North Carolina State University

Nuclear Reactor Program
Department of Nuclear Engineering

Box 7909
Raleigh, NC 27695-7909
(919) 737-2301

August 31, 1989

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Docket No. 50-297
ANNUAL REPORT

Dear Sir:

In compliance with Section 6.7.5 of the North Carolina State University PULSTAR Technical Specifications, our Nuclear Reactor Program staff has prepared the attached Annual Report for the period 1 July 1988 through 30 June 1989.

Sincerely,

Garry D. Miller

Garry D. Miller
Associate Director

TCB/GDM:vg
copy to: All with attachments:

1. USNRC Director of Regulatory Operations, Region II
2. Dr. J. Richard Mowat, Chairman
   Radiation Protection Council
3. Dr. Hayne Palmour, III, Chairman
   Reactor Safeguards Advisory Committee
4. Dr. D. W. Morgan
   Radiation Protection Officer
5. Dr. L. K. Monteith, Dean
   College of Engineering
6. Dr. Thomas S. Elleman, Head
   Department of Nuclear Engineering

IE47
1/1

PULSTAR ANNUAL REPORT TO

UNITED STATE NUCLEAR REGULATORY COMMISSION

for the

Period 1 July 1988 - 30 June 1989

Submitted by

G. D. Miller, Associate Director

NCSU NUCLEAR REACTOR PROGRAM

Prepared by Thomas C. Bray
PULSTAR Reactor Operations Manager

Reference: PULSTAR Technical Specifications
Section 6.7.5

Docket No. 50-297

Department of Nuclear Engineering
North Carolina State University
Raleigh, North Carolina 27607

August 31, 1989

DEPARTMENT OF NUCLEAR ENGINEERING

PULSTAR REACTOR ANNUAL REPORT

For the Period: 1 July 1988 - 30 June 1989

The following report is submitted in accordance with Section 6.7.5 of the PULSTAR Technical Specifications:

6.7.5.a Reactor Operating Experience:

(1) The NCSU PULSTAR Reactor has been utilized for the following:

a.	Teaching and Short Courses	75.02	hours
b.	Graduate Research	18.10	hours
c.	Faculty Research	98.65	hours
d.	Isotope Production	3.17	hours
e.	Neutron Radiography	0.40	hours
f.	Neutron Activation Analysis	2346.00	hours
g.	NPP Reactor Operator Training	738.98	hours
h.	PULSTAR Reactor Operator Training	33.42	hours
i.	Reactor Calibrations and Measurements	25.68	hours
j.	Reactor Health Physics Surveillance	7.77	hours
	TOTAL	3347.19	hours

Same reporting period 1987-1988 3250.41 hours

A cross section of experiments performed in the reactor relate to these areas:

a. Neutron Activation Analysis of animal tissue, fly ash, sediments, rain/river water, filters, resins, coal, milk, graphite, textile fiber, etc.

b. Reactor thermal power measurements for teaching laboratories.

c. Isotope Production

d. Thermal neutron depth profiling of Boron-implanted silicon.

e. Neutron diffusion length measurements in graphite.

f. Neutron Radiography.

g. Thermal neutron diffusion in oils

(2) Changes in Performance Characteristics Related to Reactor Safety:

None

(3) Results of Surveillance, Tests, and Inspections:

The reactor surveillance program has revealed no significant nor unexpected trends in reactor systems performance during this report period.

6.7.5.b Total Energy Output:

1174.934 Megawatt-hours
48.955 Megawatt-days

Pulse Operations:

0

Reactor was Critical:

1522.433 hours

Cumulative Total Energy Output since Initial Criticality:

14,838.479 Megawatt-hours
618.270 Megawatt-days

6.7.5.c Number of Emergency and Unscheduled Shutdowns:

Unscheduled shutdowns - 3 total

(1) Secondary coolant pump would not start from the remote switch in Control Room.

(2) Irradiation basket string broke while loading.

(3) ECP outside allowed window

Inadvertent scrams - 13 total

(4)	Operator error	8
(5)	Flow/Flapper scram at 100 KW	1
(6)	Manual scram switch	1
(7)	Manual scram - false fire alarm	1
(8)	Low primary flow	1
(9)	Campus electrical power interruption	1

Explanation of (1) above:

Lock-out ring had been left in stop position following maintenance.

Explanation of (2) above:

Handling string, from which the irradiation basket was suspended, parted as basket was being lowered in the vertical exposure port. Basket descended inside exposure port and came to rest where it would have had the string not parted. Operator discretion cause of manual scram; action not required by procedure.

Explanation of (3) above:

Experimenter had overestimated value of negative reactivity effect of a given irradiation target and that error caused the ECP window of ± 200 pcm to be exceeded. Shutdown following a missed ECP window is required by operating procedure. After reactivity estimate was corrected, the ACP was satisfactory.

Explanation of (4) above:

Misadjustment of the Linear power channel range switch by NPP and NRP operator trainees.

Explanation of (5) above:

Reactor was operating in free convection mode with flapper open and primary pump secured. Scram annunciator displayed a flow/flapper failure but such was not the case under free convection condition. Cause attributed to spurious Log N or Safety channel picoammeter signal.

Explanation of (6) above:

e manual scram switch developed an open-contact condition and caused a scram. Switch was determined faulty and was replaced by exact spare in stock.

Explanation of (7) above:

Fire alarm pull box was activated as a student prank while reactor was operating. Operating procedures require reactor shutdown by manual scram (followed by building evacuation) when fire alarm sounds.

Explanation of (8) above:

Primary coolant flow rate trip switch activated at a conservative 485 gpm rather than the 475 gpm designated setpoint. Small flow rate variations of brief time duration are normal in the primary cooling system.

Explanation of (9) above:

A campus electrical power interruption will result in an automatic reactor scram due to RSS design.

6.7.5d. Major Maintenance Operations:

None during this reporting period

6.7.5e. Changes in Facility, Procedures, Tests, and Experiments:

(1) Design Change 88-3, Seal Material Change in Primary Pool Hole-Sealing Device

Following the pool hole-sealing device installation on 4/15/88, periodic sealing material inspections conducted thereafter revealed undesirable shrinkage of the sealing material. Closed-cell EPDM foam selected for the original seal was responding to the pool water pressure by progressive shrinkage but there was less evidence of structural damage to the foam from radiation exposure than was anticipated. Consequently, a new sealing material, neoprene with a Shore "A" hardness of 5 to 10 durometer, was recommended by NCSU Materials Science department. The new sealing material, installed 6/13/88, has performed satisfactorily to date.

Safety Evaluation: "Reactor operational safety will not be affected by this change. Pool water level change, assuming the seal failed completely, could be maintained quite easily by the reactor Service Water System thus providing ample time for seal replacement."

(2) Design Change 89-1, PULSTAR Evacuation Horns for Burlington Labs South Wing

Following decommissioning of the R-63 facility in the South Wing, all evacuation horns and circuitry associated with the R-63 were removed. Since that time, many spaces in the South Wing have been converted to offices and laboratories and the personnel occupation level is such now that building complex evacuation notice to those occupants is considered appropriate. An additional reason for restoring evacuation horns in the South Wing is evident from the pedestrian traffic standpoint; many people enter Burlington Engineering Laboratory building via the adjoining South Wing. During an evacuation sequence, traffic control can be simplified if pedestrian entry to the building is minimized and South Wing evacuation horns will be effective in that respect.

Safety Evaluation: "Preliminary tests verify that additional evacuation horns connected as proposed do not affect performance of existing evacuation horns."

(3) Procedure Changes

Special Procedures 2.1 through 9.4 (24 total) were revised to reflect editorial and minor technical changes. All were approved by the campus review group in April 1989.

Special Procedures 3.2, 4.5, 5.8 and 5.9 are new documents composed of instructions previously contained in surveillance files and the Operations Manual. All were approved by the campus review group in April 1989.

Health Physics Procedures 20-16, 20-17, 20-18, 20-19, 20-21 and 30-2 are new documents and revised documents. All were approved by the campus review group in March and April 1989.

Environmental Procedures ERS-HV, ERS-MP, ERS-M, ERS-SW, ERS-CF, ERS-CV, ERS-TLD and ERS-RWW are surveys/analyses conducted by the NCSU Radiation Protection Office. These procedures were recently written, representing a formalization of activities routinely performed for many years in connection with NCSU PULSTAR Technical Specifications. The campus review group approved these procedures in April 1989.

The procedures enumerated above are assembled in manual/binder form and the index for each procedure category is attached to this report.

SPECIAL PROCEDURES INDEX

NO.	REV	TITLE
2.1	2	Reviewing Proposed Changes to Components, Systems, Structures, and Procedures
2.2	1	Reactor Operator Assistant Qualification
2.3	2	Reactor Operator Qualification
2.4	3	PULSTAR Drawing Control System
2.5	1	PULSTAR Reactor Surveillance
2.6	4	PULSTAR Operator Requalification
3.1	3	Removal and Installation of Control Rods and Control Rod Drive Mechanisms
→ 3.2	0	Control Rod Drive Mechanisms Post Maintenance Testing
3.3	2	Fuel Handling Procedures
3.4	1	Fuel Pin Inspection
4.1	3	Test of Pulse Interlocks
4.2	4	Pre-Pulse Checks
4.3	1	Routine Pulsing
4.4	1	Pulsing E_T Measurment by Gold Foil Irradiation
→ 4.5	0	Startup Channel Discriminator Curve
5.1	1	Draining the Primary System
5.2	2	Removal and Installation of Valve Pit Shields
5.3	1	Draining the Secondary System
5.4	1	Purification System Startup
5.5	1	Purification System Shutdown
5.6	4	Purification System Resin Change
5.7	2	Filling and Draining Beam Tubes
→ 5.8	0	Service Water System
→ 5.9	0	Pool Fill Procedure
9.1	1	Beam Tube Shielding Plugs Handling Procedure
9.2	3	Installation and Removal of Experimental Facilities, Vertical Exposure Ports (VEPs)
9.3	3	Installation and Removal of the Neutron Radiography Facility
9.4	3	Routine Operation of the Neutron Radiography Facility

Issued by the NRP Administrative Office
April 28, 1989

HEALTH PHYSICS PROCEDURES INDEX

NO.	REV	TITLE
1-1	0	Training Requirements for Selected Emergency Team Members Who Wear Self-Contained Breathing Apparatus (SCBA)
1-2	0	Maintenance of Self-Contained Breathing Apparatus (SCBA)
10-1	2	Inventory and Location of Special Nuclear Material
10-2	2	Special Nuclear Material (SNM) Accountability
10-3	2	Radiation Work Permit
10-4	0	Receipt of Radioactive Materials (yet to be issued)
10-5	2	Transfer and Shipment of Radioactive Material
20-1	2	Servicing Continuous Filter Air Sampler PULSTAR Off-line Air Sampler
20-2	2	Release of Radioactive Wastes to the Sanitary Sewer System
20-3	2	Sampling Waste Water Tanks
20-4	2	Water Samples From PULSTAR Pool Surface
20-5	2	Water Samples From Piping Valves
20-6	2	PULSTAR Deep Pool Water Samples
20-7	2	Water Sample Preparation for Neutron Activation Analysis
20-8	2	Water Sample Preparation for Gross Beta/Gamma Counting
20-9	2	pH Determination Using Corning 125 Digital Meter
20-10	2	Resistivity Measurements Using YSI Model 31 Meter
20-11	2	Preparation of Air Sample Filters for Laboratory Proportional Counting
20-12	2	Changing Continuous Air Monitors (CAM) Filters
20-13	2	Calibration of Eberline Continuous Air Monitor (CAM)
20-14	2	Radiation and Contamination Surveys of PULSTAR Bay
20-15	2	Determine Efficiency and Operating Plateau Gas Flow Proportional Counters
→ 20-16	1	Calibration (Electronic) and Efficiency checks for RM-14 Monitors
→ 20-17	0	Drift and Response Checks for Direct Read-Out Dosimeters
→ 20-18	0	Decontamination
→ 20-19	0	Lower Limit of Detection (LLD) and Minimum Detectable Concentration (MDC)
20-20	0	Sample Analysis Using The Nuclear Services Gamma Spectroscopy System (yet to be issued)
→ 20-21	0	Tritium Analysis of Waste Water
20-22	0	GM Detector Sensitivity to Argon-41 (Channel #5)
30-1	2	Access to Restricted Areas
→ 30-2	0	Radiation Safety Training

ENVIRONMENTAL PROCEDURES

INDEX

Issued by NRP Administrative Office
May 24, 1989

6.7.5(F) Radioactive Effluents:

Liquid Waste (summarized by quarters)

1. Radioactivity released during the reporting period.

Quarter	Period	(a) no. of batches	(b) total μCi	(c) tot. vol. in ltrs	(d) Diluent ltrs	(e) Tritium μCi
1st	1 Jul - 30 Sep 88	14	44.06	4.77 E4	6.25 E4	37.80
2nd	1 Oct - 31 Dec 88	6	70.98	2.05 E4	1.57 E5	66.35
3rd	1 Jan - 31 Mar 89	6	82.59	2.04 E4	1.86 E5	77.60
4th	1 Apr - 30 Jun 89	6	162.25	2.05 E4	3.85 E5	104.44

(f) 286.19 μCi were released during this reporting period.

(g) 359.88 μCi were released during this reporting period.

2. Identification of Fission and Activation Products.

The gross alpha-beta-gamma activity of the batches in (a) above were less than 4×10^{-5} μCi/ml. An isotopic analysis of these batches indicated only background activity.

3. Disposition of liquid effluents not releasable to Sanitary Sewer System. All batches of 1(a) above when diluted by campus water resulted in activity considerably less than 4×10^{-7} μCi/ml. Therefore all batches were released to the sanitary sewer system.

Gaseous Waste (summarized monthly)

1. Radioactivity discharged during the reporting period (in Curies) for:

a. Gases

Year	Period	Total Time In Hours	Curies
1988	01 Jul - 29 Jul	673.92	.343
	30 Jul - 29 Aug	741.50	.45
	30 Aug - 28 Sep	719.00	.66
	29 Sep - 27 Oct	704.50	.36
	28 Oct - 28 Nov	760.75	.44
	29 Nov - 31 Dec	792.00	.32
1989	01 Jan - 03 Feb	815.50	.47
	04 Feb - 06 Mar	744.50	.20
	07 Mar - 05 Apr	743.50	.23
	06 Apr - 03 May	671.25	.27
	04 May - 01 Jun	728.75	.35
	02 Jun - 03 Jul	735.50	.25
		8830.67	4.343

(b) Particulates whose half-life is greater than (8) days.

Filters from the particulate monitoring channel were analyzed upon removal again the following week. There was no particulate activity ((b) above) indicated on any filter during this reporting period.

2. Gases and particulate discharged during this reporting period.

Gases:

The yearly average concentration of $Argon^{41}$ released from the PULSTAR reactor facility exhaust stack during this period was 1.4×10^{-8} $\mu Ci/ml$.

Particulates:

See gaseous waste 1(b) above.

SOLID WASTE FROM REACTOR

1. total volume of solid waste - 58 ft^3

2. total activity of solid waste - 0.085 mCi

3. Dates of shipments and disposal:

11 Aug 1988	CNSI
03 Apr 1989	CNSI
05 Apr 1989	CNSI
19 Jul 1989	CNSI

6.7.5.G: Personnel Radiation Exposure Report (Reporting Period 05/01/88-05/31/89)

Faculty and Staff	Total Exposure (rem)
BIDDY, Oscar D.	0.010
BILYJ, Stephen J.	0.040
BRACKIN, Thomas L.	0.030
BRAY, Thomas C.	0.010
CAVES, John R.	0.030
DAVIS, Glenda	0.030
DOSTER, J. Michael	0.020
ELLEMAN, Thomas S.	0.020
GARDNER, Robin P.	0.010
GILLIGAN, John	0.040
GRADY, Stanley M.	0.060
HANKINS, Orlando H.	0.020
JOHNSON, Charles M.	0.040
KOHL, Jerome	0.0
LAMBERT, Joseph P. F.	0.010
LODGE, Phillip S	0.050
MANI,Kolam V.	0.010
MILLER, Gerry D.	0.010
MUNN, R. Hugh	0.0
MURTY, K. Linga	0.020
RAYNO, DONALD R.	0.010
STAM, E.	0.020
STRICKLAND, David D.	0.010
TITTLE, Charles	0.020
TURINSKY, Paul J.	0.050
VERGHESE, Kuruvilla	0.010
WEAVER, Jack N.	0.010
WEHRING, Bernard	0.010
WILSHIRE, Frank W.	0.020

OTHER:
27 film badges were issued monthly to graduate students and temporary staff;
71 film badges were issued for student laboratories;
130 film badges were issued for short courses;
333 film badges were issued for visitors.

No significant radiation exposures were reported; the majority of these radiation exposures were in the "no measurable exposure" range.

6.7.5.h Summary of Radiation and Contamination Surveys Within the Facility

Neither the radiation nor the contamination surveys indicated any trend or shift of data from past experience/surveys.

6.7.5.i Description of Environmental Surveys Outside of the Facility

(See Attachment A)

RADIATION PROTECTION OFFICE
NORTH CAROLINA STATE UNIVERSITY

ENVIRONMENTAL RADIATION SURVEILLANCE REPORT
FOR THE PERIOD
AUGUST 1988 - JULY 1989

RALTON J. HARRIS
ENVIRONMENTAL HEALTH PHYSICIST

1. INTRODUCTION

In accordance with recommendations issued by the Environmental Audit Committee in 1987, several issues have been addressed in the PULSTAR environmental monitoring program. These items are briefly discussed below:

1) Data for the environmental thermoluminescent dosimeters (TLDs) placed at each monitoring station will be included in the annual environmental radiation surveillance report.
2) The positive displacement pumps recommended to replace the current air sampling equipment have not been obtained due to budgetary restrictions. An increased maintenance program has been proposed to extend the monitoring capability of the current equipment until funding can be acquired for new equipment.
3) Gamma analysis of surface water will now be performed utilizing ion exchange techniques rather than the previous method involving evaporation of large volumes of water.
4) Strontium-90 analysis of cows' milk is being discontinued in favor of I-131 analysis. Future environmental reports will reflect this change.
5) Analysis of campus soil has been discontinued since it does not provide data pertinent to any reactor effluent releases.
6) Campus vegetation will be analyzed semiannually for both gross beta and gamma activities.

As a necessary consequence of these changes, the environmental laboratory procedures have been complete rewritten in considerable detail.

The Environmental Radiation Surveillance Laboratory of the Radiation Protection Office has joined the U.S. Environmental Protection Agency Environmental Laboratory Intercomparison Studies Program during this reporting period. A major objective of this program is to assist laboratories involved in environmental radiation measurements to develop and maintain both an intralaboratory and inter-laboratory quality control program. In part, this is accomplished through an extensive laboratory intercomparison studies program involving environmental media (milk, water, and air) and a variety of radionuclides with activities at or near environmental levels. Simulated environmental samples containing known amounts of one or more radionuclides are prepared and periodically distributed to the participating laboratory. The required analyses are performed and the results are returned to the Nuclear Radiation Assessment Division for statistical analysis and comparison with known values as well as with analytical values obtained by other participating laboratories. In addition, the Environmental Radiation Surveillance Laboratory has been able to establish a formalized schedule with the State of North Carolina Division of Facility Services for split-sample comparison of environmental samples.

2. AIR MONITORING

Table 2.1 shows the locations of the air monitoring stations. Figures 2a-2f give a graphical representation of the gross beta activities observed during this reporting period. Gross beta activities are determined by counting Millipore air filters which are collected on a weekly basis from the five (5) campus monitor stations. Due to recurring operational difficulties, data is not available for several weeks during the sampling period. These instances have been indicated on the graphs as "sampler inoperative."

The stations at David Clark, Riddick, and D. H. Hill Library show higher than usual activities during the period 12/06/88 to 12/20/88. This behavior is repeated again during the period 01/10/89 to 01/24/89. The stations at Broughton and Withers do not reflect this trend. This brief period of increased activity would appear to be due to naturally occurring radon progeny since gamma analysis has indicated only the presence of radon progeny, naturally occurring Be-7 and Cs-137 fallout activity at or below the average North Carolina background level of ~ 2 fCi m^{-3} during this period. These increased gross beta activity levels are not of concern since they are at least a factor of five (5) below the alert level value of 500 fCi m^{-3}. As a point of information, the Alert Level indicates a level of observed radioactivity which warrants further sample analysis to confirm its presence. The term "Alert" carries no implication of health or safety hazards.

The data entries of Table 2.2 prefixed by "<" are the LLD values for each nuclide. During the period 11/01/88 to 11/15/88, several nuclides show elevated LLD values which resulted from problems with instrumentation and monitoring equipment. Other fluctuations in LLD values are attributable to variations in the volume of air sampled by the monitoring system. The data of Table 2.2 indicate that none of the listed radionuclides were present in detectable concentrations. Table 2.3 gives a listing of Regulatory Limits, Alert Levels, and average North Carolina background activity levels for those nuclides for which data is available. Environmental air is currently monitored for the presence of gaseous radioiodine using charcoal cartridges as the collection medium. At present the data derived from this monitoring is of limited utility due to the low volume of air which can be sampled, and, hence, an achievable detection limit which is too large relative to the Alert Level. For this reason radioiodine data has not been tabulated in this report. Hopefully, this problem can be solved in the future with the purchase of new equipment.

- - - - - - - - - - - -

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

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

SAMPLING PERIOD 1988	NUCLIDES Co-57	Co-60	Nb-95	Zr-95	Ru-103	Ru-106	Cs-137	Ce-141	Ce-144
08/03-08/09	<1.3	<1.4	<1.7	<2.8	<2.3	<8.7	<2	<6.4	<10.4
08/09-08/16	<1.3	<1	<1.7	<2.8	<2.3	<8.7	1.9 ± 0.5	<6.4	<10.4
08/16-08/23	<1.6	<1.2	<2.1	<3.5	<2.7	<11	<1.3	<7.6	<13.3
08/23-08/30	<1.1	<0.83	<1.3	<2.2	<1.7	<7.5	<0.86	<4.6	<9.1
08/30-09/06	<1.6	<1.4	<1.6	<2.8	<2.7	<8.7	<2	<6.4	<9.1
09/06-09/13	<1.9	<1.2	<1.8	<3.0	<2.4	<11.5	1.5 ± 0.5	<7.0	<15.5
09/13-09/20	<2.2	<1.3	<1.9	<3.2	<2.6	<13.0	1.5 ± 0.5	<7.4	<17.7
09/20-09/28	<1.7	<1.0	<1.4	<2.3	<1.8	<9.9	1.4 ± 0.4	<4.9	<13.5
09/28-10/04	<2.8	<1.2	<1.7	<3	<2.7	<11	<2	<7.0	<13.0
10/04-10/11	<2.8	<1.4	<2	<3	<2.7	<13.0	<2	<7.0	<13.3
10/11-10/18	<2.8	<2.2	<2.5	<4.2	<2.7	<19.0	<2.3	<6.7	<22.7
10/18-10/25	<2.0	<1.7	<1.8	<3.0	<1.9	<14.0	<2.2	<4.5	<16.8
10/25-11/01	<2.8	<1.8	<5.3	<9.0	<10.1	<17.1	<1.9	<37.5	<22.8
11/01-11/09	<1.1	<35.9	<10.8	<19.0	---	---	<8.2	---	---
11/09-11/15	<7.2	<4.6	<12.2	<20.6	<21.6	<43.7	<4.8	<76.5	<58.2
11/15-11/22	<1.4	<1	<2.3	<3.9	<3.9	<8.7	<1	<13.6	<11.6
11/22-11/29	<1	<1	<1.4	<2.3	<2.3	<5.3	<0.6	<7.7	<7.0
11/29-12/06	<0.7	<.5	<1	<1.6	<1.5	<3.9	0.7 ± 0.3	<5.1	<5.2
12/06-12/13	<2.9	<1.9	<4.1	<6.8	<6.3	<17.6	1.6 ± 0.7	<20.5	<23.2
12/13-12/20	<2.5	<1.7	<3.5	<5.8	<5.0	<15.5	<1.8	<16.1	<20.4
12/20-01/03/89	<1.4	<1	<1.8	<3.0	<2.4	<8.8	0.8 ± 0.3	<7.4	<11.4

TABLE 2.2 CONTINUED NEXT PAGE

TABLE 2.2 AERIALLY TRANSPORTED GAMMA ACTIVITY (fCi m^{-3}) CONTINUED

SAMPLING PERIOD 1989	NUCLIDES								
	Co-57	Co-60	Nb-95	Zr-95	Ru-103	Ru-106	Cs-137	Ce-141	Ce-144
01/03-01/10	<2.2	<1.5	<2.6	<4.4	<3.5	<13.8	1.7 ± 0.4	<10.4	<18.0
01/10-01/17	<2.1	<1.4	<2.4	<3.9	<3.0	<13.0	<1.6	<8.7	<16.8
01/17-01/24	<2.4	<1.7	<2.6	<4.3	<3.1	<15.1	2.2 ± 0.5	<9.0	<19.3
01/24-01/31	<3.4	<2.4	<3.5	<5.8	<4.0	<21.1	<2.7	<11.3	<27.4
01/31-02/07	<2.2	<1.6	<2.1	<3.5	<2.4	<13.8	1.6 ± 0.7	<6.5	<17.6
02/07-02/14	<1.8	<1.3	<1.7	<2.8	<1.8	<11.4	1.2 ± 0.4	<4.9	<14.5
02/24-02/21	<1.9	<1.4	<1.7	<2.9	<1.8	<12.2	<1.6	<4.7	<15.5
02/21-02/28	<1.3	<1.0	<1.2	<1.9	---	<8.6	<1.1	<3.0	<10.9
02/28-03/07	<3.3	<2.1	<2.3	<3.9	<2.6	<20.1	<2.5	<7.0	<26.9
03/07-03/14	<3.3	<2.1	<2.3	<3.7	<2.4	<20.1	3.1 ± 0.9	<6.5	<27.0
03/14-03/21	<4.3	<3.2	<3.5	<5.7	<3.5	<27.4	<3.4	<9.1	<35.3
03/21-03/28	<1.2	<1	<1	<1.6	<1.0	<7.8	3.0 ± 0.7	<2.6	<9.9
03/28-04/04	<3.3	<2.5	<2.6	<4.3	<2.6	<21.3	2.8 ± 0.9	<6.5	<27.0
04/04-04/11	<1.2	<1	<1.0	<1.6	---	<8.1	<1	<2.4	<10.2
04/11-04/18	<3.4	<2.6	<2.9	<4.7	<3.0	<21.8	1.9 ± 1.0	<7.8	<27.9
04/18-04/25	<3.0	<1.8	<2.1	<3.6	<2.3	<17.7	<2.1	<6.1	<24.5
04/25-05/02	<3.4	<2.1	<2.4	<4.0	<2.7	<19.5	4.5 ± 0.8	<7.1	<27.5
05/03-05/09	<1.7	<1.0	<1.2	<1.9	---	<9.8	<1.2	<3.3	<13.7
05/09-05/16	<3.2	<1.9	<2.4	<4.1	<2.8	<18.5	1.9 ± 0.7	<7.6	<26.0
05/16-05/23	<2.5	<1.5	<1.8	<3.1	<2.1	<14.6	1.5 ± 0.6	<5.7	<20.5
05/23-05/30	<3.2	<1.9	<2.3	<3.8	<2.6	<17.9	<2.3	<7.0	<25.5
05/31-06/06	<1.7	<1.0	<1.2	<2.0	---	<9.7	<1.2	<3.3	<13.7
06/07-06/13	<2.2	<1.7	<2.0	<3.2	<1.9	<15.6	<2.0	<5.0	<18.5
06/13-06/21	<0.8	<0.6	<0.6	<1.1	<0.6	<5.4	3.7 ± 0.8	<1.6	<6.4
06/21-06/27	<2.2	<1.7	<2	<3	<2	<15.6	<2.0	<5.0	<19
06/27-07/05	<1.4	<1.1	<1.2	<2.1	<1.2	<10.1	1.5 ± 0.4	<3.1	<11.9
07/05-07/11	<2.2	<1.7	<1.9	<3.1	<1.8	<15.0	<1.9	<4.7	<17.9

FIGURE 2.2a

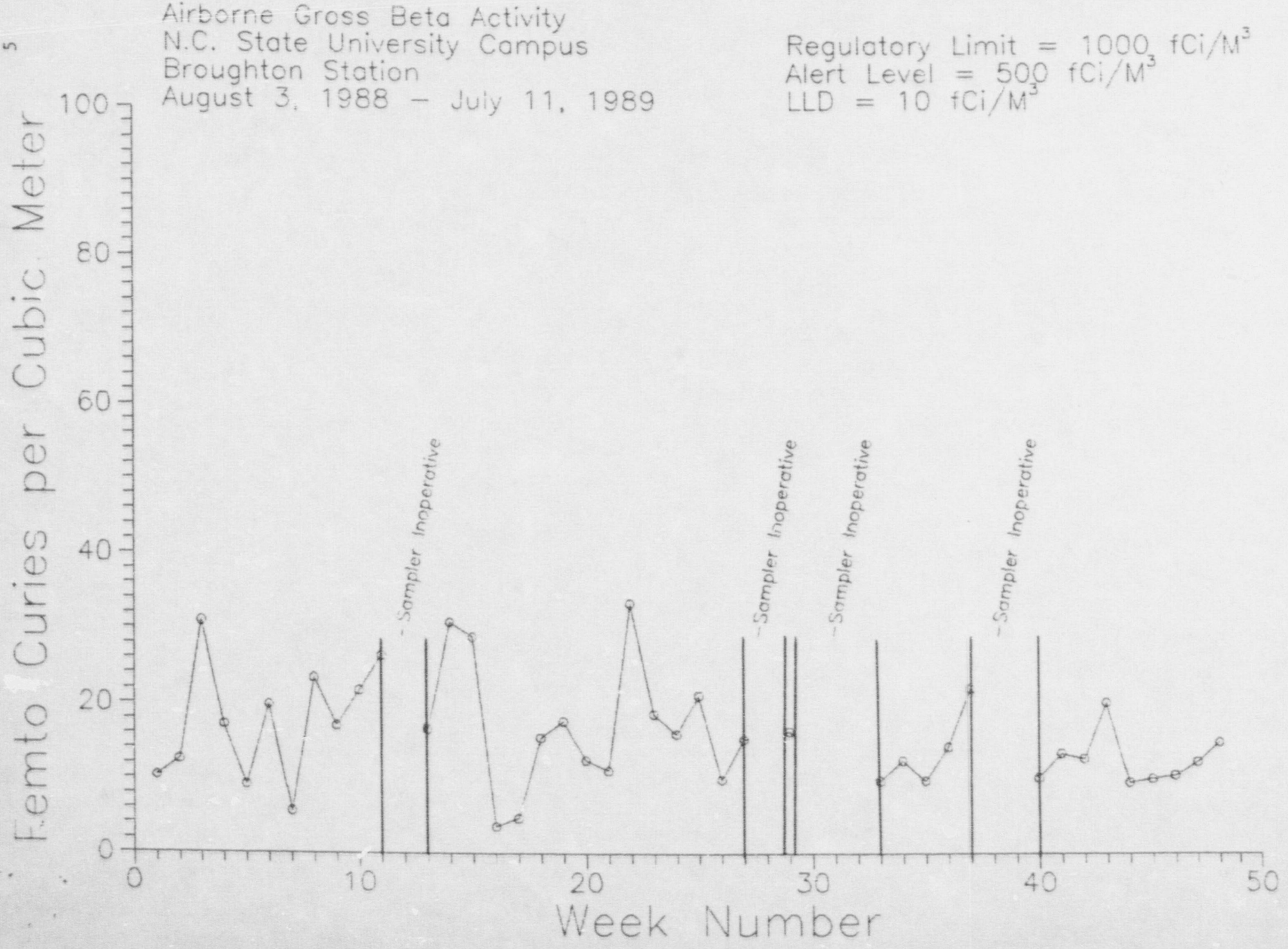

Airborne Gross Beta Activity
N.C. State University Campus
Broughton Station
August 3, 1988 – July 11, 1989
Regulatory Limit = 1000 fCi/M3
Alert Level = 500 fCi/M3
LLD = 10 fCi/M3
Femto Curies per Cubic Meter
100
80
60
40
20
0
Sampler Inoperative
Sampler Inoperative
Sampler Inoperative
Sampler Inoperative
0
10
20
30
40
50
Week Number

FIGURE 2.2b

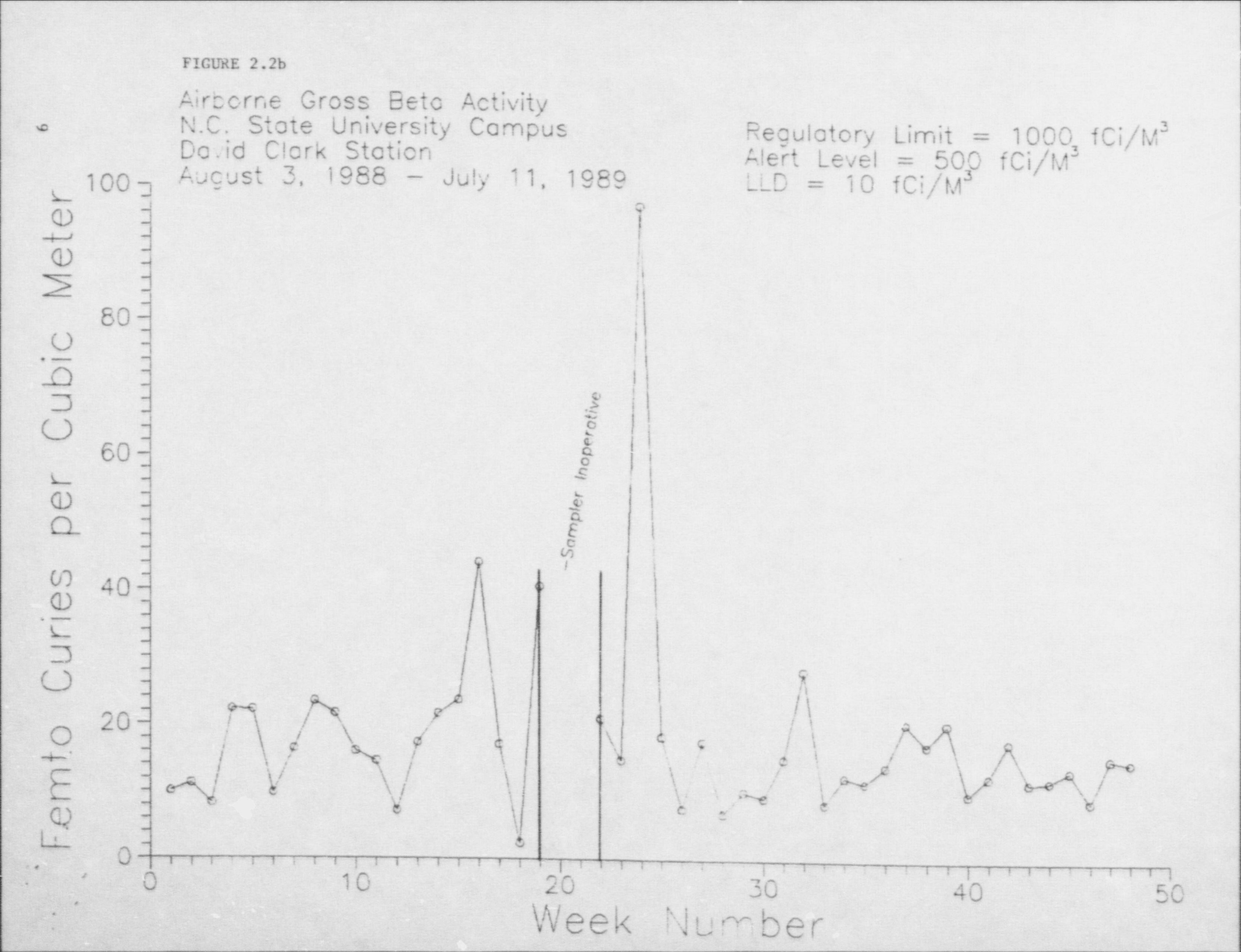

Airborne Gross Beta Activity
N.C. State University Campus
David Clark Station
August 3, 1988 – July 11, 1989
Regulatory Limit = 1000 fCi/M3
Alert Level = 500 fCi/M3
LLD = 10 fCi/M3
Femto Curies per Cubic Meter
Week Number
Sampler Inoperative
0
20
40
60
80
100
0
10
20
30
40
50

FIGURE 2.2c

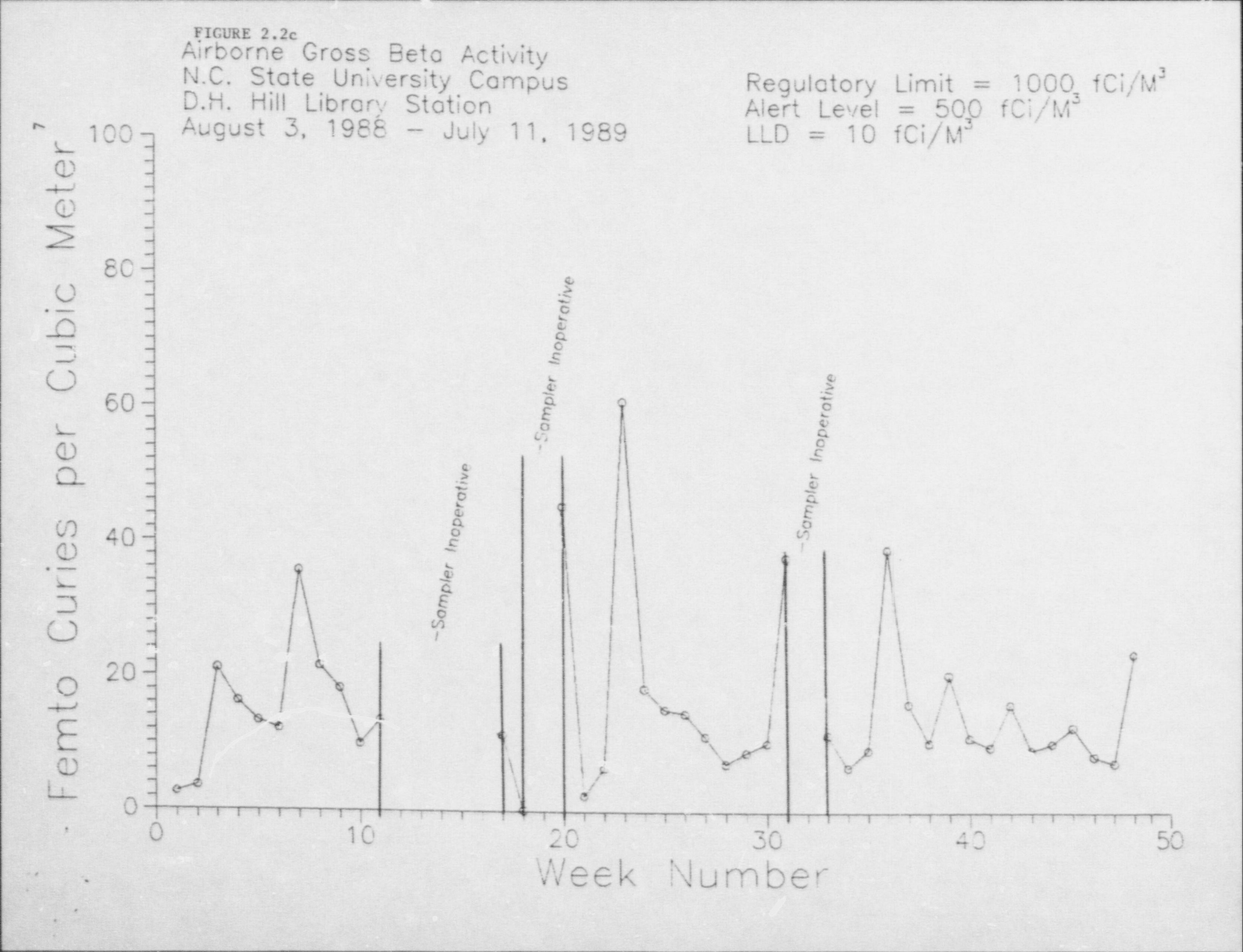

Airborne Gross Beta Activity
N.C. State University Campus
D.H. Hill Library Station
August 3, 1988 - July 11, 1989
Regulatory Limit = 1000 fCi/M3
Alert Level = 500 fCi/M3
LLD = 10 fCi/M3
Femto Curies per Cubic Meter
Week Number
Sampler Inoperative
Sampler Inoperative
Sampler Inoperative
0
20
40
60
80
100
0
10
20
30
40
50

FIGURE 2.2d

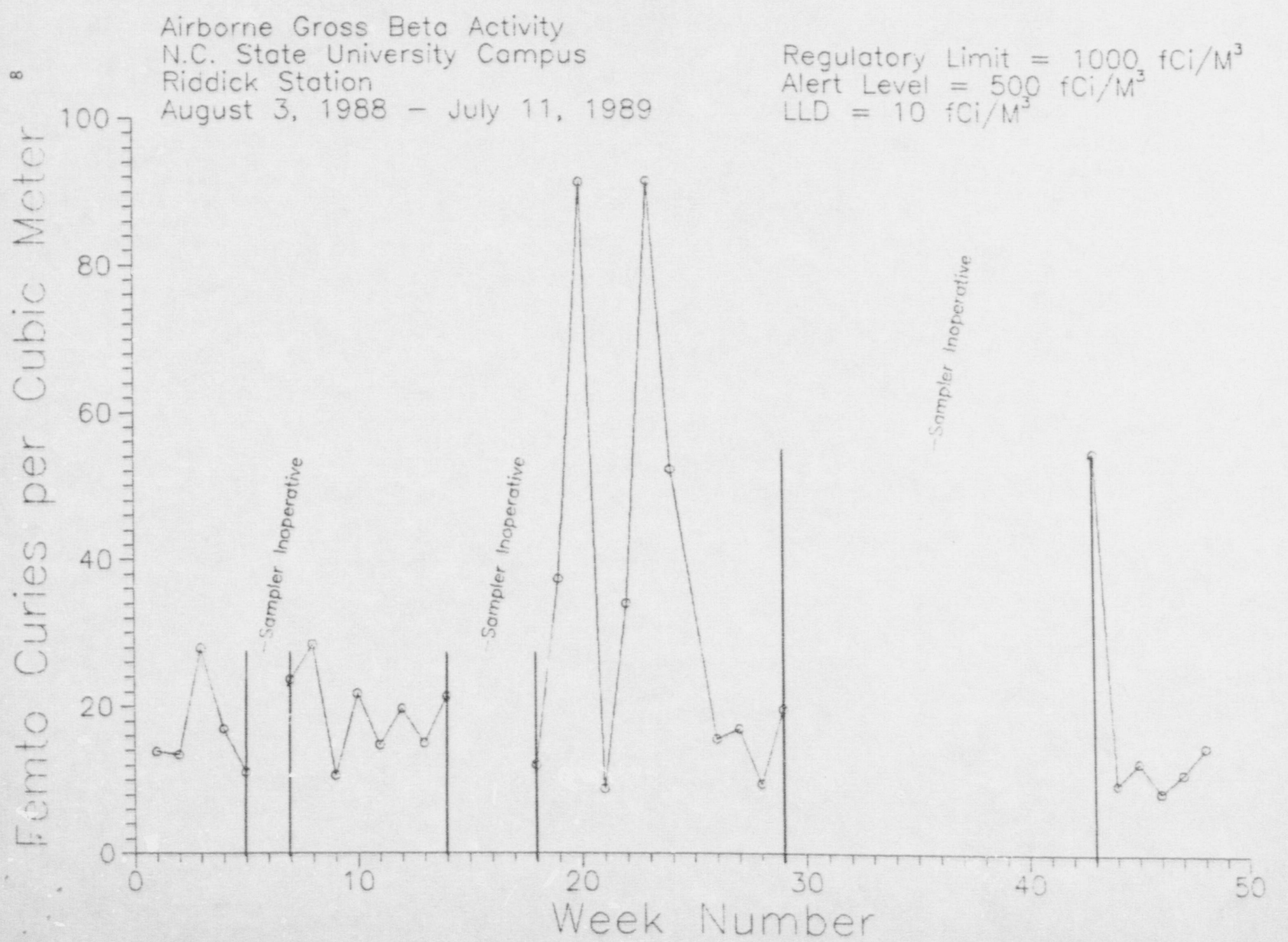

Airborne Gross Beta Activity
N.C. State University Campus
Riddick Station
August 3, 1988 – July 11, 1989
Regulatory Limit = 1000 fCi/M3
Alert Level = 500 fCi/M3
LLD = 10 fCi/M3
Femto Curies per Cubic Meter 8
100
80
60
40
20
0
Sampler Inoperative
Sampler Inoperative
Sampler Inoperative
0
10
20
30
40
50
Week Number

FIGURE 2.2e

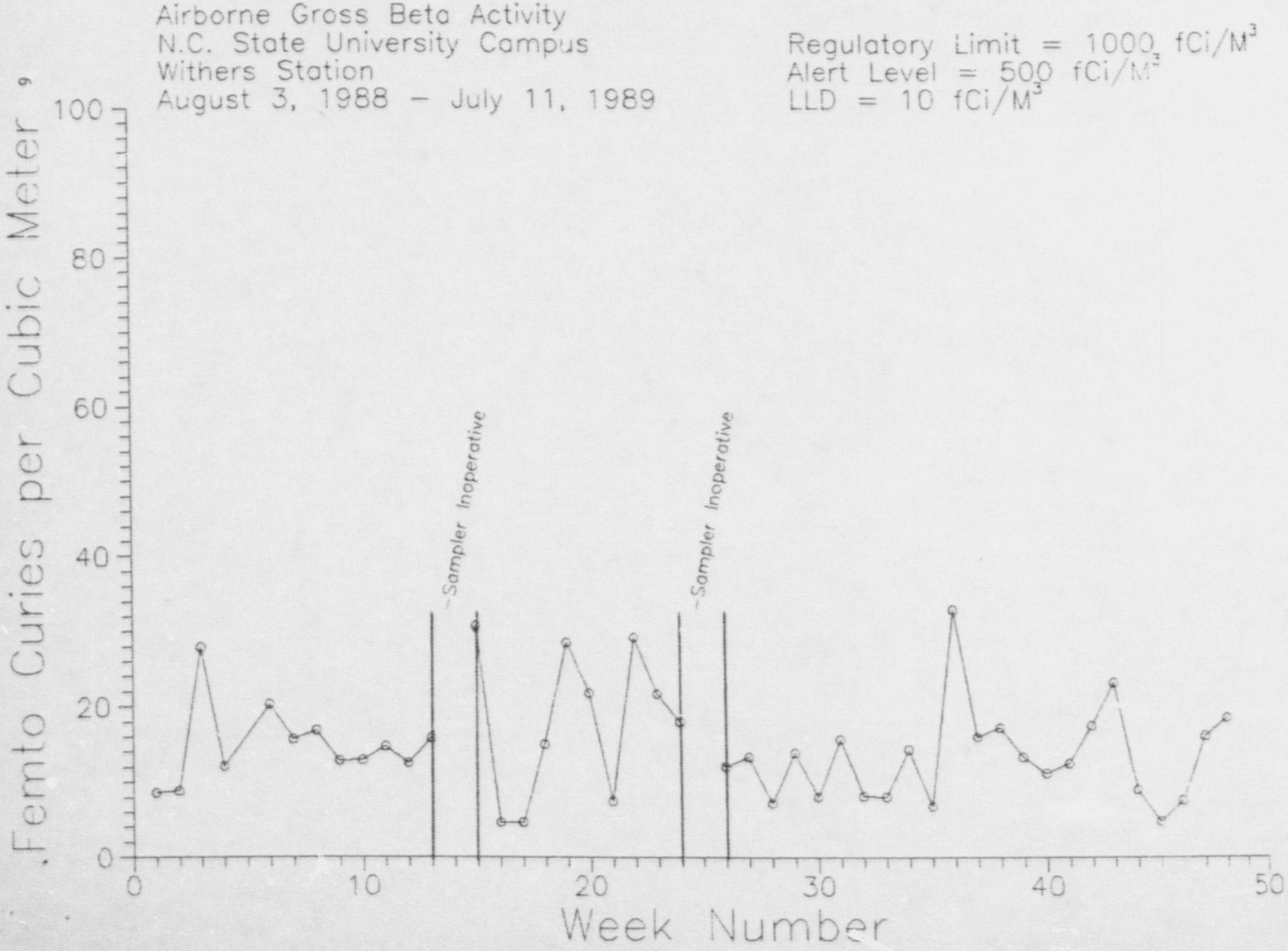

Airborne Gross Beta Activity
N.C. State University Campus
Withers Station
August 3, 1988 - July 11, 1989
Regulatory Limit = 1000 fCi/M3
Alert Level = 500 fCi/M3
LLD = 10 fCi/M3
Femto Curies per Cubic Meter
100
80
60
40
20
0
Sampler Inoperative
Sampler Inoperative
0
10
20
30
40
50
Week Number

FIGURE 2.2f

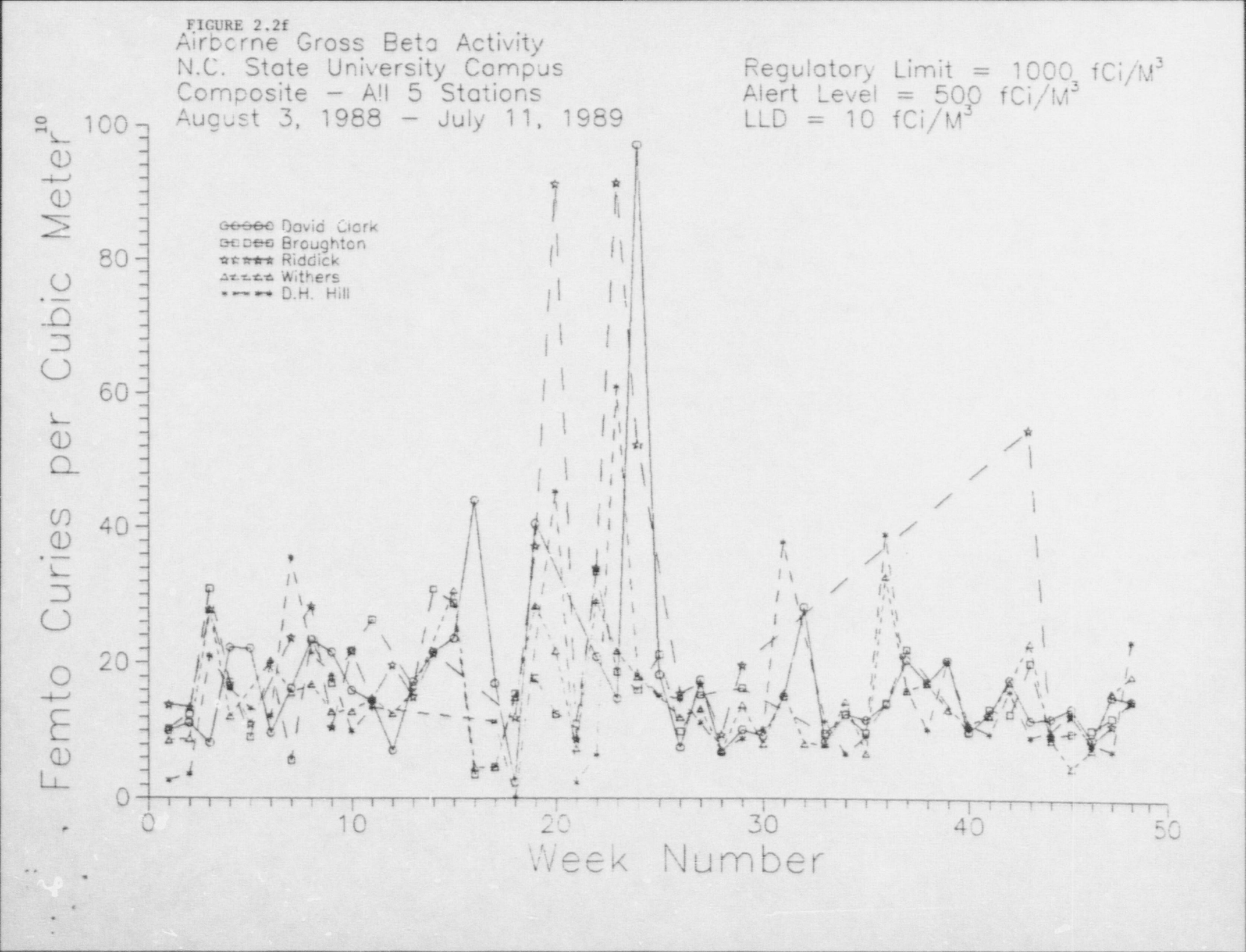

Airborne Gross Beta Activity
N.C. State University Campus
Composite – All 5 Stations
August 3, 1988 – July 11, 1989
Regulatory Limit = 1000 fCi/M3
Alert Level = 500 fCi/M3
LLD = 10 fCi/M3
David Clark
Broughton
Riddick
Withers
D.H. Hill
Femto Curies per Cubic Meter10
0
20
40
60
80
100
0
10
20
30
40
50
Week Number

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	100	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 1984-85, State of N.C. Radiation Protection Section

3. MILK (TABLE 3.1)

Monthly analyses for cows' milk from the Campus Creamery have shown concentrations of Sr-90 that are well below the FDA's Preventive Protective Action Guide value of 0.009 microcurie liter^{-1} for infants. During the next reporting period, (1989-90), Sr-90 analysis will be discontinued in favor of I-131 analysis pursuant to recommendations by the Environmental Audit Committee.

Several months of Sr-90 data are missing due to the repair of laboratory fume hoods necessary for this analysis. The available data show the activities to be at or below the LLD value of 4 pCi liter^{-1}. LLD values are determined quarterly.

- - - - - - - - - - - -

TABLE 3.1 Sr-90 IN COWS' MILK (pCi liter^{-1} $\pm$ 1 σ) LLD ~ 4 pCi liter^{-1}

DATE	ACTIVITY
AUGUST 1988	$\leq$ 4
SEPTEMBER 1988	$\leq$ 4
OCTOBER 1988	NO SAMPLE
NOVEMBER 1988	NO SAMPLE
DECEMBER 1988	NO SAMPLE
JANUARY 1989	NO SAMPLE
FEBRUARY 1989	NO SAMPLE
MARCH 1989	NO SAMPLE
APRIL 1989	$\leq$ 4
MAY 1989	$\leq$ 4
JUNE 1989	$\leq$ 4

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 ~ 0.1 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. Surface water samples analyzed during this period have not shown the presence of any gamma emitters above the detection limits specified in Table 4.2.

- - - - - - - - - - - - -

TABLE 4.1 GROSS ALPHA AND BETA ACTIVITY IN SURFACE WATER (pCi liter^{-1} $\pm$ 2 σ)
*LLD $_{\alpha}$ ~ 0.1 pCi liter^{-1} LLD$_{\beta}$ ~ 0.6 pCi liter^{-1}

		pCi liter^{-1}	
DATE	LOCATION	GROSS ALPHA	GROSS BETA
FOURTH QUARTER 1988	ON	0.1 $\pm$ 0.1	2.8 $\pm$ 0.4
	OFF	0.4 $\pm$ 0.2	3.5 $\pm$ 0.5
FIRST QUARTER 1989	ON	0.3 $\pm$ 0.1	3.4 $\pm$ 0.4
	OFF	0.1 $\pm$ 0.1	3.1 $\pm$ 0.4
SECOND QUARTER 1989	ON	0.5 $\pm$ 0.2	2.8 $\pm$ 0.4
	OFF	0.2 $\pm$ 0.1	0.6 $\pm$ 0.3

*LLD VALUES ARE DETERMINED QUARTERLY

TABLE 4.2 LOWER LIMITS OF DETECTION FOR SEVERAL GAMMA EMITTERS IN SURFACE WATER

NUCLIDE	LLD (pCi liter^{-1})
Co-60	5.4
Zn-65	13.8
Cs-137	5.3
Cs-134	5.9
Sr-85	16.7
Ru-103	36.7
Ru-106	51.3
Nb-95	16.8
Zr-95	28.5

*LLD VALUES ARE DETERMINED QUARTERLY

5. VEGETATION (TABLE 5.1)

The data of 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}. In the past only gross beta activity was generally reported for vegetation unless the activity exceeded the alert value. In these cases gamma analysis was performed to determine if any fission products were present. For future reports gamma analysis will be included as a routine procedure on all vegetation samples.

- - - - - - - - - - - -

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

SAMPLE DATE	SAMPLE LOCATION	(pCi g$^{-1} \pm \sigma$)
AUGUST 1988	NORTH CAMPUS	5.7 $\pm$ 2.1
AUGUST 1988	SOUTH CAMPUS	4.2 $\pm$ 2.2
AUGUST 1988	EAST CAMPUS	2.4 $\pm$ 2.0
AUGUST 1988	WEST CAMPUS	9.7 $\pm$ 2.6
JULY 1989	NORTH CAMPUS	10.9 $\pm$ 0.5
JULY 1989	SOUTH CAMPUS	10.9 $\pm$ 0.5
JULY 1989	EAST CAMPUS	11.0 $\pm$ 0.5
JULY 1989	WEST CAMPUS	13.5 $\pm$ 0.6

*LLD values are determined semiannually

6. THERMOLUMINESCENT DOSIMETERS (TLDs) (TABLE 6.1 AND FIGURE 6.1)

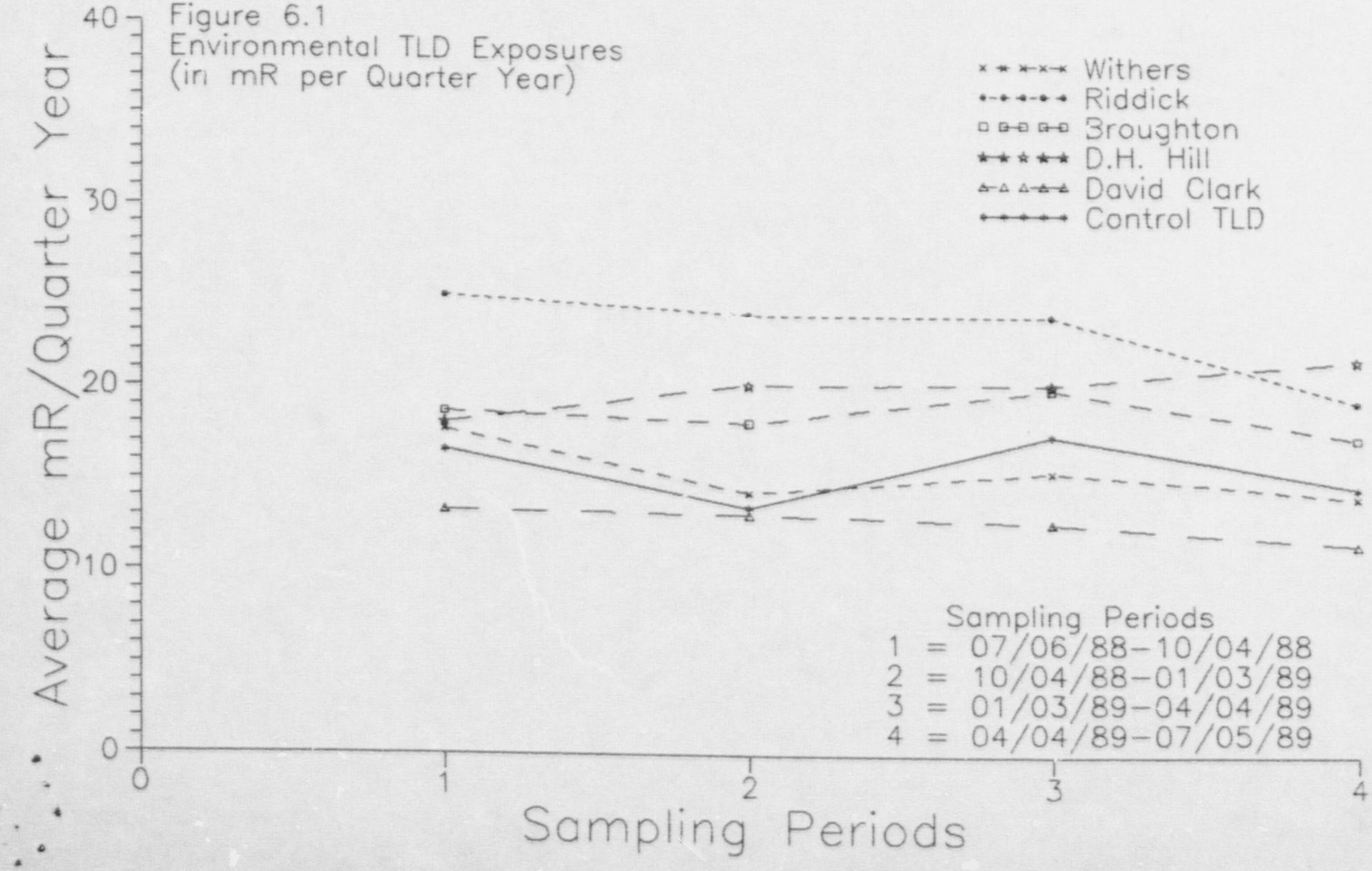
TLD analysis is contracted to Teledyne Isotopes for determination of ambient gamma exposures. The dosimeters are $CaSO_4$ doped with dysprosium and have a manufacturer-stated sensitivity of 0.5 ± 0.15 mR (90% C.L.). Exposures are integrated over a three-month period at each of the five air monitor stations 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 and Figure 6.1 give the data for these seven (7) sampling locations for the period 07/06/88 to 07/05/89. Data for the PULSTAR stack monitor is missing for this same period due to an inoperable cranking device which allows positioning of the TLD holder. This problem has now been corrected.

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 ± 1 σ)

DATE	WITHERS	RIDDICK	BROUGHTON	LIBRARY	DAVID CLARK	PULSTAR STACK	CONTROL
07/06/88-10/04/88	17.7 ± 0.8	25.0 ± 0.6	18.7 ± 0.3	18.1 ± 1.7	13.3 ± 0.5	- - - - - - - -	16.6 ± 0.1
10/02/88-01/03/89	14.3 ± 0.7	24.0 ± 0.8	18.1 ± 0.3	20.2 ± 0.4	13.1 ± 0.6	- - - - - - - -	13.5 ± 0.1
01/03/89-04/04/89	15.5 ± 0.6	24.0 ± 0.4	20.0 ± 0.7	20.3 ± 0.4	12.7 ± 0.5	- - - - - - - -	17.5 ± 1.6
04/04/89-07/05/89	14.1 ± 0.7	19.3 ± 0.2	17.3 ± 0.4	21.6 ± 0.6	11.5 ± 2.7	23.6 ± 2.4	14.6 ± 0.9

Figure 6.1
Environmental TLD Exposures
(in mR per Quarter Year)



7. CONCLUSIONS

The data obtained during this period do not show any fission product activities other than very low levels of Cs-137 which can be attributed to residual fallout. The observed environmental radioactivity is due to radon progeny, primordial radionuclides (e.g., K-40) and 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 in a manner which does not adversely affect the university environment.

8. ACKNOWLEDGMENTS

Appreciation is expressed to Mr. Paul A. Shuping of the Radiation Protection Office staff for his assistance in producing the computer-generated graphs in this report.