×10^{4} pCi/L

II.D. Milk

The dairy food chain is the critical pathway for possible radiation dose commitment around any nuclear facility. This is true for both chronic and acute releases. The critical individual would be an infant consuming milk produced from cows grazing local pastures. Milk is the critical pathway for possible dose commitment to humans from environmental contamination of H-3, I-131, Cs-137 and Sr-90. For this reason milk is sampled extensively to document the presence or absence of radioactivity due to reactor operations. A three liter milk sample is counted for determination of Cs-137, Cs-134 and Ba-La-140. To measure I-131 at the required LLD of 1.0 pCi/L, an 18 liter sample is concentrated by anion exchange and the resin counted by gamma-ray spectroscopy. The method of treating the milk is modified from that of McCurdy and Mellor, Health Physics 38: 203-213, 1980.

There are no dairies (or personal milk cows) in the facility area, 1.6 km radius. The six dairies in the adjacent area, 1.6-8 km radius, were selected as they are located in the highest X/Q areas (refer to updated FSAR). The description of these locations can be found in Table III.B.1 and Figure III.B.2. The single reference location dairy, R-8, is 22.5 km West of the reactor in the least predominant wind direction. Herd management practices are virtually identical at all dairy locations. The cows in the milking herd are never on pasture but under dry-lot management typical of Eastern Colorado.

Table II.D.1 lists the concentrations of all radionuclides that are investigated in milk samples. During 1990, elevated concentrations of I-131 were again consistently observed only at site A-22. The source of this I-131 is from nuclear medicine thyroid therapy practice in the Denver hospitals. The releases enter the S. Platte River just North of Denver. A-22 dairy uses irrigation ditch water for its herd during the summer and fall rather than well water. The ditch (Independence) receives S. Platte water upstream of FSV. This observation was first made in 1985 and discussed at length in the 1985 REMP summary report. A manuscript describing this observation and the magnitude of the I-131 concentrations has been submitted for publication in the Health Physics Journal. Note that A-22 drops out of the sampling program each November, December and January in order to meet milk collection system quotas.

K-natural, as measured by K-40, is extremely constant in milk. The mean literature value for cow milk is 1.5 g/L. K concentrations are homeostatically controlled and independent of K intake. K-nat is measured in all milk samples as a quality control measure for the other radionuclides determined in the same sample by gamma-ray spectrometry, but K-nat concentrations are no longer reported in Table II.D.1.

Table II.D.2 lists measured tritium concentrations in milk. Significant elevated tritium concentrations in milk due to reactor effluents have never been observed during the operational or defueling phase of the reactor. 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, the reported tritium concentration in milk is the tritium in water extracted from the milk. Contamination of milk samples by any radionuclide due to reactor effluents has never been observed during the operational or defueling phases of Fort St. Vrain.

Table II.D.1 Radionuclide Concentrations In Milk. (pCi/L).

LOCATION	A-6	A-18	A-22	A-23	A-24	A-26	R-8
Collection Date	1/06/90	1/13/90	1/13/90	1/13/90	1/06/90	1/13/90	1/20/90
I-131	< 0.19	< 0.41	< 0.32	< 0.3	< 0.38	< 0.42	< 0.31
Cs-134	< 3.8	< 3.3	< 3.5	< 2.3	< 4.1	< 2.6	< 2.5
Cs-137	< 5.6	< 4.9	< 4.5	< 3.5	< 5.0	3.4 (3.7)*	< 3.0
Ba-140	< 5.5	6.7 (8.0)	< 5.8	< 4.5	7.9 (8.5)	< 4.1	< 4.7
La-140	< 6.3	7.7 (9.1)	< 6.7	< 5.2	9.0 (9.8)	< 4.8	< 5.4
Collection Date	2/24/90	2/03/90	2/03/90	2/03/90	2/24/90	2/16/90	2/17/90
I31	< 0.2	< 0.27	< 0.44	< 0.35	< 0.24	< 0.31	0.36 (0.37)
Cs-134	2.9 (2.8)	< 2.4	< 3.8	< 2.7	< 1.6	< 1.4	< 1.5
Cs-137	< 2.9	3.5 (3.3)	5.6 (5.6)	< 2.9	< 1.8	2.6 (1.9)	< 1.7
Ba-140	< 3.7	< 4.9	< 6.1	< 5.0	< 2.8	< 2.7	< 2.5
La-140	< 4.3	< 5.6	< 7.0	< 5.7	< 3.2	< 3.1	< 2.9
Collection Date	3/17/90	3/10/90	3/03/90	3/03/90	3/31/90	3/17/90	3/24/90
I-131	< 0.22	< 0.19	< 0.23	< 0.2	< 0.21	< 0.27	< 0.21
Cs-134	< 2.6	< 2.5	< 2.5	< 2.7	< 2.1	< 1.4	< 2.6
Cs-137	< 3.0	3.9 (4.4)	< 3.7	< 3.3	< 2.5	< 1.6	< 3.1
Ba-140	< 4.5	< 3.9	< 2.9	< 4.3	< 3.9	< 2.1	< 4.7
La-140	< 5.2	< 4.5	< 4.5	< 5.0	< 4.4	< 2.5	< 5.4

* 1.96 σ (Due to Counting Statistics.)

Table II.D.1 Radionuclide Concentrations In Milk. (pCi/L).

LOCATION	A-6	A-18	A-22	A-23	A-24	A-26	R-8
Collection Date	4/21/90	4/07/90	4/07/90	4/07/90	4/28/90	4/14/90	4/14/90
I-131	< 0.21	< 0.24	< 0.19	< 0.3	< 0.2	< 0.34	< 0.38
Cs-134	< 2.4	< 2.1	3.2 (2.8)*	< 3.8	< 2.6	< 1.9	< 1.8
Cs-137	< 2.8	< 2.5	3.9 (3.2)	< 4.6	4.6 (3.8)	< 2.3	3.7 (3.1)
Ba-140	< 3.8	< 4.0	< 4.3	12.0 (9.1)	< 4.2	< 3.0	< 2.5
La-140	< 4.4	< 4.5	< 4.9	14.0 (10.0)	< 4.8	< 3.5	< 2.9
Collection Date	5/12/90	5/05/90	5/05/90	5/05/90	5/12/90	5/12/90	5/05/90
I-131	< 0.26	< 0.21	1.3 (0.52)	< 0.41	< 0.23	0.59 (0.55)	< 1.7
Cs-134	< 1.5	< 2.5	< 3.8	< 3.6	< 1.7	< 4.0	< 3.0
Cs-137	< 1.8	< 3.9	< 5.3	< 4.4	< 1.9	< 4.8	< 3.2
Ba-140	3.7 (3.2)	5.2 (5.1)	< 5.0	< 6.3	< 3.2	< 6.3	< 4.6
La-140	4.2 (3.7)	6.0 (5.8)	< 5.8	< 7.3	< 3.7	< 7.3	< 5.3
Collection Date	5/26/90	5/19/90	5/19/90	5/19/90	5/26/90	5/26/90	5/19/90
I-131	< 0.64	< 0.33	2.9 (0.49)	0.73 (0.57)	< 0.33	< 0.41	< 0.31
Cs-134	< 2.5	< 1.8	< 2.4	< 3.0	< 2.6	< 1.7	< 2.4
Cs-137	< 3.6	< 2.1	5.0 (4.2)	< 4.6	< 3.1	< 2.0	< 2.9
Ba-140	< 3.7	< 2.9	< 3.4	< 5.0	< 4.7	< 2.6	< 3.7
La-140	< 4.3	< 3.3	< 3.9	< 5.8	< 5.5	< 3.0	< 4.3

* 1.96σ (Due to Counting Statistics.)

Table II.D.1 Radionuclide Concentrations In Milk. (pCi/L).

LOCATION	A-6	A-18	A-22	A-23	A-24	A-26	R-8
Collection Date	6/16/90	6/02/90	6/02/90	6/02/90	6/09/90	6/09/90	6/02/90
I-131	< 0.21	< 0.21	< 0.35	< 0.41	< 0.5	< 0.32	< 0.27
Cs-134	< 2.6	< 2.8	< 3.3	2.7 (3.3)*	< 1.6	< 2.4	< 2.6
Cs-137	< 3.0	< 3.4	5.5 (4.5)	< 3.1	< 2.0	< 2.8	< 3.8
Ba-140	< 4.2	< 4.4	< 5.0	< 4.2	< 2.9	< 4.2	< 3.8
La-140	< 4.9	< 5.1	< 5.7	< 4.8	< 3.3	< 4.8	< 4.4
Collection Date	6/30/90	6/16/90	6/16/90	6/16/90	6/23/90	6/23/90	6/16/90
I-131	< 0.5	< 0.32	2.5 (0.32)	< 0.18	< 0.17	< 0.28	< 0.24
Cs-134	< 1.9	< 2.8	< 2.7	< 2.0	< 2.1	< 1.6	< 2.3
Cs-137	< 2.3	< 3.4	< 3.2	2.4 (2.7)	< 2.5	< 2.0	5.3 (4.0)
Ba-140	< 2.9	7.7 (6.1)	< 4.3	< 3.4	< 4.1	4.6 (3.5)	< 3.3
La-140	< 3.4	8.9 (7.0)	< 5.0	< 3.9	< 4.8	5.3 (4.0)	< 3.8
Collection Date	7/14/90	7/07/90	7/07/90	7/07/90	7/14/90	7/14/90	7/07/90
I-131	< 0.31	< 0.49	6.5 (0.63)	0.4 (0.46)	< 0.43	< 0.22	< 0.24
Cs-134	< 1.7	< 3.2	< 2.0	< 2.3	< 2.6	< 1.7	< 1.7
Cs-137	< 2.0	< 3.4	2.8 (3.1)	< 3.4	< 2.9	< 1.9	< 2.0
Ba-140	< 2.6	5.9 (6.3)	6.2 (5.2)	< 4.1	< 4.2	< 2.6	< 3.1
La-140	< 3.0	6.8 (6.9)	7.2 (6.0)	< 4.7	< 4.9	< 3.0	< 3.5

* 1.96 σ (Due to Counting Statistics.)

Table II.D.1 Radionuclide Concentrations In Milk. (pCi/L).

LOCATION	A-6	A-18	A-22	A-23	A-24	A-26	R-8
Collection Date	7/28/90	7/21/90	7/21/90	7/21/90	7/28/90	7/28/90	7/21/90
I-131	< 0.2	< 0.2	7.3 (0.7)*	0.31 (0.37)	< 0.3	< 0.19	< 0.36
Cs-134	< 2.2	< 2.4	< 2.3	< 2.5	< 3.2	< 2.5	3.5 (3.6)
Cs-137	4.2 (3.8)	< 3.4	< 3.3	< 3.0	< 3.7	< 3.0	6.2 (4.4)
Ba-140	3.9 (3.9)	< 3.4	< 4.0	< 4.0	< 4.8	< 3.9	< 4.8
La-140	4.5 (4.5)	< 4.0	< 4.6	< 4.6	< 5.5	< 4.5	< 5.5
Collection Date	8/11/90	8/04/90	8/04/90	8/04/90	8/11/90	8/11/90	8/04/90
I131	< 0.18	< 0.29	15.0 (0.53)	< 0.41	< 0.19	< 0.2	0.29 (0.33)
Cs-134	< 1.5	< 3.0	< 2.5	< 1.7	< 3.2	< 1.5	< 3.7
Cs-137	< 1.7	< 3.2	3.8 (3.4)	5.1 (2.4)	< 3.6	< 1.8	5.4 (5.4)
Ba-140	6.6 (3.3)	< 5.1	< 5.1	< 3.3	< 5.1	< 3.1	11.0 (9.2)
La-140	7.6 (3.8)	< 5.8	< 5.9	< 3.8	< 5.8	< 3.6	13.0 (11.0)
Collection Date	8/25/90	8/18/90	8/18/90	8/18/90	8/25/90	8/25/90	8/18/90
I-131	< 0.33	< 0.45	5.5 (0.71)	< 0.42	< 0.23	< 0.2	< 0.35
Cs-134	< 3.9	< 2.3	< 3.0	< 3.4	< 1.6	2.8 (2.3)	< 2.5
Cs-137	< 4.7	< 3.4	< 4.5	< 3.9	1.9 (2.2)	< 2.9	< 3.1
Ba-140	< 6.1	< 3.4	< 6.0	< 5.2	4.2 (3.6)	5.4 (4.3)	< 4.0
La-140	< 7.1	< 3.9	< 6.8	< 6.0	4.9 (4.1)	6.2 (4.9)	< 4.6

* 1.96σ (Due to Counting Statistics.)

Table II.D.1 Radionuclide Concentrations In Mi'k. (pCi/L).

LOCATION	A-6	A-18	A-22	A-23	A-24	A-26	R-8
Collection Date	9/08/90	9/01/90	9/01/90	9/01/90	9/08/90	9/08/90	9/01/90
I-131	< 0.23	< 0.27	1.1 (0.62)*	< 0.19	< 0.19	< 0.37	< 0.4
Cs-134	< 2.8	< 2.6	< 1.8	< 0.86	< 1.8	< 2.7	< 2.7
Cs-137	< 3.5	< 3.0	< 2.1	1.6 (1.2)	2.4 (2.4)	7.1 (4.8)	< 2.8
Ba-140	< 5.1	< 4.9	7.0 (4.1)	< 1.3	< 2.7	< 6.5	< 5.6
La-140	< 5.9	< 5.6	8.1 (4.8)	< 1.5	< 3.1	< 7.4	< 6.5
Collection Date	9/22/90	9/15/90	9/15/90	9/15/90	9/22/90	9/22/90	9/22/90
I-131	< 0.37	< 0.5	1.9 (0.62)	< 0.29	0.64 (0.45)	< 0.11	< 0.21
Cs-134	< 2.5	< 1.8	< 2.7	< 1.7	< 1.8	< 2.5	< 2.7
Cs-137	< 3.2	< 2.1	< 3.3	2.1 (2.4)	< 2.0	4.2 (3.6)	< 3.2
Ba-140	< 4.9	4.4 (3.8)	< 5.4	< 2.7	< 2.9	< 4.0	< 5.0
La-140	< 5.6	5.1 (4.4)	< 6.2	< 3.1	< 3.3	< 4.6	< 5.7
Collection Date	10/06/90	9/29/90	9/29/90	9/29/90	10/06/90	10/13/90	10/06/90
I131	< 0.31	< 0.21	7.6 (0.51)	< 0.38	< 0.27	< 0.25	0.3 (0.27)
Cs-134	< 2.7	< 1.4	< 1.7	< 2.1	< 1.9	< 1.8	< 2.8
Cs-137	< 3.5	4.3 (2.1)	< 2.2	< 2.5	3.5 (2.7)	2.7 (2.6)	< 3.4
Ba-140	< 6.2	< 3.1	< 2.9	< 3.3	< 3.8	< 3.9	< 5.3
La-140	< 7.1	< 3.6	< 3.4	< 3.8	< 4.3	< 4.5	< 6.0

* 1.96σ (Due to Counting Statistics.)

Table II.D.1 Radionuclide Concentrations In Milk. (pCi/L).

LOCATION	A-6	A-18	A-22	A-23	A-24	A-26	R-8
Collection Date	11/03/90	11/03/90	h	11/10/90	11/10/90	11/10/90	11/03/90
I-131	< 0.25	< 0.2	h	< 0.29	< 0.49	< 0.17	< 0.43
Cs-134	< 2.2	< 2.5	h	< 2.3	< 3.9	< 2.3	< 3.6
Cs-137	< 2.7	< 3.0	h	4.1 (3.4)*	< 4.8	< 2.7	< 4.4
Ba-140	< 3.5	< 5.3	h	< 3.8	11.0 (10.0)	< 3.6	10.0 (8.8)
h-140	< 4.0	< 6.1	h	< 4.4	13.0 (12.0)	< 4.1	12.0 (10.0)
Collection Date	12/08/90	12/01/90	h	12/01/90	12/08/90	12/08/90	12/01/90
I-131	< 0.49	< 0.32	h	< 0.32	< 0.4	< 0.47	< 0.33
Cs-134	< 2.5	< 3.5	h	< 2.4	< 2.8	< 3.0	< 4.2
Cs-137	< 3.1	6.8 (6.0)	h	< 3.5	< 4.1	< 3.6	< 5.0
Ba-140	< 4.1	< 5.0	h	< 6.0	< 4.0	< 4.8	< 6.7
La-140	< 4.7	< 5.8	h	< 6.9	< 4.7	< 5.5	< 7.7

* 1.96 σ (Due to Counting Statistics.)
h - sample not collected (at dairy owner's request)

Table II.D.2 Tritium Concentrations in Milk. (pCi/L)

Collection Date	Adjacent Sites						Reference
	A-6	A-18	A-22	A-23	A-24	A-26	R-8
JAN	< 420	< 420	< 420	< 420	< 420	< 420	< 420
FEB	< 420	< 420	< 420	< 420	< 420	d	< 420
MAR	< 430	< 430	< 420	550(440)*	< 420	< 430	480(440)
APR	< 420	< 420	< 420	< 420	< 420	< 420	< 420
MAY	< 400	< 400	< 400	< 400	< 400	< 400	< 400
MAY	< 390	< 420	< 420	< 420	< 390	< 390	< 420
JUN	< 400	< 390	< 390	< 390	< 400	< 400	< 390
JUN	< 400	< 400	< 390	< 400	< 400	< 400	< 400
JUL	< 400	< 390	< 390	< 390	< 400	< 400	< 390
JUL	< 390	< 390	< 390	< 390	< 390	< 390	< 390
AUG	< 390	< 390	< 390	< 390	< 390	< 390	< 390
AUG	< 390	< 390	< 390	< 390	< 390	< 390	< 390
SEP	< 390	< 390	< 390	< 390	< 390	< 390	< 390
SEP	< 390	< 390	< 390	< 390	< 390	< 390	< 390

* 1.96 σ (Due to Counting Statistics.)

d - sample lost during analysis

Table II.D.2 Tritium Concentrations in Milk. (pCi/L)

d) Fourth Quarter, 1990

Collection Date	Adjacent Sites						Reference
	A-6	A-18	A-22	A-23	A-24	A-26	R-8
OCT	< 400	< 400	< 400	< 400	< 400	< 400	< 400
NOV	< 390	< 390	h	< 390	< 390	< 390	< 390
DEC	< 400	< 390	h	< 390	< 400	< 400	< 390

h - sample not collected (at dairy owner's request)

II.E. Food Products

Food sampling locations were selected from areas possibly irrigated by surface water downstream of the FSV discharge point or by well water from the aquifer most likely to be contaminated by seepage from the farm pond. The locations of these food product collection sites are described in Table III.B.1. One sample of each principal class of food products was collected from these locations. Locations and available produce often change due to owner needs, harvest time, harvest size, etc.

Each sample is homogenized without drying immediately after collection. The sample is then counted by gamma-ray spectroscopy. Table II.E.1 lists the date of collection and the results for the 1990 harvest. Three of the food samples showed detectable Cs-137 from past Chernobyl fallout deposition and the one result with positive I-131 is assumed to be a false positive, or due to activity released into the S. Platte river from Denver hospitals. It is not possible to determine the actual source, but in any case it could not be due to Fort St. Vrain effluents. I-131 was never observed in any effluent pathway during the operational phase of the reactor and due to decay there was no I-131 in the core inventory at the sample collection time. The gamma-ray spectra were scanned for other radionuclides, but only the naturally occurring were observed, presumably due to surface soil deposits.

Table II.E.1 Radionuclide Concentrations in Food Products (pCi/kg)

Collection Date 07 SEP 90

Location	Food Type	I-131	Cs-134	Cs-137
R-6	Mellons	<7.9	<8.1	<12
A-27	Corn	17(13)*	<9.5	<14
R-6	Potatoes	<9.8	<7.9	<11
R-6	Onions	<8.0	<7.5	<9.1
R-6	Red Onions	<17	<14	<16
R-6	Peppers	<13	<14	21(24)
A-27	Watermellon	<4.5	<3.5	8.3(6.2)
A-27	Cucumbers	<19	<12	<15
A-27	Zucchini	<16	<11	<16

* 1.96σ (Due to counting statistics.)

II.F. Aquatic Pathways

Table II.F.1 shows radionuclide concentrations measured in fish samples collected at F-19, A-25 and R-10 on two dates in 1990. The fish were collected by shocking and netting and the composite sample was homogenized without cleaning and analyzed on a wet weight basis. The positive values of Cs-137 were assumed to be due to fallout. The Cs-134 value above MDC was assumed to be false positive. No fish samples were available at the upstream site for the last half of 1990.

Table II.F.2 shows the measured concentrations of both Cs-137 and Cs-134 in surface sediment collected at R-10, the downstream location. There was measurable activity of Cs-137 clearly due to the Chernobyl fallout. The cesium ions are bound nearly irreversibly by the clay mineral matrix in the sediment. The concentrations observed in 1990 were statistically less than observed in 1989.

Observation for Corbicula fluminea, a species of freshwater clam, was conducted at all fish sampling sites. These monitoring dates coincided with the fish collection dates. 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 at 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 at any of the sampling sites of the reactor surface water courses.

Table II.F.1
Radionuclide Concentrations in Fish. (pCi/kg)

Collection Date	First Half			Second Half		
Radionuclide	Upstream F-19	Effluent A-25	Downstream R-10	Upstream F-19	Effluent A-25	Downstream R-10
Cs-134	6.2 (7.2)*	< 6.0	< 4.7		< 6.3	< 16
Cs-137	< 6.7	< 6.9	5.7 (6.7)		< 7.6	35 (21)
Co-58	< 5.3	< 6.1	< 4.6		< 5.8	< 14
Mn-54	< 5.8	< 6.0	< 4.7		< 6.5	< 16
Zn-65	< 17	< 17	< 13		< 18	< 44
Fe-59	< 9.4	< 1[illegible]	< 8.4		< 13	< 25
Co-60	< 6.2	< 6.4	< 5.0		< 6.5	< 16

* 1.96σ (Due to Counting Statistics.)

II.F.2
Radionuclide Concentrations in Sediment from location R10. (pCi/kg)

Radionuclide	Collection Date 6/23/90
Cs-134	19 (22)
Cs-137	69 (22)
Radionuclide	**Collection Date 12/22/90**
Cs-134	< 8.0
Cs-137	48 (9.5)

*1.96σ (Due to Counting Statistics)

II.G. Sample Crosscheck Program

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

Medium	Analysis (radionuclide)	Frequency
Water	H-3	Triannually
Water	Gross beta, gross alpha	Semiannually
Water	Co-60, Zn-65, Cs-134, Cs-137	Triannually
Water	I-131	Semiannually
Air particulate filters	Cs-137, gross beta, gross alpha	Semiannually
Milk	I-131, Cs-137	Annually

For each radionuclide analysis of a particular medium, three independent measurements are performed and all results are reported to the EPA. It should be noted that during 1989, our laboratory became certified by the EPA for drinking water analysis.

Table II.G.1 gives the EPA crosscheck data for 1990. The EPA uses the parameter, Estimated Laboratory Precision (ELP), calculated as one standard deviation for one determination.

The normalized deviation of our mean from the known is calculated as:

$$\frac{\text{CSU mean value - EPA known value}}{\sigma \; n}$$

Where: σ = standard deviation of the mean of all participating laboratory results

n = number of analyses by our laboratory, normally n=3

The control limit is determined by the mean range of all results and three standard deviations of the range. If any result exceeds two standard deviations from the mean (warning level), the result is unacceptable. Whenever our mean value falls outside this limit, the calculations are rechecked and the sample reanalyzed if possible. During 1990 all results except 8 were within the warning level. The results exceeding the warning level have the notation (n) in Table II.G.1. If possible, the corrected values are shown in the table. The recheck process and conclusion are given below for these samples.

1. No apparent reason for aberrant result.
2. The laboratory was changing buildings on campus during this period and the alpha gas-flow system was inoperative.
3. No apparent reason for aberrant result.
4. Zn-65 correction due to Bi-214 was too high. This was corrected at end of year.
5. Ba-133 count yield was in error. This was corrected after Oct. 5 result.
6. Zn-65 correction due to Bi-214 was too high. This

was corrected at end of year.

7. Zn-65 correction due to Bi-214 was too high. This was corrected at end of year.

8. Ba-133 count yield was in error. This was corrected after Oct. 5 result.

Table II.G.2 lists independent results for H-3 in water samples split between this laboratory and the laboratory at the Fort St. Vrain Generating Station. The comparison between laboratories in general was acceptable.

Table II.G.3 lists the results of gross beta analyses of the split water samples. The procedural differences between the laboratories were previously investigated and minimized. It is concluded that the differences can be attributed only to total analytical uncertainty.

Table II.G.4 shows results of an intralaboratory crosscheck program. Replicate samples are independently analyzed. The replicate results are not statistically different and imply that the precision of the methods is acceptable.

During 1990 approximately 10% of all laboratory calculations that partly involve technician input were recalculated by a different technician. No input or calculation errors were detected. This result gives further credence to the laboratory results which are not solely computer calculated and listed.

Computer calculations are often recalculated by hand and those done during 1990 were all verified to be correct.

Table II.G.1 EPA Cross-Check Data Summary. 1990.

Date	Radio-nuclide	CSU Value	EPA Value	1 E.L.P.*	Normalized Deviation from known**
		WATER, TRITIUM (pCi/L)			
Feb 23	H-3	5800	4976	498	2.87 (1)
Jun 22	H-3	2533	2933	358	-1.93
Oct 19	H-3	7167	7203	720	-0.09
		WATER, Alpha/Beta (pCi/L)			
Jan 26	alpha	...	...	...	...
	beta	13	12.0	5.0	0.35
May 11	alpha	...	...	...	... (2)
	beta	8.0	15	5.0	-2.42
Sep 21	alpha	...	...	...	...
	beta	9.0	10	5.0	-0.35
		WATER, I-131 (pCi/L)			
Aug 10	I-131	44	39	6	1.54
		WATER, Performance (pCi/L)			
Apr 17	alpha	146	90	23	4.22 (3)
	beta	47	52	5.0	-1.73
	Cs-134	14	15	5.0	-0.35
	Cs-137	16	15	5.0	0.23
Oct 30	alpha	49	62	16	-1.44
	beta	46	53	5.0	-2.31
	Cs-134	7.7	7.0	5.0	0.23
	Cs-137	8.0	5.0	5.0	1.04
		WATER, Gamma (pCi/L)			
Feb 9	Co-60	14	15	5.0	-0.46
	Zn-65	109	139	14	-3.75 (4)
	Cs-134	15	18	5.0	-1.15
	Cs-137	20	18	5.0	0.81
	Ba-133	23	74	7.0	-12.7 (5)
Jun 8	Co-60	23	24	5.0	-0.46
	Zn-65	120	148	15	-3.23 (6)
	Cs-134	22	24	5.0	-0.81
	Cs-137	20	20	5.0	-0.12
	Ba-133	91	99	10	-1.39
Oct 5	Co-60	13	20	5.0	-2.54
	Zn-65	74	115	12	-5.97 (7)
	Cs-134	11	12	5.0	-0.35
	Cs-137	13	12	5.0	0.23
	Ba-133	33	110	11	-12.1 (8)

* E.L.P. = Expected laboratory precision.
** Normalized deviation = (CSU mean - EPA known)/(σ/ n); if this value falls between upper & lower warning levels, the accuracy is acceptable.

(2) Alpha system inoperative during period.

Table II.G.1 EPA Cross-Check Data Summary. 1990. (continued)

Date	Radio-nuclide	CSU Value	EPA Value	1 E.L.P.*	Normalized Deviation from known**	
			MILK (pCi/L)			
Apr 27	Cs-137	25	24	5.0	0.23	
	K-40	1550	1550	78	0.0	
Sep 28	Cs-137	21	20	5.0	0.23	
	K-40	1600	1700	85	-2.04	
			AIR FILTERS (pCi/L)			
Mar 30	alpha	5.0	5.0	5.0	0.0	
	beta	31	31	5.0	-0.12	
	Cs-137	13	10	5.0	0.92	
Aug 30	alpha	---	---	---	---	(2)
	beta	61	62	5.0	-0.46	
	Cs-137	23	20	5.0	1.15	

* E.L.P. = Expected laboratory precision.
** Normalized deviation = (CSU mean - EPA known)/(σ/ n), if this value falls between upper & lower warning levels, the accuracy is acceptable.

(2) Alpha system inoperative during period.

Table II.G.2

Tritium Crosscheck Analyses on Split Water Samples Determined by Colorado State University and Public Service Company. 1990

Collection Date	Sample Location	Tritium Concentrations pCi/L CSU	PSC
Jan 13	A-25	1200 (450)*	2360 (390)
Jan 13	A-21	<420	<299
Jan 3	E-41	<420	844 (370)
Feb 10	A-25	480 (450)	
Feb 10	A-21	<430	
Feb 21	E-41	<420	
Mar 10	A-25	1100 (450)	1490 (371)
Mar 10	A-21	<430	<293
Mar 14	E-41	<420	<293
Apr 14	A-25	<420	450 (453)
Apr 14	A-21	<420	479 (453)
Apr 4	E-41	<430	<371
May 12	A-25	<420	<72.80
May 12	A-21	<420	<72.80
May 14	E-41	<420	
Jun 9	A-25	<390	<362
Jun 9	A-21	<400	<362
Jun 9	E-41	<390	<362
Jul 14	A-25	<400	371 (426)
Jul 14	A-21	<400	<350
Jul 11	E-41	<390	407 (427)
Aug 11	A-25	<390	<360
Aug 11	A-21	<390	<360
Aug 1	E-41	<390	<360
Sep 8	A-25	<400	432 (434)
Sep 8	A-21	<400	<356
Sep 5	E-41	<400	<356
Oct 13	A-25	<390	364 (438)
Oct 13	A-21	<400	<360
Oct 17	E-41	<390	<360
Nov 11	A-25	<390	394 (434)
Nov 11	A-21	<390	<356
Nov 14	E-41	<400	<356
Dec 8	A-25	1900 (400)	2630 (481)
Dec 8	A-21	<400	<363
Dec 5	E-41	<400	398 (442)

* 1.96σ (Due to Counting Statistics.)

Table II.G.3

Gross Beta Cross-check Analyses on Split Water Samples Determined by Colorado State University and Public Service Company of Colorado. 1990

Collection Date	Sample Location	Gross Beta Concentrations pCi/L CSU	PSC
Jan 13	A-25	14 (6.0)*	15.30 (6.34)
Jan 13	A-21	8.6 (5.7)	14.40 (6.33)
Jan 3	E-41	9.1 (5.7)	14.10 (6.24)
Feb 10	A-25	12 (5.6)	
Feb 10	A-21	9.2 (5.5)	
Feb 21	E-41	9.1 (5.5)	
Mar 10	A-25	11 (5.5)	11.30 (6.64)
Mar 10	A-21	15 (5.7)	10.80 (6.77)
Mar 14	E-41	12 (4.1)	11.20 (6.66)
Apr 14	A-25	13 (5.9)	11.00 (7.00)
Apr 14	A-21	6.0 (5.5)	9.00 (7.00)
Apr 4	E-41	12 (5.8)	10.00 (7.00)
May 12	A-25	8.7 (5.6)	12.50 (6.85)
May 12	A-21	6.3 (5.6)	18.80 (7.19)
May 14	E-41	10 (5.7)	
Jun 9	A-25	26 (6.5)	17.00 (7.00)
Jun 9	A-21	8.6 (5.6)	9.00 (6.00)
Jun 9	E-41	2.8 (5.3)	11.00 (6.00)
Jul 14	A-25	3.4 (5.4)	16.00 (7.00)
Jul 14	A-21	5.5 (5.5)	15.00 (7.00)
Jul 11	E-41	4.3 (5.4)	10.00 (7.00)
Aug 11	A-25	8.4 (5.5)	16.60 (6.47)
Aug 11	A-21	5.6 (5.5)	21.00 (6.98)
Aug 1	E-41	5.1 (5.4)	18.50 (6.61)
Sep 8	A-25	2.8 (2.2)	12.00 (7.00)
Sep 8	A-21	1.3 (2.1)	<6.00
Sep 5	E-41	2.8 (2.2)	8.00 (7.00)
Oct 13	A-25	13 (5.9)	17.20 (6.94)
Oct 13	A-21	9.4 (5.7)	17.30 (6.97)
Oct 17	E-41	8.6 (5.6)	19.70 (7.10)
Nov 11	A-25	16 (6.0)	23.00 (7.00)
Nov 11	A-21	14 (5.9)	20.00 (7.00)
Nov 14	E-41	10 (5.7)	22.00 (7.00)
Dec 8	A-25	13 (5.8)	14.20 (6.77)
Dec 8	A-21	15 (5.9)	15.20 (6.92)
Dec 5	E-41	14 (5.8)	16.50 (6.94)

* 1.96σ (Due to Counting Statistics.)

Table II.G.4 Intralaboratory Crosscheck Results, (pCi/L), (Replicate Analysis of Same Sample)

Drinking Water (R-6)

Radio-Nuclide	1st Quarter A	1st Quarter B	2nd Quarter A	2nd Quarter B	3rd Quarter A	3rd Quarter B	4th Quarter A	4th Quarter B
Cs-134	<2.1	1.5(1.4)*	<1.9	<1.5	<2.1	<2.3	2.2(2.3)	<2.2
Cs-137	<2.6	1.7(1.7)	2.9(2.8)	2.0(2.2)	4.0(3.0)	<2.7	4.6(2.7)	3.3(3.2)
Zr-95	<4.8	<2.6	<4.1	<3.2	<4.7	<5.0	<4.1	<5.7
Nb-95	<1.9	<1.3	2.6(2.4)	<1.4	<2.0	<2.5	<1.7	<2.0
Co-58	<2.1	<1.1	<1.8	<1.4	<2.0	<2.2	<1.7	<2.1
Mn-54	<2.1	<1.2	2.0(2.4)	<1.5	<2.0	<2.2	<1.8	<2.2
Zn-65	<5.2	<4.5	<5.5	<4.2	<6.1	<7.5	<5.4	<6.2
Fe-59	<4.8	<3.3	<4.9	6.1(4.5)	<5.2	<5.9	<4.9	<5.9
Co-60	<2.3	<1.2	<1.9	<1.5	<2.2	<2.2	<1.8	<2.4
Ba-140	<3.4	<2.1	<3.4	<3.6	<3.3	<3.7	<2.9	<3.6
La-140	<3.9	<2.4	<3.9	<4.1	<3.8	<4.2	<3.4	<4.1
Gross Beta	5.1(2.4)	2.2(2.3)	2.3(1.8)	2.4(1.8)	3.2(2.3)	3.2(2.3)	5.1(2.4)	5.1(2.2)
H-3	<430	<420	<390	<390	<390	<390	<400	<400

Milk (A-23)

	1st Quarter A	1st Quarter B	2nd Quarter A	2nd Quarter B	3rd Quarter A	3rd Quarter B	4th Quarter A	4th Quarter B
Cs-134	<2.5	<1.4	<3.0	<2.1	<2.1	<2.3	<2.5	<2.9
Cs-137	<3.0	<1.6	<4.6	<2.6	<2.5	<3.2	<3.1	<4.2
Ba-140	<5.3	<2.1	<5.0	<3.5	<5.0	<3.6	<4.1	<5.5
La-140	<6.1	<2.5	<5.8	<4.0	<5.7	<3.9	<4.7	<5.5
H-3	<430	<430	<420	<420	<390	<390	<400	<400

* 1.96 σ (Due to counting statistics.)

II.H. Summary and Conclusions

Table II.H.1 summarizes the radiation and environmental radioactivity measurements conducted during 1990 in the environs of the Fort St. Vrain Nuclear Generating Station, owned and operated by Public Service Company of Colorado. The values for each sample type may be compared to pre-operational and operational periods for this reactor, as well as to the values from other U.S. environmental monitoring programs (e.g., EPA 520). It must be emphasized, however, that the mean values in Table II.H.1 are only the means of the values greater than MDC, the statistically minimum detectable concentration. The range also is given only for detectable measurements. The mean and range values, therefore, are not the true means or ranges if any of the values in the sample population were less than MDC. The format of Table II.H.1 is a requirement of the NRC.

Inspection of Table II.H.1 reveals that (except for I-131 at site A-22) there were no individual measurements that exceeded the Reporting Level (RL) (see Table III.A.3). The Chernobyl fallout was still observable in several sample types.

For the category of gross beta concentrations in drinking water, the mean for the Gilcrest well was again significantly greater than for the reference supply located in Fort Collins. This difference cannot be due to reactor effluent activity for the following reasons:

a. None of the individual fission product or activation product radionuclides measured were significantly higher in the Gilcrest drinking water.

b. Tritium concentrations measured at Gilcrest were statistically the same as those in Fort Collins.

c. The city of Gilcrest does not filter and treat its water to the same degree as Fort Collins. This has been verified and evidenced by the fact that the gamma-ray spectra of the suspended solids from Gilcrest water samples show only elevated concentrations of the natural radionuclides. It has been concluded in previous reports that the elevated gross beta concentrations in Gilcrest water are due to elevated concentrations of the naturally occurring U-238, and Th-232 decay products. The suspended solids are higher in Gilcrest water samples due to less filtration of the water.

For the category of tritium in surface water, as has been the case since reactor operation, elevated concentrations were noted at station A-25, the outlet of the (Goosequill) farm pond. A-25 is directly in the principal effluent route and elevated concentrations should be expected, to correlate with release schedules. Elevated concentrations of tritium have never been observed, however, in any human food source in direct or indirect contact with the farm pond water.

Downstream surface water concentrations of tritium have occasionally been elevated, but there is significant dilution before any human use of this water. During 1990 elevated tritium concentrations were not observed downstream and the mean values for the first and second half of 1990 were not significantly different.

I-131 was observed again in milk samples, but again only from Dairy A-22. Because the reactor did not release any significant fission products during 1990, the source of the I-131 concentrations in milk could not be reactor effluent. It was documented in the 1985 annual report that the source of the I-131 concentrations during that year was not due to the reactor but due to nuclear medicine use and release upstream of the reactor. This was an important observation as I-131 is certainly a critical radionuclide in human dose commitment possibilities, a fact of which the general public is aware. This discovery prompted increased monitoring for I-131. Upstream nuclear medicine releases of I-131 is, therefore, the only likely source of the I-131 observed again in milk samples during 1990. Irrigation water samples confirmed this conclusion. An additional continuous water sampler on the Platte River outlet of the Denver Metro Sewage District plant revealed the same variation in I-131 concentrations observed at A-22. This further confirms that the Denver hospitals are the source of the I-131.

Cs-137 was also observed in many environmental samples due to the Chernobyl fallout.

Tritium concentrations from well water site F-16 do appear to be increasing with time. This could be due to migration to the aquifer from the farm pond drainage. Typically lateral water movement in western soils is approximately 30 m/year. Weekly sampling was initiated in 1991 to observe the movement more closely, but in any case the well at F-16 is not used for drinking water purposes and elevated tritium concentrations have not been observed in any food chain sample.

Table II.H.2 presents an additional summary of mean values for selected sample types. The sample types and radionuclides were chosen on the basis of their importance in documenting possible radiation dose to humans. Air and surface water would be the predominant environmental transport routes and drinking water and milk would be the predominant sources of radiation dose if significant radioactivity release from FSV occurred. Table II.H.2 also allows comparison to the three most recent years of operation.

The arithmetic means in Table II.H.2 were calculated for all sample results. It should be noted that the tabular data presented in the body of this report contain only positive calculated values above the minimum detectable concentration (MDC) levels. 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 proper estimate of the true mean value. Because of this procedure, however, the values listed in Table II.H.2 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. It is equally true that many sample types do in fact have zero concentrations of certain radionuclides. Therefore, to obtain the correct mean value from the distribution of analytical results, all positive results must be averaged with all negative results. If the negative results were omitted, the resulting arithmetic mean would be falsely biased high.

From the values presented in Tables II.H.1 and II.H.2 and the tabular data of the report, the following observations and conclusions may be drawn:

1. Tritium was again the only radionuclide that was detected in significant concentrations in any of the effluent pathways that could be attributed to the reactor. Since the tritium is released as tritiated water, the dilution by the surrounding hydrosphere is great. Although in 1990, tritium could be detected in the effluent pathway, the mean values of downstream surface water were not statistically greater than upstream concentrations.

The tritium concentrations measured in milk produced by the nearest dairy herd were also all less than MDC.

2. 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 variation, but principally due to true environmental variation (often termed sampling error). It must be recognized and accounted for in analysis of any set of environmental data before meaningful conclusions can be drawn.

3. The Chernobyl accident fallout has totally obscured what fission product debris has remained in the FSV environs from the October 1980 Chinese atmospheric nuclear weapon test. The biosphere will contain the Chernobyl fallout, particularly Cs-137, for an equally long period. Nuclear weapon test fallout has since the inception of the project been noted to be the predominant source term above natural background. It is the variation in fallout deposition, in addition to the variation in naturally occurring radionuclides, that mandates the large number of environmental samples to detect any possible radioactivity due to reactor effluents. A simple comparison of pre-operational and operational values is of little value for most

sample types because the fallout deposition was considerably greater during the pre-operational period.

4. The prompt and sensitive detection of the Chinese weapon test and Chernobyl fallout in the past assures that the environmental monitoring program is of adequate scope and sensitivity to detect any accidental releases from the FSV reactor operation. It can be concluded from the data collected by the environmental monitoring program that the radiation dose commitments calculated for the closest inhabitants or other parts of the nearby ecosystems due to current reactor effluents are negligible. Natural background radiation and the dose commitment from atmospheric fallout are the only known significant sources of radiation dose to the residents of the area.

During the current defueling phase of the reactor it is concluded that this Radiation Environmental Monitoring Program will be more than adequate to detect and quantify any possible routine or accidental release of radioactivity.

Table II.H.1 Environmental Radiological Monitoring Program Annual Summary
Fort St. Vrain Nuclear Generating Facility, Platteville, Colorado

Medium or Pathway Samples (Unit of measurement)	Type and Total Number of Analyses Performed	Facility Locations Mean (f)[b] Range	Adjacent Locations Mean (f)[b] Range	Locations with Highest Annual Mean Name / Distance & Direction	Mean (f)[b] Range	Reference Locations Mean (f)[b] Range	Number of Nonroutine Reported Measurements
Direct Radiation (mR/day)	TLD (155)	0.40 (70/70) (0.28-0.48)	0.39 (69/69) (0.34-0.48)	F-11 WCR19 & WCR3 1.2 km	0.47 (4/4) (0.45-0.48)	0.39 (16/16) (0.32-0.46)	0
Air, Particulates (fCi/m^3)	Grossβ (361)	23 (206/206) (5.5-52)		F-7 Farm CR21 & CR34 1.5 km 145°	25 (52/52) (5.5-52)	23 (155/155) (6.6-56)	0
	Gamma Spectrometry						
	Cs-134 (28)	2.0 (2/16) (1.3-2.7)		F-16 3-Bar Ranch 1.2 km 0°	2.7 (1/4)	<2.1	0
	Cs-137 (28)	2.0 (2/16) (1.7-2.3)		F-9 Farm CR19½ & CR34 1.5 km 185°	2.3 (1/4)	<2.0	0
Air, Charcoal (pCi/m^3)	I-131 (362)	30 (11/207) (13-52)		F-16 3-Bar Ranch 1.2 km 0°	42 (2/52) (31-52)	28 (11/155) (14-49)	0
Air, Atmospheric Water Vapor (pCi/m^3)	H-3 (350)	420 (1/202)		F-7 Farm CR21 & CR34 1.5 km 145°	420 (1/52)	<430	0

[b]Mean and range based upon detectable measurements only.
Fraction (f) of detectable measurements at specified locations is indicated in parentheses.

Table II.H.1 Environmental Radiological Monitoring Program Annual Summary
Fort St. Vrain Nuclear Generating Facility, Platteville, Colorado

Medium or Pathway Samples (Unit of measurement)	Type and Total Number of Analyses Performed	Facility Locations Mean (f)[b] Range	Adjacent Locations Mean (f)[b] Range	Locations with Highest Annual Mean Name / Distance & Direction	Mean (f)[b] Range	Reference Locations Mean (f)[b] Range	Number of Nonroutine Reported Measurements
Drinking Water (pCi/L)	Grossβ (52)	4.5 (26/26) (1.3-9.5)		R-6 Gilcrest City Water 9.3 km 60°	4.5 (26/26) (1.3-9.5)	0.86 (26/26) (0.34-2.3)	0
	H-3 (52)	<430		---	---	<430	0
	Gamma Spectrometry						
	I-131 (52)	0.31 (2/26) (0.18-0.44)		R-3 Ft. Collins City Water 45 km 330°	0.44 (1/26)	0.44 (1/26)	0
	Cs-134 (52)	1.8 (3/26) (1.5-2.2)		R-6 Gilcrest City Water 9.3 km 60°	1.8 (3/26) (1.5-2.2)	<2.8	0
	Cs-137 (52)	3.5 (13/26) (1.6-6.4)		R-6, Gilcrest City Water 9.3 km 60°	3.5 (13/26) (1.6-6.4)	3.0 (9/26) (1.3-5.0)	0
	Zr-95 (52)	6.8 (1/26)		R-6, Gilcrest City Water 9.3 km 60°	6.8 (1/26)	3.4 (1/26)	0
	Nb-95 (52)	3.1 (5/26) (1.5-6.1)		R-6, Gilcrest City Water 9.3 km 60°	3.1 (5/26) (1.5-6.1)	2.0 (5/26) (1.3-2.9)	0

[b]Mean and range based upon detectable measurements only.
Fraction (f) of detectable measurements at specified locations is indicated in parentheses.

Table II.H.1 Environmental Radiological Monitoring Program Annual Summary
Fort St. Vrain Nuclear Generating Facility, Platteville, Colorado

Medium or Pathway Samples (Unit of measurement)	Type and Total Number of Analyses Performed	Facility Locations Mean (f)[b] Range	Adjacent Locations Mean (f)[b] Range	Locations with Highest Annual Mean Name / Distance & Direction	Mean (f)[b] Range	Reference Locations Mean (f)[b] Range	Number of Nonroutine Reported Measurements
Drinking Water	Co-58 (52)	1.5(1/26)		R-6 Gilcrest City Water 9.3 km 60°	1.5 (1/26)	<2.5	0
	Mn-54 (52)	2.1 (6/26) (1.2-2.8)		R-3 Ft. Collins City Water 45 km 330°	2.1 (6/26) (1.2-2.8)	2.1 (6/26) (1.3-2.4)	0
	Zn-65 (52)	9.4 (1/26)		R-6 Gilcrest City Water 9.3 km 60°	9.4 (1/26)	<7.5	0
	Fe-59 (52)	6.6 (3/26) (4.9-9.1)		R-6 Gilcrest City Water 9.3 km 60°	6.6 (3/26) (4.9-9.1)	5.6 (1/26)	0
	Co-60 (52)	2.0 (6/26) (1.2-3.7)		R-3 Ft. Collins City Water 45 km 330°	2.7 (2/26) (2.1-3.2)	2.7(2/26) (2.1-3.2)	0
	Ba-140 (52)	5.2 (3/26) (4.0-6.4)		R-6 Gilcrest City Water 9.3 km 60°	5.2 (3/26) (4.0-6.4)	<5.1	0
	La-140 (52)	5.9 (3/26) (4.6-7.3)		R-6 Gilcrest City Water 9.3 km 60°	5.9 (3/26) (4.6-7.3)	<5.9	0

[b] Mean and range based upon detectable measurements only.
Fraction (f) of detectable measurements at specified locations is indicated in parentheses.

Table II.H.1 Environmental Radiological Monitoring Program Annual Summary
Fort St. Vrain Nuclear Generating Facility, Platteville, Colorado

Medium or Pathway Samples (Unit of measurement)	Type and Total Number of Analyses Performed	Facility Locations Mean (f)[b] Range	Adjacent Locations Mean (f)[b] Range	Locations with Highest Annual Mean Name, Distance & Direction	Mean (f)[b] Range	Reference Locations Mean (f)[b] Range	Number of Nonroutine Reported Measurements
Surface Water (pCi/L)	H-3 (60)	1750 (2/36) (1600-1900)		A-25 Goosequill 2.2 km 20°	1750 (2/12) (1600-1900)	<430	0
Gamma Spectrometry							
	Cs-134 (60)	2.8 (2/36) (2.0-3.6)		A-25 Goosequill 2.2 km 20°	3.6 (1/12)	1.8(2/24) (1.4-6.5)	0
	Cs-137 (60)	3.7 (12/36) (1.8-7.1)		R-10 S. Platte at CO 60 10 km 290°	4.5 (4/12) (2.1-7.1)	3.9 (10/24) (1.9-6.5)	0
	Zr-95 (60)	4.8 (3/36) (4.2-5.2)		R-10 S. Platte at CO 60 10 km 290°	5.2 (1/12)	4.6 (2/24) (4.3-4.8)	0
	Nb-95 (60)	2.0 (2/36) (1.8-2.1)		F-19 S. Platte 1.2 km 90°	3.5 (2/12) (3.4-3.5)	3.5 (3/24) (3.4-3.5)	0
	Co-58 (60)	2.6 (2/36) (1.3-3.8)		F-20 St. Vrain 1.5 km 345°	2.6 (2/12) (1.3-3.8)	2.6(2/24) (2.4-2.7)	0
	Mn-54 (60)	2.1 (2/36) (1.7-2.5)		F-19 S. Platte 1.2 km 90°	2.8 (3/12) (2.4-3.4)	2.4(5/24) (1.4-3.4)	0
	Zn-65 (60)	<10		A-21 St. Vrain Bridge 2.4 km 220°	7.7 (1/12)	7.7 (1/24)	0

[b]Mean and range based upon detectable measurements only.
Fraction (f) of detectable measurements at specified locations is indicated in parentheses.

Table II.H.1 Environmental Radiological Monitoring Program Annual Summary
Fort St. Vrain Nuclear Generating Facility, Platteville, Colorado

Medium or Pathway Samples (Unit of measurement)	Type and Total Number of Analyses Performed	Facility Locations Mean (f)[b] Range	Adjacent Locations Mean (f)[b] Range	Locations with Highest Annual Mean Name / Distance & Direction	Mean (f)[b] Range	Reference Locations Mean (f)[b] Range	Number of Nonroutine Reported Measurements
Surface Water (pCi/L)	Gamma Spectrometry						
	Fe-59 (60)	5.9 (2/36) (4.5-7.3)		[illegible]-19 S. Platte 1.2 km 90°	7.0 (1/12)	6.4 (3/24) (5.5-7.0)	0
	Co-60 (60)	2.7 (3/36) (1.3-3.4)		F-20 St. Vrain 1.5 km 345°	3.4 (1/12)	2.5 (1/24)	0
	Ba-140 (60)	6.7 (3/36) (4.2-8.8)		R-10 S. Platte at CO 60 10 km 290°	8.8 (1/12)	5.4 (2/24) (3.5-7.2)	0
	La-140 (60)	7.6 (3/36) (4.8-10)		R-10 S. Platte at CO 60 10 km 290°	10 (1/12)	6.2 (2/24) (4.0-8.3)	0
Ground Water (pCi/L)	H-3 (8)	2500 (3/4) (800-3400)		[illegible]-16 3-Bar Ranch 1.2 km 0°	2500 (3/4) (800-3400)	<430	0
	Gamma Spectrometry						
	Cs-134 (8)	<2.4		---	---	<2.7	0
	Cs-137 (8)	4.8 (3/4) (3.0-5.9)		R-5 Miliken 9.5 km 11°	7.6 (4/4) (2.0-17)	7.6 (4/4) (2.0-17)	0
	Zr-95 (8)	<5.4		---	---	<6.2	0
	Nb-95 (8)	2.5 (1/4)		R-5 Miliken 9.5 km 11°	6.1 (2/4) (4.8-7.3)	6.1 (2/4) (4.8-7.3)	0

[b]Mean and range based upon detectable measurements only.
Fraction (f) of detectable measurements at specified locations is indicated in parentheses.

Table II.H.1 Environmental Radiological Monitoring Program Annual Summary
Fort St. Vrain Nuclear Generating Facility, Platteville, Colorado

Medium or Pathway Samples (Unit of measurement)	Type and Total Number of Analyses Performed	Facility Locations Mean (f)[b] Range	Adjacent Locations Mean (f)[b] Range	Locations with Highest Annual Mean Name / Distance & Direction	Mean (f)[b] Range	Reference Locations Mean (f)[b] Range	Number of Nonroutine Reported Measurements
Ground Water (pCi/L)	Gamma Spectrometry						
	Co-58 (8)	2.9 (1/4)		F-16 3-Bar Ranch 1.2 km 0°	2.9 (1/4)	<2.5	0
	Mn-54 (8)	1.7 (2/4) (1.4-2.0)		R-5 Miliken 9.5 km 11°	4.3 (2/4) (2.7-5.9)	4.3 (2/4) (2.7-5.9)	0
	Zn-65 (8)	<8.7		---	---	<13	0
	Fe-59 (8)	<5.9		---	---	<6.4	0
	Co-60 (8)	1.8 (1/4)		R-5 Miliken 9.5 km 11°	3.3 (4/4) (2.0-5.1)	3.3 (4/4) (2.0-5.1)	0
	Ba-140 (8)	<4.3		R-5 Miliken 9.5 km 11°	9.0 (2/4) (7.9-10)	9.0 (2/4) (7.9-10)	0
	La-140 (8)	<4.9		R-5 Miliken 9.5 km 11°	11 (2/4) (9.0-12)	11 (2/4) (9.0-12)	0

[b] Mean and range based upon detectable measurements only.
Fraction (f) of detectable measurements at specified locations is indicated in parentheses.

Table II.B.1 Environmental Radiological Monitoring Program Annual Summary
Fort St. Vrain Nuclear Generating Facility, Platteville, Colorado

Medium or Pathway Samples (Unit of measurement)	Type and Total Number of Analyses Performed	Facility Locations Mean (f)[b] Range	Adjacent Locations Mean (f)[b] Range	Locations with Highest Annual Mean Name / Distance & Direction	Mean (f)[b] Range	Reference Locations Mean (f)[b] Range	Number of Nonroutine Reported Measurements
Sediment (pCi/kg.dry)	Gamma Spectrometry						
	Cs-134 (2)	19 (1/2)		R-10 S. Platte at CO 60 10 km 290°	19 (1/2)	---	0
	Cs-137 (2)	59 (2/2) (48-69)		R-10 S. Platte at CO 60 10 km 290°	59 (2/2) (48-69)	---	0
Milk (pCi/l)	H-3 (116)		550 (1/99)	A-23 Leroy Odenbaugh Dairy 4.1 km 83°	550 (1/17)	480 (1/16)	0
	Gamma Spectrometry						
	I-131 (116)		3.6 (15/99) (0.31-15)	A-22 Percy Odenbaugh Dairy 5 km 90°	5.2 (10/17) (1.1-15)	0.32 (3/17) (0.29-0.36)	0
	Cs-134 (116)		2.9 (4/99) (2.7-3.2)	R-8 Gorzeman Dairy 23 km	3.5 (1/17)	3.5 (1/17)	0
	Cs-137 (116)		3.9 (25/99) (1.6-7.1)	R-8 Gorzeman Dairy 23 km	5.2 (4/17) (3.7-6.2)	5.2 (4/16) (3.7-6.2))	0

[b] Mean and range based upon detectable measurements only.
Fraction (f) of detectable measurement at specified locations is indicated in parentheses.

Table II.H.1 Environmental Radiological Monitoring Program Annual Summary
Fort St. Vrain Nuclear Generating Facility, Platteville, Colorado

Medium or Pathway Samples (Unit of measurement)	Type and Total Number of Analyses Performed	Facility Locations Mean (f)[b] Range	Adjacent Locations Mean (f)[b] Range	Locations with Highest Annual Mean Name / Distance & Direction	Mean (f)[b] Range	Reference Locations Mean (f)[b] Range	Number of Nonroutine Reported Measurements
Milk (pCi/L)	Gamma Spectrometry						
	Ba-140 (116)		6.4 (16/99) (3.7-12)	A-23 Leroy Odenbaugh Dairy 4.1 km 83°	12 (1/17)	11 (2/16) (10-11)	0
	La-140 (116)		7.4 (15/99) (4.2-14)	A-23 Leroy Odenbaugh Dairy 4.1 km 83°	14 (1/17)	13 (2/16) (12-13)	0
Food Products (pCi/kg, wet)	Gamma Spectrometry						
	I-131 (9)		17 (1/9)	A-27 WCR25 & WCR38 4.3 km	17 (1/4)	---	0
	Cs-134 (9)		<14	---	---	---	0
	Cs-137 (9)		15 (2/9) (8.3-21)	R-6 Hernandez Gilcrest 9.6 km 60°	21 (1/5)	---	0

[b] Mean and range based upon detectable measurements only.
Fraction (f) of detectable measurements at specified locations is indicated in parentheses.

Table II.B.1 Environmental Radiological Monitoring Program Annual Summary
Fort St. Vrain Nuclear Generating Facility, Platteville, Colorado

Medium or Pathway Samples (Unit of measurement)	Type and Total Number of Analyses Performed	Facility Locations Mean (f)[b] Range	Adjacent Locations Mean (f)[b] Range	Locations with Highest Annual Mean Name / Distance & Direction	Mean (f)[b] Range	Reference Locations Mean (f)[b] Range	Number of Nonroutine Reported Measurements
Fish (pCi/kg, wet)	Gamma Spectrometry						
	Cs-134 (5)	<16		F-19 S. Platte 1.2 km 90°	6.2 (1/1)	6.2 (1/1)	0
	Cs-137 (5)	20 (2/4) (5.7-35)		R-10 S. Platte at CO 60 10 km 290°	20 (2/2) (5.7-35)	<6.7	0
	Co-58 (5)	<14		---	---	<5.3	0
	Mn-54 (5)	<16		---	---	<5.8	0
	Zn-65 (5)	<44		---	---	<17	0
	Fe-59 (5)	<25		---	---	<9.4	0
	Co-60 (5)	<16		---	---	<6.2	0

[b]Mean and range based upon detectable measurements only.
Fraction (f) of detectable measurements at specified locations is indicated in parentheses.

Table II.H.2 Summary Table of Arithmetic Means and Standard Deviations for Selected Sample Types.

	1987		1988		1989		1990	
	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ
Atmospheric Water Vapor (pCi/L)								
H-3								
Facility	<230		470		43		<256	285
Reference	<230		172		<420		<299	288
Air (fCi/m^3)								
Gross Beta								
Facility	26		26		26		23	12
Reference	25		24		24		23	12
I-131								
Facility	1.1		1.9		2.2		1.5	3
Reference	1.2		<4.5		2.2		1.4	9
Cs-137								
Facility	0.33		0.73		0.32		0.55	0.92
Reference	0.44		1.0		0.46		0.22	0.66

Table II.H.2 Summary Table of Arithmetic Means and Standard Deviations for Selected Sample Types.

	1987		1988		1989		1990	
	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ
				Drinking Water (pCi/L)				
H-3								
Gilcrest	75		370		<390		<238	317
Ft. Collins	<230		120		<390		<215	288
Gross Beta								
Gilcrest	5.1		6.8		5.8		4.5	1.8
Ft. Collins	0.79		1.1		0.98		0.86	0.39
I-131								
Gilcrest	0.052		0.099		0.068		0.017	0.19
Ft. Collins	0.071		0.083		0.14		0.046	0.24
Cs-137								
Gilcrest	2.1		1.7		2.2		1.3	1.4
Ft. Collins	1.1		1.4		1.8		2.4	1.8

Table II.H.2 Summary Table of Arithmetic Means and Standard Deviations for Selected Sample Types.

	1987		1988		1989		1990	
	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ	$\bar{x}$	σ
Surface Water (pCi/L)								
H-3								
Effluent	7700		31000		29000		303	623
Downstream	21		430		<390		<371	397
Upstream	<230		430		<390		<415	352
Cs-137								
Effluent	1.7		1.9		1.3		1.4	1.9
Downstream	0.01		2.5		1.8		2.1	1.9
Upstream	0.32		1.4		2.0		2.2	1.9
Milk (pCi/L)								
H-3								
Adjacent	<230		70		<390		<280	330
Reference	<230		<220		<390		<290	340
I-131								
Adjacent	0.15		0.046		0.57		0.53	2.0
Reference	0.02		<0.17		<0.50		0.0060	0.33
Cs-137								
Adjacent	3.2		2.7		1.5		1.5	2.0
Reference	3.6		3.3		1.5		16	2.3

III. Radiological Environmental Monitoring Program

A. Sample Collection and Analysis Schedule

Table III.A.1 outlines the sampling design, the collection frequency and the type of analysis for all environmental samples. It should be repeated that this schedule was only adopted January 1, 1984, and while different in certain aspects from the previous schedule, has as its intent the same objective. That objective is to document the radiation and radioactivity levels in the critical pathways of possible dose to humans. Such data is necessary to prove that reactor radioactivity effluents produce environmental concentrations that are within appropriate environmental protection limits and at the same time are as low as reasonably achievable.

During 1990, there was the following change in the sampling program:

> A-26 dairy (Feichtner, 15152 WCR13, Longmont) went out of business. The new A-26 location in 1990 was the Docheff dairy, approximately 1 mile west of Feichtner's. The Docheff address is 4513 WCR 32, Longmont, CO.

Table III.B.1 gives the description of each sampling location by number, sector and distance from the reactor. Each of these sampling locations (except certain reference locations) can be identified on scale maps (Figures III.B.1

and III.B.2). Topographical maps showing greater detail, as well as photographs of principal sampling sites are on file in the CSU laboratory.

During September 1990 the land-use census was conducted to determine the locations of the nearest residence, the nearest milk animal, and the nearest garden producing broad leaf vegetation in each of the 16 meteorological sectors around the reactor. These locations by address are shown in Table III.C.1. Figure III.C.1 shows these locations in each sector. At the time of the 1990 census it was verified that the closest permanent residence in Sector 16 was the critical receptor with regards to mean annual dose commitment and is at the Russell farm F-16.

A few residents in the sampling sectors up to a distance of 8 km from the plant have cows or goats that could be used for personal milk consumption. However, from direct discussion with these persons, this is not a common practice and all cow milk produced is transported to commercial processors. The milk produced locally is diluted by a large milk shed, processed and distributed over a large area for consumption. For this reason the elevated I-131 in milk from A-22 would never be detected in the composited milk supply.

Table III.A.2 lists the LLD concentration values for each sample type and radionuclide measured in this report. These LLD values are the actual values pertinent to the sample sizes, counting yields, and counting times used in the project. Typical decay periods were used in the calculations.

It should be noted that the LLD values are in all cases equal to or less than those required by the technical specifications.

Table III.A.3 lists the USNRC reporting level for each sample type and radionuclide.

Table III.A.1 Operational Radiological Environmental Monitoring Program

Exposure Pathway and/or Sample	Number of Samples and Locations	Sampling Collection Frequency	Type and Frequency of Analysis
AIRBORNE			
Tritium Oxide Radioiodine and Particulates	Samples from seven locations: Four samples from off-site locations (in different sectors) of the highest calculated annual average ground level D/Q and airborne X/Q. One sample from the vicinity of a community having the highest calculated annual average ground level D/Q. Two samples from control location 15 to 30 kilometers (10 to 20 miles) distant and in the least prevalent wind direction.	Continuous sampler operation with sample collection weekly or as required by dust loading, whichever is more frequent.	Radioiodine Canister: Analyze weekly for I-131 liquid scintillation counting for tritium on water vapor extracted from silica gel on each sample collected. Particulate Sampler: Gross beta radioactivity following filter change, composite (by location) for gamma isotopic quarterly.[d]
DIRECT RADIATION	Forty stations with two or more dosimeters or one instrument for measuring and recording dose rate continuously to be placed as follows: 1) an inner ring of stations in the general area of the site boundary and an outer ring in the 4 to 5 mile range from the site with a station in each sector of each ring (16 sectors × 2 rings = 32 stations). The balance of the stations, eight, shall be placed in special interest areas such as population centers, nearby residences, schools, and in two or three areas to serve as control stations.	Quarterly exposure.	Gamma dose quarterly.
WATERBORNE			
Surface	One sample upstream, each stream, one sample downstream.	Samples collected monthly.	Gamma isotopic analysis and tritium monthly.
Surface (Farm Pond)	One sample in immediate area of discharge.	Composite sample over one week period. The weekly composites will be combined for the monthly sample.	Gamma isotopic analysis and composite for tritium monthly.

[a] If gross beta activity in air or water is greater than ten times the yearly mean of control sample for any medium, gamma isotopic analysis should be performed on the individual samples.

Table III.A.1. OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM (continued)

Exposure Pathway and/or Sample	Number of Samples and Locations	Sampling Collection Frequency	Type and Frequency of Analysis
Ground	Samples from two sources most likely to be effected.	Quarterly	Gamma isotopic and tritium.
Drinking	One sample from the nearest water supply which could be effected by facility's discharge.	Composite sample over two week period.	Composite for tritium, gross beta, and gamma isotopic analyses every two weeks.
	One sample from a control location.		
Sediment from Shoreline	One sample from downstream area with existing or potential recreational value.	Semi-annually	Gamma isotopic analysis semi-annually.
INGESTION			
Milk	Samples from milking animals in all locations, up to a total of three locations, within 5 kilometers.	Semi-monthly when animals are on pasture, monthly at other times.	Gamma isotopic and I-131 analysis semi-monthly when animals are on pasture; monthly at other times.
	One sample from milking animals in each of three areas between 5 to 8 kilometers distant having the highest dose potential. [b]		
	One sample from milking animals at a control location (15 to 30 kilometers) distant and in the least prevalent wind direction).	Semi-monthly when animals are on pasture, monthly at other times.	Gamma isotopic and I-131 analysis semi-monthly when animals are on pasture; monthly at other times.
Aquatic Biota	Sample fish in vicinity of discharge point, upstream and downstream.	Sample semi-annually.	Gamma isotopic analyses.
Food Products	One sample of each principal class of food products from any area which is irrigated by water in which liquid plant wastes have been discharges.	At time of harvest.	Gamma isotopic analyses.

[b] The dose shall be calculated for the maximum organ and age group using the methodology contained in Regulatory Guide 1.109 and the actual parameters particular to the site.

Table III.A.2 Detection Capabilities for Environmental Sample Analysis

Analysis	Lower Limit of Detection (LLD)*					
	Water (pCi/L)	Airborne Particulate or Gas (fCi/m^3)	Fish (pCi/kg, wet)	Milk (pCi/L)	Food Products (pCi/kg, wet)	Sediment (pCi/kg, dry)
Gross Beta	3.86	3.25				
H-3	494					
I-131	0.89	66.4		0.89	56.8	
Cs-134	5.50	8.06	19.5	4.98	44.4	90.6
Cs-137	6.60	7.86	18.5	6.14	44.6	100
Zr-95	10.12					
Nb-95	4.12					
Co-58	4.60		12.8			
Mn-54	4.60		12.7			
Zn-65	10.94		23.6			
Fe-59	8.40		31.4			
Co-60	4.40		14.5			
Ba-140	6.66			8.00		
La-140	7.66			9.16		

* As suggested in NUREG-0472. All values are at or below values listed in Table 8.2-2 of technical specifications.

Table III.A.3 Reporting Levels for Nonroutine Operating Reports

REPORTING LEVELS FOR NONROUTINE OPERATING REPORTS

REPORTING LEVEL (RL)

Analysis	Water (pCi/ℓ)	Airborne Particulate or Gas (pCi/m³)	Fish (pCi/kg,wet)	Milk (pCi/ℓ)	Broad Leaf Vegetation (pCi,kg, wet)
H-3	2×10^4[a]				
Mn-54	1×10^3		3×10^4		
Fe-59	4×10^2		1×10^4		
Co-58	1×10^3		3×10^4		
Co-60	3×10^2		1×10^4		
Zn-65	3×10^2		2×10^4		
Nb-95, Zr-95	4×10^2				
I-131	2	0.9		3	1×10^2
Cs-134	30	10	1×10^3	60	1×10^3
Cs-137	50	20	2×10^3	70	2×10^3
Ba-140, La-140	2×10^2			3×10^2	

[a] for drinking water samples. This is 40CFR Part 141 value.

Table III.B.1 Radiological Environmental Monitoring Program (continued)
Sampling Site Descriptions

(F: Facility Area 0-1.6 km. A: Adjacent Area 1.6-8 km. R: Reference Area)

Exposure Pathway	Site No.	Location Description (see map)	Sector	Distance, km
Direct Radiation	F-1	Pole by gate to Goosequill road on dirt extension of CR 21.	1	1.3
	F-2	21st pole N of ditch on dirt extension of CR 21 just before road drops down to river bottom.	2	1.1
	F-3	17th pole N of ditch on dirt extension of CR 21 or first pole N of E-W road.	3	0.7
	F-4	15th pole N of ditch on dirt extension of CR 21, S of pump road, midway between F-3 and F-5.	4	0.7
	F-5	11th pole N of ditch on dirt extension of CR 21, near drive to pump house.	5	0.6
	F-6	8th pole N of ditch on dirt extension of CR 21, by E-W concrete ditch, S of bridge.	6	0.8
	F-7	Old dairy barn, 1st pole N after crossing ditch on dirt extension of CR 21.	7	1.2
	F-8	1st pole W of pump house on N side of road 0.4 km E of CR 19½.	8	1.3
	F-9	Pole E of first shed at intersection of CR 19½ and CR 34.	9	1.5
	F-10	Pole on NW corner of intersection of dirt extension of CR 19 and 34.	10	1.5

Table III.B.1 Radiological Environmental Monitoring Program (continued)
Sampling Site Descriptions

(F: Facility Area 0-1.6 km. A: Adjacent Area 1.6-8 km. R: Reference Area)

Exposure Pathway	Site No.	Location Description (see map)	Sector	Distance, km
Direct Radiation	F-11	7th pole N of intersection of dirt extension of CR 19 with CR 34.	11	1.2
	F-12	0.5 km S of FSV Visitor Center take dirt road W across field, go into farmyard of Aristocrat Brangus. (If chain across road enter from CR 36). TLD is located on pole at SE corner of corral across from Aristocrat Brangus office.	12	1.6
	F-13	Take first dirt road S of Visitor Center. Go W across railroad tracks, follow dirt road to metal staircase going down off dike. TLD is taped to railing.	13	0.5
	F-14	2nd pole 0.1 km S intersection CR 36½ & Rd 19.	14	1.5
	F-15	2nd pole 0.7 km S of intersection of CR 38 on CR 19.	15	1.5
	F-16	Pole at NE corner of potato cellar at 3 Bar Ranch (Russell's).	1	1.2
	F-17	Visitor Center, on N end of cross beam over entrance.	13	0.2
	F-18	Pole closest to house on SW corner, 17250 CR 19½. The address of 17250 is taped to the Mountain Bell underground cable warning post.	16	0.8

Table III.B.1 Radiological Environmental Monitoring Program (continued)
Sampling Site Descriptions

(F: Facility Area 0-1.6 km. A: Adjacent Area 1.6-8 km. R: Reference Area)

Exposure Pathway	Site No.	Location Description (see map)	Sector	Distance, km
Direct Radiation	A-1	Pole on NW corner of intersection of CR 44 and CR 21.	1	6.7
	A-2	Pole on NE corner intersection of CR 42 and CR 25½.	2	6.8
	A-3	Pole on NE corner of intersection of CR 42 and CO 60.	3	7.5
	A-4	1st pole NE of intersection of CR 29 and CR 38, take CR 29 E out of Gilcrest to CR 38.	4	7.4
	A-5	SE corner of CR 34 and CR 29. Taped to road sign on SW corner of intersection.	5	7.2
	A-6	Pole on S side of CR 32 near drive to dairy 13278 CR 32.	6	7.1
	A-7	Niles Miller dairy. 0.4 km E of US 85 on 12854 CR 30. TLD is located on pole at NE corner of house.	7	7.3
	A-8	On CO 66 (CR30) farm on S side of road (address 9476) Pole in front of house.	8	4.7
	A-9	Corner of CO 66 (CR 30) and CR 19, Miller produce stand. Second pole S on CR 19, on E side of road.	9	4.6
	A-10	Pole on SE corner at intersection CR 26½ & CR 15.	10	7.8
	A-11	At intersection of CO 66 and CR 13, 2nd pole N of intersection on E side of CR13.	11	7.2

Table III.B.1 Radiological Environmental Monitoring Program (continued)
Sampling Site Descriptions

(F: Facility Area 0-1.6 km. A: Adjacent Area 1.6-8 km. R: Reference Area)

Exposure Pathway	Site No.	Location Description (see map)	Sector	Distance, km
Direct Radiation	A-12	On CR 34, pole E of house N of Lake Thomas 2 km from I-25.	12	7.2
	A-13	Pole opposite lake, N of silage pits E side of CR 13 2.9 km N of CR 34.	13	5.8
	A-14	Intersection of CR 13 and CR 40, NW corner.	14	6.9
	A-15	Intersection of CR 42 and CR 15, NW corner.	15	6.7
	A-16	Intersection of CR 44 and CR 19, SW corner.	16	6.8
	A-17	Platteville school (S edge of town on Main St.) pole on NW corner just outside school intramural field.	6	5.9
	A-20	1st pole N of white picket fence and driveway into turkey farm on S end of building that is parallel with CR 19.	9	2.5

Table III.B.1 Radiological Environmental Monitoring Program (continued)
Sampling Site Descriptions

(F: Facility Area 0-1.6 km. A: Adjacent Area 1.6-8 km. R: Reference Area)

Exposure Pathway	Site No.	Location Description (see map)	Sector	Distance, km
Direct Radiation	R-1	Milliken School, on CR 21½. TLD is located on pole which is located at SE corner of Lola park, across the street from school.		9.3
	R-2	Johnstown School (Letford Elementary), turn left at school crossing on Idaho St. onto Jay Ave. and proceed to school. TLD is located on pole at SE corner of main entrance to school on W side of town.		10.8
	R-3	CSU dairy farm on W Drake, N of Vet Hospital, Ft. Collins, CO. Pole is E of hay barn next to railroad tracks.		45.1
	R-4	Air sampler corner US 287 and CO 66, Longmont Dairy Store. TLD is located on pole directly behind air sampler.		20.5
	R-7	Behind Gilcrest School quonset auditorium, pole on SW end of school property, just before garage.		9.3
Waterborne Sediment from Shoreline	R-10	Sediment from S. Platte River at bridge on CO 60.		10.1

Table III.B.1 Radiological Environmental Monitoring Program Sampling Site Descriptions

(F: Facility Area 0-1.6 km. A: Adjacent Area 1.6-8 km. R: Reference Area)

Exposure Pathway	Site No.	Location Description (see map)	Sector	Distance, km
Airborne	F-7	Farm at intersection of CR 21 and CR 34. Air sampler is located on west side of shop. Silica gel inside building on N end of workbench.	7	1.5
	F-9	First shed along drive at end of Rd 19½ intersection with Rd 34. Silica gel is located in shed.	9	1.5
	F-16	Potato cellar at 3 Bar Ranch (Russell's). Silica gel in mailbox on tree to S of pump.	16	1.2
	A-19	Hunting cabin between Goosequill ditch and Platte River. Air sampler is on W side of cabin, silica gel is in box on tree north of air sampler.	1	1.7
	R-3	Colorado State University Dairy, W. Drake Rd., Ft. Collins, CO. W side of shed directly N of main dairy building. Silica gel inside mailbox.		45.1
	R-4	Intersection of US 66 and US 287, E side of dairy store, north edge of Longmont. Silica gel is in mailbox attached to utility pole.		20.5
	R-11	Air sampler is located in alley behind PSC office, next to garage. Silica gel is located next to air sampler in mailbox and on top of post, 13 1/2 Parish St., Johnston, CO.		10.5

Table III.B.1 Radiological Environmental Monitoring Program (continued)
Sampling Site Descriptions

(F: Facility Area 0-1.6 km. A: Adjacent Area 1.6-8 km. R: Reference Area)

Exposure Pathway	Site No.	Location Description (see map)	Sector	Distance, km
Waterborne Surface	F-19	S. Platte at dam located on dirt road E of pump house #3 directly E of reactor.	4	1.2
	F-20	St. Vrain creek on Rd. 19½ 0.3 km from discharge into St. Vrain creek. Directly N of reactor.	16	1.5
	A-21	St. Vrain creek at bridge on Rd. 34, E of Rd. 19.	11	2.4
	A-25	Goosequill Pond outlet. Continuous sampler located in green box adjacent to the green shed on the N end of the pond.	1	2.2
	R-10	S. Platte river at bridge on CO 60 where highway has just turned and headed South.		10.1
Ground	F-16	Well behind residence at 3 Bar Ranch (Russell's), 17578 WCR 19 1/2.	1	1.2
	R-5	Well at 108 S. Grace, Milliken.		9.5
Drinking	R-3	CSU dairy W Drake Rd., Ft. Collins, CO, N of Vet Hospital. Water sample is taken from hydrant inside the entrance to the milking parlor.		45.1
	R-6	Gilcrest U.S. Post Office located on Birch St. and Rd. 40 off of Hwy 85. Water taken from utility sink inside Post Office.		9.3

Table III.B.1 Radiological Environmental Monitoring Program (continued)
Sampling Site Descriptions

(F: Facility Area 0-1.6 km. A: Adjacent Area 1.6-8 km. R: Reference Area)

Exposure Pathway	Site No.	Location Description (see map)	Sector	Distance, km
Ingestion				
Milk	A-6	Hendrickson Dairy, 13278 Rd. 32 (Grand Ave.) 1.6 km E of US 85.	6	7.1
	A-18	Boos Dairy, 11258 W Rd. 40, W of US 85 behind modular home.	2	4.7
	A-22	Percy Odenbaugh Dairy, S on dirt rd from "LeRoy & Paul Odenbaugh Dairy" sign. Dairy sign on WCR 36, E of Rd 23. Dairy sign is located next to mailbox of Mike Thomas.	5	3.2
	A-23	Leroy Odenbaugh Dairy, 11733 Rd 36, W of Rd 25.	4	4.1
	A-24	Marostica Dairy, 20718 Rd 17, 4 miles S of CO 60.	16	6.9
	A-26	L & F Dairy (Fiechtner), E of Rd 13 on Rd 32. 6165 WCR 32.	11	7.8
	R-8	Gorzman Dairy, 2056 S. CR 17, located off exit #255 W of I-25 dirctly N of Johnson's Corner restaurant.		22.5
Fish				
	F-19	S. Platte at dam located on dirt Rd E of pump house #3 directly E of reactor.	4	1.1
	A-25	Goosequill pond outlet.	1	2.2
	R-10	S. Platte river at bridge on CO 60.		10.1

Table III.B.1 Radiological Environmental Monitoring Program (continued)
Sampling Site Descriptions

(F: Facility Area 0-1.6 km. A: Adjacent Area 1.6-8 km. R: Reference Area)

Exposure Pathway	Site No.	Location Description (see map)	Sector	Distance, km
Food Products	A-27	Fields on SE corner of intersection of WCR 25 and WCR 38.	4	4.3
	A-28	Residence 11399 WCR 40½.	2	5.3
	R-6	Hernandez Produce Stand, Highway 85, Gilcrest.		9.6

Figure III.B.1

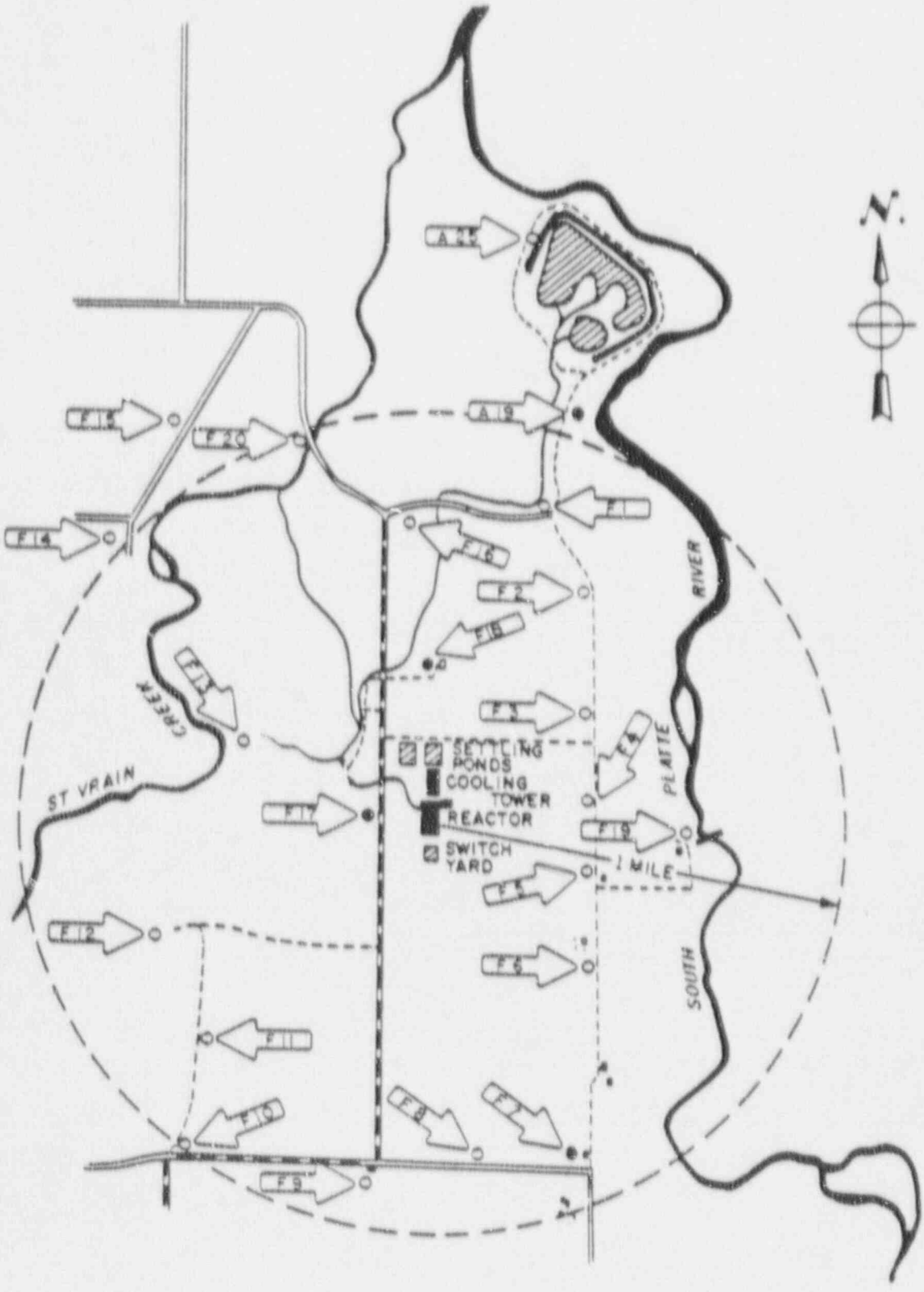


Figure III.B.2 Adjacent and Reference Sampling Locations

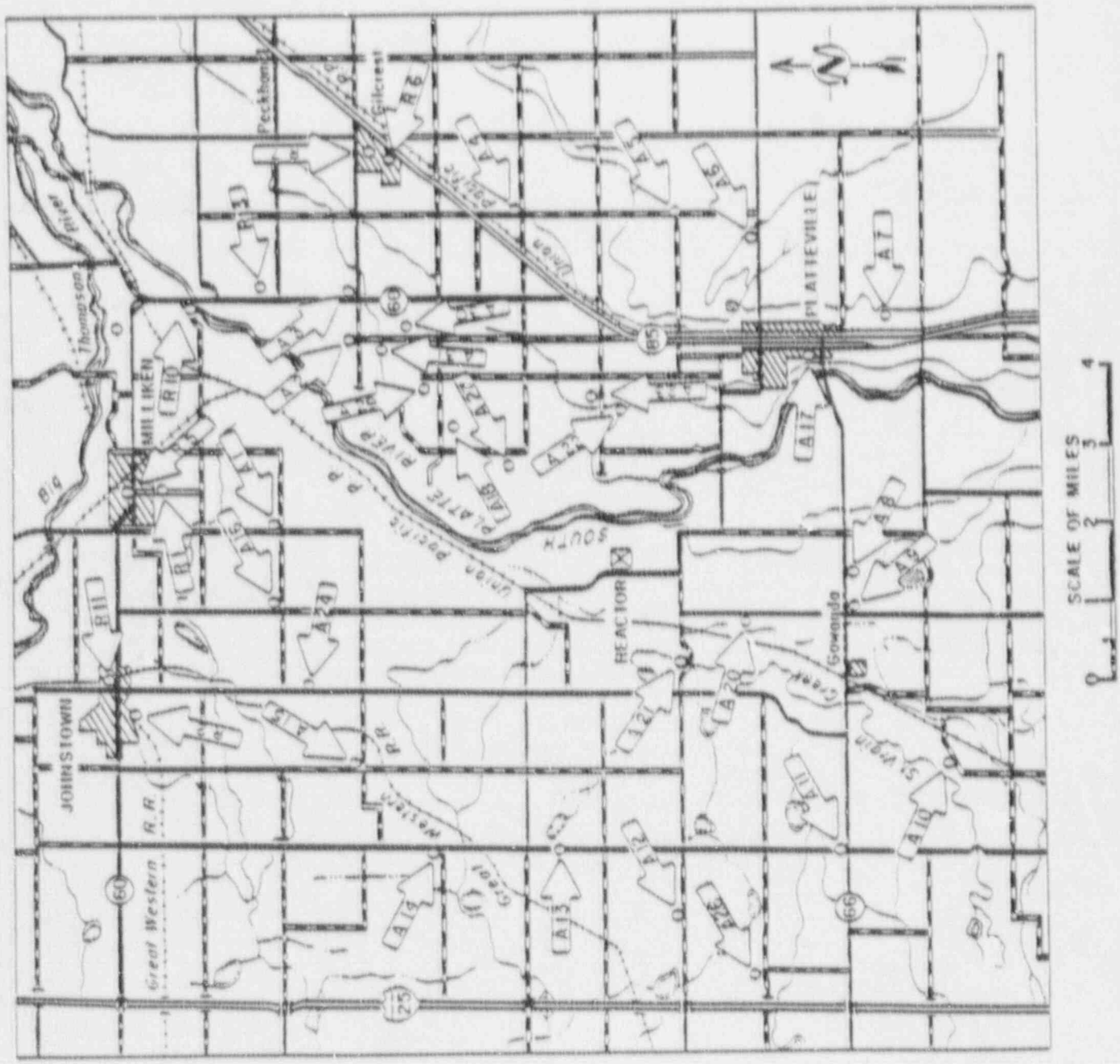
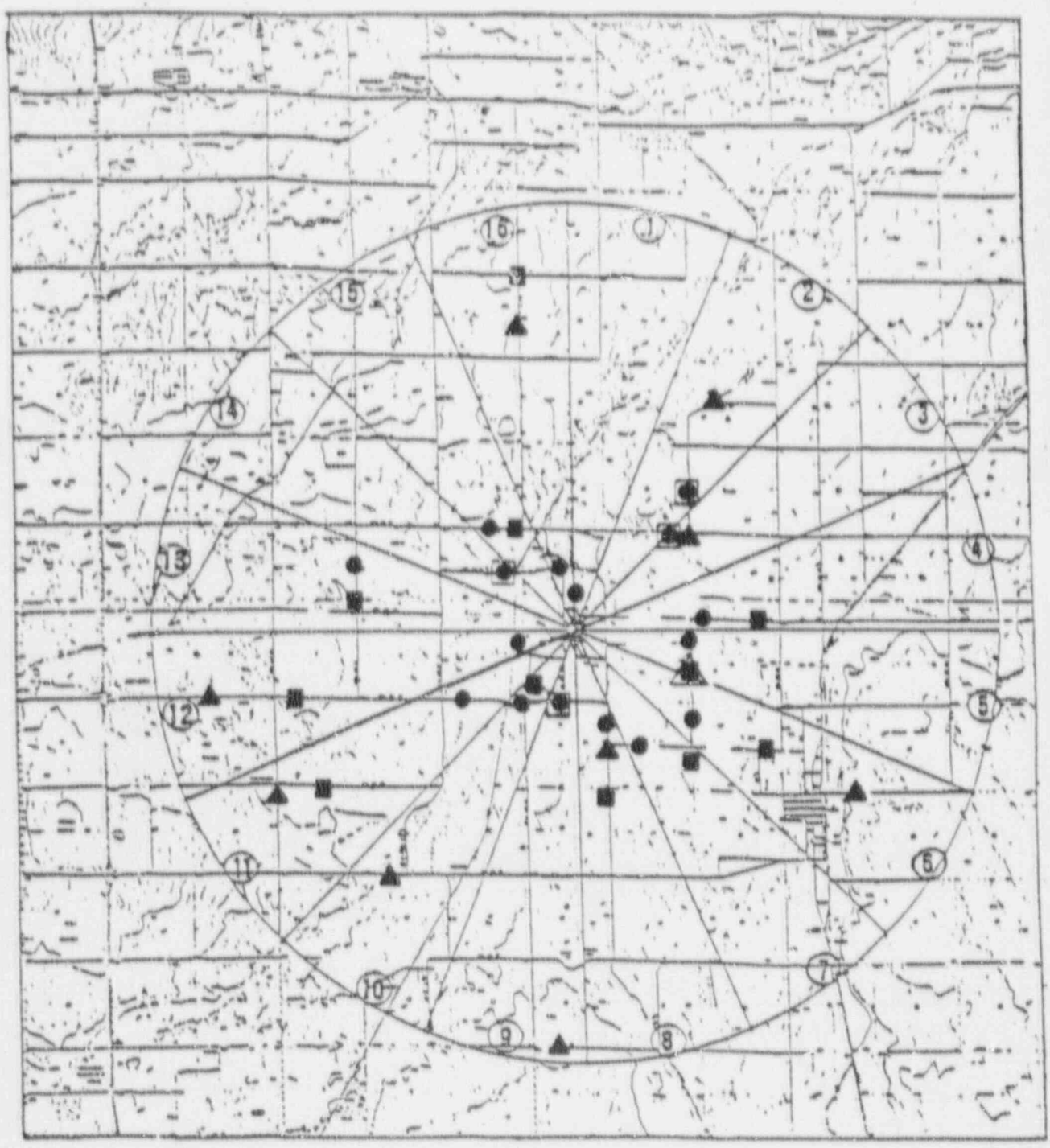


Table III.C.1 1990 Land Use Census*

Sector	Nearest Residence	Nearest Garden	Nearest Milk Animal
1	17578 CR 191/2	9626 CR 44**	***
2	18311 CR 23	18999 CR 23	11283 CR 40-1/2
3	11100 CR 38	11100 CR 38	11165 CR 38
4	11247 CR 36	11777 CR 36	11777 CR 36**
5	16543 CR 23	16134 CR 23	16134 CR 23
6	11056 CR 32	11585 CR 32**	11585 CR 32**
7	9999 CR 34	9999 CR 34**	***
8	15883 CR 21	14605 CR 21	15152 CR 13**
9	9379 CR 34	9379 CR 34	9033 CR 26
10	9061 CR 34	15449 CR 19	7388 CO 66
11	8745 CR 34	6769 CR 32	4513 CR 32**
12	Aristocrat Ranch	6519 CR 34	5492 CR 34
13	17038 CR 17**	17038 CR 17	***
14	8896 CR 19	8896 CR 19	***
15	9115 CR 38	9115 CR 38**	***
16	9239 CR 30	19751 CR 19**	18986 CR 19**

* Census Date: Sept. 7, 1990
** New Location
*** No milk animals

Figure III.C.1 Land Use Census, 1990



● Nearest Residence

■ Nearest Garden

▲ Nearest Milk Animal