RADIATION PROTECTION OFFICE
NORTH CAROLINA STATE UNIVERSITY

ENVIRONMENTAL RADIATION SURVEILLANCE REPORT
FOR THE PERIOD
JULY 1, 1991 - JUNE 30, 1992

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1. INTRODUCTION

The Environmental Radiation Surveillance Program exists to provide routine measurements of the university environment surrounding the PULSTAR Reactor. The specific objectives of this program include:

1) Providing information that assesses the adequacy of the protection of the university community and the public-at-large;

2) Meeting requirements of regulatory agencies;

3) Verifying radionuclide containment in the reactor facility;

4) Meeting legal liability obligations; and

5) Providing public assurance and acceptance.

During June 1992, the environmental program was reviewed by Mr. Craig Bassett of the U.S. Nuclear Regulatory Commission. The conclusion of his inspection was that the environmental monitoring program was being conducted adequately. (NRC Inspection Report No. 50-297/92-01).

2. AIR MONITORING (TABLES 2.1, 2.2, AND 2.3; FIGURES 2a THRU 2e)

This reporting period ends one (1) full year of operating the new air sampling systems installed at the five campus locations listed in Table 2.1. With the exception of a few minor wiring problems, these samplers have operated nearly continuously (24 hrs per day) without any malfunctions. Instances of missing data for the stations at Clark Labs, Withers Hall, and Riddick Hall are due to undersized wiring in the sampler unit which caused the fuse to blow. This problem has now been corrected.

Figures 2a thru 2e show bar graphs of gross beta activity (fCi/cubic meter vs. week number). The highest gross beta activity observed was 28.2 fCi m^{-3} and the yearly campus average was 11.7 fCi m^{-3}. The bar at week number 44 represents a two week period from 04/29/92 to 05/15/92. The air samplers were allowed to run continuously during the period without changing the filters to examine the effect of excessive dust loading. The results indicate that this probably causes decreased retention efficiency for airborne particulates and leads to an underestimation of the true gross beta activity of the filters.

Table 2. 2. lists LLD values for several gamma emitters which would be indicative of fission product activity. No gamma activity due to any of these radionuclides was detected. An examination of Table 2.2 reveals that around 09/12/91 LLD values for some of the listed radionuclides increased by a factor of 2 to 3. The explanation for this increase was slow in forthcoming due to another sporadic electronics problem in the MCA computer system. Failure of the detector preamplifier was finally diagnosed as the problem by the manufacturer. This problem has now been corrected. The reliability of the data acquired during this period was assured by counting a calibrated mixed gamma standard.

TABLE 2.1 LOCATION OF AIR MONITORING STATIONS

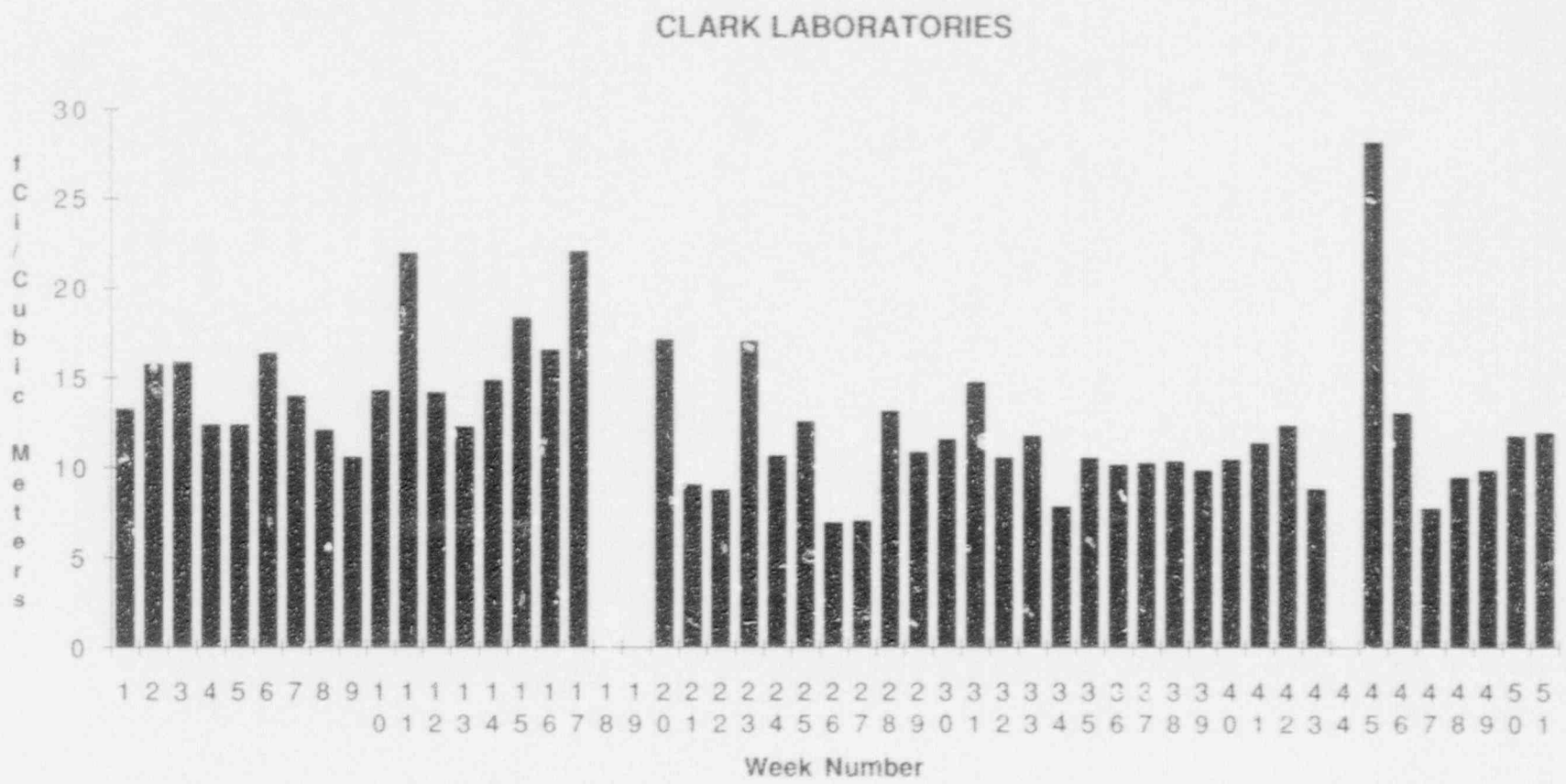
SITE	DIRECTION[1]	DISTANCE[2] (meters)	ELEVATION[3] (meters)
BROUGHTON	SOUTHWEST	125	-17
DAVID CLARK LABS	WEST	500	-18
LIBRARY	NORTHWEST	192	+11
RIDDICK	SOUTHEAST	99	-14
WITHERS	NORTHEAST	82	-6

[1]DIRECTION-DIRECTION FROM REACTOR STACK
[2]DISTANCE-DISTANCE FROM REACTOR STACK
[3]ELEVATION-ELEVATION RELATIVE TO THE TOP OF THE REACTOR STACK

FIGURE 2a

AIRBORNE GROSS BETA ACTIVITY
N. C. STATE UNIVERSITY CAMPUS

REGULATORY LIMIT=1000 fCi/CUBIC M
ALERT LEVEL=500 fCi/CUBIC M
LLD~1 fCi/CUBIC M



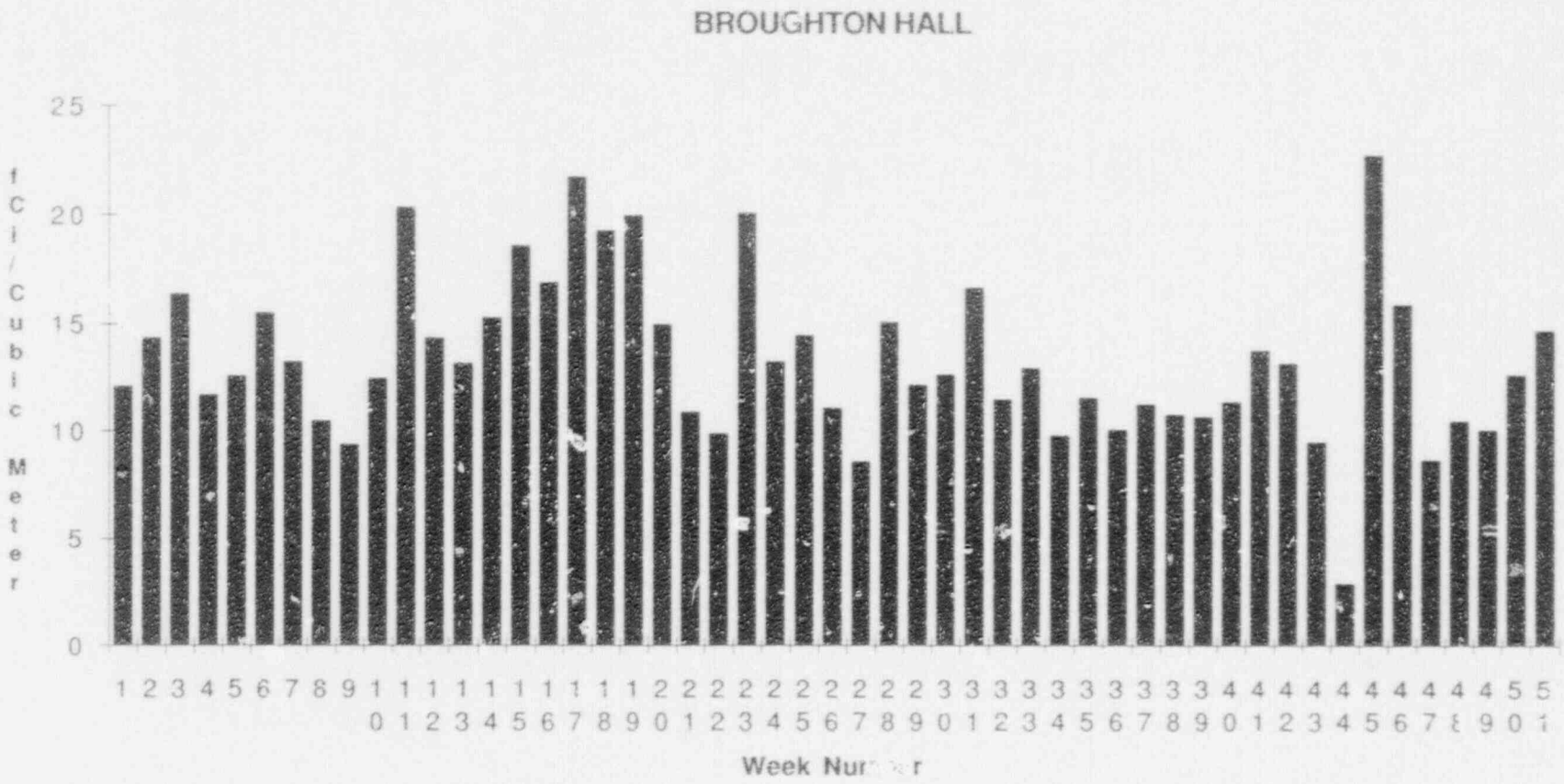
WEEK NUMBER FROM JULY 02, 1991 THROUGH JULY 01, 1992

JULY 02 BEGINS AT WEEK #1

FIGURE 2b

AIRBORNE GROSS BETA ACTIVITY
N. C. STATE UNIVERSITY CAMPUS

REGULATORY LIMIT=1000 fCi/Cubic M
ALERT LEVEL=500 fCi/CUBIC M
LLD=1 fCi/CUBIC M



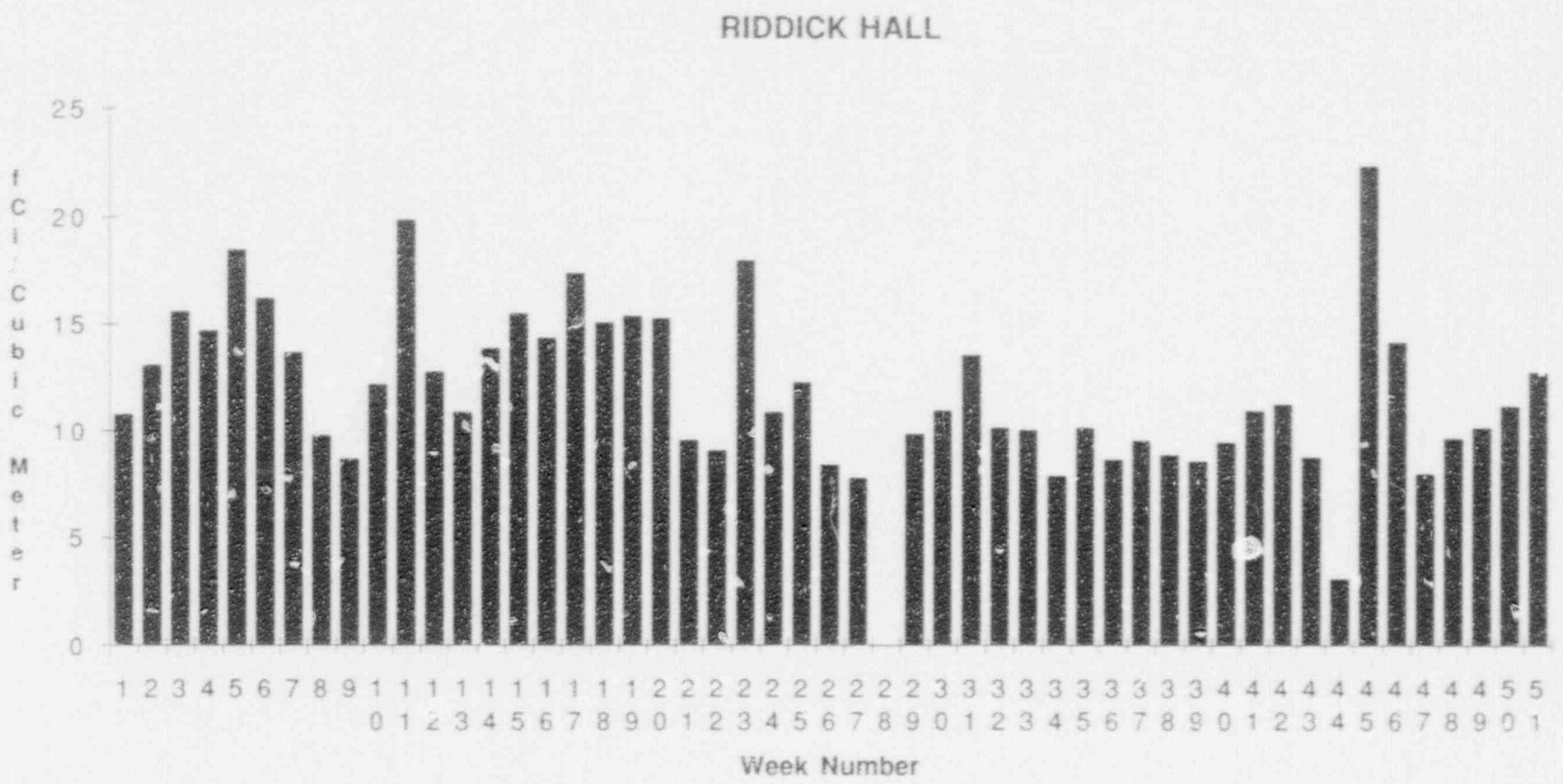
WEEK NUMBER FROM JULY 02, 1991 THROUGH JULY 01, 1992

JULY 02 BEGINS AT WEEK #1

FIGURE 2c

AIRBORNE GROSS BETA ACTIVITY
N. C. STATE UNIVERSITY CAMPUS

REGULATORY LIMIT=1000 fCi/CUBIC M
ALERT LEVEL=500 fCi/CUBIC M
LLD~1 fCi/CUBIC M



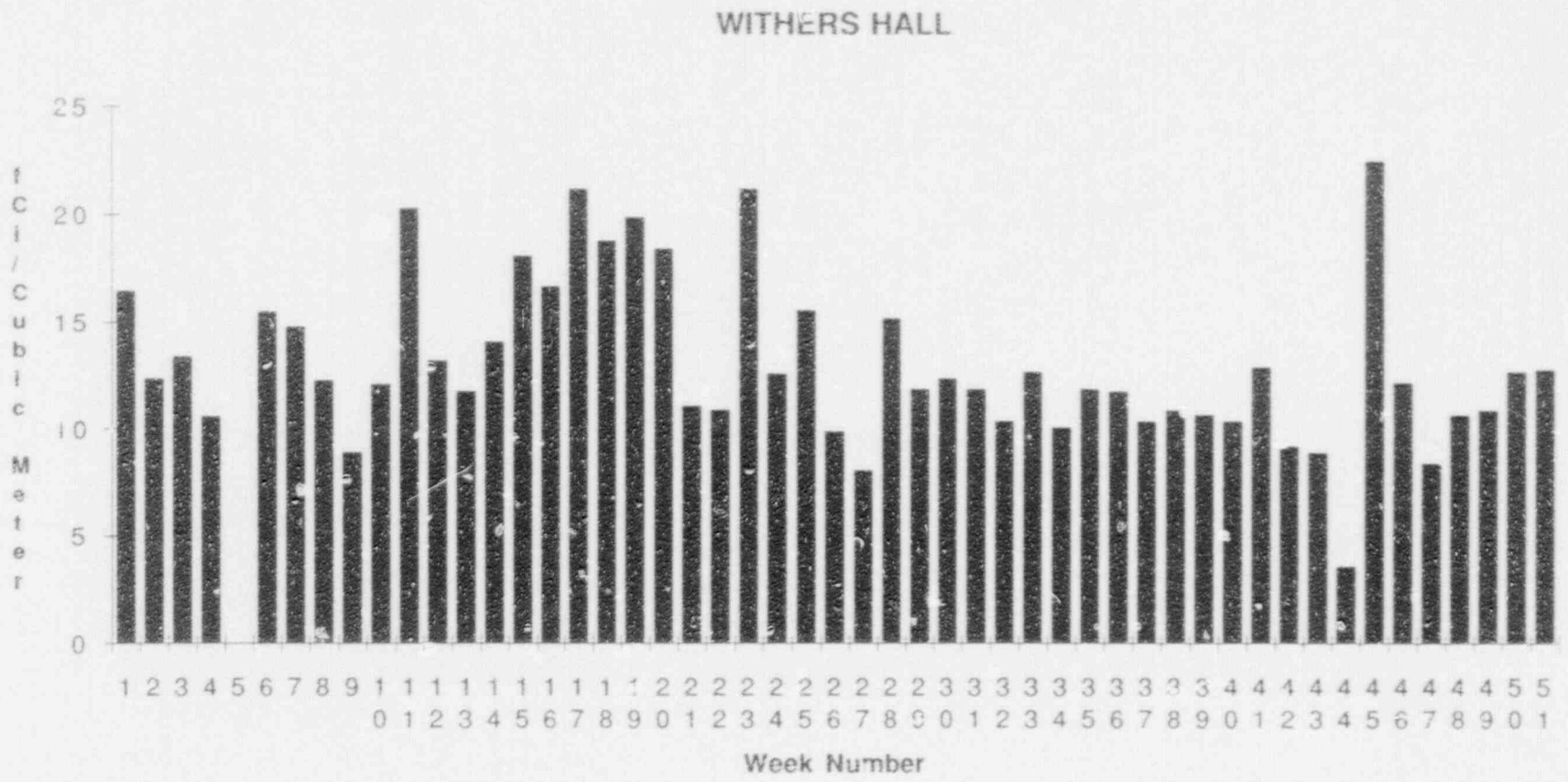
WEEK NUMBER FROM JULY 02, 1991 THROUGH JULY 01, 1992

JULY 02 BEGINS AT WEEK #1

FIGURE 2d

AIRBORNE GROSS BETA ACTIVITY
N. C. STATE UNIVERSITY CAMPUS

REGULATORY LIMIT=1000 fCi/CUBIC M
ALERT LEVEL=500 fCi/CUBIC M
LLD~1 fCi/CUBIC M



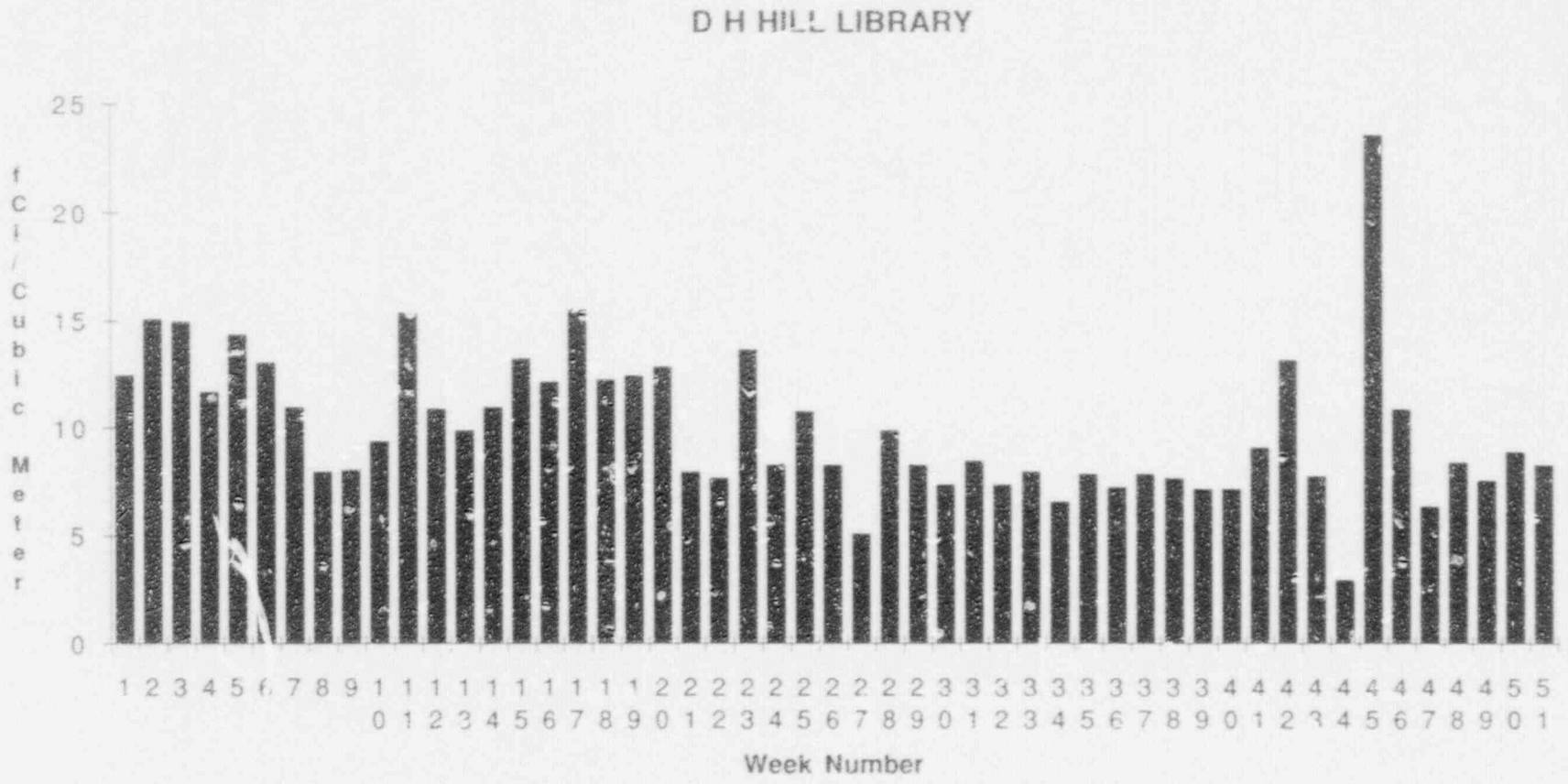
WEEK NUMBER FROM JULY 02, 1991 THROUGH JULY 01, 1992

JULY 02 BEGINS AT WEEK #1

FIGURE 2e

AIRBORNE GROSS BETA ACTIVITY
N. C. STATE UNIVERSITY CAMPUS

REGULATORY LIMIT=1000 fCi/CUBIC M
ALERT LEVEL=500 fCi/CUBIC M
LLD~1 fCi/CUBIC M



WEEK NUMBER FROM JULY 02, 1991 THROUGH JULY 01, 1992

JULY 02 BEGINS AT WEEK #1

TABLE 2.2 AERIALLY TRANSPORTED GAMMA ACTIVITY (LLD Values in fCi m^{-3})

	NUCLIDES								
SAMPLING PERIOD	Co-57	Co-60	Nb-95	Zr-95	Ru-103	Ru-106	Cs-137	Ce-141	Ce-144
1991									
07/02-07/09	0.08	0.13	0.17	0.28	0.17	0.96	0.11	0.26	0.63
07/09-07/16	0.08	0.12	0.15	0.25	0.14	1.0	0.11	0.23	0.59
07/16-07/23	0.08	0.12	0.14	0.26	0.14	0.99	0.12	0.21	0.61
07/23-07/31	0.08	0.12	0.13	0.24	0.14	1.0	0.11	0.18	0.61
07/31-08/06	0.11	0.19	0.19	0.31	0.18	1.5	0.16	0.23	0.84
08/06-08/13	0.06	0.11	0.09	0.18	0.10	0.79	0.09	0.12	0.49
08/13-08/20	0.08	0.13	0.13	0.19	0.12	1.0	0.12	0.15	0.65
08/20-08/28	0.06	0.10	0.10	0.15	0.09	0.77	0.09	0.11	0.47
08/28-09/03	0.12	0.19	0.18	0.27	0.17	1.4	0.16	0.20	0.91
09/03-09/12	0.06	0.09	0.08	0.15	0.08	0.67	0.08	0.10	0.42
09/12-09/17	0.14	0.23	0.21	0.32	0.20	1.7	0.19	0.25	1.1
09/17-09/24	0.13	0.21	0.21	0.30	0.18	1.5	0.19	0.22	1.0
09/24-10/01	0.14	0.27	0.24	0.44	0.22	1.9	0.22	0.33	1.1
10/01-10/08	0.13	0.23	0.21	0.38	0.20	1.5	0.18	0.28	1.0
10/08-10/15	0.16	0.29	0.24	0.40	0.21	2.1	0.22	0.32	1.2
10/15-10/22	0.15	0.31	0.23	0.37	0.19	2.1	0.24	0.29	1.1
10/22-10/29	0.22	0.36	0.35	0.52	0.28	2.9	0.32	0.37	1.7
10/29-11/06	0.16	0.28	0.29	0.48	0.26	2.3	0.26	0.37	1.3
11/06-11/13	0.18	0.35	0.28	0.48	0.26	2.6	0.28	0.37	1.4
11/13-11/19	0.16	0.30	0.25	0.44	0.23	2.3	0.26	0.33	1.2
11/19-11/27	0.27	0.50	0.40	0.77	0.38	3.6	0.45	0.51	2.1
11/27-12/03	0.24	0.50	0.40	0.73	0.39	3.7	0.39	0.52	2.0
12/03 - 12/10	0.17	0.32	0.25	0.47	0.25	2.3	0.27	0.33	1.3
12/10 - 12/16	0.21	0.43	0.33	0.55	0.29	2.9	0.31	0.44	1.6
12/16-12/20	0.15	0.28	0.24	0.43	0.21	2.1	0.23	0.30	1.2
12/20-12/31	0.16	0.32	0.26	0.44	0.22	2.0	0.24	0.29	1.2

ALL ENTRIES IN TABLE 2.2 ARE LLD VALUES.

TABLE 2.2 AERIALLY TRANSPORTED GAMMA ACTIVITY (LLD Values in fCi m^{-3})

	NUCLIDES								
SAMPLING PERIOD	Co-57	Co-60	Nb-95	Zr-95	Ru-103	Ru-106	Cs-137	Ce-141	Ce-144
1992									
12/31-01/07	0.14	0.26	0.22	0.42	0.19	1.9	0.22	0.26	1.1
01/07-01/14	0.17	0.32	0.28	0.47	0.25	2.3	0.27	0.26	1.3
01/14-01/21	---	---	---	POWER FAILURE		---	---	---	---
01/21-01/28	0.19	0.37	0.33	0.53	0.30	2.7	0.25	0.41	1.5
01/28-02/04	0.20	0.36	0.36	0.65	0.34	2.8	0.32	0.49	1.5
02/04-02/11	0.22	0.41	0.32	0.80	0.44	2.9	0.32	0.65	1.5
02/11-02/18	0.21	0.39	0.32	0.46	0.30	2.3	0.25	0.38	1.3
02/18-02/26	0.16	0.26	0.29	0.49	0.26	2.2	0.24	0.37	1.2
02/26-03/04	0.17	0.26	0.28	0.45	0.27	2.3	0.23	0.34	1.3
03/04-03/10	0.32	0.61	0.61	1.1	0.57	4.6	0.50	0.81	2.5
03/10-03/17	0.22	0.25	0.24	0.40	0.3	2.4	0.27	0.31	1.4
03/17-03/24	0.20	0.26	0.25	0.39	0.21	2.3	0.26	0.26	1.3
03/24-04/02	0.21	0.25	0.26	0.34	0.23	2.5	0.30	0.28	1.2
04/02-04/07	0.24	0.31	0.30	0.29	0.22	2.4	0.28	0.32	1.5
04/07-04/14	0.30	0.28	0.29	0.28	0.27	2.2	0.31	0.35	1.4
04/14-04/21	0.24	0.31	0.28	0.32	0.31	2.3	0.27	0.29	1.3
04/21-04/29	0.22	0.26	0.27	0.29	0.29	2.1	0.26	0.27	1.2
*04/29-05/15	0.23	0.45	0.42	0.76	0.39	2.7	0.25	0.58	1.5
05/15-05/22	0.21	0.28	0.31	0.32	0.22	2.1	0.31	0.40	1.4
05/22-05/27	0.24	0.27	0.27	0.29	0.19	2.0	0.26	0.31	1.3
05/27-06/03	0.07	0.11	0.11	0.18	0.11	0.9	0.10	0.14	0.53
06/03-06/10	0.07	0.12	0.10	0.16	0.10	0.9	0.09	0.14	0.50
06/10-06/16	0.08	0.14	0.11	0.18	0.11	0.9	0.12	0.14	0.62
06/16-06/23	0.09	0.17	0.14	0.21	0.11	1.0	0.12	0.15	0.65
06/23-07/01	0.08	0.14	0.11	0.20	0.11	0.9	0.11	0.14	0.63

*SAMPLE TAKEN OVER A TWO WEEK PERIOD

TABLE 2.3 REGULATORY LIMITS, ALERT LEVELS, AND BACKGROUND LEVELS FOR AIRBORNE RADIOACTIVITY (fCi m^{-3})

NUCLIDE	REGULATORY LIMIT	ALERT LEVEL	AVERAGE N.C. BACKGROUND LEVEL
GROSS ALPHA	20	10	4
GROSS BETA	1000	500	100
Cs-137	5×10^5	10	2
Ce-144	2×10^5	100	0
Ru-106	2×10^5	30	0
I-131	1×10^5	10	0

Reference: Environmental Radiation Surveillance Report 1986-88, State of N.C. Radiation Protection Section

3. MILK (TABLE 3.1)

Milk samples are collected each month from the Campus Creamery, the Lake Wheeler Road Dairy and the Randleigh Dairy Farm.

The FDA's Preventive Action Guide (PAG) for I-131 is 1.5 X 10^4 pCi/liter for infants. All analyses during this period show activities at least three (3) orders of magnitude below the PAG.

The analyses are performed in duplicate and the higher value is reported in each case.

TABLE 3.1 I-131 IN COWS' MILK (pCi $liter^{-1}$ $\pm$ 1 σ) LLD ~ 3 pCi $liter^{-1}$

	pCi $liter^{-1}$		
DATE	CAMPUS CREAMERY	LAKE WHEELER	RANDLEIGH
JULY 1991	≤ 3.3	≤ 3.4	≤ 3.3
* AUGUST 1991	No SampleData	No Sample Data	No Sample Data
SEPTEMBER 1991	≤ 1.4	≤ 1.4	≤ 1.4
OCTOBER 1991	≤ 3.0	≤ 3.0	< 3.0
NOVEMBER 1991	≤ 3.0	≤ 3.0	≤ 3.0
DECEMBER 1991	≤ 3.0	≤ 3.0	≤ 3.0
JANUARY 1992	≤ 3.5	≤ 3.5	≤ 3.5
FEBRUARY 1992	≤ 3.0	≤ 3.0	≤ 3.0
MARCH 1992	≤ 3.0	≤ 3.0	≤ 3.0
APRIL 1992	≤ 4.0	≤ 4.0	≤ 4.0
MAY 1992	≤ 3.0	≤ 3.0	≤ 3.0
JUNE 1992	≤ 3.0	≤ 3.0	≤ 3.0

* Samples lost due to refrigerator malfunction.

4. SURFACE WATER (TABLES 4.1 AND 4.2)

Table 4.1 gives the gross alpha and beta activities for water from Rocky Branch at points where it enters (ON) and exits (OFF) the campus. The LLD values for gross alpha and beta activities are ~ 0.4 pCi liter^{-1} and ~ 0.6 pCi liter^{-1}, respectively. For gross alpha activity the Alert Level is 5 pCi liter^{-1} and the Regulatory Limit is 15 pCi liter^{-1}. For gross beta activity the Alert Level is 12.5 pCi liter^{-1} and the Regulatory Limit is 50 pCi liter^{-1}. Samples with gross alpha or beta activities exceeding these Alert Levels would require gamma analysis to identify the radionuclides present. A problem with the HPGe gamma detection equipment required a recalibration of detection efficiencies. The LLD values in Table 4.2 are for the second quarter of 1992.

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TABLE 4.1 GROSS ALPHA AND BETA ACTIVITY IN SURFACE WATER (pCi liter^{-1} $\pm$ 2 σ)
***LLD $_{\alpha}$ ~ 0.4 pCi liter^{-1} LLD$_{\beta}$ ~ 0.4 pCi liter^{-1}**

		pCi liter^{-1}	
DATE	LOCATION	GROSS ALPHA	GROSS BETA
THIRD QUARTER 1991	ON	< 0.3	< 0.4
	OFF	< 0.3	< 0.4
FOURTH QUARTER 1991	ON	< 0.4	1.6 $\pm$ 0.4
	OFF	< 0.4	1.1 $\pm$ 0.4
FIRST QUARTER 1992	ON	< 0.3	< 0.4
	OFF	< 0.3	< 0.4
SECOND QUARTER 1992	ON	< 0.5	1.7 $\pm$ 0.4
	OFF	< 0.5	< 0.4

*LLD VALUES ARE DETERMINED QUARTERLY

TABLE 4.2 LOWER LIMITS OF DETECTION FOR SEVERAL GAMMA EMITTERS IN SURFACE WATER FROM NCSU ERSL ANALYSIS

NUCLIDE	LLD (pCi liter^{-1})
Co-60	0.4
Zn-65	0.7
Cs-137	0.3
Cs-134	0.4
Sr-85	0.4
Ru-103	0.3
Ru-106	3.0
Nb-95	0.4
Zr-95	0.5

*LLD VALUES ARE FOR THE 2ND QUARTER OF 1992

5. VEGETATION (TABLE 5.1 and 5.2)

Table 5.1 gives gross beta activities for grass samples collected on the NCSU Campus. The reported activities are all below the Alert Level of 20 pCi gram $^{-1}$. Table 5.2 lists LLD values for several gamma emitters. No gamma activity due to any of these radionuclides has been observed in campus vegetation. The beta and gamma activities are reported as pCi per gram of green vegetation.

TABLE 5.1 GROSS BETA ACTIVITY IN CAMPUS VEGETATION *LLD ~ 0.5 pCi g^{-1}

SAMPLE DATE	SAMPLE LOCATION	(pCi g^{-1} ± 2σ)
DECEMBER 1991	NORTH CAMPUS	2.6 ± 0.1
DECEMBER 1991	SOUTH CAMPUS	2.4 ± 0.1
DECEMBER 1991	EAST CAMPUS	3.3 ± 0.1
DECEMBER 1991	WEST CAMPUS	2.3 ± 0.1
JUNE 1992	NORTH CAMPUS	2.7 ± 0.1
JUNE 1992	SOUTH CAMPUS	4.6 ± 0.2
JUNE 1992	EAST CAMPUS	2.9 ± 0.1
JUNE 1992	WEST CAMPUS	2.9 ± 0.1

*LLD values are determined semiannually

Table 5.2 LLD VALUES FOR GAMMA EMITTERS IN VEGETATION

NUCLIDE	LLD (pCi gram^{-1})*
Co-60	0.01
Zn-65	0.02
Cs-137	0.01
Cs-134	0.01
Sr-85	0.01
Ru-103	0.01
Nb-95	0.01
Zr-95	0.02

*LLD VALUES ARE FOR THE 2ND QUARTER OF 1992

6. THERMOLUMINESCENT DOSIMETERS (TLDs) (TABLE 6.1)

TLD analysis is contracted to Teledyne Isotopes for determination of ambient gamma exposures. The dosimeters are $CaSO_4$ doped with dysprosium and have a manufacturer-stated sensitivity of 0.5 ± 0.15 mR (90% C.L.). Exposures are integrated over a three-month period at each of the five air monitor stations listed in Table 2.1 and also at the top of the PULSTAR Reactor stack. A control station is located in 214 David Clark Laboratories. Table 6.1 gives the data for these seven (7) sampling locations for the period 04/29/91 to 04/07/92.

The observed exposures are those expected to be produced by background radiations in this area of North Carolina. The data of Table 6.1 agrees well with the state-wide average exposure rate of ~ 18 - 20 mR per quarter year.

TABLE 6.1 ENVIRONMENTAL TLD EXPOSURES (mR/QUARTER YEAR ± 2 σ)

DATE	WITHERS	RIDDICK	BROUGHTON	LIBRARY	DAVID CLARK	PULSTAR STACK	CONTROL
* 04/29/91-06/27/91	10.4±1.4	17.4±1.9	14.2±0.8	18.0±1.9	10.3±2.7	6.8±0.9	13.2±4.0
06/27/91-09/27/91	12.2±0.7	19.6±2.4	14.7±1.0	17.2±2.3	12.2±0.6	12.0±1.1	12.9±3.2
09/27/91-01/02/92	14.8±1.4	22.0±1.9	18.2±1.5	19.3±1.2	12.4±2.8	13.2±1.2	15.9±1.3
01/02/92-04/07/92	13.5±1.6	21.4±3.4	19.0±2.1	19.3±1.8	12.4±1.2	12.7±0.7	14.5±1.3
04/07/92-06/27/92	- - - - -	- - - -	DATA NOT YET AVAILABLE		- - - - -	- - - - -	- - - - -

*THIS DATA WAS UNAVAILABLE FOR INCLUSION IN THE 1990-91 REPORT.

7. QUALITY CONTROL INTERCOMPARISON PROGRAM

The Environmental Radiation Surveillance Laboratory of the Radiation Protection Office has participated in the U. S. EPA Environmental Laboratory Intercomparison Studies Program during this reporting period. The objective of this program is to provide laboratories performing environmental radiation measurements with unknowns to test their analytical techniques. The results of the intercomparison studies are given in Table 7.1 a-h. All samples are analyzed in triplicate and reported as an average value with an experimental sigma (1s).

Appendix 1 gives an explanation of the quantities listed in the tables and an example calculation.

TABLE 7.1a GROSS ALPHA ACTIVITY AIR FILTER - INTERCOMPARISON STUDY - 30 AUGUST 1991

The known value for gross alpha activity is 25.0 pCi/filter with an expected laboratory precision 6.0 (1s, 1 determination).

NCSU - ENVIRONMENTAL LABORATORY RESULTS

ALPHA

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg)	(known)
OA	25.0	25.0	27.0	1.15	0.197	25.67	-0.77	0.19

STATISTICAL SUMMARY OF 172 PARTICIPANTS

Statistic	Respondents	Non-outliers
Mean	29.12	Grand Avg 28.33
Std. Dev.	11.82	5.03
Variance	139.72	25.35
% Coef. of Var.	40.58	17.77
% deviation of mean from known value	16.50	13.31
Norm. dev. of mean from known value	0.35	0.66
Median	27.33	27.33
% deviation of median from known value	9.33	9.33
Norm. dev. of median from known value	0.20	0.46

TABLE 7.1b GROSS BETA ACTIVITY AIR FILTER - INTERCOMPARISON STUDY - 30 AUGUST 1991

The known value for gross beta activity is 92.0 pCi/filter with an expected laboratory precision of 10.0 (1s, 1 determination).

NCSU - ENVIRONMENTAL LABORATORY RESULTS

BETA

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng inal (R + SR)	Average	Normalized deviation (grand-avg)(known)	
CA	95.0	97.0	96.0	1.00	0.118	96.00	0.08	0.69

STATISTICAL SUMMARY OF 172 PARTICIPANTS

Statistic	Respondents		Non-outliers
Mean	97.25	Grand Avg	95.54
Std. Dev.	20.93		9.04
Variance	438.26		81.80
% Coef. of Var.	21.53		9.47
% deviation of mean from known value	5.71		3.85
Norm. dev. of mean from known value	0.25		0.39
Median	95.00		95.00
% deviation of median from known value	3.26		3.26
Norm. dev. of median from known value	0.14		0.33

TABLE 7.1c ^{137}Cs ACTIVITY AIR FILTER INTERCOMPARISON STUDY - 30 AUGUST 1991

The known value for Cesium-137 activity is 30.0 pCi/filter with an expected laboratory precision of 5.0 (1s, 1 determination).

NCSU - ENVIRONMENTAL LABORATORY RESULTS

137 Cs

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg)/(known)	
CA	31.00	31.00	31.00	0.00	0.000	31.00	-0.51	0.35

STATISTICAL SUMMARY OF 172 PARTICIPANTS

Statistic	Respondents		Non-outliers
Mean	36.36	Grand Avg	32.48
Std. Dev.	44.41		5.38
Variance	1971.96		28.91
% Coef. of Var.	122.13		16.55
% deviation of mean from known value	21.20		8.26
Norm. dev. of mean from known value	0.14		0.46
Median	31.67		31.67
% deviation of median from known value	5.56		5.56
Norm. dev. of median from known value	0.04		0.31

TABLE 7.1d GROSS ALPHA ACTIVITY AIR FILTER - INTERCOMPARISON STUDY - 27 MARCH 1992

The known value for gross alpha activity is 7.0 pCi/filter with an expected laboratory precision of 5.0 (1s, 1 determination).

NCSU - ENVIRONMENTAL LABORATORY RESULTS

ALPHA

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg)(known)	
CA	8.0	7.0	9.0	0.58	0.118	7.67	-0.24	0.23

STATISTICAL SUMMARY OF 179 PARTICIPANTS

Statistical	Respondents		Non-outliers
Mean	9.25	Grand Avg	8.35
Std. Dev.	7.20		1.69
Variance	51.88		2.84
% Coef. of Var.	77.88		20.20
% deviation of mean from known value	32.13		19.25
Norm. dev. of mean from known value	0.31		0.80
Median	8.00		8.00
% deviation of median from known value	14.29		14.29
Norm. dev. of median from known value	0.14		0.59

TABLE 7.1e GROSS BETA ACTIVITY AIR FILTER - INTERCOMPARISON STUDY -27 MARCH 1992

The known value for gross beta activity is 41.0 pCi/filter with an expected laboratory precision of 5.0 (1s, 1 determination).

NCSU - ENVIRONMENTAL LABORATORY RESULTS

Beta

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg)(known)	
QA	42.0	42.0	42.0	0.00	0.000	42.0	-0.11	0.35

STATISTICAL SUMMARY OF 179 PARTICIPANTS

Statistic	Respondents		Non-outliers
Mean	42.19	Grand Avg	42.32
Std. Dev.	10.06		3.31
Variance	101.17		10.98
% Coef. of Var.	23.84		7.83
% deviation of mean from known value	2.90		3.23
Norm. dev. of mean from known value	0.12		0.40
Median	42.00		42.00
% deviation of median from known value	2.44		2.44
Norm. dev. of median from known value	0.10		0.30

TABLE 7.11 GROSS ALPHA ACTIVITY IN WATER - INTERCOMPARISON STUDY -15 MAY 1992

The known value for gross alpha activity is 15.0 pCi/liter with an expected laboratory precision of 5.0 (1s, 1 detc mination).

NCSU - ENVIRONMENTAL LABORATORY RESULTS

GROSS ALPHA

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg)(known)	
QA	17.0	18.0	16.0	1.00	0.236	17.00	0.92	0.69

STATISTICAL SUMMARY OF 233 PARTICIPANTS

Statistic	Respondents		Non-outliers
Mean	16.13	Grand Avg	14.34
Std. Dev.	12.25		4.94
Variance	150.15		24.36
% Coef. of Var.	75.97		34.41
% deviation of mean from known value	7.53		-4.37
Norm. dev. of mean from known value	0.09		-0.13
Median	14.33		14.17
% deviation of median from known value	-4.44		-5.56
Norm. dev. of median from known value	-0.05		-0.17

TABLE 7.1g GROSS BETA ACTIVITY IN WATER - INTERCOMPARISON STUDY -15 MAY 1992

The known value for gross beta activity is 44.0 pCi/liter with an expected laboratory precision of 5.0 (1s, 1 determination).

NCSU - ENVIRONMENTAL LABORATORY RESULTS

GROSS BETA

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand-avg)(known)	
CA	39.0	39.0	38.0	0.58	0.118	38.67	-1.43	-1.85

STATISTICAL SUMMARY OF 233 PARTICIPANTS

Statistic	Respondents		Non-outliers
Mean	44.89	Grand Avg	42.79
Std. Dev.	26.78		6.81
Variance	717.24		46.42
% Coef. of Var.	59.66		15.92
% deviation of mean from known value	2.03		-2.75
Norm. dev. of mean from known value	0.03		-0.18
Median	43.67		43.67
% deviation of median from known value	-0.76		-0.76
Norm. dev. of median from known value	-0.01		-0.05

TABLE 7.1h TRITIUM IN WATER - INTERCOMPARISON STUDY - 21 JUNE 1991*

The known value for tritium activity is 12480.0 pCi/liter with an expected laboratory precision of 1248.0 (1s, 1 determination).

NCSU - ENVIRONMENTAL LABORATORY RESULTS

^{3}H

Lab	Res. 1	Res. 2	Res. 3	Exper. Sigma	Rng anal (R + SR)	Average	Normalized deviation (grand avg)(known)	
QA	14162	13995	14053	84.72	0.079	14070	2.27	2.21

STATISTICAL SUMMARY OF 159 PARTICIPANTS

Statistic	Respondents		Non-outliers
Mean	12218.27	Grand Avg	12434.92
Std. Dev.	1864.38		940.81
Variance	3475926.91		885115.64
% Coef. of Var.	15.26		7.57
% deviation of mean from known value	-2.10		-0.36
Norm. dev. of mean from known value	-0.14		-0.05
Median	12387.67		12413.83
% deviation of median from known value	-0.74		-0.53
Norm. dev. of median from known value	-0.05		-0.07

*These results have been included in this report as they were received after submission of the 1990-91 report.

8. CONCLUSIONS

The data obtained during this period do not show any fission product activities. The observed environmental radioactivity is due primarily to radon progeny, primordial radionuclides (e.g., K-40) and those radionuclides (e.g., Be-7) which originate in the upper atmosphere as the result of cosmic ray interactions. These facts justify the conclusion that the PULSTAR Reactor facility continues to operate safely and does not release fission product materials into the environment.

9. ACKNOWLEDGMENTS

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The graphs in this report are available due to the assistance of Mr. Worth Bowman, and the entire arrangement and typing are due to the excellent efforts of Mrs. Ginger Davis.

APPENDIX 1

The vertical columns in Tables 7 are identified as columns 1-8 from left to right.

Column 1: Laboratory identification code (e.g., QA).

Columns 2, 3, 4: Laboratory results given in triplicate.

Column 5: Standard deviation (1s) of the experimental results.

Column 6: Normalized range value in "mean range + standard error of the range".

Column 7: Average value of the triplicate analysis.

Column 8: Normalized deviation from the grand average value of all laboratories expressed in σ_m units.

Column 9: Normalized deviation from the known value expressed in σ_m units.

The following example calculation gives a set of data, the mean value, the experimental sigma, and the range. These statistics provide measures of the central tendency and dispersion of the data.

The normalized range is computed by first finding mean range, R, the control limit, CL, and the standard error of the range, σ_R. The normalized range measures the dispersion of the data (precision) in such a form that control charts may be used. Control charts allow one to readily compare past analytical performance with present performance. In the example, the normalized range equals 0.3 which is less than 3 which is the upper control level. The precision of the results is acceptable.

The normalized deviation is calculated by computing the deviation and the standard error of the mean, σ_m. The normalized deviation allows one to measure central tendency (accuracy) readily through the use of control charts. Trends in analytical accuracy can be determined in this manner. For this example, the normalized deviation is -0.7 which falls between +2 and -2 which are the upper and lower warning levels. The accuracy of the data is acceptable.

Finally, the experimental error of all laboratories, the grand average, and the normalized deviation from the grand average are calculated in order to ascertain the performance of all the laboratories as a group. Any bias in methodology or instrumentation may be indicated by these results.

EXAMPLE CALCULATIONS

Experimental data:

Known value = μ = 3273 pCi ^{3}H/liter urine on September 24, 1974

Expected laboratory precision = σ = 357 pCi/liter

Laboratory	Sample	Result
D	x_1	3060 pCi/liter
D	x_2	3060 pCi/liter
D	x_3	3240 pCi/liter

Mean = $\bar{x}$

$$\bar{x} = \frac{\sum_{i=1}^{N} x_i}{N} = \frac{9360}{3} = 3120 \text{ pCi/liter}$$

where N = number of results = 3

Experimental sigma = s

$$s = \sqrt{\frac{\sum_{i=1}^{N} (x_i)^2 - \frac{\left(\sum_{i=1}^{N} x_i\right)^2}{N}}{N - 1}}$$

$$s = \sqrt{\frac{(3060)^2 + (3060)^2 + (3240)^2 - \frac{(3060 + 3060 + 3240)^2}{3}}{2}}$$

s = 103.9 pCi/liter

Range = r

r = | maximum result - minimum result |

r = | 3240 - 3060 | = 180 pCi/liter

Range Analysis (RNG ANLY)*

Mean range = $\overline{R}$

$\overline{R} = d_2\sigma$ where d_2** = 1.693 for N = 3

$= (1.693)\ (357)$

$\overline{R} = 604.4$ pCi/liter

Control limit = CL

$CL = \overline{R} + 3\sigma_R$

$= D_4\overline{R}$ where D_4** = 2.575 for N = 3

$= (2.575)\ (604.4)$

CL = 1556 pCi/liter

Standard error of the range = σ_R

$\sigma_R = (R + 3\sigma_R - \overline{R}) \div 3$

$= (D_4\overline{R} - \overline{R}) \div 3$

$= (1556 - 604.4) \div 3$

$\sigma_R = 317.2$ pCi/liter

Let range = $r = w\overline{R} + x\sigma_R = 180$ pCi/liter

Define normalized range = $w + x$

for $r > \overline{R}$, $w = 1$

then $r = w\overline{R} + x\sigma_R = \overline{R} + x\sigma_R$

or $x = \dfrac{r - \overline{R}}{\sigma_R}$

therefore $w + x = 1 + x = 1 + \dfrac{r - \overline{R}}{\sigma_R}$

*Rosenstein, M., and A. S. Goldin, "Statistical Techniques for Quality Control of Environmental Radioassay," AQCS Report Stat-1, U.S. Department of Health Education and Welfare, PHS, November 1964.

**From table "Factors for Computing Control Limits," Handbook of Tables for Probability and Statistics, 2nd Edition, The Chemical Rubber Co., Cleveland, Ohio, 1968, p. 454.

for $r \leq R$, $x = 0$

then $r = w\overline{R} + x\sigma_R = w\overline{R}$

or $w = \frac{r}{\overline{R}}$

therefore $w + x = w + 0 \quad \frac{r}{\overline{R}}$

since $r < \overline{R}$, $(180 < 604.4)$

$$w + x = \frac{180}{604.4}$$

$$w + x = 0.30$$

Normalized deviation of the mean from the known value = ND

Deviation of mean from the known value = D

$$D = \overline{x} - \mu$$

$$= 3120 - 3273$$

$$D = -153 \text{ pCi/liter}$$

Standard error of the mean = σ_m

$$\sigma_m = \frac{\sigma}{\sqrt{N}}$$

$$= \frac{357}{\sqrt{3}}$$

$$\sigma_m = 206.1 \text{ pCi/liter}$$

$$ND = \frac{D}{\sigma_m}$$

$$= \frac{-153}{206.1}$$

$$ND = -0.7$$

Control limit = CL

$CL = (\mu \pm 3\sigma_m)$

Warning Limit = WL

$WL = (\mu \pm 2\sigma_m)$

Experimental sigma (all laboratories) = s_t

$$s_t = \sqrt{\frac{\sum_{i=1}^{N} (x_i)^2 - \frac{\left(\sum_{i=1}^{N} x_i\right)^2}{N}}{N - 1}}$$

$$= \sqrt{\frac{162039133 - \frac{(49345)^2}{15}}{14}}$$

$$s_t = 149 \text{ pCi/liter}$$

Grand average = GA

$$GA = \frac{\sum_{i=1}^{N} x_i}{N}$$

$$= \frac{49345}{15}$$

$$GA = 3290 \text{ pCi/liter}$$

Normalized deviation from the grand average = ND'

Deviation of the mean from the grand average = D'

$$D' = \bar{x} - GA$$

$$= 3120 - 3290$$

$$D' = -170 \text{ pCi/liter}$$

$$ND' = \frac{D'}{\sigma_m}$$

$$= \frac{-170}{206.1}$$

$$ND' = -0.8$$