SUSQUEHANNA STEAM ELECTRIC STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
UNITS 1 AND 2
1987 ANNUAL REPORT

Prepared By The
Pennsylvania Power and Light Company
Environmental and Chemistry Group

April 1988

Facility Operating License Nos. NPF-14 & NPF-22
Docket Nos. 50-387 & 50-388

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I. EXECUTIVE SUMMARY

In 1987, there were more than 1000 routine samples collected at 148 locations, and over 2800 routine analyses performed in support of the Radiological Environmental Monitoring Program (REMP). The extent of the sampling and the types and sensitivities of the analyses performed met and exceeded the requirements of the technical specifications for the Susquehanna Steam Electric Station (SSES). The result of this effort was verification of the SSES Effluent Monitoring Program data that indicate that the operation of SSES has no deleterious effect on the health and safety of the public or the environment.

Of the three pathways (airborne, waterborne, and terrestrial) by which man can be exposed to radioactivity, only the waterborne pathway was found to contain radionuclides which could be attributable to the operation of the SSES. In the waterborne pathway, however, there was no increase in the levels of radionuclides detected from those seen in previous years.

The amounts of the radionuclides detected in 1987 are so small, as in past years, that the maximum dose to an individual in the general public is only a small fraction of a percent of the dose permitted by the Nuclear Regulatory Commission as stated in 10CFR50, Appendix I. The maximum potential off-site dose via the aquatic pathway was calculated to be less than 0.001 millirem/year. This is negligible compared to the public's exposure from natural background radiation of approximately 100 millirem/year.

II. INTRODUCTION

The preoperational radiological environmental monitoring program (REMP) for Pennsylvania Power & Light Company (PP&L) at the Susquehanna Steam Electric Station (SSES) was conducted from April 1972 to September 1982. On September 10, 1982, Unit #1 became critical, thereby initiating the operational phase of the program. The preoperational phase of the program, as well as the initial phase of the operational program (September 10, 1982 through June 1983), was conducted by Radiation Management Corporation (RMC). NUS Corporation conducted the REMP from June 1983 until August 1984 when Teledyne Isotopes (TI) took over the operational REMP. The analytical program is now being conducted by Teledyne Isotopes under contract with Pennsylvania Power & Light Company. Starting in August 1984, Icthyological Associates (PP&L's biological consultants) assumed responsibility for the sample collection portion of the program. In June 1985, Ecology III became PP&L's biological consultants (essentially utilizing the same staff) and they continued to perform sample collection activities through 1987.

This report covers the period from January 5, 1987 through January 8, 1988. Teledyne Isotopes performed all the analyses except the TLD program which is conducted by PP&L. A detailed Quality Control and Quality Assurance Program is conducted along with the Radiological Program. Data from programs conducted in prior years have been presented in a series of annual reports. (1-13, 21, 27, 28).

A. Site and Station Description

The Susquehanna Station contains two BWR generating units, each with a capacity of about 1050 MWe. Unit #1 achieved initial criticality on September 10, 1982. Unit #2 achieved initial criticality on May 8, 1984. The site is located on an approximately 1500 acre tract along the Susquehanna River, five miles northeast of Berwick in Salem Township, Luzerne County, Pennsylvania.

The area surrounding the site can generally be characterized as rural, with forest and agricultural lands predominating. More specific information on the demography, hydrology, meteorology and land use characteristics of the local area may be found in the Environmental Report[14], the Final Safety Analysis Report[15] and the Final Environmental Statement[16] for SSES.

B. Fundamentals of Radiological Environmental Monitoring Programs

Radioactive materials are present in man's environment as the result of both natural processes and of man's technological developments.

Normally, people and organisms are continually exposed to naturally occurring radiation and radionuclides from terrestrial and cosmic sources. The main contribution of man-made radioactivity to members of the public is from the medical services field (x-rays, radioactive medical treatments, etc.).

Background levels vary with time and location as they are influenced by external events such as cosmic ray bombardment, weapons test fallout, and seasonal variations. These levels also can vary spatially within relatively short distances reflecting variations in geological composition and other factors. Because of these spatial and temporal variations, the environmental radiological surveys of the plant environs are divided into preoperational and operational phases. The preoperational phase of the program of sampling and measuring radioactivity in various media permits a characterization of the radiation levels and concentrations prior to plant operation along with an indication of the degree of natural variation to be expected. The operational phase of the program obtains data which, when considered along with the data obtained in the preoperational phase, assist in the evaluation of the radiological impact of plant operation.

From a nuclear power plant, there are three basic pathways in which a member of the public may be potentially exposed to radioactivity. Figure 1 artistically depicts these pathways of radioactive material uptake: 1) inhalation (breathing); 2) ingestion (eating, drinking); and 3) whole body irradiation directly from the plant or from immersion in airborne effluents.

Therefore, to effectively monitor the radioactivity in the environment, it is important to sample those media which can potentially affect the human body either directly or indirectly. Media normally sampled to capture radiological environmental monitoring program requirements include:

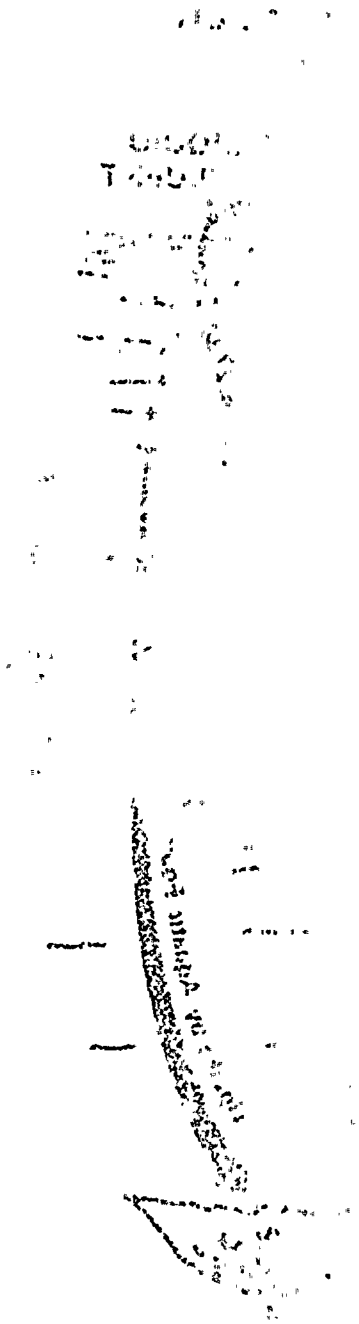
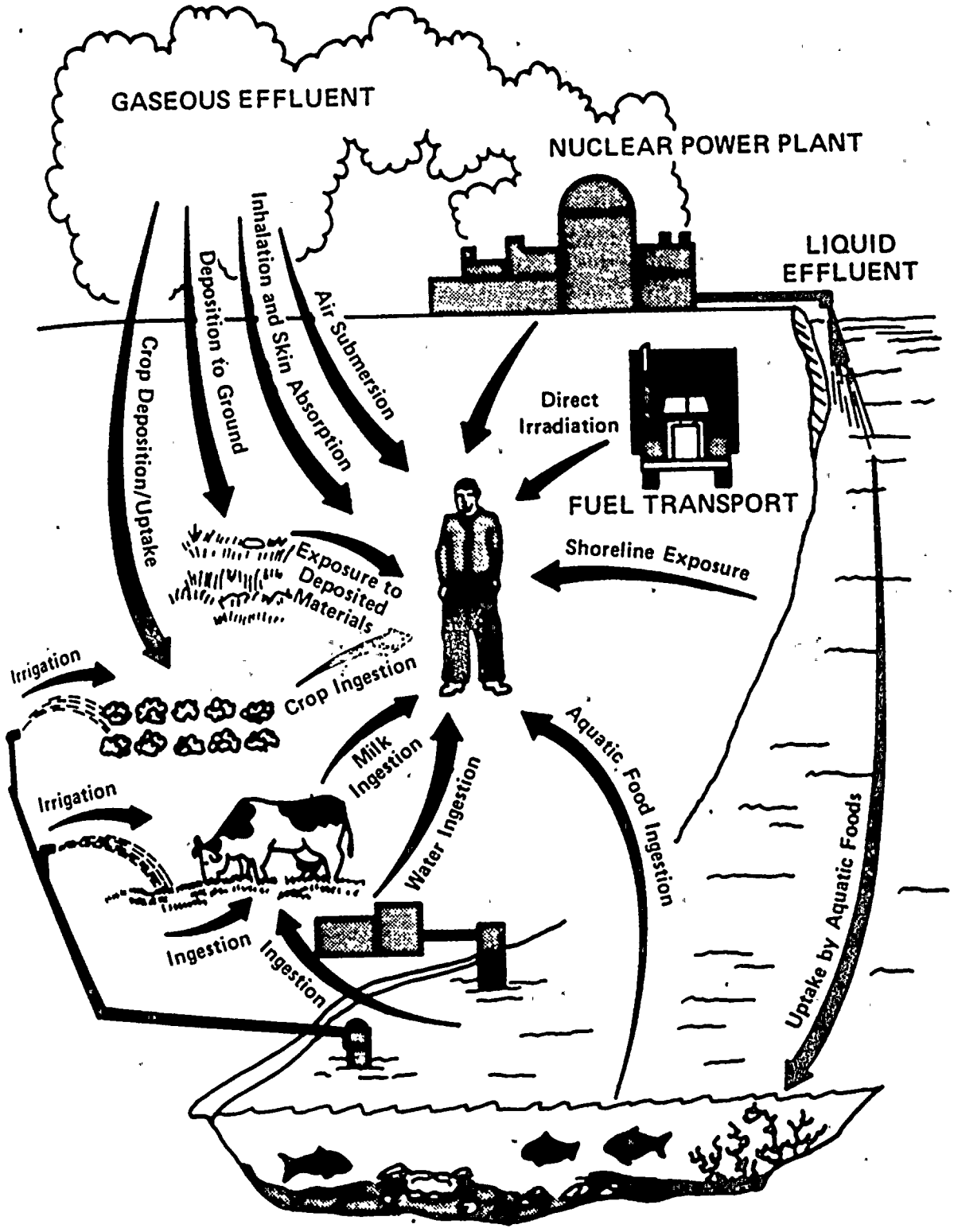


FIGURE 1

EXPOSURE PATHWAYS TO HUMANS



Atmospheric Sampling - Air is sampled to evaluate potential radiation exposures from inhaled radionuclides in gaseous (iodine) or particulate form. Direct radiation and air submersion exposures are also monitored. Precipitation is sampled to follow the movement of radionuclides from air to terrestrial and aquatic media.

Terrestrial Sampling - Plant life, primarily in the form of food products (fruits, vegetables, etc.), is sampled because it is a primary source for ingestion of radionuclides. Common game animals normally hunted for food (deer, squirrels) are also sampled.

Milk and eggs are sampled because they are widely consumed. Additionally, milk is one of the few foods commonly consumed soon after production, and therefore, may also contain relatively short-lived radionuclides when consumed.

Soil samples are also collected to provide an additional means of monitoring the air-to-ground pathway.

Aquatic Sampling - River water is sampled to verify the results of any liquid releases of radionuclides from the facility, and drinking water supplies are sampled to identify and evaluate any potential radiation exposure through ingestion.

Fish are sampled since they are a primary aquatic food source. Algae and sediment are collected since they are indicators and accumulators, of radionuclides in the aquatic system.

C. Objectives of the SSES REMP

The objectives of the operational Susquehanna SES Radiological Environmental Monitoring Program are:

1. To identify, measure and evaluate existing radionuclides in the environs of the SSES, and to determine whether any significant increase occurs in the concentration of radionuclides in critical pathways.

2. To verify that SSES operations have adequate reactor effluent control.

3. To assess actual or potential dose impacts to the public.

4. To verify that SSES operations have no detrimental effects on the health and safety of the public or on the environment.

5. To fulfill the obligations of the Radiological Environmental Surveillance Sections of the SSES Technical Specifications.

D. Regulatory Overview

United States Nuclear Regulatory Commission (USNRC) regulations require that nuclear power plants be designed, constructed, and operated to keep levels of radioactive material in effluents to unrestricted areas as low as reasonably achievable (ALARA) (10 CFR 50.34 and 10 CFR 20.1c). To ensure that these criteria are met, each license authorizing reactor operation includes technical specifications (10 CFR 50.36a) which contain requirements governing radioactive effluents.

In-plant monitoring is used to ensure that predetermined release limits are not exceeded. However, as a precaution against unexpected and undefined processes which might allow undue accumulation of radioactivity in any sector of man's environment, a program for monitoring the plant environs is also included in the Susquehanna Technical Specifications. The regulations governing the quantities of radioactivity in reactor effluents allow nuclear power plants to contribute, at most, only a few percent increase above normal background radioactivity.

The SSES REMP was designed on the basis of the USNRC Radiological Assessment Branch Technical Position on radiological environmental monitoring as described in Revision 1, November 1979.[17] PP&L has expanded the basic program required by the NRC to aid in the characterization of area radiation levels and SSES impact.

E. Scope of the SSES REMP

In 1987, the SSES Radiological Environmental Monitoring program included the measurement of ambient gamma radiation by thermoluminescent dosimetry; the determination of the activities of gamma emitters and gross alpha and gross beta activities in shoreline and flocculated sediments; the determination of the activity of gamma emitters and gross beta activity in fish; the determination of gross beta and gross alpha activities, and the activities of gamma emitters in airborne particulates, and the measurement of airborne iodine-131 activity; the measurement of gross beta and gross alpha activities, and the activities of gamma emitters, iodine-131 and tritium in water; the measurements of gross beta and gross alpha activities, and the activities of gamma emitters, and tritium in precipitation; the measurement of iodine-131 activity, gross beta minus potassium-40 activity, and the activities of gamma emitters in cow milk; and the determination of the activities of gamma emitters in game, poultry, honey, eggs, various fruits and vegetables, algae, and in soil and vegetation.

Sampling locations are selected on the basis of local ecology, metoerology, physical characteristics of the region, and demographic and land use features of the site vicinity.

There were more than 1000 routine samples collected, and over 2800 routine analyses performed in support of the REMP program in 1987. The numbers exclude measurements of ambient gamma radiation by thermoluminescent dosimetry, duplicate and split samples and analyses, other quality control samples, analyses performed independently by Pennsylvania State University, and other non-routine samples and analyses.

III. PROGRAM DESCRIPTION

One-hundred forty-eight locations were included in the SSES monitoring program for 1987. Environmental sampling locations were divided into two classes, indicator and control. Indicator samples are those collected at locations which are expected to manifest station effects, if any exist, and were selected on the basis of distance from the site, topography, hydrology, meteorology, demography, and drainage characteristics. Control samples are collected at locations which are believed will be unaffected by station operation. These provide a basis on which to evaluate fluctuations in radioactivity at indicator locations in relation to natural phenomena and fallout. The number and locations of monitoring points were determined by considering the locations where the highest off-site environmental concentrations have been predicted from plant effluent source terms, site hydrology, and site meteorological conditions. Other factors considered were applicable regulations, population distribution, ease of access to sampling stations, security and future program integrity.

The operational environmental radiological program for SSES is summarized in Table 1. Table 2 describes sample locations, associated media, and approximate distance and direction from the site. Figures 2 and 3 illustrate the locations of sampling stations relative to SSES.

In addition to the described analytical program, a milk animal, vegetable garden and residence survey was performed in 1987. This

survey located the nearest milk animal, garden and residence in each sector (out to 5 miles) and will be updated annually. These land use parameters are used in the assessment of potential radiological doses to hypothetical individuals and populations of the stated regions.

TABLE 1
(Page 1 of 3)

Annual Analytical Schedule for the
Susquehanna Steam Electric Station (PP&L)
Radiological Environmental Monitoring Program - 1987

Media	No. of Locations	Sample Freq.(a)	Analysis Required	Anal. Freq.(b)
Airborne Particulates (AP)	10	W	Gross Beta (c) Gross Alpha Gamma Spec	W QC QC
Airborne Iodine (C)	10	W	I-131	W
Sediment (SH)	6	SA	Gross Alpha Gross Beta Gamma Spec	SA SA SA
Flocculated Sediment (SS)	2	SA	Gross Alpha Gross Beta Gamma Spec	SA SA SA
Fish (FI)	3	SA	Gross Beta Gamma Spec (on edible portion)	SA SA
Surface Water(d) (WT)	9	MC or M	Gross Alpha Gross Beta I-131 Gamma Spec Tritium	M M M M M
Well (ground) Water (WG)	7	M	Gross Alpha Gross Beta Gamma Spec Tritium	M M M M
Drinking Water(e) (PW)	2	MC	Gross Alpha Gross Beta I-131 Gamma Spec Tritium	M M M M M

Note: See footnotes at end of table.

TABLE 1
(Page 2 of 3)

Annual Analytical Schedule for the
Susquehanna Steam Electric Station (PP&L)
Radiological Environmental Monitoring Program - 1987

Media	No. of Locations	Sample Freq.(a)	Analysis Required	Anal. Freq.(b)
Rain Water (WP)	10	QC	Gross Alpa	Q
			Gross Beta	Q
			Gamma Spec	Q
			Tritium	Q
Cow Milk (M)	9	M, SM(f)	Gross Beta-K-40	SM, M
			I-131	SM, M
			Gamma Spec	SM, M
Food Products (FD,FL,FV,FP,FR) Various Fruits and Vegetables	5	A	Gamma Spec	A
Game (AG,AS,AW,AN)	6	A	Gamma Spec	A
Meat, Poultry and Eggs (ME,PO,E)	2	A	Gamma Spec	A
Soil (S)	10	A	Gamma Spec	A
Vegetation (VT)	10	A	Gamma Spec	A

Note: See footnotes at end of table.

TABLE 1
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Annual Analytical Schedule for the
Susquehanna Steam Electric Station (PP&L)
Radiological Environmental Monitoring Program - 1987

Media	No. of Locations	Sample Freq.(a)	Analysis Required	Anal. Freq.(b)
Direct Radiation (TQ)	91	Q	TLD	Q
	1	A	TLD	A
Algae (VA)	2	M	Gamma Spec	M

(a) W = weekly, M = monthly, SM = semi-monthly, Q = quarterly, QC = quarterly composite, SA = semi-annual, A = annual, MC = monthly composite.

(b) Codes are the same as for sample frequency.

(c) If the gross beta activity is greater than 10 (ten) times the yearly mean of the control sample, gamma analysis should be performed on the individual filter. Perform the gross beta analysis 24 hours or more following filter change to allow for radon and thoron daughter decay.

(d) Stations 6S6 and 6S7 are sampled weekly to assure automatic composite sampler operation which is time proportional. Stations 5S8 and 6S5 are grab sampled weekly. Individual composites of the weekly samples are made on a monthly basis (MC) and analyzed.

(e) Stations 12H2 RAW and 12H2 TREATED are sampled weekly. Individual composites of the weekly samples are made on a monthly basis (MC) and analyzed. 12H2 Raw is a time proportional automatic composite sampler. 12H2 Treated is a daily grab sample.

(f) Stations 12B2, 14B1, 10D1, 5E1, 13E3 and 10G1 are analyzed semi-monthly from April through October.

TABLE 2
(Page 1 of 7)

Sample Locations and Media for the SSES
Radiological Environmental Monitoring Program - 1987

Location Code	Description[a]	Sample Type
IND[b]	0.9-1.4 mile ESW, at or below Discharge Structure	FI
1S[c]	N, SSES Site Location	AS
1S2	0.2 mile N, Perimeter Fence	TQ
2S2	0.9 mile NNE, Energy Information Center	AP,C,TQ,WP
2S3	0.2 mile NNE, Perimeter Fence	TQ
2S4	0.9 mile NNE, Energy Information Center	S,VT
2S5	0.9 mile NNE, Energy Information Center-PIC	TQ
2S6	0.9 mile NNE, Energy Information Center	WG
3S3	0.5 mile NE, Recreational Area	TQ
3S4	0.3 mile NE, Perimeter Fence	TQ
3S5	0.9 mile NE, Riverlands Security Office	WG
4S1	1.0 mile ENE, Susquehanna River Flood Plain	TQ
4S2	0.5 mile ENE, Site - Peach Stand	WG
4S3	0.2 mile ENE, Perimeter Fence	TQ
4S4	0.5 mile ENE, Training Center	WG
5S1	0.8 mile E, North of Biological Consultants	TQ
5S4	0.8 mile E, West of Biological Consultants	AP,C,TQ,WP
5S5	0.8 mile E, West of Biological Consultants	S,VT
5S7	0.3 mile E, Perimeter Fence	TQ
5S8	0.8 mile E, Area under power line	WT
6S4	0.2 mile ESE, Perimeter Fence	TQ
6S5	0.9 mile ESE, Outfall Area	WT
6S6	0.8 mile ESE, River water intake line	WT
6S7	0.4 mile ESE, Cooling tower blowdown discharge line	WT
6S8	0.2 mile ESE, Site Pole No. 44316/N34036	TQ
6S9	0.2 mile ESE, Perimeter Fence (south)	TQ
7S6	0.2 mile SE, Perimeter Fence	TQ
8S2	0.2 mile SSE, Perimeter Fence	TQ
9S2	0.2 mile S, Security Fence	TQ
10S1	0.4 mile SSW, Perimeter Fence	TQ
10S2	0.2 mile SSW, Security Fence	TQ

Note: See footnotes at end of table.

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Sample Locations and Media for the SSES
Radiological Environmental Monitoring Program - 1987

Location Code	Description[a]	Sample Type
11S2	0.4 mile SW, Golomb House (44016/N33986)	AP,C,TQ,WP
11S3	0.3 mile SW, Security Fence	TQ
11S4	0.4 mile SW, Golomb House	S,VT
11S5	0.5 mile WSW, EOF Building	WG
11S6	0.5 mile SW, SW REMP Garden	TQ
12S3	0.4 mile WSW, Perimeter Fence	TQ
13S2	0.4 mile W, Perimeter Fence	TQ
13S4	0.4 mile W, Security Fence (LLRWHF-south)[d]	TQ
13S5	0.4 mile W, Security Fence (LLRWHF-north)[d]	TQ
14S5	0.5 mile WNW, Site Pole No. 43996/N34230	TQ
14S6	0.7 mile WNW, Site Pole No. 43869/N34174	TW
15S[c]	0.4-0.9 mile NW, Sybert's Hill Area	AS
15S4	0.6 mile NW, Transmission Line	AP,C,TQ,WP,S,VT
15S5	0.4 mile NW, Perimeter Fence	TQ
16S[c]	0.5 mile NNW, SSES Site	AS
16S1	0.3 mile NNW, Perimeter Fence (east)	TQ
16S2	0.3 mile NNW, Perimeter Fence (west)	TQ
LTAW	Lake Took-a-while, NE to ESE on site	WT,SH,FI
1A[c]	0.1-1.0 mile N, Sybert's Hill Area	AG
AG3	0.8 mile E, above River Water Intake - surface	VA
AG4	0.9 mile ESE, below Discharge Diffuser - surface	VA
6A4	0.6 mile ESE, former State Police	TQ
7A1	0.4 mile SE, Kline Residence	TQ
7A2	0.6 mile SE Bell Bend Pole No. 44437/N33887	TQ
8A2	0.9 mile SSE, Bell Bend Pole 44395/N33679	TQ
15A3	0.9 mile NW, Serafin Farm	TQ
16A2	0.8 mile NNW, Rupinski Farm	TQ

Note: See footnotes at end of table

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Sample Locations and Media for the SSES
Radiological Environmental Monitoring Program - 1987

Location Code	Description[a]	Sample Type
1B[c]	1.0-2.0 miles N, Sybert's Hill Area	AG
1B1	1.4 miles N, Mingle Inn Road	TQ
2B[c]	1.6 miles NNE, Gould Island	SH,SS
2B3	1.3 miles NNE, former Luzerne Outerwear	TQ
2B4	1.4 miles NNE, Dura Bond Corporation	TQ
4B1	1.2 miles ENE, Stone Crusher Trail	TQ
5B2	1.4 miles E, Pa. Route 239 Intersection	TQ
6B2	1.4 miles ESE, Wapwallopen	TQ
7B[c]	1.2 miles SW, Bell Bend	SH,SS
7B2	1.5 miles SE, Heller's Orchard	FD
7B3	1.7 miles SE, Council Cup	TQ
7B4	1.5 miles SE, Heller's Orchard Store	TQ
8B2	1.4 miles SSE, Lawall Residence	TQ
8B3	1.5 miles SSE, Wapwallopen Post Office	TQ
9B[c]	1-2 miles S, Off Site	AG
9B1	1.3 miles S, Transmission Line east of Route 11	AP,C,TQ,WP
9B2	1.3 miles S. Transmission Line east of Route 11	S,VT
10B[c]	1-2 miles SSW, Off Site	AG
10B2	2.0 miles SSW, Algatt Residence	TQ
10B3	1.7 miles SSW, General Tank Equip. Co.	TQ
10B4	1.4 miles SSW, General Tank Equip. Co.	TQ
12B1	1.3 miles WSW, Kisner Farm	E,FD,PO
12B2	1.7 miles WSW, Shultz Farm	M
12B3	2.0 miles WSW, Young Farm	M
12B4	1.7 miles WSW, Shultz Farm	TQ
14B1	1.7 miles WNW, Walker Run Creek	TQ
14B2	1.8 miles WNW, Stola Farm	M
15B1	1.7 miles NW, Mingle Inn Trailer Park	TQ
16B[c]	1-2 miles, NNW, Off Site	AG
16B1	2.7 miles ESE, Walton Power Line	TQ
16B2	1.7 miles NNW, High Tension Lines	TQ

Note: See footnotes at end of table.

TABLE 2
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Sample Locations and Media for the SSES
Radiological Environmental Monitoring Program - 1987

Location Code	Description[a]	Sample Type
6C1	2.7 miles ESE, Moyer Farm	M
11C[c]	2.6 miles SW, Hess Island	SH
11C1	2.0 miles SW, Salem Township Fire Company	TQ
1D2	4.0 miles N, near Mocanaqua Substation	AP,C,TQ,WP
1D3	3.9 miles N, near Mocanaqua Substation	WT
1D4	4.0 miles N, near Mocanaqua Substation	S, VT
3D1	3.4 miles NE, Pond Hill	AP,C,TQ,WP
3D2	3.4 miles NE, Pond Hill	S,VT
8D3	4.0 mile, SSE Mowry Residence	TQ
9D1	3.6 miles S, Smith Farm	TQ
10D1	3.0 miles SSW, Ross Ryman Farm	M,FM
10D2	3.0 miles SSW, Ross Ryman Farm	TQ
11D1	3.3 miles SW, Zehner Farm	FD
12D2	3.7 miles WSW, Dagostin Farm	M
12D3	3.7 miles WSW, Dagostin Residence	TQ
1E1	4.5 miles N, Lane Residence	TQ
1E2	4.2 miles N, Shickshinny Municipal Building-PIC	TQ
4E1	4.8 miles ENE, Pole #46422/N35197	TQ
5E1	4.5 miles E, Bloss Farm	M
5E2	4.5 miles E, Bloss Farm	TQ
6E1	4.7 miles ESE, St. James Church	TQ
7E1	4.2 miles SE, Harwood Trans. Line Ple #2	TQ
11E1	4.7 miles SW, Jacobsen Residence	TQ

Note: See footnotes at end of table

TABLE 2
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Sample Locations and Media for the SSES
Radiological Environmental Monitoring Program - 1987

Location Code	Description[a]	Sample Type
12E1	4.7 miles WSW, Berwick Hospital	AP,C,TQ,WP
12E2	4.7 miles WSW, Berwick Hospital	S,VT
12E4	4.7 miles WSE, Berwick Hospital	WG
13E3	5.0 miles W, Dent Farm	M
13E4	4.1 miles W, Kessler Farm	TQ
14E1	4.1 miles WNW, Canouse Farm	TQ
2F[c]	6.4 miles NNE, between Shickshinny and former State Hospital	SH
2F1	5.9 miles NNE, St. Adalberts Cemetery	TQ
3F1	9.1 miles NE, Valania Residence	TQ
3F2	9.9 miles NE, Sheatown Intersection	TQ
8F2	8.5 miles SSE, Huff Residence	TQ
12F[c]	6.9 miles WSW, Old Berwick Test Track	SH
12F1	5.3 miles WSW, Berwick Bridge	WT
12F2	5.2 miles WSW, Berwick Substation	TQ
12F3	5.2 miles WSW, Berwick Water Co.	WG
12F4	5.2 miles, WSW, Berwick City Hall-PIC	TQ
12F5	7.5 miles WSW, Seesholtz Farm	FR
15F1	5.4 miles NW, Zawatski Farm	TQ
16F1	7.8 miles NNW, Hidlay Residence	TQ
3G2	10.7 miles NE, Nanticoke Municipal Building-PIC	TQ
3G3	16 miles NE, WB Horton St. Substation	TQ
3G4	17 miles NE, WB Service Center	TQ
4G1	14 miles NE, WB Service Center	TQ
7G1	14 miles SE, Hazleton Chem Lab	AP,C,TQ,WP,S,VT
7G2	12 miles SE, Hazleton	TQ
10G1	14 miles SSW, Davis Farm	M,FM
12G1	15 miles WSW, PP&L Service Center, Bloomsburg	AP,C,TQ,WP
12G2	17 miles WSW, US Radium Site, Bloomsburg	WT
12G3	15 miles WSW, PP&L Service Center, Bloomsburg	S,VT
12G4	10 miles WSW, Naus Residence	TQ

Note: See footnotes at end of table

TABLE 2
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Sample Locations and Media for the SSES
Radiological Environmental Monitoring Program - 1987

Location Code	Description[a]	Sample Type
2H[c]	30 miles NNE, near Falls, PA	FI
2H1	21 miles NNE, Yalicks Residence	FD
12H1	26 miles WSW, Merck Co.	WT
12H2RAW	26 miles WSW, Danville Water Co.	PW
12H2TREATED	26 miles WSW, Danville Water Co.	PW

(a) All distances measured from standby gas treatment vent at 44200/N34117 (PA Grid System).

(b) No actual location is indicated since fish are sampled over an area which extends through 3 sectors (5, 6, 7) near the outfall area.

(c) Station code is omitted because no permanent locations exist; samples are taken based on availability.

(d) Low Level Radwaste Holding Facility.

(e) See Section VI Program Changes.

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Sample Locations and Media for the SSES
Radiological Environmental Monitoring Program - 1987

Location Codes:

The location codes are based on direction and distance from the site. The first two numbers represent each of the 16 angular sectors of 22-1/2 degrees centered about the reactor site. Sector one is divided evenly by the north axis and other sectors are numbered in a clockwise direction; i.e., 2=NNE, 3=NE, 4=ENE, etc. The next digit is a letter which represents the radial distance from the station:

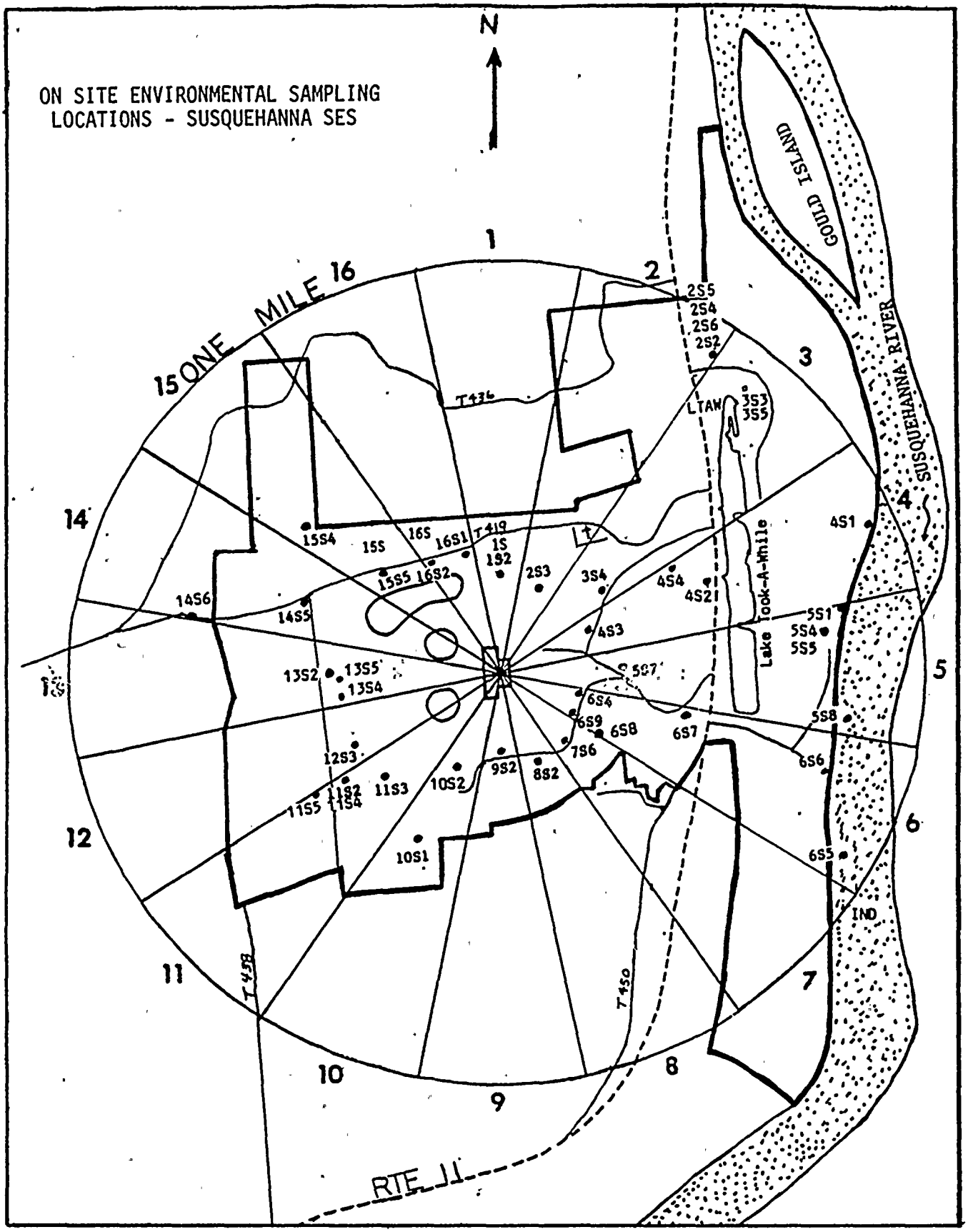
S = Site(1) location
A = 0-1 miles off-site
B = 1-2 miles off-site
C = 2-3 miles off-site
D = 3-4 miles off-site
E = 4-5 miles off-site
F = 5-10 miles off-site
G = 10-20 miles off-site
H = >20 miles off-site

The last number is the station numerical designation within each sector and zone, e.g., 1, 2, 3, ...
Site is defined as that area within PP&L's property boundary.

Sample Type Codes

AG = Animals/Game (Deer)
AS = Animals/Squirrel
AP = Air Particulate Filters
C = Charcoal Filters
E = Eggs
FD = Food/Garden Crops
FH = Food/Garden Crops - Honey
FL = Food/Garden Crops - Green Leafy Vegetables (cabbage, lettuce, spinach, swiss chard, etc.)
FP = Food/Garden Crops - Potatoes
FR = Food/Garden Crops - Fruit (applies, strawberries, melons)
FV = Food/Garden Crops - Vegetables (sweet corn, green beans, tomatoes, squash)
FI = Fish
FM = Feed and Forage - Milk Producers (pasture grass)
M = Milk
PO = Poultry
PW = Potable Water
S = Soil
SH = Sediment/Shoreline (0-4' of water)
SS = Sediment/Silt (Floc)
TQ = TLD
VA = Vegetation - Aquatic
VT = Vegetation - Terrestrial
WG = Water - Ground (Well)
WP = Water - Precipitation
WT = Water - Surface

Figure 2


ON SITE ENVIRONMENTAL SAMPLING
LOCATIONS - SUSQUEHANNA SES
N
ONE MILE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
GOULD ISLAND
SUSQUEHANNA RIVER
Lake Took-A-While
T436
T419
T458
T450
RTE 11
IND
2S5
2S4
2S6
2S2
3S3
3S5
4S1
4S4
4S2
4S3
5S1
5S4
5S5
5S7
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11S5
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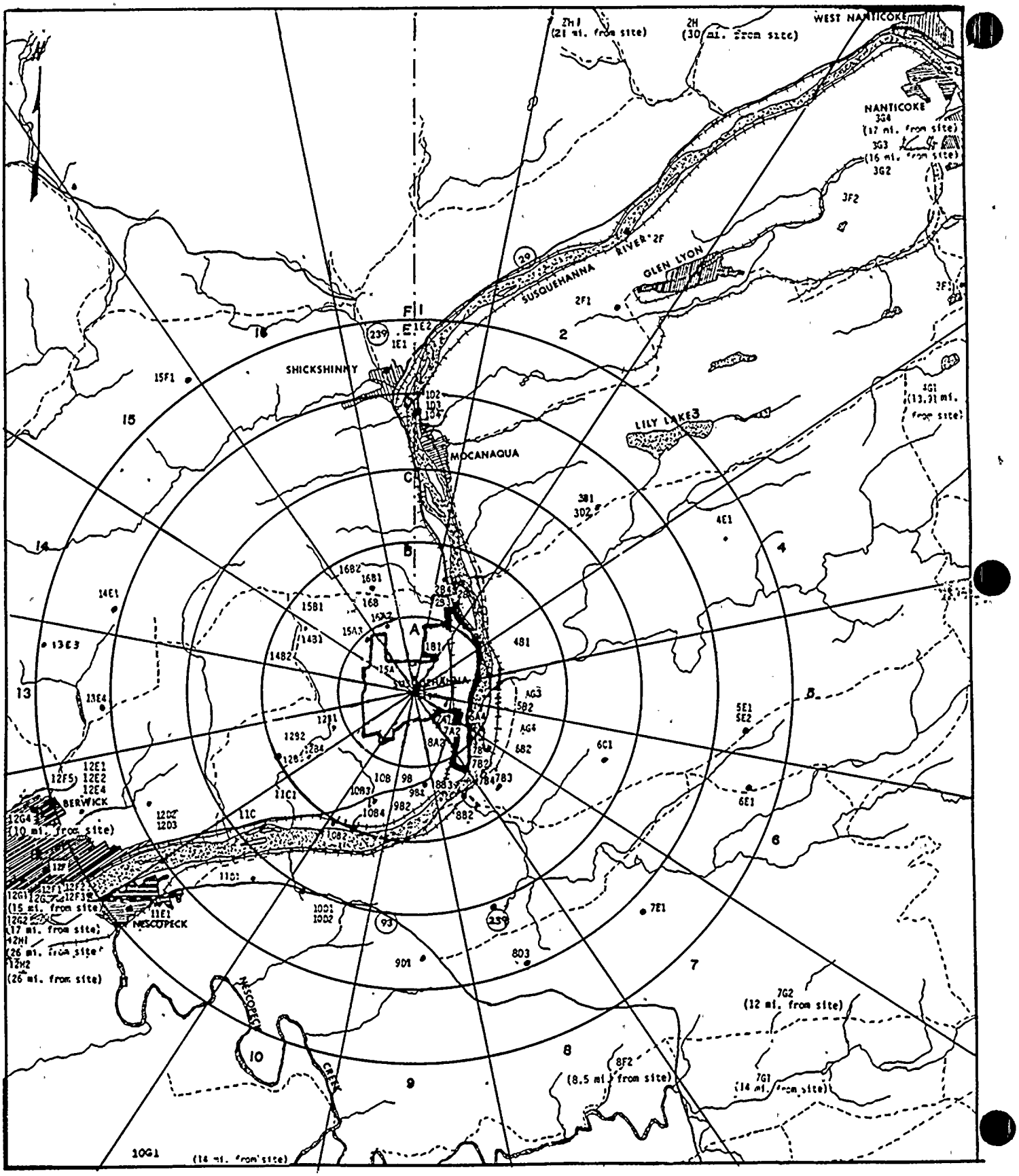
11S3
12S3
13S2
13S5
13S4
14S6
14S5
15S4
15S
16S
16S1
15S5
16S2
1S
1S2
2S3
3S4

Figure 3

OFF SITE ENVIRONMENTAL SAMPLING LOCATIONS - SUSQUEHANNA SES



IV. SAMPLING METHODS AND PROCEDURES

To derive meaningful and useful data from the radiological environmental monitoring program, sampling methods and procedures are required which will provide samples representative of potential pathways of the area.

A. Direct Radiation

Thermoluminescent dosimeters (TLDs) were used to determine the direct (ambient) radiation levels at ninety-two (92) monitoring points as described in Tables 1 and 2. Sampling locations were chosen according to the criteria given in the USNRC Branch Technical Position on Radiological Monitoring (Revision 1, November 1979).[17]

The area around the station was divided into 16 radial sectors of 22 1/2 degrees each. TLDs were placed in all sectors. The TLDs were placed at locations selected considering local meteorologic and topographic characteristics and population distribution characteristics. There were six (6) control locations: 3G3, 3G4, 4G1, 7G1, 12G1, and 12G4.

In 1987 direct radiation measurements were made using Panasonic UD-801 thermoluminescent dosimeters (TLDs) consisting of calcium sulfate doped with thulium. The dosimeters were exchanged on a quarterly basis. Element correction factors were determined for each dosimeter.

B. Surface Water

Surface water was sampled at nine locations from the Susquehanna River and other surrounding bodies of water. Time proportional automatic composite samples were collected monthly at 12H1 (Merck Company). Monthly samples were also composited from weekly grab samples at location 5S8 (under the power line) and location 6S5 (outfall area). Monthly grab samples were collected at location 1D3 (Mocanaqua Substation), location 12F1 (Berwick Bridge), location 12G2 (between Bloomsburg and Berwick), and Lake Took-A-While (LTAW). Monthly surface water samples were analyzed for gross alpha, gross beta, gamma emitters, iodine-131 and tritium. Stations 5S8, 6S6 and 1D3 were the control stations.

Time proportional automatic composite water samplers were installed in 1983 at the river water intake (6S6) and the cooling tower blowdown discharge line (6S7). These samples are collected at least weekly. Monthly composites of weekly samples were analyzed for gross alpha, gross beta, iodine-131, gamma emitters and tritium. Locations 5S8 and 6S5 provide alternate data for locations 6S6 and 6S7, respectively, in the event that the automatic samplers malfunction.

C. Drinking Water

Drinking water was sampled by means of a time proportional automatic composite sampler on a weekly basis from station 12H2 RAW. A daily

grab sample was taken at 12H2 TREATED and composited into a weekly sample. These stations are located at the Danville Water Company (drinking water supply closest to SSES which could be affected by plant discharge). 12H2 RAW is taken from the Susquehanna river intake structure while 12H2 TREATED is drawn from the supply line after processing. Monthly composites of the 12H2 RAW and 12H2 TREATED samples were analyzed for gross alpha, gross beta, gamma emitters, iodine-131 and tritium.

D. Algae

Susquehanna River algae collections were set up at six locations beginning in May 1984 as a special study (not required by technical specifications) to locate the source of iodine-131 upstream of the SSES as postulated earlier (11). In 1987, algae samples were collected from two of the six previous locations: AG-3 (the SSES river water intake structure) and AG-4 (below the cooling tower blowdown discharge diffuser). Location AG-3 is the control, and AG-4 is the indicator location.

E. Fish

Fish sampling was conducted in the spring (April-May) and the fall (September-October) at three locations for this program. Downstream of the SSES on the Susquehanna River was selected as an indicator location (IND), and an upstream location was chosen as a control location (2H). Fish samples were also taken from Lake Took-A-While (LTAW), an indicator station.

Available edible species were filleted at the time of collection. The edible portions were frozen and shipped to the laboratory for analysis by gamma spectrometry and for gross beta.

F. Shoreline and Flocculated Sediment

Shoreline sediment (0 to 4 ft. of water) samples were collected in May and November at six locations in the Susquehanna River. These were Bell Bend (7B), Hess Island (11C), the old Berwick test track (12F), Gould Island (2B), between Shickshinny and the Retreat State Correctional Institution (2F) and Lake Took-A-While (LTAW). Flocculated sediments were also collected at location 7B and 2B in May and November. Floculated sediment is the top, loose layer of sediment in the river, that is easily moved and shifted by the water. Samples were analyzed for gamma emitting nuclides, gross alpha and gross beta. The control locations are 2B and 2F.

G. Ground (Well) Water

Seven wells, the Energy Information Center (2S6), the Riverlands Facility (3S5), the Peach Stand (4S2), the Training Center (4S4), the EOF Building (11S5), the Berwick Hospital (12E4) and the Berwick Water Company (12F3), a control station, were sampled monthly. Gross alpha, gross beta, gamma and tritium analyses were performed on monthly samples.

H. Airborne Particulates/Air Iodine-131/Precipitation

Airborne pathways were examined by analyzing air particulates, air iodine and precipitation. Air particulates were collected on Gelman type-A/E, glass fiber filters with low volume air samplers. Air iodine was collected on one-inch-deep Science Applications, Inc. charcoal cartridges. Air sample volumes were measured with temperature-compensated dry-gas meters.

The samplers were run continuously and the filters and charcoal cartridges exchanged weekly. The elapsed time of sampling was recorded on an elapsed-time meter. The initial and final volumes as registered on the dry gas meter, were recorded by the sample collector.

Atmospheric pathway samples were collected at ten locations; the Energy Information Center (2S2), the Biological Consultants (5S4), the Golomb House (11S2), the north west transmission line (15S4), the transmission line east of route 11 (9B1), the Mocanaqua Substation (1D2), Pond Hill (3D1), the Berwick Hospital (12E1), the Hazleton Chemistry Lab (7G1), and at the PP&L Service Center at Bloomsburg (12G1). The last two locations, 7G1 and 12G1, were the controls. Air filters were analyzed weekly for gross beta, then composited quarterly and analyzed for gross alpha and gamma emitters. Air iodine was collected on a charcoal cartridge in series with the air particulate filter at all locations. The charcoal cartridges are warranted to have an efficiency of removal of elemental iodine of 99%. The charcoal cartridges were analyzed weekly for iodine-131.

Precipitation samples were collected at least monthly from locations 2S2, 5S4, 11S2, 15S4, 9B1, 1D2, 3D1, 12E1, 7G1 (control) and 12G1 (control), composited quarterly, and analyzed for gross alpha, gross beta, tritium and gamma emitters.

I. Milk

Cow milk samples were collected monthly from nine locations; 12B2, 12B3, 6C1, 10D1, 12D2, 5E1, 13E3, 14B1, and 10G1 (control). Samples were collected semi-monthly from April through October from locations 12B2, 5E1, 13E3, 10D1, 14B1, and 10G1. Each monthly and semi-monthly sample was analyzed for gross beta minus potassium-40, iodine-131, and gamma emitters.

J. Vegetation, Top and Bottom Soil

One vegetation sample and one top soil and bottom soil sample were taken at each of eight indicator stations: 2S4, 5S5, 11S4, 15S4, 9B2, 1D4, 3D2, 12E2, and two control stations: 7G1 and 12G3. These samples were taken in September by compositing twelve plugs at each location. The top soil consists of the first 2 inches of soil and the bottom soil is from the depth of 2 to 6 inches. All samples were analyzed for gamma-emitting nuclides.

K. Food Products

Fruits and Vegetables

Gamma spectrometry was used to analyze various types of food products collected from farms or gardens within the vicinity of SSES. These included the following: apples, cantalope, strawberries, honey, sweet corn, cabbage, lettuce, potatoes, green beans, tomatoes, and red beets. Indicator locations that were sampled were 11D1, 12F5, 7B2, and 12B1. The control location sampled was 2H1. No farms could be located in the vicinity of SSES that irrigated their fields with Susquehanna River water in 1987; consequently, no crops sampled would be indicators of radionuclides in that pathway.

Meat

Meat samples consisting of eggs and duck were collected from indicator location 12B1 and 10D1 respectively. The edible portion was analyzed for gamma emitters.

Game

Three deer samples and three composite squirrel samples were collected in the fall and the flesh was analyzed for gamma emitters. The deer samples were collected from indicator stations 9B, 10B, and 16B, while the squirrel samples were collected from indicator stations 1S, 15S, and 16S.

V. SUMMARY AND DISCUSSION OF 1987 ANALYTICAL RESULTS

The analytical methods used by Teledyne Isotopes meet the lower limit of detection (LLD) requirements set forth in the Susquehanna Steam Electric Station Technical Specifications. The procedures, specifications and an explanation of the analytical calculation methods used in the laboratory for these analyses are summarized in Appendix B. Data from the radiological analyses of environmental media collected are tabulated and discussed below.

Radiological analyses of environmental media characteristically approach and frequently fall below the limits of state-of-the-art measurement methods. (18) For the gamma spectrometric results listed in this report only those radionuclides positively detected are listed in the tables. A positively detected radionuclide is one in which the activity is greater than a critical value. The critical value is equivalent to half the LLD. (22) However, due to the presence of the natural Be-7, K-40, Ra-226 and Th-228 decay chains in background gamma spectrometric results, natural radionuclides are reported only if their level exceeds LLD. Typical LLD's of selected nuclides searched for by gamma spectrometry are listed in Table 20.

For analyses other than gamma spectrometry, "LT" is used in the data tables where activity was not positively detected. The use of "LT" in the data tables in Section XII is the equivalent of the less than symbol ($<$). The number following "LT" is a result of calculation as defined in Appendix B and Appendix C.

Tables 5 through 19 give the radioanalytical results for individual samples. A statistical summary of the results based only on positively detected activities appears in Table 3.

A. Direct Radiation

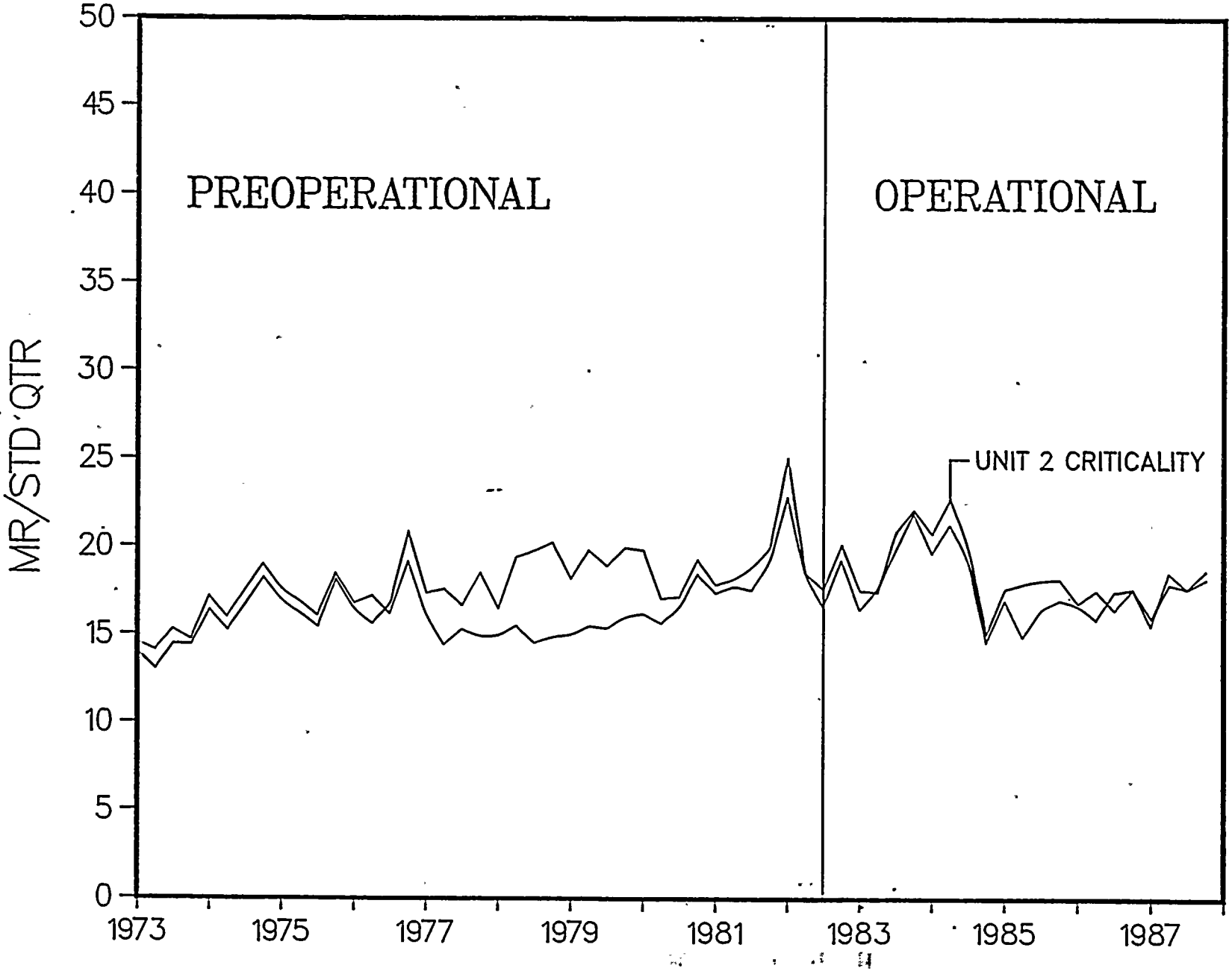
Thermoluminescent Dosimetry

Thermoluminescent dosimeters (TLDs) included in the Radiological Environmental Monitoring Program (REMP) were placed at 92 locations. Sixteen of these locations were co-located with TLDs belonging to the Nuclear Regulatory Commission. Four other REMP TLD locations were additionally monitored by pressurized ion chambers (PICs). Totals of 332 indicator TLD readings and 28 control TLD readings were obtained from quarterly processings during the year. The detailed results of these TLD readings can be found in Table 5. A description of PP&L's TLD system may be found in Appendix B.

The range of indicator TLD readings was from 0.13 to 0.27 mR/day, and the range of control TLD readings was from 0.14 to 0.22 mR/day in 1987. The averages for the year of both the indicator and control TLD readings individually were the same at 0.19 mR/day. The ambient radiation levels in 1987 may be compared with those dating back to the beginning of 1973 by referring to Figure 4 which trends both indicator and control data.

Oakley (19) calculates an ionizing radiation dose equivalent of 82 mrem/year from natural sources for the Wilkes-Barre area. Since

FIGURE 4
AMBIENT RADIATION LEVELS



Oakley's values represent averages covering wide geographical areas, the measured ambient radiation average of 69 mR/year for the immediate locale of SSES is consistent with Oakley's observations. Significant variations occur between geographical areas as a result of geological composition and altitude differences. Temporal variations result from changes in cosmic ray intensity, local human activities, and factors such as ground cover and soil moisture.

Pressurized Ion Chambers

In 1987, pressurized ion chamber (PIC) data was collected continuously at locations in Berwick (12F4), Nanticoke (3G2), Shickshinny (1E2), and at the Susquehanna Energy Information Center (2S5). TLD data was also obtained at these locations. Although some differences existed between TLD and PIC data, the two monitoring methods agreed well enough to provide additional corroboration of the ability of our TLD network to satisfactorily monitor the ambient radiation levels in the vicinity of SSES. PIC measurements are recorded on paper strip charts, whch are periodically reviewed and then archived. Further reduction of the data is not routinely performed.

B. SURFACE WATER

Surface water was sampled monthly or composited monthly from nine (9) locations including three (3) control locations. Samples were analyzed for gross alpha, gross beta, iodine-131, tritium, and gamma emitting radionuclides. A total of 108 surface water samples were

analyzed. Seventy-two (72) indicator sample analyses were performed and thirty-six (36) control sample analyses were carried out. The detailed results of these analyses can be found in Table 6.

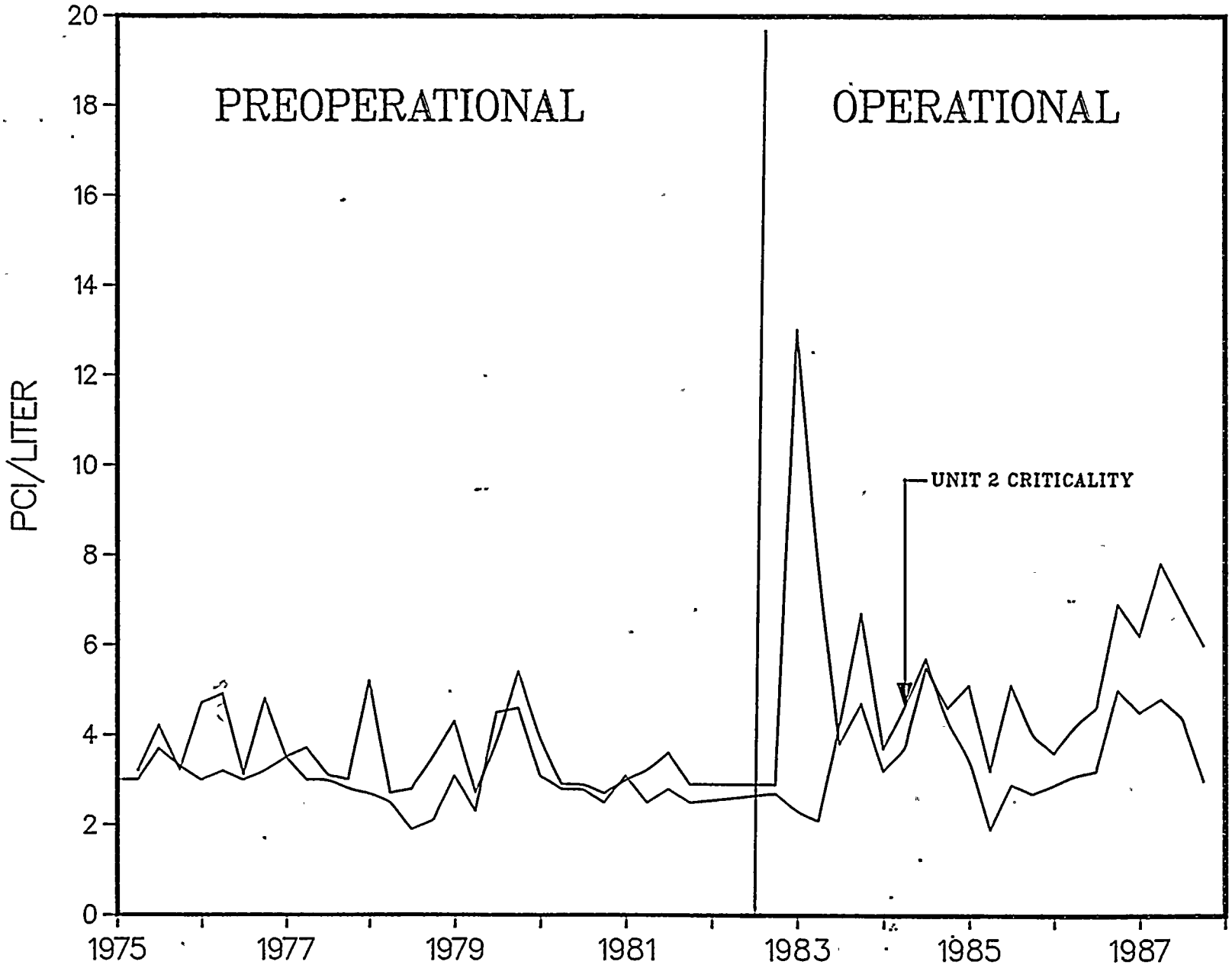
Only eight (8) of seventy-two (72) indicator samples analyzed for gross alpha activity yielded positive values (above the lower limit of detection), ranging from 2.3 to.5.7 pCi/liter. The range of yearly average gross alpha activities for indicator locations over the previous three years was from 1.2 to 6.5 pCi/liter. Six out of eight of the positive indicator results in 1987 occurred in March and April, as well as all of the three positive gross alpha activities from the control locations. This is probably due to river conditions that are more likely at this time of year such as higher flow rates and greater turbulence. These conditions tend to produce a larger-than-normal sediment load in the water. The naturally-occurring alpha-emitting radionuclides, radium-226 and thorium-228, are routinely identified in sediment samples. The average gross alpha activity in indicator surface water samples was 4.3 pCi/liter in 1987, higher than the averages in the previous three years. The average gross alpha activity for the control locations in 1987 of 3.1 pCi/liter is also higher than the averages of the alpha activities at those locations for the three previous years. The highest gross alpha activity observed for all locations in 1987 was in a sample obtained from the river seventeen (17) miles WSW, near the former US Radium Site, Bloomsburg.

All gross beta activity analyses at both indicator locations (72 locations out of 72) and control locations (36 locations out of 36)

produced positive results in 1987. The range of gross beta activities, 2 to 27 pCi/liter, for indicator locations in 1987 is within the range of activities, 1.3 to 79 pCi/liter for the previous operational period at the SSES, 1982 through 1986. Excluding the gross beta activities for samples from the cooling tower blowdown discharge line (sample location 6S7), the range of gross beta activities, 2 to 16 pCi/liter, from all other indicator locations for 1987 is within the range, 1.4 to 18 pCi/liter for the preoperational period, 1975 through 1981. (Since 1975, gross beta analyses are performed on unfiltered aliquots from surface water samples. Before 1975, gross beta activities were determined separately on the insoluble and soluble fractions of the surface water samples.)

The average gross beta activity, 6.9 pCi/liter, for all indicator locations in 1987 exceeds the averages for each of the previous operational years, 1982 through 1986, except the average for 1983, 7.7 pCi/liter. (Refer to Figure 5 trending gross beta activities separately for surface water indicator and control locations from 1975 through 1987.) The average gross beta activity for all indicator locations, excluding location 6S7, during 1987 was 4.6 pCi/liter. This may be compared to the gross beta activity, 3.9 pCi/liter, for all locations during the preoperational period 1975 through 1981. It is also of interest to contrast the average beta activity, 4.6 pCi/liter, for the indicators (without location 6S7) in 1987 with the average gross beta activity, 4.2 pCi/liter, at the control locations in 1987.

FIGURE
GROSS BETA ACTIVITY IN SURFACE WATER



Location 6S7, the cooling tower blowdown discharge line sample point, is a measure of the concentration of the activity of the water that may be periodically discharged to the river. It is not, however, likely to be representative of the concentration of the activity in the river water more than a few feet from the discharge pipe.

The usefulness of gross beta analyses are as indicators of whether performance of certain non-routine specific radionuclide analyses may be beneficial. When gross beta activities exceed 15 pCi/liter, strontium-89 and strontium-90 analyses are performed. In 1987, these analyses were performed in ten out of twelve monthly samples from location 6S7. In each case, no strontium-89 or strontium-90 was positively detected.

No iodine-131 was positively detected in surface water during 1987. This contrasts sharply with the preoperational years 1979 through 1981 and the operational years 1982 through 1986, when iodine-131 was positively detected each year. Alternate sources of iodine concentrations in surface water are medical uses in the area.

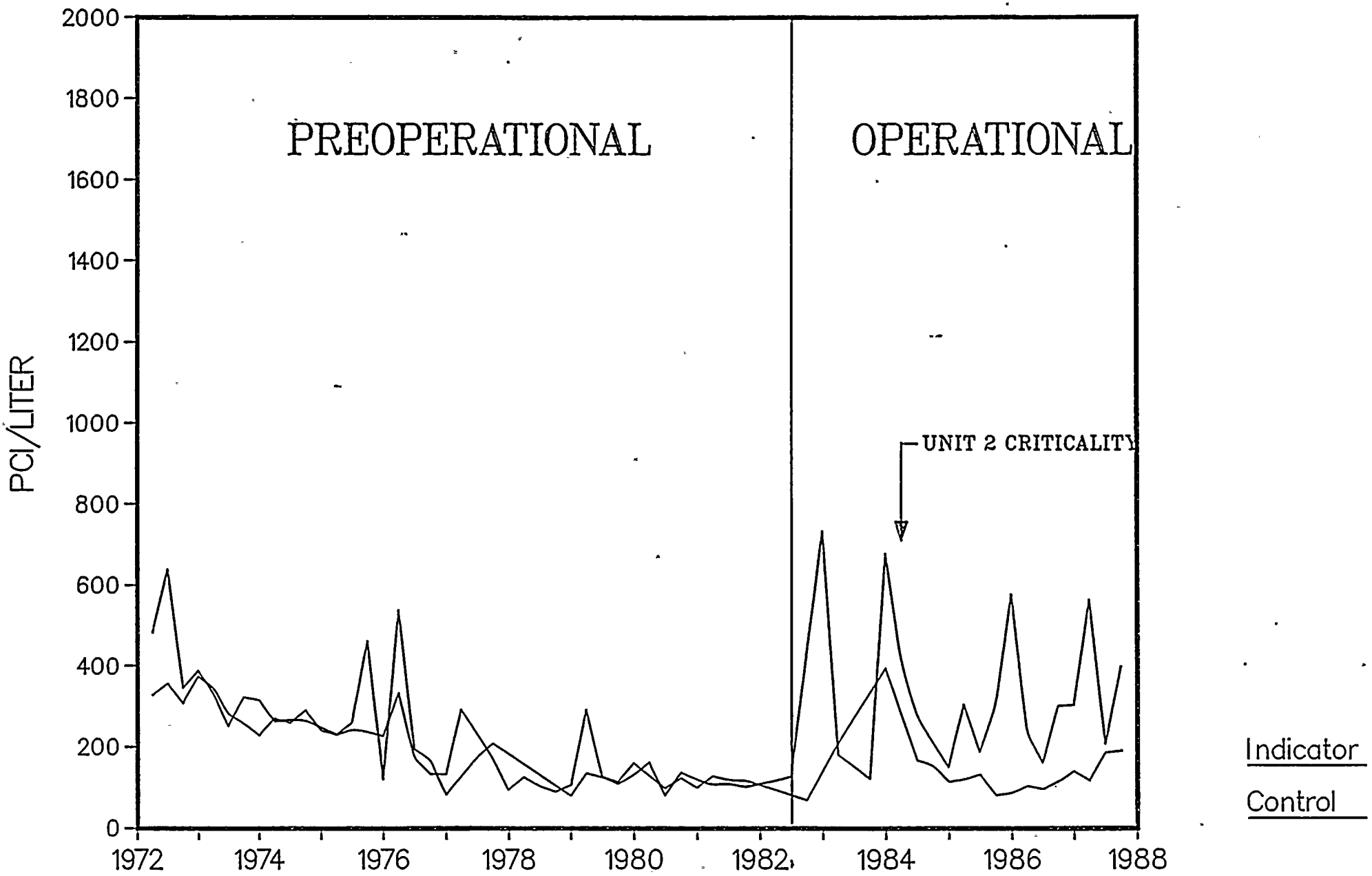
Tritium was positively detected in the indicator surface water samples in 53 out of 72 analyses. The indicator tritium activities for 1987 ranged from 58 pCi/liter up to 3000 pCi/liter. The average indicator tritium activity in 1987 was 366 pCi/liter. The 1987 average indicator tritium activity was higher than any of the average annual surface water tritium activities for the years 1973 through 1986. In 1972, however, the first year the REMP was performed in the vicinity of SSES, the average tritium activity for all locations

sampled (tritium was positively detected in 42 out of 42 samples) was 410 pCi/liter with a range from 140 to 1200 pCi/liter. (Refer to Figure 6 trending tritium activities separately for surface water indicator and control locations from 1972 through 1987.) If the indicator location 6S7 is excluded from the 1987 data, the average indicator tritium activity becomes 118 pCi/liter. This is below the average tritium activity, 152 pCi/liter, of the control locations in 1987.

The highest average station tritium activity, considering all sample locations, in 1987 was found to be 1222 pCi/liter at location 6S7, where the individual activities throughout the year ranged from 74 to 3000 pCi/liter. The highest tritium activity reported at location 6S7, 3000 pCi/liter, in 1987 is well below the NRC nonroutine reporting levels of 20,000 pCi/liter when a drinking water pathway exists or 30,000 pCi/liter when no drinking water pathway exists. The calculated dose to the maximally exposed individual is presented in Section V-L.

Gamma spectrometry positively detected naturally occurring potassium-40 in 2 out of 72 indicator samples and 1 out of 36 control samples. The average potassium-40 activity in the indicator samples was 15 pCi/liter. The potassium-40 activity in the one control sample was 25 pCi/liter. Naturally occurring thorium-228 was detected once at an activity of 2.5 pCi/l in a cooling tower blowdown discharge line sample.

FIGURE 3
TRITIUM ACTIVITY IN SURFACE WATER



[illegible]

Also detected by gamma spectrometry were the following radionuclides: manganese-54, chromium-51, cobalt-60, cesium-137, and cerium-141. The cesium-137 activity appeared only in 4 out of 36 control samples. The cesium-137 activity, ranging from 0.9 to 4.9 pCi/l, is attributed to fallout from previous atmospheric nuclear weapons testing and the Chernobyl incident. The manganese-54, chromium-51, and cobalt-60 identified by gamma spectrometry, were all found in samples from the location of the cooling tower blowdown discharge and are attributed to the operation of SSES. The average activities of these radionuclides found in 1987 are as follows: 5.5 pCi/liter of manganese-54, 22 pCi/liter of chromium-51, and 5 pCi/liter of cobalt-60. The calculated dose to the maximally exposed individual due to radionuclides resulting from operation of SSES is presented in Section V-L. The other man-made radionuclide, cerium-141, identified by gamma spectrometry, was detected only once in a sample from the SSES intake structure which is a control location. Although this is a relatively short-lived radionuclide (its half-life is about 32 days), its absence from any indicator samples tends to discount SSES as the probable source of this radionuclide. Also, the fact that no other fission products or activation products, such as manganese-54, were identified in this sample does not lend support to the existence of cerium-141 in the sample because of SSES operation.

C. DRINKING WATER

Twenty-four drinking water samples were taken during 1987 from the Danville Water Company's facility 26 miles WSW of SSES on the Susquehanna River. (The detailed results of the analyses of the

samples can be found in Table 7.) Half of the samples were taken prior to treatment of the water (these are referred to as the raw water samples) and the other half were taken after treatment. From 1977 (when drinking water samples were first collected) through 1984, drinking water samples were also obtained from the Berwick Water Company at location 12F2 (12F3), 5.2 miles WSW of SSES. The drinking water supply for the Berwick Water Company is not, however, water from the Susquehanna River, but actually well water. Since there are no drinking water supplies on the Susquehanna River upstream of SSES that would be appropriate to serve as a control location, the Danville drinking water samples may be compared to surface water control samples.

Gross alpha activity has been monitored in drinking water since 1980. No alpha activity was positively detected in drinking water in 1987. Typically, since 1980, alpha activity was observed each year in a small minority of these samples. The other exceptional year was 1981 when no samples yielded any alpha activity above the lower limit of detection. Gross alpha activity was found in 3 out of 36 surface water control samples at an average activity of 3.1 pCi/liter.

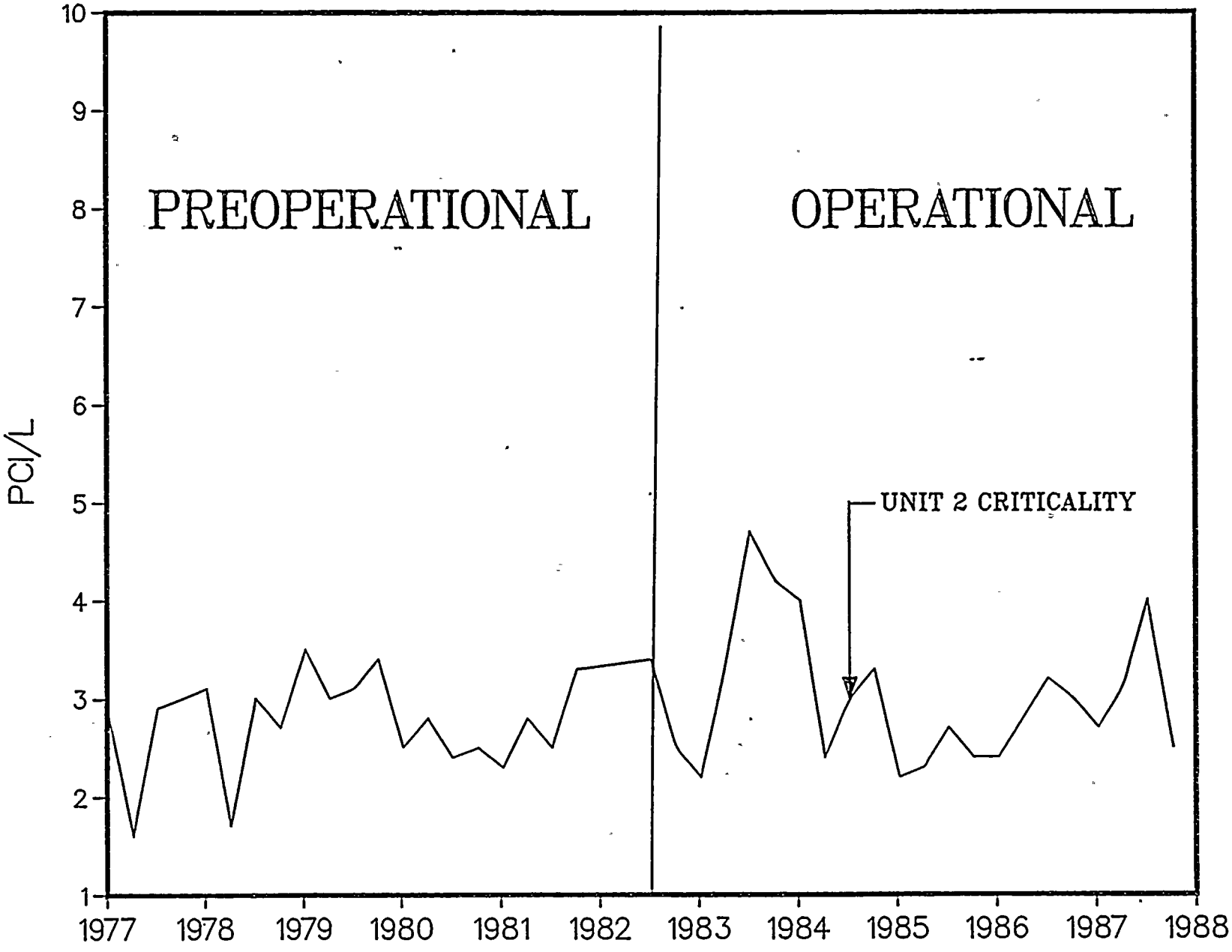
Gross beta activity was detected in 24 out of 24 drinking water samples in 1987. The average gross beta activity for 1987 was 3.1 pCi/liter, within the range of yearly average gross betas, 2.2 to 5.4 pCi/liter, from 1977 through 1986. The average drinking water gross beta activity was 4.2 pCi/liter for surface water control locations in 1987. The range of gross beta activities, 1.5 to 5.5 pCi/liter, in the samples in 1987 was within the range, 0.38 to 21 pCi/liter of

previous years' analyses. (Refer to Figure 7 trending gross beta activities separately for indicator and control drinking water samples from 1977 through 1987.) The gross beta activities in drinking water samples for 1987 do not indicate any contribution to the radioactivity of the drinking water from the operation of SSES.

No iodine-131 was detected in drinking water samples for 1987. This is the same result that was obtained for 1985 and 1986. Since 1980, iodine-131 has only been detected in drinking water 4 years out of a total of 8 years.

Tritium was positively detected in 18 out of 24 samples in 1987. The average tritium activity, 129 pCi/liter, in drinking water samples in 1987 is within the range of yearly average tritium activities, 83 to 220 pCi/liter, from 1977 through 1986. However, one of the highest tritium activities, 460 pCi/liter, in any individual sample since the beginning of 1977 was measured in June of 1987. This happened to coincide in time with the highest tritium activity, 3000 pCi/liter, observed at location 6S7 in 1987. It must be noted, however, that after examining many months of data, there does not appear to be a significant correlation between tritium activities at 6S7 and 12H2. For example, the surface water tritium activity, 2800 pCi/liter, measured at location 6S7 in December of 1987 is not accompanied by a notable drinking water tritium activity. The average drinking water tritium activity, 129 pCi/liter, for 1987 is below the average tritium activity, 152 pCi/liter, for surface water control locations in 1987.

FIGURE 7
GROSS BETA ACTIVITY IN DRINKING WATER



No gamma-emitting radionuclides were positively detected in drinking water samples in 1987. Based on the above results, none of the activities found in drinking water in 1987 is attributed to the operation of SSES.

D. ALGAE

A total of 13 algae samples were collected from two locations, indicator location AG4 (below the discharge diffuser) and control location AG3 (above the river water intake structure), from May 1987 through November 1987. (One sample was not collected at location AG3 in October due to high water in the Susquehanna River in September that washed away the algae collector. The algae collector was promptly replaced, but insufficient sample mass was present in October for proper analysis.) The algae samples were analyzed by gamma spectrometry. The detailed results of the analyses of these samples can be found in Table 8.

All 13 samples produced detectable amounts of the naturally occurring radionuclides beryllium-7, potassium-40, and thorium-228. Another naturally occurring radionuclide, radium-226, was detected in 3 out of 13 samples. With the exception of beryllium-7, which is cosmogenic in origin (produced by the interaction of cosmic radiation in the atmosphere), these radionuclides are terrestrial in origin (found in the earth's crust). Beryllium-7 activity levels were higher in both indicator and control samples in 1987 than in 1985 and 1986, but substantially lower than the values reported in 1984. Potassium-40 activity showed similar results, being higher than it

was in 1985 and 1986, but significantly lower than in 1984. Thorium-228 activity appeared to remain essentially constant from 1985 through 1987, and radium-226 suggested no trend, higher or lower, from 1985 through 1987. None of the changes in the activities of these naturally occurring radionuclides can be attributed to the operation of SSES.

Two fission-product radionuclides were positively detected in algae in 1987. Iodine-131 was detected in 2 out of 6 control samples and 1 out of 7 indicator samples in 1987. Iodine-131 has been positively detected in a portion (typically less than half) of both indicator and control samples each year from 1984 through 1987. In 1987, a single indicator algae sample was determined to have 1.0 pCi/gram(dry) of iodine-131 activity. The average iodine-131 activity in the two control samples in 1987 was 0.8 pCi/gram(dry). Comparison of these iodine-131 activities in algae with those of previous years provides no readily discernable increasing or decreasing trends. As in past years, the presence of iodine-131 in algae does not appear to be from SSES operation, but from medical sources upstream of SSES. With the exception of 1984, iodine-131 has been found more times in control algae samples each year than it has been found in indicator algae samples.

Cesium-137, with a half life in excess of 30 years, was detected in 2 out of 6 control algae samples, and it was found in 3 out of 7 indicator algae samples in 1987. The average cesium-137 activity in the control algae samples in 1987 was approximately 0.3 pCi/gram(dry). Cesium-137 in the environment comes from fallout

resulting from past atmospheric nuclear weapons' tests. No trend in cesium-137 activities in algae since 1984 is obvious. As algae data continues to be accumulated, assuming that atmospheric nuclear testing is not resumed, a decline in cesium-137 activity should eventually be observed. The average cesium-137 activities in the control and indicator algae samples in 1987 were 0.27 and 0.19 pCi/gram(dry), respectively.

The activation-product radionuclides seen in one indicator algae sample in July of 1987 were chromium-51, manganese-54, cobalt-58, and cobalt-60. All of these radionuclides were observed in indicator algae samples in 1985 and 1986, except for chromium-51 which wasn't observed in 1985. Except for cobalt-58, these radionuclides have also been observed in the surface water samples from the cooling tower blowdown discharge. Cobalt-58 was measured in a July 1987 sample at an activity of about 0.28 pCi/gram(dry). This activity level is lower than the average activity levels of cobalt-58 in indicator algae samples from 1985 and 1986 when it was also observed. Manganese-54 was seen at 0.65 pCi/gram(dry) in the July 1987 algae sample. This activity level is lower than the 1986 average, but slightly above the level observed in 1985. Cobalt-60 was measured at 0.94 pCi/gram(dry) in the July 1987 indicator algae sample. The 1987 cobalt-60 was slightly less than the 1986 average activity, but higher than the 1985 average. Chromium-51 has been detected at higher activity levels in algae than any of the other radionuclides. Although the 1986 chromium-51 level was higher than the activity in 1987, chromium-51 was analyzed to be 3.3 pCi/gram(dry) in the July 1987 sample. The activities of these radionuclides observed in algae are attributable to SSES operation.

E. FISH

A total of five different species of fish were collected at three different locations over April, May, September, and October 1987. The species included smallmouth bass, largemouth bass, channel catfish, brown bullhead catfish, and white sucker. The largemouth bass and brown bullhead catfish were obtained from Lake-Took-a-While (LTAW) located on PP&L property on the opposite side of Route 11 from the station. The smallmouth bass, channel catfish, and white sucker were all obtained from the Susquehanna River at a control location 30 miles NNE near Falls, Pennsylvania and at an indicator location between 0.9 and 1.4 miles ESE of the site, at or below the discharge structure.

As in every fish sample taken since the Spring of 1984, when gross beta analyses first began to be performed on fish flesh, all 9 indicator samples and all 6 control samples showed gross beta activity above the lower limit of detection (LLD). The gross beta activities ranged from 3.0 to 7.4 pCi/gram (wet) within the indicator samples and from 3.8 to 6.9 pCi/gram(wet) within the control samples in 1987. The average indicator gross beta activity was 5.3 pCi/gram(wet) and the average control gross beta activity was 5.4 pCi/gram(wet) in 1987. These 1987 averages for both indicator and control samples are within the ranges of their respective averages from 1984 through 1986. The primary source of this beta activity appears to be naturally occurring potassium-40, since no manmade radionuclides or other naturally occurring radionuclides are being detected at sufficient levels to account for this. (The detailed results of these analyses can be found in Table 9.)

Gamma spectrometry of fish in 1987 showed no gamma-emitting radionuclides in fish above the lower limits of detection, except for potassium-40 and cesium-137. Potassium-40 was detected in all indicator and control samples, ranging from 3.2 to 5.6 pCi/gram(wet) in the indicator samples to 3.3 to 4.7 pCi/gram(wet) in the control samples. The potassium-40 average activities for the indicator and control locations were essentially identical at 3.9 pCi/gram(wet) for the indicators and 4.0 pCi/gram(wet) for the controls. The yearly average potassium-40 activities for indicators from 1977 through 1986 range from a low of 2.7 pCi/gram(wet) in 1978 to a high of 3.7 pCi/gram(wet) in 1985 and 1986. The yearly average potassium-40 activities for controls from 1977 through 1987 range from a low of 2.8 pCi/gram(wet) also in 1978 to a high of 3.7 pCi/gram(wet) in 1985. By comparison to the potassium-40 activities, the cesium-137 activities appear very small, on the order of two orders of magnitude smaller. As in all other environmental media monitored, the source of the cesium-137 activity currently being seen is the residual fallout from atmospheric nuclear weapons testing. Cesium-137 activity was positively detected in 4 out of 9 indicator samples and 5 out of 6 control samples in 1987. The average cesium-137 activity in 1987 was 0.018 pCi/gram(wet) for the indicator samples and 0.012 pCi/gram(wet) for the control samples. Since 1977, the cesium-137 yearly average activities in fish from both indicator and control locations have normally been measured between 0.01 and 0.02 pCi/gram(wet). The only year when a higher average activity than 0.02 pCi/gram(wet) was reported was 1980 when it was 0.042 pCi/gram(wet) for indicator locations based on positive detection in

only one indicator sample. No trend (higher or lower) for cesium-137 activities for the 1977-1987 period is apparent. Fish samples have shown no radioactivity attributable to SSES operation.

F. SHORELINE AND FLOCCULATED SEDIMENT

Shoreline sediment was sampled in May and November 1987 at two control locations and four indicator locations. The sediment was analyzed for gross alpha activity, gross beta activity, and the activity of gamma-emitting radionuclides. The detailed results of these analyses can be found in Table 10.

Gross alpha activity was positively detected in 8 out of 8 indicator samples and 4 out of 4 control samples. The gross alpha activity at the indicator locations ranged from 6.5 to 29.0 pCi/gram(dry), while the gross alpha activity at the control locations ranged from 9.8 to 14 pCi/gram(dry) in 1987. The average gross alpha activity in sediment for indicator locations was 17 pCi/gram(dry), and for control locations it was 13 pCi/gram(dry). For comparison, gross alpha activities in sediment have been determined every year since 1982. The range of yearly average gross alpha activities in sediment at the indicator locations for the period 1982 through 1986 was 6 to 13 pCi/gram(dry), with a mean value of 9.1 pCi/gram(dry). From 1982 through 1987, the indicator locations on the Susquehanna River have been at Bell Bend - 1.2 miles SE, Hess's Island - 2.6 miles SW, and near the Old Berwick Test Track - 6.9 miles WSW. The average gross alpha activity, 9.8 pCi/gram(dry), at the control locations for the 1982-1986 period was higher than the average for the indicator

locations, although the range of yearly average activities, 5.7 to 12 pCi/gram(dry) did not extend as high.

Gross beta activity was positively detected in 8 out of 8 indicator sediment samples and 4 out of 4 control samples. The gross beta activities at the indicator locations ranged from 19 to 38 pCi/gram(dry). The gross beta activities in the sediment at control locations ranged from 25 to 32 pCi/gram(dry). The average gross beta activity in sediment for indicator locations was 31 pCi/gram(dry), and for control locations it was essentially the same at 30 pCi/gram(dry) in 1987. The gross beta activities in sediment in 1987 can be compared to the gross beta activities during the period 1984 through 1986. (Prior to 1984, no gross beta analyses were performed on sediment.) The gross beta activities in sediment at indicator locations ranged from approximately 20 to 26 pCi/gram(dry) between 1984 and 1986, averaging about 23 pCi/gram(dry). The sediment gross beta activities at control locations ranged from about 21 pCi/gram(dry) to 30 pCi/gram(dry), averaging about 25 pCi/gram(dry).

Gamma spectrometry in 1987 identified the following naturally occurring radionuclides in sediment at levels above their lower limits of detection: potassium-40, radium-226, thorium-228, and beryllium-7. With the exception of beryllium-7, which was identified only twice, once in an indicator sample and once in a control sample, the other three radionuclides were found in every indicator and control sample in 1987. Potassium-40 activity in sediment in 1987 ranged between 6.2 and 14 pCi/gram(dry) in indicator samples and between 9.9 and 14 pCi/gram(dry) in control samples. The average

potassium-40 activities measured in sediment in 1987 for indicator and control samples were 11 and 12 pCi/gram(dry), respectively. Radium-226 activity in sediment in 1987 varied between 1.0 and 1.9 pCi/gram(dry), with an average of 1.6 pCi/gram(dry), for indicator samples. In control samples, the radium-226 varied between 1.5 and 2.2 pCi/gram(dry), with an average of 1.9 pCi/gram(dry). The ranges of thorium-228 activity at indicator and control locations were 0.72 to 1.3 and 1.0 to 1.5 pCi/gram(dry), respectively. The average thorium-228 activity, 1.1 pCi/gram(dry), in sediment at the indicator locations in 1987 was essentially identical to the average of 1.2 pCi/gram(dry) at the control locations. The averages for the activities of all the naturally occurring radionuclides measured by gamma spectrometry in sediment in 1987 are within the ranges of yearly averages reported for those radionuclides from 1974 through 1986. It should be noted though that before 1984 (except for 1982) thorium-232 activities were reported instead of thorium-228 activities. The reported thorium-232 activities, as a whole, for the period 1974 through 1983 tended to be lower than the thorium-228 activities reported in the last four years.

The only man-made gamma-emitting radionuclides positively detected in sediment in 1987 were cesium-137 and manganese-54. Cesium-137 was detected in 6 out of 8 indicator samples and 3 out of 4 control samples. The cesium-137 activities in sediment at indicator locations in 1987 ranged from 0.021 to 0.21 pCi/gram(dry), averaging 0.12 pCi/gram(dry). The average cesium-137 activity in sediment at the control locations was 0.16 pCi/gram(dry). Cesium-137 has been positively detected in sediment every year from 1974 through 1987 at

average yearly activities ranging from 0.07 to 0.3 pCi/gram(dry). The cesium-137 activities in sediment originated from the fallout following previous atmospheric nuclear weapons tests. No trend in the activity of cesium-137 in sediment appears to be indicated. The cesium-137 activity in sediment is not attributable to SSES operations. Manganese-54 was detected in 1 out of 8 indicator samples at an activity of 0.026 pCi/gram(dry). Manganese-54 was previously detected in 3 indicator samples in 1985 and 2 indicator samples in 1978. Manganese-54 activity in 1987 is within the range of previously detected activities. The manganese-54 detected in the one sediment sample in 1987 is attributable to the operation of SSES.

Flocculated sediment (floc) samples began being collected in 1986 at one control location, 1.6 miles NNE near Gould Island, and one indicator location, 1.2 miles SE at Bell Bend. Floc is the top, loose layer of sediment in the river that is easily moved and shifted by the water. It is thought that material carried by the water would be most readily transferred to this floc. The limited data collected in 1986 and 1987 do not point to the appearance of radionuclides in the floc that haven't also been identified in the underlying sediment; but the data, so far, do hint at the possibility of higher gross alpha and beta activities as well as naturally occurring radium-226 and thorium-228 in the floc than is being seen in the underlying sediment. Gross alpha activity ranged from 20 to 24 pCi/gram(dry) and averaged 22 pCi/gram(dry) in 1987 indicator floc samples. The average alpha activity in the control samples was essentially the same at 21 pCi/gram (dry). Gross beta activity in the indicator floc samples in 1987 ranged from 39 to 47

pCi/gram(dry), with an average of 43 pCi/gram(dry). The average beta activity in the control samples was 38 pCi/gram(dry). Naturally occurring radium-226 in 1987 indicator floc samples ranged from 2.4 to 3.7 pCi/gram(dry), averaging 3.1 pCi/gram(dry). The average radium-226 activity in the control samples was 2.9 pCi/gram(dry). Naturally occurring thorium-228 in 1987 indicator floc samples ranged from 0.9 to 1.6 pCi/gram(dry), with an average of 1.3 pCi/gram(dry). The average thorium-228 activity in the control samples was also 1.3 pCi/gram(dry). Naturally occurring and cosmogenic beryllium-7 was observed in one indicator floc sample in 1987 at an activity of 1.1 pCi/gram(dry). As with the underlying sediment, the only manmade radionuclide positively detected in floc in 1987 was cesium-137. The cesium-137 yearly average activity in indicator floc samples was 0.16 pCi/gram(dry), and in control samples it was 0.24 pCi/gram(dry). This cesium-137 activity is not attributed to SSES operations.

G. GROUND WATER

Ground water was sampled monthly at seven locations in 1987, including one control location. A total of 66 indicator samples and 12 control samples were collected. The detailed results of the analyses of these samples can be observed in Table 11.

Gross alpha activity has been analyzed in ground water since 1980. It is usually positively detected in a small number of samples annually. In 1987, gross alpha activity was detected above the lower limit of detection (LLD) in only 4 out of 66 indicator samples, and it was not greater than the LLD in any control samples. In all four

instances when it exceeded the LLD in 1987, the samples were obtained from location 4S2, 0.5 miles ENE at the Peach Stand. The gross alpha activity at this location ranged from 3.6 to 4.5 pCi/liter, averaging 4.0 pCi/liter. The yearly average gross alpha activities in ground water from 1980 through 1986 ranged from less than LLD in 1981 to 2.8 pCi/liter in 1986.

Gross beta activity has been analyzed in ground water since 1977. It is positively detected in a majority of samples every year. In 1987, gross beta activity was positively detected in 39 out of 66 indicator samples and it was found above the LLD in 11 out of 12 control samples. The gross beta activities ranged from 1.3 to 4.2 pCi/liter in indicator ground water samples in 1987, averaging 2.3 pCi/liter. In control ground water samples in 1987, the gross beta activities ranged from 1.4 to 3.1 pCi/liter, averaging 2.1 pCi/liter. From 1979 through 1986, the ground water yearly average gross beta activities in indicator samples ranged from 2.1 to 3.7 pCi/liter. As with the gross alpha activity, the location with the highest yearly average gross beta activity, 3.1 pCi/liter, is 4S2, 0.5 miles ENE at the Peach Stand.

Tritium activity has been positively detected in some ground water samples every year from 1972 through 1987. In 1987, tritium was positively detected in 33 out of 66 indicator samples and in 9 out of 12 control samples. The tritium activities in 1987 ranged from 69 to 250 pCi/liter at the indicator locations, averaging 107 pCi/liter. The range of tritium activities at control locations in 1987 was from 83 to 160 pCi/liter, averaging 110 pCi/liter. The location with the

highest annual average tritium activity, 133 pCi/liter, in 1987 was 3S5, 0.9 miles NE at the Riverlands Security Office. For comparison, yearly average tritium activities from 1972 through 1986 have ranged from 85 to 420 pCi/liter at indicator locations.

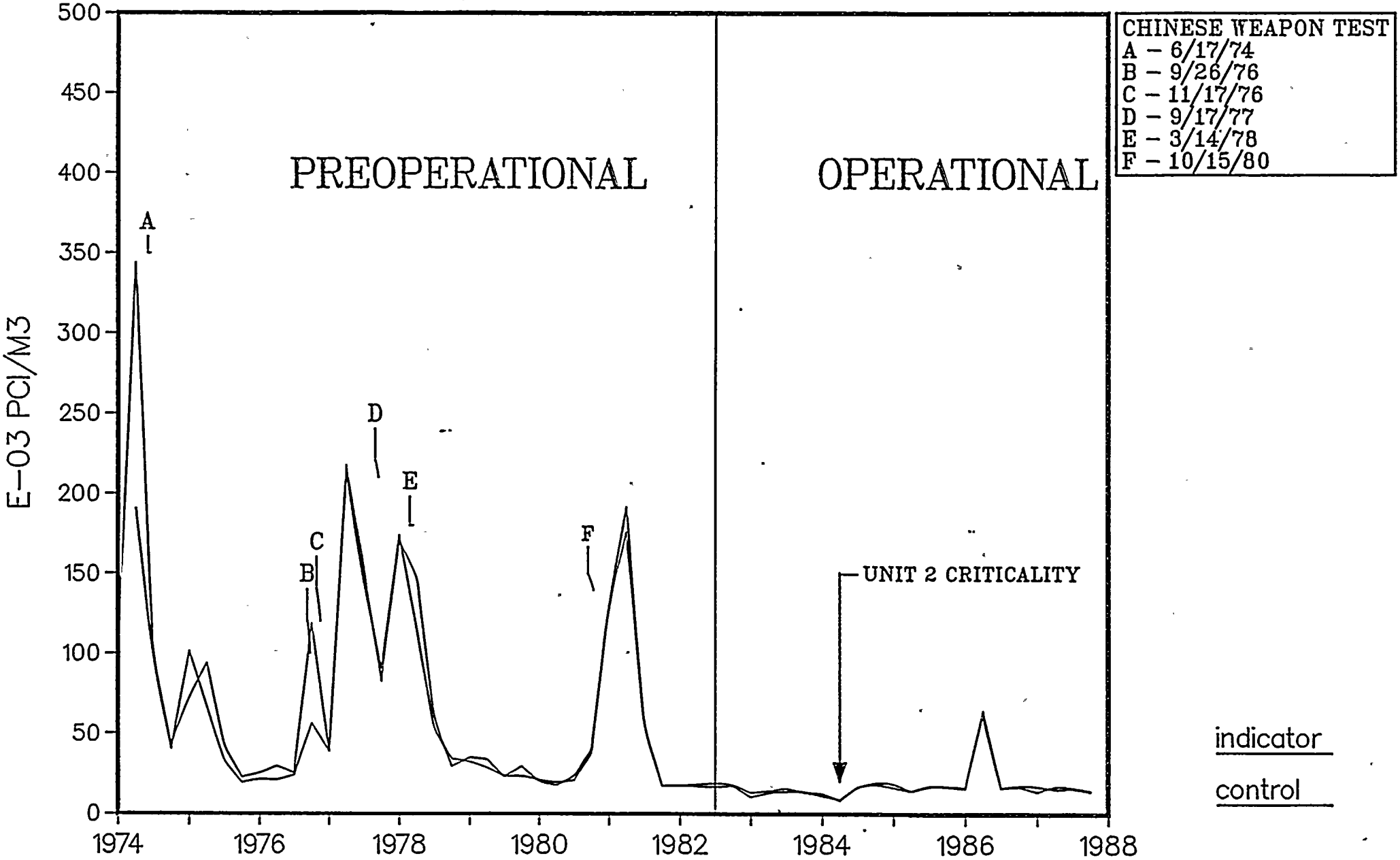
Gamma spectrometry of ground water has yielded few positively detected radionuclides since it was begun in 1979. Cesium-137 was detected in 1985 and 1986. Potassium-40 was found in 1979, 1981, and 1985. Thorium-228 was observed in 1985 and 1986. Potassium-40 and thorium-228, as discussed previously, are naturally occurring, and cesium-137 is present due to fallout from atmospheric nuclear weapons tests. In 1987, cobalt-60 was detected in a ground water sample collected January 6 from indicator location 11S5, 0.5 miles WSW at the Emergency Operations Facility (EOF). Subsequently, a sample was again collected at this location January 14. Analysis of this second sample was unable to confirm the presence of cobalt-60 at this location. Follow-up analyses of six samples obtained from various sources at the EOF on January 21 also failed to positively detect cobalt-60. No radioactivity detected in ground water can be attributed to the operation of SSES.

H. AIR PARTICULATE

The results of a total of 530 routine air samples collected at 10 locations (except for the week of 12/30/86 to 1/6/87 when 11 locations were sampled) during 1987 are included in this report. Four hundred twenty-four samples were collected at eight indicator locations and 106 samples were collected at 2 control locations. The detailed results of these analyses can be found in Tables 12 and 13.

The particulate filters were collected weekly and analyzed individually for gross beta activity. Quarterly, the particulate filters were composited and analyzed for gross alpha activity and the activity of specific radionuclides identified by gamma spectrometry. Gross beta activity was positively detected in all 530 weekly samples, which includes both indicators and controls. The range of gross beta activities in air samples in 1987 for both indicator and control samples was from 7.2 to 76 E-3 pCi/m^3 with an average of 16 E-3 pCi/m^3 for each. This may be compared to the range of yearly average gross beta activities for indicator samples from 1978 through 1986 of 13 to 97 E-3 pCi/m^3. (Refer to Figure 8 trending gross beta activity in air particulates separately for indicators and controls from 1974 to 1987.) A yearly average of 97 E-3 pCi/m^3 occurred in the preoperational years 1978 and 1981. Since 1981, the highest gross beta activity occurred in 1986 due to the Chernobyl incident. Prior to this, the unusually high gross beta activities may generally be attributed to fallout from atmospheric nuclear weapons tests. Gross alpha activity was positively detected in 32 out of 32 indicator analyses and 8 out of 8 control analyses. Gross alpha activities in indicator samples in 1987 ranged from 1.4 to 5.5 E-3 pCi/m^3, averaging 3.3 E-3 pCi/m^3. Gross alpha activities in control samples in 1987 ranged from 1.6 to 4.2 E-3 pCi/m^3, averaging 3.0 E-3 pCi/m^3. Gross alpha activities have been monitored every year since 1980. (Refer to Figure 9 trending gross alpha activity in air particulates separately for indicators and controls from 1980 through 1987.) The range of yearly average gross alpha activities from 1980 through 1986 has been 2.8 to 6.8 E-3 pCi/m^3 for indicator samples and

FIGURE 8


CHINESE WEAPON TEST
A – 6/17/74
B – 9/26/76
C – 11/17/76
D – 9/17/77
E – 3/14/78
F – 10/15/80
PREOPERATIONAL
OPERATIONAL
UNIT 2 CRITICALITY
E-03 PCI/M3
500
450
400
350
300
250
200
150
100
50
0
1974
1976
1978
1980
1982
1984
1986
1988
indicator
control

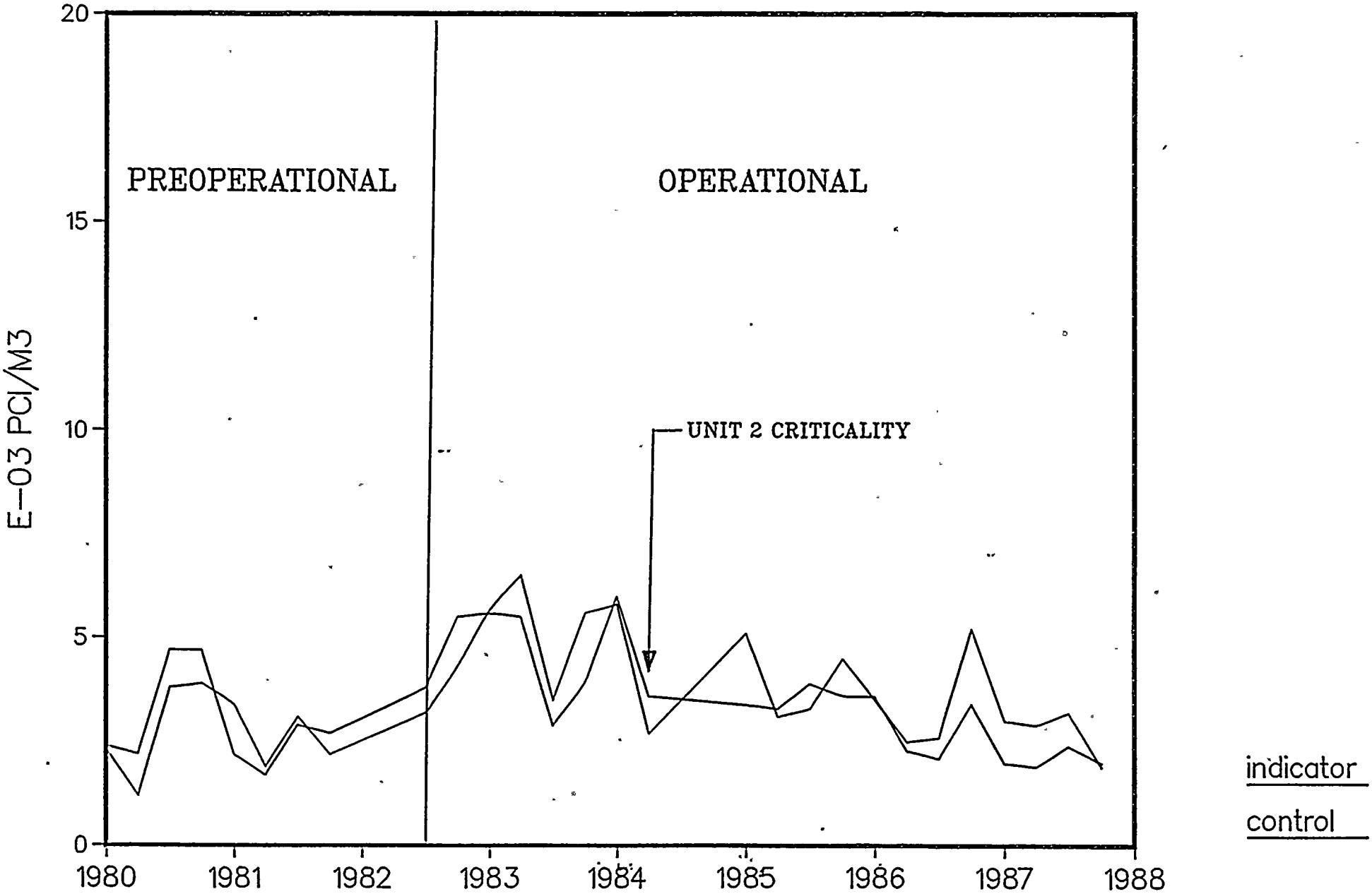
[illegible]

2.2 to 9.0 E-3 pCi/m^3 for control samples. The yearly average gross alpha activities in air samples in 1987 do not appear to differ significantly from those reported during the preoperational years 1980 and 1981. It might also be noted that no correlation is obvious between high gross beta activities and high gross alpha activities in air.

Gamma spectrometry positively detected only two naturally occurring radionuclides, beryllium-7 and potassium-40, in air samples in 1987. No anthropogenic (man-made) radionuclides were positively detected. Beryllium-7 was found in 32 out of 32 indicator analyses and 8 out of 8 control analyses. Beryllium-7 for indicator locations in 1987 ranged from 47 to 102 E-3 pCi/m^3, averaging 73 E-3 pCi/m^3. At control locations in 1987, beryllium-7 ranged from 51 to 99 E-3 pCi/m^3, averaging 65 E-3 pCi/m^3. From 1978 through 1986, beryllium-7 yearly average activities ranged from 62 through 81 E-3 pCi/m^3 at indicator locations and 53 to 85 E-3 pCi/m^3 at control locations. Potassium-40 was positively detected in only 6 out of 32 indicator analyses and 1 out of 8 control analyses in 1987. The range of potassium-40 activities for indicator locations in 1987 was 2.3 to 8.5 E-3 pCi/m^3, averaging 5.2 E-3 pCi/m^3. Potassium-40 yearly average activities have been reported for only four previous years. These previously reported activities have ranged from 3.5 to 12 E-3 pCi/m^3.

None of the results from the analyses of air particulate filters indicate radioactivity attributable to the operation of SSES.

FIGURE
GROSS ALPHA ACTIVITY IN AIR PARTICULATES



AIR IODINE

Routine iodine-131 analyses by gamma spectrometry of 529 charcoal cartridges did not positively detect that radionuclide in any air samples in 1987. Iodine-131 was detected infrequently from 1976, when it was first monitored, through 1986. Since operation of SSES began in 1982, iodine-131 has only been positively detected in air sampling in 1986 due to the Chernobyl incident.

PRECIPITATION

Precipitation samples from 8 indicator locations and 2 control locations were analyzed quarterly in 1987 for gross alpha activity, gross beta activity, tritium activity, and the activity of gamma-emitting radionuclides identified by gamma spectrometry. The detailed results of these analyses can be found in Table 14.

Gross alpha activity was detected in 22 out of 32 indicator samples and 6 out of 8 control samples in 1987. The gross alpha activity in indicator samples in 1987 ranged from 0.5 to 3.4 E-3 pCi/liter, averaging 1.3 E-3 pCi/liter. The gross alpha activity in control samples in 1987 ranged from 0.5 to 2.4 E-3 pCi/liter, averaging 1.1 E-3 pCi/liter. The range of yearly average gross alpha activities from 1984 through 1986 was 0.61 to 1.1 E-3 pCi/liter for indicator samples and 0.93 to 1.0 E-3 pCi/liter for control samples. Considering the uncertainties associated with the yearly averages, the differences from one year to the next are not significant. Nothing in the data indicates gross alpha activity in precipitation attributable to SSES operation.

Gross beta activity was detected in all 32 indicator precipitation samples and all 8 control precipitation samples in 1987. The gross beta activity in indicator samples in 1987 ranged from 1.2 to 7.2 E-3 pCi/liter, averaging 4.3 E-3 pCi/liter. The gross beta activity in control samples in 1987 ranged from 3.0 to 8.7 E-3 pCi/liter, averaging 5.2 E-3 pCi/liter. The range of yearly average gross beta activities from 1984 through 1986 was 2.5 to 3.5 E-3 pCi/liter for indicator samples and 3.4 to 4.5 E-3 pCi/liter for control samples. The location with the highest yearly average gross beta activity, 6.0 E-3 pCi/liter, in 1987 was 12G1, 15 miles WSW of the site. Because of the associated uncertainties and the fact that the yearly average gross beta activities at the control locations have been consistently higher than those at the indicator locations, nothing in the data indicates gross beta activity in precipitation attributable to SSES operation.

Tritium activity was positively detected in 14 out of 32 indicator samples, and it was observed in 3 out of 8 control samples in 1987. The tritium activity in indicator samples in 1987 ranged from 71 to 260 E-3 pCi/liter, averaging 139 E-3 pCi/liter. The tritium activity in control samples in 1987 ranged from 73 to 130 E-3 pCi/liter, averaging 99 E-3 pCi/liter. Tritium activity has been monitored every year since 1980. The yearly average tritium activities from 1980 through 1986 ranged from 94 to 213 E-3 pCi/liter at indicator locations and from 92 through 530 E-3 pCi/liter at control locations. Considering previous data (including preoperational data), the observed tritium activity in precipitation is not attributed to SSES operation.

The only gamma-emitting radionuclides positively detected in precipitation in 1987 were naturally occurring potassium-40 and man-made cesium-137. Potassium-40 was found in 3 out of 32 indicator samples in 1987, but it was not observed in any control samples in 1987. The potassium-40 activity in these 1987 samples ranged from 53 to 132 pCi/liter, averaging 87 pCi/liter. Potassium-40 has only been positively detected in two previous years, 1985 and 1986, since gamma spectrometry was first performed on precipitation samples in 1980. The activity reported in 1987 exceeds the yearly average activities for each of these years. The potassium-40 activity in precipitation can not be attributed to SSES operation. The cesium-137 from fallout was detected once in a control sample at an activity of 3.9 pCi/liter. It was also detected in precipitation in 1981, 1985, and 1986.

I. MILK

In 1987, 131 indicator milk samples and 19 control milk samples were routinely analyzed for gross beta minus potassium-40 activity, iodine-131 activity, and the activity of gamma-emitting radionuclides by gamma spectrometry. Any milk samples showing gross beta minus potassium-40 activity at 15 pCi/liter or higher were also analyzed for strontium-89 and strontium-90. (This applied to 6 samples in 1987.) Milk was sampled at a total of 9 locations in 1987 - 1 location being a control. The frequency of sampling was monthly, except for 6 locations where it was sampled semi-monthly from April through October. The detailed results of these analyses can be found in Table 15.

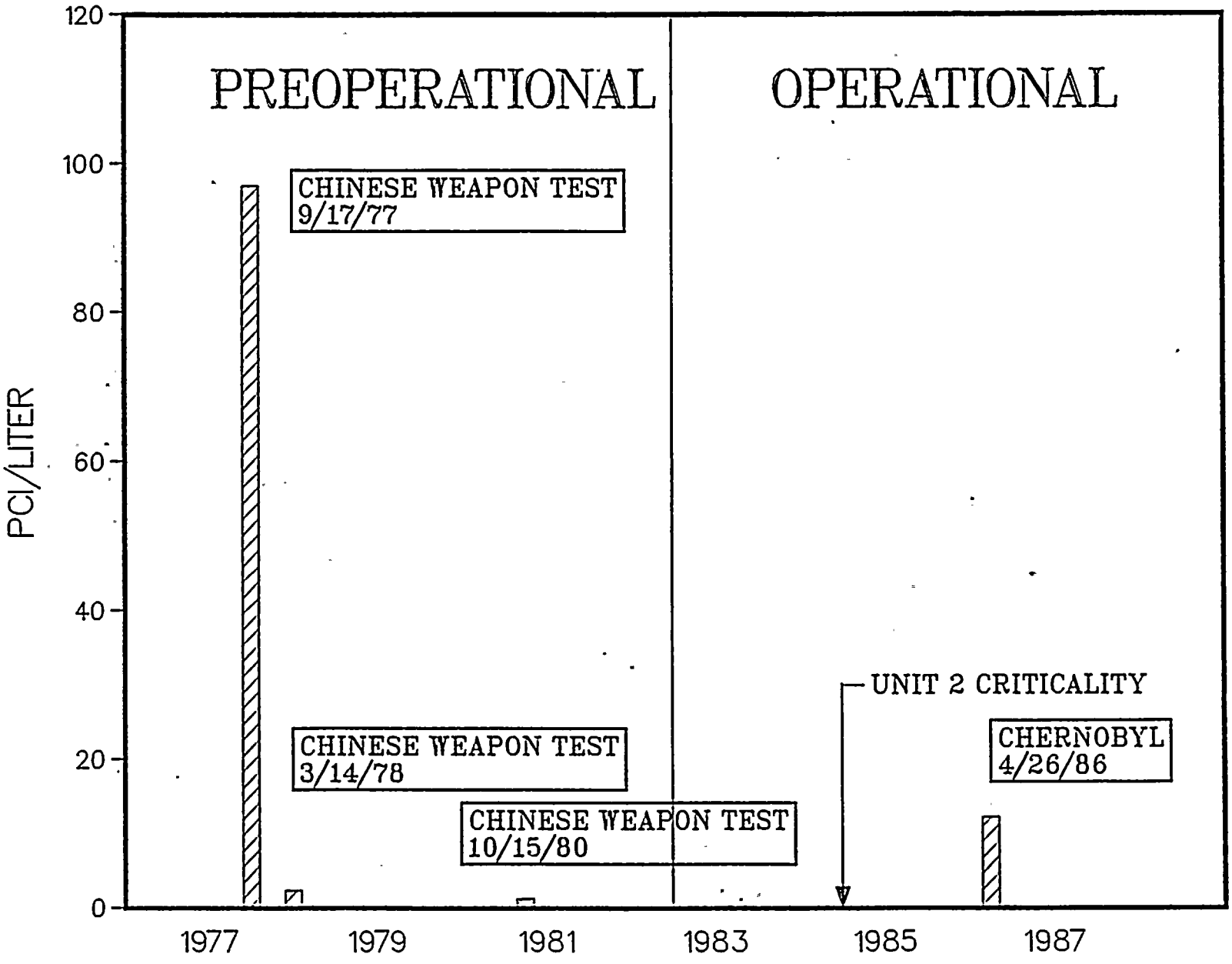
Since naturally occurring and beta-emitting potassium-40 normally accounts for the large majority of the activity in milk, removing this activity before performing a gross beta analysis provides a more sensitive method for detecting the activities of other beta-emitters that may be present, such as strontium-90. Gross beta minus potassium-40 analyses have been performed since 1985. Gross beta minus potassium-40 was positively detected in 127 out of 131 indicator samples, ranging from 2.6 to 19 pCi/liter, and it was observed in 19 out of 19 control samples, ranging from 5.3 to 14 pCi/liter. In 1987, the indicator yearly average for this analysis was 7.1 pCi/liter and the control yearly average was 9.7 pCi/liter. The indicator yearly average for 1987 is slightly lower than the indicator averages for the previous two years. The control yearly average for 1987 is somewhat higher than the previous two years. Strontium-90 analyses were done on 6 indicator samples in 1987. All six analyses positively detected strontium-90, ranging from 3.1 to 10 pCi/liter in the milk. The average strontium-90 activity in the milk at the locations monitored in 1987 was 6.8 pCi/liter. This is essentially the same as the 1986 yearly average strontium-90 activity, 6.6 pCi/liter. In 1985, no strontium-90 activities were reported in milk. From 1975 through 1982, prior to SSES operation, strontium-90 analyses were routinely performed on milk samples, with yearly averages being reported separately for both indicator and control locations. The 1987 average strontium-90 activity is within the range of activities, 1.7 to 7.5 pCi/liter, reported for indicator and control locations during this preoperational period. The source of the strontium-90 before SSES operation and since criticality

appears to be the Chinese atmospheric nuclear weapons tests, referred to in previous REMP annual reports, that took place in 1972, 1974, 1976, 1977, 1978, and 1980.

Iodine-131 has been chemically separated from the milk in samples and counted routinely since 1977. (Refer to Figure 10 trending iodine-131 activity in milk separately for indicators and controls from 1977 through 1988.) Typically, iodine-131 is not positively detected in any milk samples during a monitored year. The 1987 monitoring year was no exception; no iodine-131 above the lower limit of detection was observed in either indicator or control samples. The preoperational years 1976, 1978, and 1980 were exceptional years in the sense that activity was positively detected due to fallout. Iodine-131 activity was also detected in milk samples in 1986 in the vicinity of SSES as a result of the Chernobyl incident.

Gamma spectrometry of milk samples in 1987 positively detected naturally occurring potassium-40 in all indicator samples, ranging from 928 to 1490 pCi/liter, and in all control samples, ranging from 988 to 1420 pCi/liter. The average potassium-40 activity in indicator samples in 1987 was 1258 pCi/liter, and in control samples the average was 1299 pCi/liter in 1987. These can be compared to the range of yearly average potassium-40 activities, 222-1700 pCi/liter, reported from 1973 through 1986 in both indicator and control samples. Gamma spectrometry in 1987 also positively detected cesium-137 in milk from the fallout of previous years' atmospheric

FIGURE 10
IODINE–131 ACTIVITY IN MILK



nuclear weapons tests and Chernobyl fallout. (Cesium-137 remains in the environment following fallout for a relatively long time because of its 30 year half-life.) Cesium-137 was detected in 1987 in only 20 out of 131 indicator samples, ranging from 3.1 to 20 pCi/liter, and it was found in only 5 out of 19 control samples ranging from 3.7 to 6.3 pCi/liter. The average cesium-137 activities at indicator and control locations in 1987 were 6.9 and 4.5 pCi/liter respectively. This activity may be compared to the range of yearly average cesium-137 activities, 1.6 to 11 pCi/liter, at both indicator and control locations from 1974 through 1986. The only years during the Radiological Environmental Monitoring Program that cesium-137 was not positively detected in milk were in 1973 and 1984. No other gamma-emitting radionuclides have been positively detected in milk in 1987 or any other year REMP was conducted, except for 1986. Cesium-137 was detected once in June, 1986, following the Chernobyl incident.

No radioactivity identified in milk is attributed to SSES operation.

J. VEGETATION, TOP AND BOTTOM SOIL

Vegetation, usually grass, and top and bottom soil were sampled once at each of 8 indicator locations and 2 control locations during 1987. The locations for sampling vegetation and soil are the same as those for sampling air. The detailed results of these analyses can be found in Tables 16 and 17. Sixteen indicator soil samples were collected and 4 control soil samples were obtained in 1987. Half the soil samples were "top" samples taken from the top 2 inches of soil.

The other half of the soil samples were gathered from a depth of 2 to 6 inches and are called "bottom" samples. The soil samples, as with the vegetation samples, were analyzed by gamma spectrometry.

Naturally occurring potassium-40, radium-226, and thorium-228 were positively detected in all indicator and control soil samples in 1987. The fallout radionuclide cesium-137 was also found in all indicator and control soil samples in 1987. Manganese-54 was detected in one indicator soil sample in 1987. Potassium-40 in the indicator soil samples for 1987 ranged from 7.7 to 41 pCi/gram(dry), averaging 12 pCi/gram(dry). In the 1987 control soil samples, potassium-40 ranged from 7.7 to 10 pCi/gram(dry), averaging 8.8 pCi/gram(dry). The yearly average potassium-40 activities from 1984 through 1986 ranged from 10 to about 11 pCi/gram(dry) at indicator locations, and it ranged from 7.4 to approximately 11 pCi/gram(dry) at control locations. Radium-226 in the indicator soil samples for 1987 ranged from 1.0 to 3.1 pCi/gram(dry), averaging 1.7 pCi/gram(dry). In the control samples for 1987, radium-226 ranged from 1.6 to 2.4 pCi/gram(dry), averaging 1.9 pCi/gram(dry). The yearly average radium-226 activities from 1984 through 1986 ranged from 1.8 to 2.5 pCi/gram(dry) at indicator locations and it ranged from 1.8 to 2.0 pCi/gram(dry) at control locations. Thorium-228 in the indicator soil samples for 1987 ranged from 0.56 to 2.5 pCi/gram(dry), averaging 1.1 pCi/gram(dry). Thorium-228 in the 1987 control soil samples ranged from 0.94 to 1.2 pCi/gram(dry), averaging 1.0 pCi/gram(dry). The yearly average thorium-228 activities from 1984 through 1986 ranged from 1.1 to 1.3 pCi/gram(dry) at the indicator locations and it ranged from 1.1 to 1.2 pCi/gram(dry) at

control locations. Cesium-137 in the indicator soil samples for 1987 ranged from 0.036 to 0.76 pCi/gram(dry), averaging 0.31 pCi/gram(dry). In the 1987 control soil samples, the cesium-137 activity ranged from 0.14 to 1.7 pCi/gram(dry), averaging 0.64 pCi/gram(dry). The yearly average cesium-137 activities from 1984 through 1986 ranged from 0.32 to 0.36 pCi/gram(dry) at indicator locations and it ranged from 0.59 to 1.2 pCi/gram(dry) at control locations. No trends in the activities of potassium-40, radium-226, thorium-228, and cesium-137 in soil are suggested by the data in 1987. Manganese-54 was detected at 0.02 pCi/gram(dry) in a bottom sample from location 5S5, 0.8 miles east of the site. This is the first year that manganese-54 has been detected in soil.

Ten vegetation samples, 8 indicator samples and 2 control samples, were collected in 1987. Naturally occurring beryllium-7 and potassium-40 were positively detected in the vegetation in 1987 as well as the fallout radionuclide cesium-137. Beryllium-7 average activity, 2.6 pCi/gram(wet), in the indicator vegetation samples in 1987 exceeded the 1986 average activity, 0.8 pCi/gram(wet), but the average of the control samples decreased slightly from 2.2 pCi/gram(wet) in 1986 to 2.0 pCi/gram(wet) in 1987. Potassium-40 average activity, 6.2 pCi/gram(wet), in the indicator vegetation samples in 1987 was the same as the 1986 average activity, while the control vegetation sample activity increased from 4.9 pCi/gram(wet) in 1986 to 7.2 pCi/gram(wet) in 1987. Cesium-137 yearly average activity in vegetation increased from 0.02 pCi/gram(wet) in 1986 to 0.06 pCi/gram(wet) in 1987 at indicator locations and decreased from 0.04 to 0.03 pCi/gram(wet) from 1986 to 1987 at control locations.

No other gamma-emitting radionuclides were positively detected in vegetation in either 1987 or 1986.

Manganese-54 was detected at a level below the typical lower limits of detection (LLDs) for manganese-54 of 0.064 and 0.097 pCi/gram(dry) for 1986 and 1985 respectively. Because it was detected in only one soil sample at such a low level and because it was not detected in any air particulate samples, it is concluded that the manganese-54 did not originate from SSES. No radioactivity in any of the vegetation or soil samples is attributed to the operation of the SSES.

K. FOOD PRODUCTS

A total of 24 fruit, vegetable, and honey samples and 8 game, poultry, and egg samples were analyzed by gamma spectrometry during 1987. The detailed results of these analyses can be found in Tables 18 and 19.

FRUITS, VEGETABLES, AND HONEY

Sample collection began in June and ended in October. Collection took place at one control location and four different indicator locations. The fruits sampled were strawberries, apples, and cantalopes. The vegetables sampled were lettuce, sweet corn, cabbage, tomatoes, green beans, red beets, and potatoes. The gamma-emitting radionuclides positively detected in 1987 were naturally occurring beryllium-7 and potassium-40 and the fallout

radionuclide cesium-137. Cosmogenic beryllium-7 was observed once in lettuce, and cesium-137 was seen in honey, cabbage, and cantalope. Potassium-40 was positively detected in every sample.

The 1987 potassium-40 activity in indicator samples ranged from 0.77 to 5.1 pCi/gram(wet), averaging 2.1 pCi/gram(wet), and in control samples the activity ranged from 0.69 to 4.9 pCi/gram(wet), averaging 2.4 pCi/gram(wet). The yearly average potassium-40 activities at indicator locations from 1981 through 1986 ranged from 2.0 to 4.2 pCi/gram(wet).

The beryllium-7 activity in 1987, detected in one indicator sample (lettuce) was 0.25 pCi/gram(wet). This activity is within the range of yearly average beryllium-7 activities, 0.18 to 1.6 pCi/gram(wet), from 1981 through 1986. Beryllium-7 is normally only found in a small portion of the total samples each year.

Cesium-137 was observed in samples of honey and cantalope from indicator locations and a cabbage sample from the control location in 1987. The activity, 0.14 pCi/gram(wet), in the honey is above the range of indicator activities, 0.018 to 0.060 pCi/gram(wet), for cesium-137 from 1981 through 1986. Like beryllium-7, cesium-137 is normally detected in only a small fraction of the total samples for the year. Cesium-137 has been detected though in honey every year from 1981 through 1987, except 1986, at higher activities than in any fruits or vegetables in which the radionuclide was positively detected in the same year.

A potato sample and bean leaves were analyzed for carbon-14, in addition to the usual gamma-spectrometric analysis, in 1987. The average activity was 8.5 pCi/gram carbon.

No radionuclides identified in food are attributed to SSES operation.

GAME, POULTRY, AND EGGS

Deer and squirrel were the game sampled in 1987. Three samples of each were collected. Potassium-40 was positively detected in all of the game samples, and cesium-137 was also found in all of the squirrel samples and two of the deer samples. As in past years, the squirrel samples showed substantially higher cesium-137 activity than the deer samples.

The poultry sampled was a duck. The only gamma-emitting radionuclide positively detected in the duck and egg samples was potassium-40.

The average potassium-40 activity of the game, poultry, and egg samples in 1987 was 2.78 pCi/gram(wet). This falls within the range of yearly average potassium-40 activities, 2.65 to 4.8 pCi/gram(wet), from 1972 through 1986. The average cesium-137 activity, 0.40 pCi/gram(wet), that was found only in the game in 1987 was within the range of such activities, 0.03 to 8.8 pCi/gram(wet), reported from 1972 through 1986.

No radioactivity found in game, poultry, or egg samples in 1987 can be attributed to operation of SSES.

L. CALCULATED DOSE TO THE HYPOTHETICAL MAXIMALLY EXPOSED INDIVIDUAL

The only radioactivity detected in the environment from the operation of SSES in 1987 was in the surface water pathway. As described previously, tritium was frequently observed in the cooling tower blowdown discharge at levels exceeding those found at the control locations. Manganese-54 and cobalt-60 were each seen in the discharge on two occasions, and chromium-51 was found there three times in 1987. Although not detected directly in the discharge, cobalt-58 was assumed to be present in the discharge at those times that cobalt-60 was identified. For the purpose of performing dose calculations according to the methodology of the Offsite Dose Calculation Manual, the radionuclides just referred to were assumed to be present continuously in the discharge during each month that they were detected, at activities equivalent to the means of the activities at which they were measured in 1987. (These activities can be found in the REMP Summary presented in Table 3.) Since cobalt-58 was not positively detected in the discharge but was measured in algae once during 1987, the cobalt-58 activity in the discharge was estimated by multiplying the activity of cobalt-60 in the discharge by 0.3, which is the ratio of the cobalt-58 to cobalt-60 activities found in the algae in 1987. Also, the activity, 1070 pCi/liter, of tritium on which dose calculations were actually based was equal to the mean tritium activity, 1222 pCi/liter, from discharge line samples less the mean tritium activity, 152 pCi/liter, for the control locations during 1987.

Calculations performed using the LADTAP II code and conservative discharge volume estimates indicated that the maximally exposed age group would be the child. The calculated dose to a child at the nearest downriver municipal water supplier via the drinking water, shoreline, and fish pathways was less than 0.001 millirem to the total body. This dose is less than 0.02 percent of the 6 millirem limit (as expressed in 10 CFR 50, Appendix I) to the maximally exposed individual. This value can also be compared to the value of approximately 100 millirem/year that each individual receives from natural background radioactivity.

VI. DEVIATIONS FROM THE PROGRAM - 1987

The analysis sensitivities required by the Nuclear Regulatory Commission were met throughout 1987. The program sampling schedule was followed, except as discussed below or footnoted in Tables 5, 6, 7 and 12.

Deviations occurred as the result of missing TLDs, the loss of electrical power to sampling equipment and the malfunctioning of pumps and timers.

A total of five TLDs were lost at three different locations during 1987, presumably because of vandalism. Three TLDs were lost, one in each of three consecutive calendar quarters (the second, third, and fourth quarters) at the same location. Each of the other two TLDs were lost at different locations in the second and third quarters. The specific locations are footnoted in Table 5.

The time proportional automatic composite sampler on the cooling tower discharge line was unable to function two days in May due to the loss of electrical power and two days in August because of a pump problem. In April, a quantity corresponding to a three day collection period was discarded inadvertently by maintenance personnel. The most significant problem with this automatic composite sampler occurred in November and December. On November 15 and 16, the pump malfunctioned. This problem was corrected on November 17. From November 19 to November 23, water was being collected, but the timer was not functioning properly. From November 23, 1987 until January 12, 1988 the sampler was not automatically functioning because the timer was not operable. Between November 23 and

the end of the last 1987 sample collection period, January 4, 1988, water was collected for composite by manual means. The automatic composite sampler was returned to complete service on January 12, 1988 when the timer was replaced.

In January 1987, a timer problem also occurred with the automatic composite sampler at the Danville Water Authority's facility. The sampler was not able to collect raw (untreated) water at the facility from January 5 through January 13, 1987. A two gallon grab sample was collected January 12 to be added to the monthly composite. Also, at the Danville Water Authority, a smaller than normal amount of treated water, which is not automatically sampled, was collected by Danville Water Authority personnel from February 23 to March 2, 1987.

A loss of electrical power from November 24 to December 2, 1987 at the air sample station at PP&L's Bloomsburg Service Center resulted in collection of a volume of air deemed insufficient for its analysis to be of practical value. This resulted in no data at this location for the November 23 - December 1, 1987 sample period.

VII. PROGRAM CHANGES - 1987

1. The food/garden crop collection at the southeast (7S5) and southwest (11S6) REMP gardens were eliminated in 1987.

2. Duck meat was collected at station 10D1 in 1987, even though this sample was reportedly dropped in the "Program Changes" section of the 1986 REMP Annual Report.

VIII. CONCLUSION

In 1987, REMP detected the naturally occurring radionuclides beryllium-7, potassium-40, radium-226, and thorium-228 in the environment. Potassium-40 was seen in all media except surface water, drinking water, and ground water. Beryllium-7 was observed in algae, sediment, air, vegetation, and lettuce. Radium-226 and thorium-228 were only found in algae, sediment, and soil.

The 1987 REMP also determined the presence of the following eight man-made radionuclides in the environment: tritium, chromium-51, manganese-54, cobalt-58, cobalt-60, strontium-90, iodine-131, and cesium-137. The cesium-137 from weapons testing fallout was found in all media except drinking water, ground water, and air. Tritium was seen in all four water media in which it was monitored. Strontium-90, another fallout radionuclide, was only observed in milk. (The only other medium that was analyzed for strontium-90 was surface water on those occasions when gross beta activities increased to 15 pCi/liter or more.) The remaining five man-made radionuclides (chromium-51, manganese-54, cobalt-58, cobalt-60, and iodine-131) were observed in either surface water, algae, sediment, or soil. Of the five man-made radionuclides detected, iodine-131 is not attributed to the operation of SSES. Iodine-131 was found in two algae control samples and one algae indicator sample.

The man-made radionuclides detected in surface water, as sampled at the cooling tower blowdown discharge line, and cobalt-58, which was assumed

to have been present because of its detection in algae, were used to estimate the off-site dose impact. The resulting conservatively calculated radiation dose to a hypothetically exposed individual was less than 0.001 mrem to the whole body. This calculated dose is essentially in agreement with the corresponding value presented in the Semiannual Effluent and Waste Disposal reports for SSES in 1987 (29 and 30).

Monitoring the ambient radiation levels in the vicinity of SSES by thermoluminescent dosimetry has similarly demonstrated no significant impact on the health and safety of the public living around SSES. The annual exposure of about 69 mR indicated by REMP TLD monitoring can not be determined to be different from the exposure due to natural background radiation that would be received if SSES was not operational or had never been constructed.

TABLE 3

SUMMARY OF DATA FOR THE SSES OPERATIONAL BIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM - 1987

Name of Facility: Susquehanna Steam Electric Station
Location of Facility: Luzerne County, Pennsylvania

Reporting Period: January 5, 1987 to January 8, 1988

MEDIUM OR PATHWAY SAMPLED UNIT OF MEASUREMENT)	TYPE AND TOTAL NUMBER OF ANALYSES PERFORMED(1)	LOWER LIMIT OF DETECTION (LLD) (2)	ALL INDICATOR LOCATIONS MEAN (f)(3) (RANGE)	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN(f)(3) (RANGE)	CONTROL LOCATIONS MEAN (f)(3) (RANGE)	NUMBER OF NONROUTINE REPORTED MEASUREMENT(4)
Direct Radiation (mrem/day)	TLD 360	-	0.19 (332/332) (0.13-0.27)	Station 9S2 0.2 miles S	0.26(4/4) (0.24-0.27)	0.19 (28/28) (0.14-0.22)	0
Surface Water (pCi/l)	Gross Alpha 108	2	4.3 (8/72) (2.3-5.7)	Station 12 G2 17 miles WSW	5.1(2/12) (4.5-5.7)	3.1 (3/36) (2.8-3.3)	0
	Gross Beta 108	4	6.9 (72/72) (2.0-27)	Station 6S7 Discharge	18 (12/12) (13-27)	4.2 (36/36) (2.3-10)	0
	Tritium 108	2000	366 (53/72) (58-3000)	Station 6S7 Discharge	1222 (12/12) (74-3000)	152 (21/36) (83-330)	0
	Gamma Spec 108						
	K-40	-	15 (2/72) (14.5-15)	Station 6S6 0.8 miles ESE	25 (1/12) -	25 (1/36) -	0
	Mn-54	15	5.5 (4/72) (0.8-18)	Station 6S7 Discharge	5.5 (4/12) (0.8/18)	<LLD	0
	Cr-51	-	22 (4/72) (10-34)	Station 6S7 Discharge	22 (4/12) (10-34)	<LLD	0
	Co-60	15	5 (2/72) (1-9)	Station 6S7 Discharge	5 (2/12) (1-9)	<LLD	0

NOTE: SEE THE FOOTNOTES AT THE END OF THE TABLE

TABLE 3

SUMMARY OF DATA FOR THE SSES OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM - 1987

Name of Facility: Susquehanna Steam Electric Station
Location of Facility: Luzerne County, Pennsylvania

Reporting Period: January 5, 1987 to January 8, 1988

MEDIUM OR PATHWAY SAMPLED UNIT OF MEASUREMENT)	TYPE AND TOTAL NUMBER OF ANALYSES PERFORMED(1)	LOWER LIMIT OF DETECTION (LLD) (2)	ALL INDICATOR LOCATIONS MEAN (f)(3) (RANGE)	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN(f)(3) (RANGE)	CONTROL LOCATIONS MEAN (f)(3) (RANGE)	NUMBER OF NONROUTINE REPORTED MEASUREMENT(4)
Surface Water (pCi/l)	Cs-137	18	< LLD -	Station 1D3 3.9 miles N	4.9 (1/12) -	2.7(4/36)	0
	Ce-141	-	< LLD	Station 6S8 0.8 miles ESE	1.9(1/12)	1.9(1/36)	
Potable Water	Gross Alpha 24	-	< LLD	-		Only Indicator Stations	0
	Gross Beta 24	-	3.1 (24/24) (1.5-5.5)	Station 12H2Raw 26 miles WSW	3.3(12/12) (1.5-5.5)	sampled for this medium	0
	Tritium 24	2000	129 (18/24) (68-460)	Station 12H2 Treated 26 miles WSW	143 (9/12) (68-460)		0
	Gamma Spec 24						
Algae (pCi/g (dry))	Gamma Spec 13						
	Be-7	-	6.8 (7/7) (3.5-11)	Station AG3 0.8 miles E	7.5 (6/6) (3.9-11)	7.5 (6/6) (3.9-11)	0

NOTE: SEE THE FOOTNOTES AT THE END OF THE TABLE

TABLE 3

SUMMARY OF DATA FOR THE SSES OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM - 1987

Name of Facility: Susquehanna Steam Electric Station
Location of Facility: Luzerne County, Pennsylvania

Reporting Period: January 5, 1987 to January 8, 1988

MEDIUM OR PATHWAY SAMPLED UNIT OF MEASUREMENT)	TYPE AND TOTAL NUMBER OF ANALYSES PERFORMED(1)	LOWER LIMIT OF DETECTION (LLD) (2)	ALL INDICATOR LOCATIONS MEAN (f)(3) (RANGE)	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN(f)(3) (RANGE)	CONTROL LOCATIONS MEAN (f)(3) (RANGE)	NUMBER OF NONROUTINE REPORTED MEASUREMENT(4)
Algae (pCi/g(dry))	K-40	-	18 (7/7) (15-21)	Station AG4 0.9 miles ESE	18 (7/7) (15-21)	15 (6/6) (13-17)	0
	Mn-54	-	0.65 (1/7) -	Station AG4 0.9 miles ESE	0.65 (1/7)	<LLD	0
	Co-58	-	0.28 (1/7) -	Station AG4 0.9 miles ESE	0.28 (1/7) -	<LLD	0
	Co-60	-	0.94 (1/7) -	Station AG4 0.9 miles ESE	0.94 (1/7) -	<LLD	0
	Cr-51	-	3.3 (1/7) -	Station AG4 0.9 miles ESE	3.3 (1/7) -	<LLD	0
	Cs-137	-	0.19 (3/7) (0.12-0.25)	Station AG3 0.8 miles E	0.27 (2/6) (0.21-0.33)	0.27 (2/6) (0.21-0.33)	0
	I-131	-	1.0 (1/7) -	Station AG4 0.9 miles ESE	1.0 (1/7)	0.8 (2/6) (0.7-0.9)	0
	Ra-226	-	5.6 (2/7) (4.5-6.6)	Station AG4 0.9 miles ESE	5.6 (2/7) (4.5-6.6)	3.1 (1/6) -	0
	Th-228	-	1.2 (7/7) (0.8-2.1)	Station AG3 30 miles NNE	1.2 (6/6) (0.9-1.7)	1.2 (6/6) (0.9-1.7)	0

NOTE: SEE THE FOOTNOTES AT THE END OF THE TABLE

TABLE 3

SUMMARY OF DATA FOR THE SSES OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM - 1987

Name of Facility: Susquehanna Steam Electric Station
Location of Facility: Luzerne County, Pennsylvania

Reporting Period: January 5, 1987 to January 8, 1988

MEDIUM OR PATHWAY SAMPLED UNIT OF MEASUREMENT)	TYPE AND TOTAL NUMBER OF ANALYSES PERFORMED(1)	LOWER LIMIT OF DETECTION (LLD) (2)	ALL INDICATOR LOCATIONS MEAN (f)(3) (RANGE)	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN(f)(3) (RANGE)	CONTROL LOCATIONS MEAN (f)(3) (RANGE)	NUMBER OF NONROUTINE REPORTED MEASUREMENT(4)
Fish (pCi/g (wet))	Gross Beta 16		5.3 (9/9) (3.0-7.4)	Station 2H 30 miles NNE	5.4 (6/6) (3.8-6.9)	5.4 (6/6) (3.8-6.9)	0
	Gamma Spec 16						
	K-40	-	3.9 (9/9) (3.2-5.6)	Station IND 0.9-1.4 miles ESE	4.1 (6/6) (3.2-5.6)	4.0 (6/6) (3.3-4.7)	0
	Cs-137	0.15	0.018 (4/9) (0.010-0.023)	Station IND 0.9-1.4 miles ESE	0.018 (3/6) (0.010-0.023)	0.012 (5/6) (0.005-0.016)	0
Sediment (pCi/g (dry))	Gross Alpha 12	-	17 (8/8) (6.5-29)	Station LTAW 0.8 miles NE	24 (2/2) (18-29)	13 (4/4) (9.8-14)	0
	Gross Beta 12	-	31 (8/8) (19-38)	Station 12F 6.9 miles WSW	34 (2/2) (30-37)	30 (4/4) (25-32)	0
	Gamma Spec 12						
	Be-7	-	0.7 (1/8) -	Station 7B 1.2 miles SE	0.7 (1/2) -	0.6 (1/4) -	0
	K-40	-	11 (8/8) (6.2-14)	Station 7B 1.2 miles SE	13 (2/12) (12-14)	12 (4/4) (9.9-14)	0

NOTE: SEE THE FOOTNOTES AT THE END OF THE TABLE

TABLE 3

SUMMARY OF DATA FOR THE SSES OPERATIONAL ECOLOGICAL ENVIRONMENTAL MONITORING PROGRAM - 1987

Name of Facility: Susquehanna Steam Electric Station
Location of Facility: Luzerne County, Pennsylvania

Reporting Period: January 5, 1987 to January 8, 1988

MEDIUM OR PATHWAY SAMPLED UNIT OF MEASUREMENT)	TYPE AND TOTAL NUMBER OF ANALYSES PERFORMED(1)	LOWER LIMIT OF DETECTION (LLD) (2)	ALL INDICATOR LOCATIONS MEAN (f)(3) (RANGE)	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN(f)(3) (RANGE)	CONTROL LOCATIONS MEAN (f)(3) (RANGE)	NUMBER OF NONROUTINE REPORTED MEASUREMENT(4)
Sediment (pCi/g (dry))	Mn-54	-	0.026 (1/8) -	Station 7B 1.2 miles SE	0.026 (1/8)	<LLD	0
	Cs-137	0.18	0.12 (6/8) (0.021-0.21)	Station 7B 1.2 miles SE	0.19 (2/2) (0.17-0.21)	0.16 (3/4) (0.13-0.20)	0
	Ra-226	-	1.6 (8/8) (1.0-1.9)	Station 2F 6.4 miles NNE	2.0 (2/2) (1.8-2.2)	1.9 (4/4) (1.5-2.2)	0
	Th-228	-	1.1 (8/8) (0.72-1.3)	Station 7B 1.2 miles SE	1.3 (2/2) (1.2-1.3)	1.2 (4/4) (1.0-1.5)	0
Floc (pCi/g(dry))	Gross Alpha 4	-	22 (2/2) (20-24)	Station 7B 1.2 miles SE	22 (2/2) (20-24)	21 (2/2) (20-22)	0
	Gross Beta 4	-	40 (2/2) (32-47)	Station 2B 1.6 miles NNE	41 (2/2) (39-43)	41 (2/2) (39-43)	0
	Gamma Spec 4						
	Be-7	-	1.1 (1/2) -	Station 7B 1.2 miles SE	1.1 (1/2) -	<LLD	0
	K-40	-	15 (2/2) (12-18)	Station 2B 1.6 miles NNE	17 (2/2) (14-20)	17 (2/2) (14-20)	0

NOTE: SEE THE FOOTNOTES AT THE END OF THE TABLE

TABLE 3

SUMMARY OF DATA FOR THE SSES OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM - 1987

Name of Facility: Susquehanna Steam Electric Station
Location of Facility: Luzerne County, Pennsylvania

Reporting Period: January 5, 1987 to January 8, 1988

MEDIUM OR PATHWAY SAMPLED UNIT OF MEASUREMENT)	TYPE AND TOTAL NUMBER OF ANALYSES PERFORMED(1)	LOWER LIMIT OF DETECTION (LLD) (2)	ALL INDICATOR LOCATIONS MEAN (f)(3) (RANGE)	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN(f)(3) (RANGE)	CONTROL LOCATIONS MEAN (f)(3) (RANGE)	NUMBER OF NONROUTINE REPORTED MEASUREMENT(4)
Floc (pCi/g(dry))	Cs-137	-	0.16 (2/2) (0.10-0.22)	Station 2B 1.6 miles NNE	0.24 (2/2) (0.23-0.25)	0.24(2/2) (0.23-0.25)	0
	Ra-226	-	3.1 (2/2) (2.4-3.7)	Station 7B 1.2 miles SE	3.1 (2/2) (2.4-3.7)	2.9 (2/2) (2.1-3.6)	0
	Th-228	-	1.3 (2/2) (0.9-1.6)	Station 7B 1.2 miles SE	1.3 (2/2) (0.9-1.6)	1.3 (2/2) (1.0-1.5)	0
Well Water (pCi/l)	Gross 78 Alpha	-	4.0 (4/66) (3.6-4.5)	Station 4S2 0.5 miles ENE	4.0 (4/12) (3.6-4.5)	<LLD	0
	Gross 78 Beta	-	2.3 (39/66) (1.3-4.2)	Station 4S2 0.5 miles ENE	3.1 (9/12) (1.9-4.0)	2.1 (11/12) (1.4-3.1)	0
	Tritium 78	2000	107 (33/66) (69-250)	Station 3S5 0.9 miles NE	133 (2/6) (96-170)	110 (9/12) (83-160)	0
	Gamma 78 Spec K-40		<LLD	Station 12 F3 5.2 miles WSW	59 (1/12) -	59 (1/12) -	
	Co-60	15	11 (1/66) -	Station 11S5 0.5 miles WSW	11 (1/12) -	<LLD	0

NOTE: SEE THE FOOTNOTES AT THE END OF THE TABLE

TABLE 3

SUMMARY OF DATA FOR THE SSES OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM - 1987

Name of Facility: Susquehanna Steam Electric Station
Location of Facility: Luzerne County, Pennsylvania

Reporting Period: January 5, 1987 to January 8, 1988

MEDIUM OR PATHWAY SAMPLED UNIT OF MEASUREMENT)	TYPE AND TOTAL NUMBER OF ANALYSES PERFORMED(1)		LOWER LIMIT OF DETECTION (LLD) (2)	ALL INDICATOR LOCATIONS MEAN (f)(3) (RANGE)	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN(f)(3) (RANGE)	CONTROL LOCATIONS MEAN (f)(3) (RANGE)	NUMBER OF NONROUTINE REPORTED MEASUREMENT(4)
Air Particulates (E-03pCi/m³)	Gross Beta	530	10	16 (424/424) (7.2-76)	Station 2S2 0.9 miles NNE	17.3 (53/53) (7.4-76)	16 (106/106) (7.2-30)	0
Air Particulates (E-03pCi/m³) Quarterly Composite	Gross Alpha	40	-	3.3 (32/32) (1.4-5.5)	Station 15S4 0.6 mile NW	3.5 (4/4) (2.3-5.5)	3.0 (8/8) (1.6-4.2)	0
	Gamma Spec	40						
	Be-7		-	73 (32/32) (47-102)	Station 3D1 3.4 miles NE	80 (4/4) (57-99)	65 (8/8) (51-99)	0
	K-40		-	5.2 (6/32) (2.3-8.5)	Station 12E1 4.7 miles WSW	8.5 (1/4) -	5.8 (1/8) -	0
Precipitation (pCi/l)	Gross Alpha	40	-	1.2 (22/32) (0.5-3.4)	Station 11S2 0.4 miles SW	2.0 (2/4) (0.5-3.4)	1.1 (6/8) (0.5-2.4)	0
	Gross Beta	40	-	4.3 (32/32) (1.2-7.2)	Station 12G1 15 miles WSW	6.0 (4/4) (4.0-8.7)	5.2 (8/8) (3.0-8.7)	0
	Tritium	40	2000	139 (14/32) (71-260)	Station 9B1 1.3 miles S	250 (1/4) -	131 (3/8) (73-190)	0
	Gamma Spec	40						

NOTE: SEE THE FOOTNOTES AT THE END OF THE TABLE

TABLE 3

SUMMARY OF DATA FOR THE SSES OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM - 1987

Name of Facility: Susquehanna Steam Electric Station
Location of Facility: Luzerne County, Pennsylvania

Reporting Period: January 5, 1987 to January 8, 1988

MEDIUM OR PATHWAY SAMPLED UNIT OF MEASUREMENT)	TYPE AND TOTAL NUMBER OF ANALYSES PERFORMED(1)		LOWER LIMIT OF DETECTION (LLD) (2)	ALL INDICATOR LOCATIONS MEAN (f)(3) (RANGE)	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN(f)(3) (RANGE)	CONTROL LOCATIONS MEAN (f)(3) (RANGE)	NUMBER OF NONROUTINE REPORTED MEASUREMENT(4)
Precipitation (pCi/l)	K-40		-	87 (3/32) (53-132)	Station 5S4 0.8 miles E	132 (1/4) -	<LLD	0
	Cs-137			<LLD	Station 12G1 15 miles WSW	3.9 (1/4) -	3.9 (1/8) -	
Milk (pCi/l)	Gross Beta Minus K-40	150	-	7.1 (127-131) (2.6-19)	Station 12B3 2 miles WSW	14 (12/12) (4.1-19)	9.7 (19/19) (5.3-14)	0
	I-131	150	1	<LLD	-		<LLD	0
	Sr-90		-	6.8 (6/6) (3.1-10)	Station 12B3 2 miles WSW	7.5 (5/5) (3.1-10)	-	0
	Gamma Spec	150						
	K-40		-	1258 (131/131) (928-1490)	Station 13E3 5.0 miles W	1311 (19/19) (1020-1500)	1299 (19/19) (988-1420)	0
	Cs-137		18	6.9 (20/131) (3.1-20)	Station 12B3 2 miles WSW	14 (2/12) (8.5-20)	4.5 (5/19) (3.7-6.3)	0

NOTE: SEE THE FOOTNOTES AT THE END OF THE TABLE

TABLE 3

SUMMARY OF DATA FOR THE SSES OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM - 1987

Name of Facility: Susquehanna Steam Electric Station
Location of Facility: Luzerne County, Pennsylvania

Reporting Period: January 5, 1987 to January 8, 1988

MEDIUM OR PATHWAY SAMPLED UNIT OF MEASUREMENT)	TYPE AND TOTAL NUMBER OF ANALYSES PERFORMED(1)	LOWER LIMIT OF DETECTION (LLD) (2)	ALL INDICATOR LOCATIONS MEAN (f)(3) (RANGE)	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN(f)(3) (RANGE)	CONTROL LOCATIONS MEAN (f)(3) (RANGE)	NUMBER OF NONROUTINE REPORTED MEASUREMENT(4)
Soil (pCi/g(dry))	Gamma Spec 20						
	K-40	-	12 (16/16) (7.7-41)	Station 12E2 Top 4.7 miles WSW	41 (1/1) -	8.8 (4/4) (7.7-10)	0
	Mn-54		0.02 (1/16) -	Station 5S5 Bot 0.8 miles E	0.02 (1/1) -	<LLD	
	Cs-137	-	0.31 (16/16) (0.036-0.76)	Station 7G1 Top 14 miles SE	1.7 (1/1) -	0.64 (4/4) (0.14-1.7)	0
	Ra-226	-	1.7 (16/16) (1.0-3.1)	Station 3D2 Top 3.4 miles NE	3.1 (1/1) -	1.9 (4/4) (1.6-2.4)	0
	Th-228	-	1.1 (16/16) (0.56-2.5)	Station 12E2 Bot 4.7 miles WSW	2.5 (1/1) -	1.0 (4/4) (0.94-1.2)	0
Vegetation (pCi/g(wet))	Gamma Spec 10						
	Be-7	-	2.6 (8/8) (0.67-5.3)	Station 9B2 1.3 miles S	5.3 (1/1) -	2.0 (2/2) (1.6-2.4)	0
	K-40	-	6.2 (8/8) (4.5-7.2)	Station 12G3 15 miles WSW	8.2 (1/1) -	7.2 (2/2) (6.1-8.2)	0

NOTE: SEE THE FOOTNOTES AT THE END OF THE TABLE

TABLE 3

SUMMARY OF DATA FOR THE SSES OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM - 1987

Name of Facility: Susquehanna Steam Electric Station
Location of Facility: Luzerne County, Pennsylvania

Reporting Period: January 5, 1987 to January 8, 1988

MEDIUM OR PATHWAY SAMPLED UNIT OF MEASUREMENT)	TYPE AND TOTAL NUMBER OF ANALYSES PERFORMED(1)	LOWER LIMIT OF DETECTION (LLD) (2)	ALL INDICATOR LOCATIONS MEAN (f)(3) (RANGE)	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN(f)(3) (RANGE)	CONTROL LOCATIONS MEAN (f)(3) (RANGE)	NUMBER OF NONROUTINE REPORTED MEASUREMENT(4)
Food Products (pCi/g(Carbon))	Cs-137	-	0.06 (1/8)	Station 3D2 3.4 miles NE	0.06 (1/1) -	0.026 (1/2) -	0
	C-14	-	8.5 (2/2)	Station 11D1 3.3 miles SW	8.5 (2/2) -	Only one Indicator Station Analyzed for this.	0
Food Products (pCi/g(wet))	Gamma Spec 24						
	Be-7	-	0.25 (1/15)	Station 11D1 3.3 miles SW	0.25 (1/9) -	<LLD	0
	K-40	-	2.1 (15/15) (0.77-5.1)	Station 11D1 3.3 miles SW	2.9 (9/9) (0.9-5.1)	2.4 (9/9) (0.69-4.9)	0
	Cs-137	0.08	.075 (2/15) (.0092-0.14)	Station 7B2	0.14 (1/3)	0.014 (1/9)	0
Game, Poultry, Eggs (pCi/g(wet))	Gamma Spec 8					Only Indicator stations	
	K-40	-	2.8 (8/8) (1.1-3.4)	Station 10D1 3.0 miles SSW	3.4 (1/1) -	sampled for this medium	

NOTE: SEE THE FOOTNOTES AT THE END OF THE TABLE

TABLE 3

SUMMARY OF DATA FOR THE SSES OPERATIONAL [redacted]OLOGICAL ENVIRONMENTAL MONITORING PROGRAM - 1987

Name of Facility: Susquehanna Steam Electric Station
Location of Facility: Luzerne County, Pennsylvania

Reporting Period: January 5, 1987 to January 8, 1988

MEDIUM OR PATHWAY SAMPLED UNIT OF MEASUREMENT)	TYPE AND TOTAL NUMBER OF ANALYSES PERFORMED(1)	LOWER LIMIT OF DETECTION (LLD) (2)	ALL INDICATOR LOCATIONS MEAN (f)(3) (RANGE)	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN(f)(3) (RANGE)	CONTROL LOCATIONS MEAN (f)(3) (RANGE)	NUMBER OF NONROUTINE REPORTED MEASUREMENT(4)
Game, Poultry, Eggs (pCi/g(wet))	Cs-137	-	0.40 (6/8) (0.01-1.2)	Station 16S 0.5 miles NNW	1.2 (1/1) -		0

1. The total number of analyses does not include duplicates or splits or repeat analyses.

2. The Technical Specifications LLD is given when applicable.

3. Means and ranges are based upon detectable activities only. (f) is the ratio of positive results to the number of samples analyzed.

4. USNRC reporting levels as specified in the Technical Specifications.

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NOTE: SEE THE FOOTNOTES AT THE END OF THE TABLE

X. LAND USE CENSUS

The USNRC Branch Technical Position on "An Acceptable Radiological Environmental Monitoring Program" (November 1979, Revision 1), states that "a census shall be conducted annually during the growing season to determine the location of the nearest milk animal and nearest garden greater than 50 square meters (500 sq. ft.) producing broad leaf vegetation in each of the 16 meteorological sectors within a distance of 8 km (5 miles)." To comply with this requirement, a land-use survey was conducted for the Susquehanna SES during the period June 30, 1987 through August 7, 1987. The closest garden (greater than 50 square meters, producing broad leaf vegetation) and residence in each radial sector was determined and all dairy animals within five (5) miles were identified.

Table 4 lists the nearest dairy animals, the nearest garden and residence in each sector identified during the survey. These land-use parameters are used in the assessment of potential radiological doses to individuals and populations of the stated regions.

TABLE 4

Nearest residence, garden, and dairy animal in each of the 16 meteorological sectors within a 5-mile radius of the Susquehanna Steam Electric Station, 1987.

Sector	Direction	Nearest Residence	Nearest Garden	Nearest Dairy Animal
1	N	1.33 mi	1.28 mi	> 5.0 mi
2	NNE	0.93 mi	1.10 mi.	> 5.0 mi
3	NE	2.33 mi	2.33 mi	> 5.0 mi
4	ENE	2.12 mi	4.80 mi	2.7 mi
5	E	1.40 mi	1.40 mi	4.5 mi
6	ESE	0.54 mi	2.60 mi	2.5 mi
7	SE	0.38 mi	0.57 mi	2.6 mi
8	SSE	0.66 mi	0.66 mi	3.5 mi
9	S	1.10 mi	1.10 mi	3.9 mi
10	SSW	1.24 mi	1.24 mi	3.0 mi
11	SW	1.48 mi	1.48 mi	> 5.0 mi
12	WSW	1.16 mi	1.16 mi	1.7 mi
13	W	0.76 mi	1.47 mi	5.0 mi
14	WNW	0.71 mi	0.52 mi	1.8 mi
15	NW	0.86 mi	2.16 mi	> 5.0 mi
16	NNW	0.65 mi	2.33 mi	4.2 mi

XI. REFERENCES

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30. Pennsylvania Power and Light Company, "Susquehanna Steam Electric Station, Semi-annual Effluent Waste Disposal Report, Data Period: July - December 1987, February 1988.

TABLE 5

DIRECT RADIATION - THERMOLUMINESCENT DOSIMETRY RESULTS (1)

SSES 1987

Location	First Quarter 1/5/87 to 4/3/87	Second Quarter 4/3/87 to 6/26/87	Third Quarter 6/26/87 to 9/30/87	Fourth Quarter 9/30/87 to 1/8/88
TLDs WITHIN PP&L PROPERTY BOUNDARY				
+ 1S2	0.18±0.03	0.19±0.01	0.20±0.01	0.21±0.01
2S2	0.16±0.01	0.18±0.01	0.18±0.01	0.18±0.01
+ 2S3	0.17±0.01	0.19±0.00	0.20±0.01	0.19±0.01
3S3	0.15±0.01	0.18±0.01	0.16±0.01	0.19±0.02
+ 3S4	0.17±0.01	0.18±0.01	0.18±0.02	0.18±0.01
4S1	0.14±0.01(4)	0.16±0.01	0.14±0.02	0.17±0.01
+ 4S3	0.19±0.02	0.21±0.01	0.20±0.01	0.22±0.02
5S1	0.13±0.02(4)	0.14±0.02	0.14±0.03	0.16±0.01
5S4	0.16±0.00	0.18±0.01	0.18±0.02	0.19±0.02
+ 5S7	0.15±0.01	0.15±0.02	0.16±0.01	0.18±0.01
+ 6S4	0.22±0.01	0.23±0.01	0.23±0.02	0.24±0.01
6S8	0.16±0.01	0.19±0.01	0.18±0.01	0.19±0.01
+ 6S9	0.17±0.01	0.18±0.02	0.20±0.01	0.20±0.01
+ 7S6	0.16±0.01	0.21±0.01	0.19±0.00	0.20±0.02
+ 8S2	0.18±0.01	0.19±0.02	0.20±0.01	0.21±0.00
+ 9S2	0.24±0.01	0.25±0.01	0.26±0.01	0.27±0.01
+ 10S1	0.16±0.02	0.19±0.01	0.18±0.01	0.19±0.02
10S2	0.24±0.01	0.25±0.02	0.25±0.02	0.26±0.02
11S2	0.15±0.01	0.16±0.01	0.16±0.01	0.17±0.01
+ 11S3	0.22±0.01	0.26±0.02	0.25±0.02	0.27±0.01
11S6	0.15±0.01	0.17±0.01	0.17±0.01	0.18±0.01
+ 12S3	0.20±0.01	0.21±0.02	0.24±0.01	0.25±0.01
+ 13S2	0.19±0.00	0.22±0.02	0.21±0.02	0.23±0.00
13S4	0.23±0.02	0.26±0.02	0.25±0.00(5)	0.27±0.01
13S5	0.22±0.02	0.25±0.01	0.25±0.03	0.25±0.00
+ 14S5	0.20±0.01	0.22±0.01	0.22±0.01	0.22±0.01
14S6	0.19±0.01	0.22±0.01	0.21±0.02	0.21±0.01
15S4	0.15±0.00	0.17±0.01	0.17±0.01	0.17±0.01
+ 15S5	0.17±0.00	0.20±0.02	0.19±0.00	0.20±0.02
+ 16S1	0.19±0.02	0.21±0.01	0.21±0.01	0.20±0.01
+ 16S2	0.20±0.01	0.22±0.03	0.21±0.00	0.21±0.01

See footnotes at end of table

TABLE 5

DIRECT RADIATION - THERMOLUMINESCENT DOSIMETRY RESULTS (1)

SSES 1987

Location	First Quarter 1/5/87 to 4/3/87	Second Quarter 4/3/87 to 6/26/87	Third Quarter 6/26/87 to 9/30/87	Fourth Quarter 9/30/87 to 1/1/88
0-1 MILE OFFSITE				
+ 6A4	0.19±0.01	0.22±0.01	0.20±0.01	0.22±0.01
7A1	0.16±0.01	0.19±0.01	0.18±0.01	0.19±0.02
7A2	0.17±0.00(4)	0.20±0.02	0.19±0.00(4)	0.20±0.01
8A2	0.16±0.01	(2)	(2)	(2)
15A3	0.17±0.01	0.21±0.00	0.20±0.01	0.21±0.01
16A2	0.15±0.01	0.19±0.01	0.17±0.01	0.18±0.01
1-2 MILES OFFSITE				
*1B1	0.17±0.02	0.19±0.01	0.20±0.01	0.19±0.01
+ 2B3	0.17±0.03	0.19±0.02	0.18±0.01(4)	0.19±0.00
*2B4	0.17±0.01	0.18±0.01	0.18±0.02	0.19±0.02
*4B1	0.16±0.01	0.18±0.01	0.18±0.02	0.18±0.01
*5B2	0.19±0.01	0.19±0.01	0.20±0.01	0.19±0.02
*6B2	0.18±0.01	0.20±0.02	0.20±0.01	0.19±0.01
7B3	0.16±0.01	0.19±0.01	0.18±0.01	0.19±0.02
*7B4	0.18±0.01	0.19±0.01	0.20±0.00	0.20±0.01
+ 8B2	0.18±0.01	0.19±0.01	0.18±0.01	0.19±0.00
*8B3	0.19±0.02	0.19±0.01	0.18±0.02	0.20±0.01
9B1	0.16±0.01	0.18±0.02	0.18±0.01	0.18±0.01
10B2	0.15±0.00	0.16±0.01	0.16±0.01	0.17±0.01(4)
10B3	0.14±0.01	(2)	0.16±0.01	0.19±0.05(4)
*10B4	0.18±0.01(4)	0.19±0.00	0.20±0.00	0.19±0.00
12B4	0.17±0.01	0.18±0.01	0.18±0.02	0.18±0.01
*12B5	0.17±0.01	0.18±0.02	0.18±0.02	0.18±0.02
*13B1	0.19±0.03	0.19±0.02	0.19±0.00	0.19±0.01
*14B1	0.21±0.02(4)	0.19±0.03	(2)	0.20±0.01
*15B1	0.18±0.02	0.18±0.02	0.18±0.02	0.18±0.01
16B1	0.14±0.01	0.18±0.02	0.16±0.01	0.17±0.01
*16B2	0.17±0.03(4)	0.18±0.01	0.18±0.00(5)	0.17±0.01
2-3 MILES OFFSITE				
*11C1	0.20±0.00	0.22±0.01	0.22±0.01	0.22±0.00

See footnotes at end of table

TABLE 5

DIRECT RADIATION - THERMOLUMINESCENT DOSIMETRY RESULTS (1)

SSES 1987

Location	First Quarter 1/5/87 to 4/3/87	Second Quarter 4/31/87 to 6/26/87	Third Quarter 6/26/87 to 9/30/87	Fourth Quarter 9/30/87 to 1/8/88
3-4 MILES OFFSITE				
+ 1D2	0.18±0.00	0.20±0.01	0.21±0.01	0.21±0.02
+ 3D1	0.19±0.01	0.22±0.02	0.21±0.02	0.22±0.01
+ 8D3	0.15±0.01	0.20±0.01	0.19±0.02	0.19±0.01
+ 9D1	0.17±0.01	0.20±0.02	0.20±0.01	0.20±0.1
+ 10D2	0.17±0.02(4)	0.20±0.01	0.20±0.01	0.19±0.02
12D3	0.18±0.01	0.20±0.01	0.20±0.01	0.20±0.01
4-5 MILES OFFSITE				
1E1	0.16±0.01	0.16±0.01	0.17±0.01	0.17±0.02(4)
+ 4E1	0.18±0.01	0.19±0.02	0.20±0.01	0.19±0.01
+ 5E2	0.19±0.01	0.20±0.01	0.20±0.02	0.20±0.01
+ 6E1	0.19±0.01	0.23±0.01	0.22±0.01	0.23±0.02
+ 7E1	0.17±0.01	0.22±0.01	0.21±0.01	0.22±0.02
+ 11E1	0.14±0.01	0.17±0.01	0.15±0.01	0.17±0.01
+ 12E1	0.16±0.01	0.19±0.01	0.18±0.01	0.20±0.01
+ 13E4	0.18±0.01	0.21±0.01	0.20±0.01	0.21±0.01
+ 14E1	0.17±0.01	0.19±0.00	0.20±0.01	0.20±0.00
5-10 MILES OFFSITE				
+ 2F1	0.17±0.01	0.19±0.02	0.18±0.01	0.19±0.02
+ 3F1	0.16±0.00(4)	0.18±0.01	0.18±0.00(4)	0.18±0.01
*3F2	0.18±0.02(4)	0.19±0.01	0.19±0.02	0.19±0.01
8F2	0.16±0.01	0.18±0.01	0.19±0.00	0.18±0.00
12F2	0.18±0.01	0.21±0.01	0.20±0.01	0.20±0.01
+ 15F1	0.17±0.01(4)	0.20±0.01	0.20±0.00	0.20±0.01
+ 16F1	0.18±0.01	0.23±0.01	0.20±0.02	0.22±0.02

See footnotes at end of table

TABLE 5

DIRECTION RADIATION - THERMOLUMINESCENT DOSIMETRY RESULTS

SSES 1987

Location	First Quarter 1/5/87 to 4/3/87	Second Quarter 4/3/87 to 6/26/87	Third Quarter 6/26/87 to 9/30/87	Fourth Quarter 9/30/87 to 1/8/88
10-20 MILES OFFSITE				
+ 3G3	0.18±0.01	0.21±0.02	0.20±0.00	0.21±0.02
3G4	0.17±0.01	0.20±0.01	0.19±0.01	0.20±0.01
+ 4G1	0.18±0.01	0.23±0.01	0.22±0.01	0.22±0.01
+ 7G1	0.18±0.00	0.21±0.01	0.20±0.01	0.22±0.01
*7G2	0.17±0.01	0.20±0.01	0.19±0.01	0.20±0.02
+ 12G1	0.14±0.01	0.16±0.01	0.15±0.01	0.17±0.01
12G4	0.17±0.01	0.21±0.01	0.20±0.00(4)	0.21±0.01
Overall Average(3)	0.17±0.04	0.20±0.05	0.19±0.05	0.20±0.02
PIC LOCATIONS				
12F4	0.22±0.01	0.23±0.01	0.24±0.03	0.26±0.02
2S5	0.14±0.02	0.16±0.01	0.15±0.01	0.16±0.01
1E2	N/A	0.17±0.02	N/A	N/A
3G2	0.15±0.01	0.17±0.01	0.16±0.02	0.16±0.01

NOTES

(1) All results are in mR/day. Uncertainties for individual measurements are two standard deviations of the average of four readings per station.

(2) TLD Missing.

(3) Uncertainties of row averages are two standard deviations calculated from the mean of each.

(4) Mean is average of 3 TLD elements.

(5) Mean is average of 2 elements from a single TLD. Inappropriate response on remaining TLD was attributed to excessive moisture in package.

(+) Tech Spec Locations.
(*) NRC Co-Located Stations.

TABLE 6
(Page 1 of 3)
GROSS ALPHA, GROSS BETA, TRITIUM, IODINE-131, AND GAMMA* SPECTROMETRY OF SURFACE WATER
Results in pCi/l ± 2 s
SSES 1987

LOCATION	COLLECTION DATE	Gr-Alpha	Gr-Beta	Tritium	I-131	K-40	Mn-54	Co-60	Cs-137	Other Activity
5S8	01/12/87 to 02/09/87	LT 2	2.6 ± 1.0	LT 70						
6S6	01/05/87 to 02/09/87	LT 2	2.9 ± 1.0	87 ± 44						
1D3	01/06/87	LT 2	3.2 ± 1.0	LT 60						
6S5	01/12/87 to 02/09/87	LT 2	2.3 ± 0.9	LT 70						
6S7	01/05/87 to 02/09/87	3.8 ± 1.8	13 ± 2	1200 ± 100				1.3 ± 1.0		
LTAW	01/06/87	LT 2	5.6 ± 1.3	120 ± 40						
12F1	01/06/87	LT 2	2.8 ± 0.9	LT 70						
12G2	01/06/87	LT 2	3.0 ± 0.9	86 ± 42						
12H1	01/05/87 to 02/09/87	LT 2	2.5 ± 0.9	120 ± 50						
5S8	02/16/87 to 03/09/87	LT 2	5.3 ± 1.1	220 ± 50						
6S6	02/09/87 to 03/09/87	LT 2	2.8 ± 0.9	LT 60						
1D3	02/09/87	LT 2	2.6 ± 1.0	LT 70						
6S5	02/16/87 to 03/09/87	LT 2	4.4 ± 1.0	120 ± 40						
6S7	02/09/87 to 03/09/87	LT 2	14 ± 2	800 ± 50			0.8 ± 0.8			
LTAW	02/09/87	LT 2	5.3 ± 1.3	220 ± 50						
12F1	02/10/87	LT 2	3.5 ± 1.0	99 ± 44						
12G2	02/10/87	LT 2	2.6 ± 1.0	150 ± 50						
12H1	02/09/87 to 03/09/87	LT 2	2.6 ± 0.9	120 ± 30						
5S8	03/16/87 to 04/06/87	2.8 ± 2.2	10 ± 1	140 ± 40						
6S6	03/09/87 to 04/06/87	LT 2	2.7 ± 0.8	99 ± 38		25 ± 11				
1D3	03/10/87	3.3 ± 2.1	8.1 ± 1.2	150 ± 50						
6S5	03/16/87 to 04/06/87	2.3 ± 1.9	7.2 ± 1.2	58 ± 28						
6S7 (1)	03/09/87 to 04/06/87	5.5 ± 4.1	27 ± 3	1300 ± 100						Cr-51 25 ± 10
LTAW	03/10/87	LT 2	4.5 ± 1.1	85 ± 39						
12F1	03/10/87	3.7 ± 2.3	10 ± 1	180 ± 40						
12G2	03/10/87	4.5 ± 2.4	8.4 ± 1.2	64 ± 38						
12H1	03/09/87 to 04/06/87	LT 2	2.0 ± 0.8	110 ± 40						
5S8	04/13/87 to 05/11/87	LT 2	4.5 ± 1.0	86 ± 40						
6S6	04/06/87 to 05/11/87	LT 1	8.6 ± 1.3	160 ± 30						Ce-141 1.9 ± 1.7
1D3	04/07/87	3.3 ± 2.2	10 ± 1	110 ± 40						
6S5	04/13/87 to 05/11/87	LT 2	3.2 ± 0.9	LT 70						
6S7 (1)	04/06/87 to 05/11/87	LT 2	16 ± 2	1200 ± 100						Cr-51 20 ± 9
LTAW	04/07/87	LT 2	6.3 ± 1.3	160 ± 40						
12F1	04/07/87	4.4 ± 2.6	12 ± 2	110 ± 40						
12G2 (1)	04/07/87	5.7 ± 3.2	16 ± 2	93 ± 42						
12H1	04/06/87 to 05/11/87	LT 2	5.7 ± 1.1	LT 70						

See Footnotes

TABLE 6
(Page 2 of 3)
GROSS ALPHA, GROSS BETA, TRITIUM, IODINE-131, AND GAMMA* SPECTROMETRY OF SURFACE WATER
Results in pCi/l ± 2 s
SSES 1987

LOCATION	COLLECTION DATE	Gr-Alpha	Gr-Beta	Tritium	I-131	K-40	Mn-54	Co-60	Cs-137	Other Activity
5S8	05/18/87 to 06/08/87	LT 2	2.6 ± 1.0	92 ± 44						
6S6	05/11/87 to 06/08/87	LT 2	2.9 ± 1.0	140 ± 40						
1D3	05/12/87	LT 2	2.8 ± 1.0	LT 70						
6S5	05/18/87 to 06/08/87	LT 2	3.8 ± 1.0	82 ± 34						
6S7 (1,2)	05/11/87 to 06/08/87	LT 2	17 ± 2	1000 ± 100						
LTAW	05/12/87	LT 2	6.9 ± 1.4	120 ± 40						
12F1	05/12/87	LT 2	2.7 ± 1.0	LT 70						
12G2	05/12/87	LT 2	3.6 ± 1.0	LT 70						
12H1	05/11/87 to 06/08/87	LT 1	3.6 ± 1.0	LT 70						
5S8	06/15/87 to 07/06/87	LT 2	4.1 ± 1.1	LT 100						
6S6	06/08/87 to 07/06/87	LT 2	4.0 ± 1.1	140 ± 80						
1D3	06/09/87	LT 1	3.5 ± 1.0	83 ± 43						
6S5	06/15/87 to 07/06/87	LT 2	3.6 ± 1.1	LT 80						
6S7 (1)	06/08/87 to 07/06/87	LT 2	21 ± 3	3000 ± 100			2.2 ± 1.1		Cr-51	34 ± 10
LTAW	06/09/87	LT 2	6.8 ± 1.4	140 ± 40						
12F1	06/09/87	LT 1	3.9 ± 1.0	65 ± 40						
12G2	06/09/87	LT 1	4.7 ± 1.1	130 ± 40						
12H1	06/08/87 to 07/06/87	LT 2	3.5 ± 1.0	LT 80						
5S8	07/13/87 to 08/10/87	LT 2	4.3 ± 1.0	190 ± 50						
6S6	07/06/87 to 08/10/87	LT 2	4.0 ± 0.9	320 ± 50						
1D3	07/07/87	LT 2	5.1 ± 1.2	LT 80						
6S5	07/13/87 to 08/10/87	LT 2	4.0 ± 1.0	120 ± 40						
6S7 (1)	07/06/87 to 08/10/87	LT 2	16 ± 2	800 ± 90		14.5 ± 6.4				
LTAW	07/07/87	LT 2	6.4 ± 1.3	LT 80						
12F1	07/07/87	LT 2	4.9 ± 1.2	LT 80						
12G2	07/07/87	LT 2	5.1 ± 1.1	LT 80						
12H1	07/06/87 to 08/10/87	LT 2	4.0 ± 0.9	120 ± 50						
5S8	08/17/87 to 09/08/87	LT 2	4.5 ± 1.1	LT 80						
6S6	08/10/87 to 09/08/87	LT 2	3.3 ± 1.0	120 ± 50						
1D3	08/11/87	LT 2	5.4 ± 1.2	110 ± 50					4.9 ± 3.2	
6S5	08/17/87 to 09/08/87	LT 2	3.0 ± 0.9	110 ± 50						
6S7 (1,3)	08/10/87 to 09/08/87	4.3 ± 3.1	20 ± 3	710 ± 60		15 ± 8				
LTAW	08/11/87	LT 2	9.6 ± 1.6	80 ± 43						
12F1	08/11/87	LT 2	4.6 ± 1.2	130 ± 40						
12G2	08/11/87	LT 2	3.6 ± 1.1	130 ± 40						
12H1	08/10/87 to 09/08/87	LT 2	3.8 ± 1.0	140 ± 40						

See Footnotes

TABLE 6
(Page 3 of 3)
GROSS ALPHA, GROSS BETA, TRITIUM, IODINE-131, AND GAMMA* SPECTROMETRY OF SURFACE WATER
Results in pCi/l ± 2 s
SSES 1987

LOCATION	COLLECTION DATE	Gr-Alpha	Gr-Beta	Tritium	I-131	K-40	Mn-54	Co-60	Cs-137	Other Activity
5S8	09/14/87 to 10/05/87	LT 2	6.1 ± 1.1	LT 70						
6S6	09/08/87 to 10/05/87	LT 2	3.5 ± 0.9	LT 70						
1D3	09/08/87	LT 2	3.3 ± 1.0	LT 70						
6S5	09/14/87 to 10/05/87	LT 2	4.8 ± 1.0	82 ± 51						
6S7 (1)	09/08/87 to 10/05/87	LT 2	18 ± 2	740 ± 50			0.8 ± 0.7			
LTAW	09/08/87	LT 2	5.1 ± 1.1	76 ± 47					2.1 ± 2.4	
12F1	09/08/87	LT 2	3.5 ± 1.0	LT 80						
12G2	09/08/87	LT 2	4.8 ± 1.0	100 ± 50						
12H1	09/08/87 to 10/05/87	LT 2	2.7 ± 0.9	LT 80						
5S8	10/12/87 to 11/09/87	LT 2	3.2 ± 1.0	120 ± 50					2.7 ± 2.7	
6S6	10/05/87 to 11/09/87	LT 2	3.6 ± 1.0	LT 80					0.9 ± 0.8	
1D3	10/06/87	LT 1	4.4 LT 1.0	LT 90						
6S5	10/12/87 to 11/09/87	LT 1	2.6 ± 1.0	LT 70						
6S7	10/05/87 to 11/09/87	LT 2	19 ± 2	110 ± 50						Th-228 2.5 ± 1.4
LTAW	10/06/87	LT 2	6.6 ± 1.2	84 ± 44						
12F1	10/06/87	LT 1	4.7 ± 1.0	LT 90						
12G2	10/06/87	LT 1	2.3 ± 0.9	95 ± 49						
12H1	10/05/87 to 11/09/87	LT 2	2.2 ± 0.9	LT 70						
5S8	11/16/87 to 12/07/87	LT 1	2.8 ± 0.9	250 ± 50						
6S6	11/09/87 to 12/07/87	LT 1	2.6 ± 0.9	150 ± 40						
1D3	11/09/87	LT 2	2.4 ± 0.9	LT 70						
6S5	11/16/87 to 12/07/87	LT 1	2.1 ± 0.9	130 ± 40						
6S7 (4)	11/09/87 to 12/07/87	LT 2	16 ± 2	1000 ± 100						
LTAW	11/10/87	LT 1	4.3 ± 1.2	110 ± 50						
12F1	11/10/87	LT 2	2.4 ± 0.9	LT 80						
12G2	11/10/87	LT 2	2.3 ± 0.9	95 ± 49						
12H1	11/09/87 to 12/07/87	LT 0.8	3.1 ± 0.8	96 ± 43						
5S8	12/14/87 to 01/04/88	LT 1	2.3 ± .7	LT 80						
6S6	12/07/87 to 01/04/88	LT 1	2.7 ± .8	96 ± 52						
1D3	12/08/87	LT 1	3.2 ± 0.9	330 ± 60						
6S5	12/14/87 to 01/04/88	LT 1	2.9 ± .8	110 ± 40						
6S7 (1,5)	12/07/87 to 01/04/88	LT 2	18 ± 2	2800 ± 100			18 ± 2	8.8 ± 1.4		Cr-51 10 ± 8
LTAW	12/08/87	LT 2	5.5 ± 1.4	190 ± 50						
12F1	12/08/87	LT 2	7.1 ± 1.4	150 ± 40						
12G2	12/08/87	LT 0.6	2.1 ± 0.7	160 ± 50						
12H1	12/07/87 to 01/04/88	LT 2	2.4 ± 0.8	110 ± 40						

* Only gamma emitters detected are reported; typical LLD values are found on Table 20.
(1) Sr-89 and Sr-90 analyses were performed; results detected were less than the LLD.
(2) Electricity out of service for 2 days.
(3) Pump out of service for two days.
(4) Automatic composite sampler out of service beginning 11/23/87 - samples taken at intervals manually to the end of the sample period
(5) Automatic composite sampler was out of service throughout the entire sampling period - manual sampling was done.
(6) Iodine-131 determed by radiochemical methods. See appendix B-5, all values are less than 0.1 pCi/l unless noted.

TABLE 7
GROSS ALPHA, GROSS BETA, TRITIUM, IODINE-131 AND GAMMA* SPECTROMETRY OF DRINKING WATER
Results in pCi/l ± 2 s
SSES 1987

LOCATION	COLLECTION DATE		Gr-Alpha	Gr-Beta	Tritium	I-131	K-40	Mn-54	Co-60	Cs-137	Other Activity
12H2R	01/13/87 to 02/09/87	(1)	LT 2	3 ± 1.0	96 ± 36						
12H2T	01/05/87 to 02/09/87		LT 2	2.3 ± 0.9	LT 90						
12H2R	02/09/87 to 03/09/87		LT 2	3 ± 0.9	180 ± 50						
12H2T	02/09/87 to 03/09/87		LT 2	2.6 ± 0.9	150 ± 50						
12H2R	03/09/87 to 04/06/87		LT 2	3.5 ± 0.9	LT 60						
12H2T	03/09/87 to 04/06/87		LT 2	1.9 ± 0.8	81 ± 37						
12H2R	04/06/87 to 05/11/87		LT 2	3.9 ± 1.0	LT 70						
12H2T	04/06/87 to 05/11/87		LT 2	2.2 ± 0.9	68 ± 41						
12H2R	05/11/87 to 06/08/87		LT 1	2.9 ± 1.0	LT 70						
12H2T	05/11/87 to 06/08/87		LT 2	3 ± 1.0	110 ± 50						
12H2R	06/08/87 to 07/06/87		LT 2	3.1 ± 1.0	110 ± 50						
12H2T	06/08/87 to 07/06/87		LT 2	3.3 ± 1.0	460 ± 60						
12H2R	07/06/87 to 08/10/87		LT 2	4.4 ± 1.1	100 ± 40						
12H2T	07/06/87 to 08/10/87		LT 1	2.3 ± 0.9	87 ± 50						
12H2R	8/10/87 to 9/08/87		LT 2	4.2 ± 1.1	84 ± 44						
12H2T	8/10/87 to 9/08/87		LT 2	3.5 ± 1.0	97 ± 46						
12H2R	09/08/87 to 10/05/87		LT 1	5.5 ± 1.1	150 ± 50						
12H2T	09/08/87 to 10/05/87		LT 2	3.8 ± 0.9	LT 90						
12H2R	10/05/87 to 11/09/87		LT 2	1.5 ± 0.9	85 ± 45						
12H2T	10/05/87 to 11/09/87		LT 2	2.9 ± 1	LT 90						
12H2R	11/09/87 to 12/07/87		LT 2	2.8 ± 0.8	88 ± 51						
12H2T	11/09/87 to 12/07/87		LT 2	2.8 ± 0.8	100 ± 50						
12H2R	12/09/87 to 01/04/88		LT 1	2.3 ± 0.8	140 ± 40						
12H2T	12/07/87 to 01/07/88		LT 1	2.9 ± 0.9	130 ± 50						

* Only gamma emitters detected are reported; typical LLD values are found on Table 20.
(1) Sample unavailable from 1/5/87 to 1/13/87, due to a malfunctioning timer on the composite sampler (one 2 gallon sample was collected 1/12/87 at location 1305).
(2) Smaller than normal sample volume collected on 2/23/87 (1/2 gallon instead of around 2 gallons).

TABLE 8
GAMMA× SPECTROMETRY OF ALGAE
SSES 1987
Results in pCi/g (dry) ± 2 s

LOCATION	COLLECTION DATE	Be-7	K-40	Mn-54	Co-58	Co-60	I-131	C-137	Ra226	Th228	Other Activity
AG-3	05/08/87 to 06/08/87	6.6 ± 2.1	14 ± 3							1.2 ± .4	
AG-4	05/08/87 to 06/08/87	4.7 ± 1.8	15 ± 3						6.6 ± 3.1	0.91 ± .15	
AG-3	06/08/87 to 07/06/87	8.5 ± 1.6	13 ± 2					0.21 ± .15		0.94 ± .17	
AG-4	06/08/87 to 07/06/87	6.8 ± 1.4	15 ± 2	0.65 ± .16	0.28 ± .13	0.94 ± .18				0.92 ± .16	Cr-51 3.3 ± 1.3
AG-3	07/06/87 to 08/10/87	10 ± 2	14 ± 2				0.89 ± .20	0.33 ± .15		1.7 ± .2	
AG-4	07/06/87 to 08/10/87	11 ± 1.2	16 ± 2				1.0 ± .2	0.12 ± .10		1.6 ± .2	
AG-3	08/10/87 to 09/08/87	11 ± 1	16 ± 2				0.7 ± .2	0.21 ± .10	3.1 ± 1.6	1.2 ± .2	
AG-4	08/10/87 to 09/08/87	11 ± 2	18 ± 2							0.78 ± .17	
AG3 N/C	9/8/87 NOT COLLECTED										
AG-4	9/08/87 to 10/05/87	5.8 ± 1.7	20.6 ± 3.3					0.25 ± .21		2.1 ± .2	
AG-3	09/23/87 to 11/09/87	4.9 ± 1.7	16.8 ± 2.7							1.1 ± .3	
AG-4	10/05/87 to 11/09/87	4.6 ± 1.6	21.4 ± 2.7						4.45 ± 2.6	1.1 ± .3	
G-3	11/09/87 to 12/07/87	3.9 ± 1.4	14 ± 2							1.3 ± .3	
G-4	11/09/87 to 12/07/87	3.5 ± 1.5	20 ± 3							0.93 ± .28	

× Only gamma emitters detected are reported; typical LLD values are found in table 20.

TABLE 9
GROSS BETA AND GAMMA* SPECTROMETRY OF FISH
SSES 1987
Results in pCi/g (wet) ± 2 s

SAMPLE TYPE		COLLECTION DATE	Gr-Beta	K-40	Cs-137	Other Activity
SMALLMOUTH BASS	2H	04/23/87	3.8 ± 0.1	3.5 ± 0.4	0.010 ± 0.008	
WHITE SUCKER	2H	04/23/87	5.4 ± 0.2	4.7 ± 0.5	0.014 ± 0.012	
CHANNEL CATFISH	2H	04/24/87	6.5 ± 0.2	3.3 ± 0.3	0.012 ± 0.008	
SMALLMOUTH BASS	IND	05/05/87	3.0 ± 0.1	5.6 ± 0.6		
WHITE SUCKER	IND	05/05/87	5.2 ± 0.1	4.0 ± 0.4		
CHANNEL CATFISH	IND	05/05/87	6.1 ± 0.2	3.2 ± 0.3	0.021 ± 0.010	
LARGEMOUTH BASS	LTAW	05/12/87	7.4 ± 0.2	3.2 ± 0.3		
BULLHEAD / CATFISH	LTAW	05/12/87	4.1 ± 0.1	3.5 ± 0.4	0.016 ± 0.010	
SMALLMOUTH BASS	2H	09/29/87	3.9 ± 0.1	3.7 ± 0.4		
WHITE SUCKER	2H	09/28/87	6.0 ± 0.2	3.8 ± 0.4	0.005 ± 0.005	
CHANNEL CATFISH	2H	09/29/87	6.9 ± 0.3	4.7 ± 0.5	0.016 ± 0.011	
SMALLMOUTH BASS	IND	10/16/87	6.1 ± 0.2	4.3 ± 0.4	0.010 ± 0.008	
WHITE SUCKER	IND	10/16/87	6.4 ± 0.2	4.1 ± 0.4		
CHANNEL CATFISH	IND	10/20/87	5.1 ± 0.2	3.2 ± 0.3	0.023 ± 0.008	
LARGEMOUTH BASS	LTAW	10/20/87	4.6 ± 0.1	3.9 ± 0.4		

* Only gamma emitters detected are reported; typical LLD values are found on Table 20.

TABLE 10
GROSS ALPHA, GROSS BETA AND GAMMA* SPECTROMETRY OF SHORELINE AND FLOCCULATED SEDIMENT
SSES 1987
Results in Units of pCi/g (dry) ± 2 s

LOCATION	COLLECTION DATE	Gr-Alpha	Gr-Beta	Be-7	K-40	Mn-54	Co-60	Cs-137	Ra-226	Th-228	Other Activity
2B (FLOC)	05/21/87	22 ± 8	43 ± 3		20 ± 3			0.25 ± 0.16	3.6 ± 2.2	1.5 ± 0.2	
7B (FLOC)	05/21/87	24 ± 8	47 ± 4		18 ± 2			0.22 ± 0.13	3.7 ± 2.1	1.6 ± 0.2	Ra-228 1.5 ± 1.0
2B	05/21/87	14 ± 7	32 ± 3	0.56 ± 0.22	11 ± 1			0.13 ± 0.02	1.5 ± 0.3	0.9 ± 0.1	
2F	05/20/87	14 ± 7	30 ± 3		10 ± 1	0.026 ± 0.020		0.14 ± 0.01	1.8 ± 0.3	1.1 ± 0.1	
7B	05/21/87	19 ± 8	34 ± 3	0.68 ± 0.27	12 ± 1			0.17 ± 0.02	1.9 ± 0.4	1.3 ± 0.1	
LTAW	05/28/87	18 ± 8	35 ± 3		12 ± 1				1.6 ± 0.3	1.2 ± 0.1	
11C	05/28/87	12 ± 7	38 ± 3		11 ± 1			0.18 ± 0.03	1.5 ± 0.7	1.3 ± 0.1	
12F	05/28/87	19 ± 8	37 ± 3		10 ± 1				1.9 ± 0.3	1.2 ± 0.1	
2B GLD ISL	11/25/87	9.8 ± 6.0	32 ± 3		14 ± 1			0.2 ± 0.02	1.9 ± 0.3	1.1 ± 0.1	
2F	11/25/87	14 ± 7	25 ± 3		12 ± 1				2.2 ± 0.8	1.5 ± 0.2	
7B	11/25/87	13 ± 7	27 ± 3		14 ± 1			0.21 ± 0.03	1.7 ± 0.4	1.2 ± 0.1	
TLAW	11/25/87	29 ± 9	31 ± 3		11 ± 1				1.6 ± 0.7	0.99 ± 0.10	
11C	11/27/87	6.5 ± 5.2	19 ± 2		6 ± 1			0.03 ± 0.027	1.1 ± 0.5	0.72 ± 0.07	
12F	11/25/87	18 ± 8	30 ± 3		10 ± 1			0.11 ± 0.04	1.3 ± 0.6	0.89 ± 0.09	
2B (FLOC)	11/25/87	20 ± 8	32 ± 3		14 ± 1			0.23 ± 0.07	2.1 ± 1.0	0.99 ± 0.10	
7B (FLOC)	11/25/87	20 ± 8	39 ± 3	1.08 ± 0.55	12 ± 1			0.09 ± 0.072	2.4 ± 1.1	0.85 ± 0.09	

* Only gamma emitters detected are reported; typical LLD values are found le 2.

TABLE 11
(Page 1 of 2)
GROSS ALPHA, GROSS BETA, TRITIUM AND GAMMA* SPECTROMETRY IN GROUND (WELL) WATER
SSES 1987
Results in pCi/l ± 2 s

LOCATION	DATE	Gr-Alpha	Gr-Beta	H-3	K-40	Cs-137	Other Activity
12F3	01/06/87	LT 2	2.0 ± 1.1	110 ± 50			
2S6	01/06/87	LT 1	LT 1	LT 70			
3S5 (1)							
4S2	01/06/87	LT 2	3.2 ± 1.3	78 ± 47			
4S4	01/06/87	LT 1	1.9 ± 0.8	96 ± 50			
11S5	01/06/87	LT 2	3.0 ± 1.1	LT 80		Co-60	11 ± 3
12E4	01/06/87	LT 2	2.7 ± 1.1	85 ± 48			
12F3	02/10/87	LT 2	2.7 ± 1.1	89 ± 40			
2S6	02/09/87	LT 2	LT 1	LT 70			
3S5 (1)							
4S2	02/09/87	LT 2	4.0 ± 1.4	LT 70			
4S4	02/10/87	LT 2	1.5 ± 0.8	LT 70			
11S5	02/10/87	LT 2	LT 1	LT 80			
12E4	02/10/87	LT 2	4.2 ± 1.2	LT 80			
12F3	03/10/87	LT 2	1.9 ± 1.0	83 ± 38			
2S6	03/10/87	LT 2	LT 1	LT 60			
3S5 (1)							
4S2	03/10/87	3.8 ± 2.6	3.7 ± 1.3	82 ± 39			
4S4	03/10/87	LT 2	LT 1	100 ± 40			
11S5	03/10/87	LT 2	LT 1	140 ± 50			
12E4	03/10/87	LT 2	2.9 ± 1.1	110 ± 40			
12F3	04/07/87	LT 2	1.8 ± 1.0	LT 70			
2S6	04/07/87	LT 2	LT 1	75 ± 40			
3S5 (1)							
4S2	04/07/87	LT 2	4.0 ± 1.2	93 ± 44			
4S4	04/07/87	LT 2	2.2 ± 0.8	100 ± 40			
11S5	04/07/87	LT 2	1.5 ± 0.9	LT 60			
12E4	04/07/87	LT 2	2.2 ± 1.0	87 ± 39			
12F3	05/12/87	LT 2	2.1 ± 1.1	95 ± 40			
2S6	05/12/87	LT 2	LT 1	LT 70			
3S5	05/12/87	LT 2	2.3 ± 0.8	LT 70			
4S2	05/12/87	4.1 ± 2.8	3.0 ± 1.3	69 ± 43			
4S4	05/12/87	LT 2	2.0 ± 0.8	84 ± 48			
11S5	05/12/87	LT 2	LT 1	LT 70			
12E4	05/12/87	LT 2	1.8 ± 1.1	83 ± 40			
12F3	06/09/87	LT 2	1.5 ± 0.9	94 ± 45			
2S6	06/09/87	LT 2	LT 1	LT 70			
3S5	06/09/87	LT 1	1.3 ± 0.7	96 ± 40			
4S2	06/09/87	4.5 ± 3.6	LT 1	110 ± 40			
4S4	06/09/87	LT 1	1.9 ± 0.8	84 ± 42			
11S5	06/09/87	LT 2	1.5 ± 1.0	130 ± 40			
12E4	06/09/87	LT 2	2.2 ± 1.0	110 ±			

See Footnotes

TABLE 11
(Page 2 of 2)
GROSS ALPHA, GROSS BETA, TRITIUM AND GAMMA* SPECTROMETRY IN GROUND (WELL) WATER
SSES 1987
Results in pCi/l ± 2 s

LOCATION	DATE	Gr-Alpha	Gr-Beta	H-3	K-40	Cs-137	Other Activity
12F3	07/07/87	LT 2	2.5 ± 1	160 ± 80	59 ± 25		
2S6	07/07/87	LT 2	LT 1	LT 100			
3S5	07/07/87	LT 1	1.8 LT 0.8	170 ± 80			
4S2	07/07/87	LT 2	1.9 ± 1.1	210 ± 100			
4S4	07/07/87	LT 1	1.8 LT 0.8	LT 100			
11S5	07/07/87	LT 2	LT 1	LT 100			
12E4	07/07/87	LT 2	2.1 ± 1.1	120 ± 80			
12F3	08/11/87	LT 2	LT 1	88 ± 48			
2S6	08/11/87	LT 1	LT 1	LT 60			
3S5	08/11/87	LT 1	1.4 ± 0.8	LT 70			
4S2	08/11/87	LT 2	LT 2	LT 60			
4S4	08/11/87	LT 1	2.0 ± 0.9	110 ± 50			
11S5	08/11/87	LT 2	LT 1	88 ± 40			
12E4	08/11/87	LT 2	LT 1	69 ± 42			
12F3	9/08/87	LT 1	1.8 ± 1	140 ± 50			
2S6	9/08/87	LT 2	LT 1	LT 80			
3S5	9/08/87	LT 2	2.1 ± 0.8	LT 60			
4S2	9/08/87	LT 2	LT 2	250 ± 50			
4S4	9/08/87	LT 2	LT 1	95 ± 45			
11S5	9/08/87	LT 2	LT 1	70 ± 43			
12E4	9/08/87	LT 1	2.2 ± 1	95 ± 47			
12F3	10/06/87	LT 2	1.4 ± 0.9	LT 90			
2S6	10/06/87	LT 1	LT 1	LT 70			
3S5	10/06/87	LT 1	LT 1	LT 80			
4S2	10/06/87	3.6 ± 2.9	1.9 ± 1	LT 80			
4S4	10/06/87	LT 1	1.4 ± 0.8	LT 80			
11S5	10/06/87	LT 2	LT 1	LT 80			
12E4	10/06/87	LT 2	1.5 ± 0.9	LT 80			
12F3	11/10/87	LT 1	2.6 ± 1	LT 70			
2S6	11/10/87	LT 2	1.6 ± 0.7	LT 80			
3S5 (1)							
4S2	11/10/87	LT 2	3.2 ± 1.1	LT 70			
4S4	11/10/87	LT 2	2.3 ± 0.8	LT 80			
11S5	11/10/87	LT 2	LT 1	LT 80			
12E4	11/10/87	LT 2	1.9 ± 0.9	LT 80			
12F3	12/08/87	LT 2	3.1 ± 1.0	130 ± 50			
2S6	12/08/87	LT 2	LT 1	LT 50			
3S5 (1)							
4S2	12/08/87	LT 2	3.1 ± 1.1	87 ± 45			
4S4	12/08/87	LT 2	1.8 ± 0.7	LT 80			
11S5	12/08/87	LT 2	LT 1	110 ± 50			
12E4	12/08/87	LT 2	2.4 ± 1.0	120 ± 40			

* Only gamma emitters detected are reported; typical LLD values are found in table 20.
(1) The Riverland Security Office was closed during the colder months of the year.

TABLE 12
(Page 1 of 2)
GROSS BETA OF AIR PARTICULATE FILTERS
SSES 1987
Results in E-03 pCi/m³ ± 2 s

MONTH	COLLECTION DATE	7G1	12G1	7H1	2S2	5S4	11S2	15S4	9B1	1D2	3D1	12E1
JAN	12/30/86 to 01/06/87	16 ± 2	19 ± 2	12 ± 2	18 ± 2	19 ± 2	18 ± 2	19 ± 2	18 ± 2	17 ± 2	17 ± 2	19 ± 2
	01/06/87 to 01/13/87	13 ± 2 (1)	16 ± 2	(2)	15 ± 2	16 ± 2	14 ± 2	14 ± 2	14 ± 2	15 ± 2	14 ± 2	17 ± 2
	01/13/87 to 01/21/87	14 ± 2	13 ± 2		16 ± 2	14 ± 2	15 ± 2	14 ± 2	14 ± 2	14 ± 2	14 ± 2	14 ± 2
	01/21/87 to 01/27/87	16 ± 2	18 ± 2		18 ± 2	18 ± 2	18 ± 2	17 ± 2	18 ± 2	18 ± 2	17 ± 2	17 ± 2
	01/27/87 to 02/03/87	21 ± 2	26 ± 2		76 ± 7(3)	25 ± 2	25 ± 2	30 ± 2(4)	26 ± 2	25 ± 2	23 ± 2	25 ± 2
FEB	02/03/87 to 02/10/87	13 ± 2	16 ± 2		18 ± 2	17 ± 2	16 ± 2	16 ± 2(5)	18 ± 2	18 ± 2	17 ± 2	17 ± 2
	02/10/87 to 02/17/87	13 ± 2	13 ± 2		14 ± 2	15 ± 2	14 ± 2	13 ± 2	13 ± 2	14 ± 2	15 ± 2	12 ± 2
	02/17/87 to 02/24/87	14 ± 2	14 ± 2		15 ± 2	15 ± 2	13 ± 2	13 ± 2	14 ± 2	14 ± 2	13 ± 2	12 ± 2
	02/24/87 to 03/03/87	8 ± 2	9 ± 2		9 ± 2	10 ± 2	10 ± 2	8 ± 2	9 ± 2	10 ± 2	10 ± 2	8 ± 2
MAR	03/03/87 to 03/10/87	19 ± 2	21 ± 2		21 ± 2	20 ± 2	21 ± 2	22 ± 2	21 ± 2	21 ± 2	19 ± 2	24 ± 2
	03/10/87 to 03/17/87	16 ± 2	18 ± 2		16 ± 2	19 ± 2	17 ± 2	18 ± 2	19 ± 2	18 ± 2	18 ± 2	18 ± 2
	03/17/87 to 03/24/87	8 ± 2	9 ± 2		8 ± 2	8 ± 2	9 ± 2	9 ± 2	10 ± 2	9 ± 2	7 ± 1	8 ± 2
	03/24/87 to 03/31/87	13 ± 2	14 ± 2		17 ± 2	17 ± 2	15 ± 2	17 ± 2	18 ± 2	15 ± 2	13 ± 2	16 ± 2
APR	03/31/87 to 04/07/87	9 ± 2	9 ± 2		7 ± 2	9 ± 2	8 ± 2	8 ± 2	9 ± 2	8 ± 2	8 ± 2	9 ± 2
	04/07/87 to 04/14/87	13 ± 2	13 ± 2		12 ± 2	13 ± 2	13 ± 2	11 ± 2	12 ± 2	12 ± 2	12 ± 2	15 ± 2
	04/14/87 to 04/21/87	8 ± 2	9 ± 2		9 ± 2	10 ± 2	8 ± 2	8 ± 2	9 ± 2	9 ± 2	7 ± 2	9 ± 2
	04/21/87 to 04/28/87	11 ± 2	13 ± 2		12 ± 2	11 ± 2	11 ± 2	12 ± 2	11 ± 2	13 ± 2	10 ± 2	11 ± 2
MAY	04/28/87 to 05/05/87	12 ± 2	13 ± 2		13 ± 2	14 ± 2	14 ± 2	12 ± 2	14 ± 2	14 ± 2	12 ± 2	13 ± 2
	05/05/87 to 05/12/87	17 ± 2	17 ± 2		18 ± 2	17 ± 2	16 ± 2	12 ± 2	18 ± 2	19 ± 2	18 ± 2	18 ± 2
	05/12/87 to 05/19/87	9 ± 4	13 ± 2		12 ± 2	14 ± 2	13 ± 2	13 ± 2	13 ± 2	13 ± 2	12 ± 2	13 ± 2
	05/19/87 to 05/26/87	9 ± 2	12 ± 2		10 ± 2	9 ± 2	11 ± 2	9 ± 2	12 ± 2	10 ± 2	10 ± 2	12 ± 2
	05/26/87 to 06/02/87	18 ± 2	18 ± 2		16 ± 2	19 ± 2	17 ± 2	18 ± 2	18 ± 2	17 ± 2	18 ± 2	19 ± 2
JUN	06/02/87 to 06/09/87	14 ± 2	15 ± 2		14 ± 2	15 ± 2	14 ± 2	14 ± 2	13 ± 2	13 ± 2	12 ± 2	14 ± 2
	06/09/87 to 06/16/87	12 ± 2	14 ± 2		16 ± 2	15 ± 2	14 ± 2	14 ± 2	13 ± 2	14 ± 2	13 ± 2	15 ± 2
	06/16/87 to 06/23/87	15 ± 2	17 ± 2		15 ± 2	16 ± 2	17 ± 2	14 ± 2	16 ± 2	16 ± 2	15 ± 2	16 ± 2
	06/23/87 to 06/30/87	12 ± 2	12 ± 2		12 ± 2	12 ± 2	12 ± 2	12 ± 2	11 ± 2	12 ± 2	11 ± 2	13 ± 2

See Footnotes

TABLE 12
(Page 2 of 2)
GROSS BETA OF AIR PARTICULATE FILTERS
SSES 1987
Results in E-03 pCi/m³ ± 2 s

MONTH	COLLECTION DATE	7G1	12G1	7H1	2S2	5S4	11S2	15S4	9B1	1D2	3D1	12E1
JUL	06/30/87 to 07/07/87	12 ± 2	14 ± 2		12 ± 2	14 ± 2	13 ± 2	12 ± 2	13 ± 2	13 ± 2	14 ± 2	14 ± 2
	07/07/87 to 07/14/87	18 ± 2	18 ± 2		17 ± 2	18 ± 2	15 ± 2	17 ± 2	18 ± 2	14 ± 2	18 ± 2	19 ± 2
	07/14/87 to 07/21/87	20 ± 2	21 ± 2		18 ± 2	18 ± 2	19 ± 2	19 ± 2	20 ± 2	19 ± 2	22 ± 2	20 ± 2
	07/21/87 to 07/28/87	20 ± 2	22 ± 2		21 ± 2	20 ± 2	19 ± 2	20 ± 2	22 ± 2	20 ± 2	20 ± 2	21 ± 2
AUG	07/28/87 to 08/04/87	14 ± 2	17 ± 2		16 ± 2	17 ± 2	17 ± 2	16 ± 2	16 ± 2	16 ± 2	17 ± 2	15 ± 2
	08/04/87 to 08/11/87	16 ± 2	17 ± 2		16 ± 2	16 ± 2	16 ± 2	15 ± 2	15 ± 2	16 ± 2	18 ± 2	17 ± 2
	08/11/87 to 08/18/87	13 ± 2	17 ± 2		14 ± 2	13 ± 2	13 ± 2	12 ± 2	13 ± 2	16 ± 2	14 ± 2	14 ± 2
	08/18/87 to 08/25/87	15 ± 2	17 ± 2		17 ± 2	17 ± 2	16 ± 2	16 ± 2	17 ± 2	17 ± 2	16 ± 2	17 ± 2
	08/25/87 to 09/01/87	11 ± 2	13 ± 2		13 ± 2	12 ± 2	12 ± 2	13 ± 2	14 ± 2	13 ± 2	13 ± 2	13 ± 2
SEP	09/01/87 to 09/08/87	12 ± 2	12 ± 2		14 ± 2	12 ± 2	12 ± 2	11 ± 2	12 ± 2	13 ± 2	12 ± 2	13 ± 2
	09/08/87 to 09/15/87	17 ± 2	15 ± 2		16 ± 2	15 ± 2	15 ± 2	16 ± 2	16 ± 2	16 ± 2	15 ± 2	17 ± 2
	09/15/87 to 09/22/87	15 ± 2	16 ± 2		16 ± 2	15 ± 2	14 ± 2	15 ± 2	16 ± 2	16 ± 2	15 ± 2	14 ± 2
	09/22/87 to 09/29/87	19 ± 2	21 ± 2		20 ± 2	21 ± 2	21 ± 2	20 ± 2	22 ± 2	21 ± 2	19 ± 2	22 ± 2
OCT	09/29/87 to 10/06/87	17 ± 2	17 ± 2		14 ± 2	16 ± 2	16 ± 2	16 ± 2	16 ± 2	15 ± 2	15 ± 2	16 ± 2
	10/06/87 to 10/13/87	13 ± 2	15 ± 2		13 ± 2	13 ± 2	11 ± 2	12 ± 2	14 ± 2	14 ± 2	14 ± 2	14 ± 2
	10/13/87 to 10/20/87	28 ± 3	30 ± 3		28 ± 2	27 ± 2	28 ± 2	29 ± 2	28 ± 2	25 ± 2	27 ± 2	25 ± 2
	10/20/87 to 10/27/87	20 ± 2	22 ± 2		21 ± 2	20 ± 2	20 ± 2	18 ± 2	20 ± 2	19 ± 2	22 ± 2	20 ± 2
NOV	10/27/87 to 11/03/87	20 ± 2	22 ± 2		20 ± 2	17 ± 2	19 ± 2	20 ± 2	20 ± 2	23 ± 2	19 ± 2	21 ± 2
	11/03/87 to 11/10/87	29 ± 3	30 ± 3		30 ± 3	28 ± 2	25 ± 2	25 ± 2(8)	26 ± 3(8)	28 ± 3	28 ± 3	29 ± 3
	11/10/87 to 11/17/87	24 ± 2	25 ± 2		26 ± 2	23 ± 2	24 ± 2	24 ± 2	24 ± 2	24 ± 2	23 ± 2	23 ± 2
	11/17/87 to 11/24/87	17 ± 2	15 ± 2		16 ± 2	16 ± 2	14 ± 2	16 ± 2	16 ± 2	15 ± 2	14 ± 2	16 ± 2
	11/24/87 to 12/01/87	19 ± 2	(6)		20 ± 2	20 ± 2	17 ± 2	19 ± 2	21 ± 2	21 ± 2	19 ± 2	18 ± 2
DEC	12/01/87 to 12/08/87	10 ± 2	11 ± 2(7)		10 ± 2	11 ± 2	11 ± 2	11 ± 2	11 ± 2	10 ± 2	11 ± 2	10 ± 2
	12/08/87 to 12/15/87	16 ± 2	20 ± 2		19 ± 2	20 ± 2	18 ± 2	17 ± 2	18 ± 2	18 ± 2	17 ± 2	17 ± 2
	12/15/87 to 12/22/87	10 ± 2	13 ± 2		13 ± 2	13 ± 2	12 ± 2	13 ± 2	11 ± 2	12 ± 2	12 ± 2	11 ± 2
	12/22/87 to 12/29/87	19 ± 2	22 ± 2		22 ± 2	23 ± 2	22 ± 2	20 ± 2	23 ± 2	25 ± 2	22 ± 2	22 ± 2
	12/29/87 to 01/05/88	22 ± 2	25 ± 2		25 ± 2	24 ± 2	26 ± 2	24 ± 2	24 ± 2	26 ± 2	23 ± 2	25 ± 2

(1) Flow meter and pump changed on 1/13/87.
(2) Sampling location discontinued for 1987.
(3) Low sample volume indicatedd - dry gas meter digits appear to be sticking.
(fitter unusually dark and torn)
(4) Stop date 2/4/87
(5) Start date 2/4/87
(6) Insufficient sampler volume due to sampler malfunction
(7) Loss of power for a day, sample collection started on 12/2/87
(8) Major forest fires in some southen states, led to heavy deposition on the filters.

TABLE 13
GROSS ALPHA AND GAMMA* SPECTROMETRY OF COMPOSITED AIR PARTICULTES
SSES 1987
Results in E-03 pCi/m3 ± 2 s

LOCATION	COLLECTION DATE	Gr-alpha	Be-7	K-40	Ru-103	Ru-106	Cs-134	Cs-137	Other Activity
7G1	01/06/87 to 04/07/87	2.8 ± 0.6	73 ± 7.3	5.8 ± 3.1					
12G1	01/06/87 to 04/07/87	4 ± 0.7	51 ± 5.1						
2S2	01/06/87 to 04/07/87	4 ± 0.8	67 ± 6.7						
5S4	01/06/87 to 04/07/87	3.6 ± 0.7	86 ± 8.6						
11S2	01/06/87 to 04/07/87	3.1 ± 0.7	62 ± 6.1						
15S4	01/06/87 to 04/07/87	3.6 ± 0.6	67 ± 7.8						
9B1	01/06/87 to 04/07/87	3.8 ± 0.7	75 ± 7.5						
1D2	01/06/87 to 04/07/87	3.8 ± 0.7	67 ± 6.7						
3D1	01/06/87 to 04/07/87	3.2 ± 0.6	75 ± 7.5						
12E1	01/06/87 to 04/07/87	3.8 ± 0.7	76 ± 7.6						
7G1	04/07/87 to 07/07/87	2.1 ± 0.6	99 ± 10						
12G1	04/07/87 to 07/07/87	3 ± 0.6	62 ± 6						
2S2	04/07/87 to 07/07/87	2.4 ± 0.6	84 ± 8						
5S4	04/07/87 to 07/07/87	2.9 ± 0.5	99 ± 10	5.1 ± 2.6					
11S2	04/07/87 to 07/07/87	2.4 ± 0.5	82 ± 8						
15S4	04/07/87 to 07/07/87	2.6 ± 0.5	84 ± 8						
9B1	04/07/87 to 07/07/87	2.5 ± 0.6	93 ± 9	2.3 ± 1.3					
1D2	04/07/87 to 07/07/87	2.6 ± 0.5	102 ± 10						
3D1	04/07/87 to 07/07/87	3 ± 0.7	99 ± 10						
12E1	04/07/87 to 07/07/87	3.2 ± 0.6	91 ± 9						
7G1	07/07/87 to 10/06/87	1.6 ± 0.5	58 ± 6						
12G1	07/07/87 to 10/06/87	2.3 ± 0.5	70 ± 7						
2S2	07/07/87 to 10/06/87	2 ± 0.4	79 ± 8						
5S4	07/07/87 to 10/06/87	2.5 ± 0.5	71 ± 7						
11S2	07/07/87 to 10/06/87	3 ± 0.6	87 ± 9						
15S4	07/07/87 to 10/06/87	2.3 ± 0.5	70 ± 7						
9B1	07/07/87 to 10/06/87	1.4 ± 0.4	87 ± 9						
1D2	07/07/87 to 10/06/87	1.8 ± 0.5	50 ± 0.5						
3D1	07/07/87 to 10/06/87	1.5 0.5	88 ± 9	2.9 ± 1.7					
12E1	07/07/87 to 10/06/87	2.4 ± 0.6	75 ± 8	8.5 ± 3.3					
7G1	10/06/87 to 01/05/88	3.9 ± 0.6	5.3 ± 0.5						
12G1	10/06/87 to 01/05/88	4.2 ± 0.6	5.2 ± 0.5						
2S2	10/06/87 to 01/05/88	4.6 ± 0.6	4.7 ± 0.5						
5S4	10/06/87 to 01/05/88	5.2 ± 0.6	5.2 ± 0.5						
11S2	10/06/87 to 01/05/88	4.5 ± 0.6	5.2 ± 0.5						
15S1	10/06/87 to 01/05/88	5.5 ± 0.7	5.1 ± 0.5	4.0 ± 2.1					
9B1	10/06/87 to 01/05/88	4.7 ± 0.7	4.8 ± 0.5	8.2 ± 2.3					
1D2	10/05/87 to 01/05/88	5.2 ± 0.6	5.1 ± 0.5						
3D1	10/06/87 to 01/05/88	4.3 ± 0.6	5.7 ± 0.6						
12E1	10/06/87 to 01/05/88	3.9 ± 0.6	5.3 ± 0.5						

* Only gamma emitters detected are reported; typical LLD values are found on Table 20.

TABLE 14
GROSS ALPHA, GROSS BETA, TRITIUM AND GAMMA* SPECTROMETRY OF PRECIPITATION
SSES 1987
Results in pCi/l ± 2 s

LOCATION	COLLECTION DATE	Gr-Alpha	Gr-Beta	H-3	Be-7	K-40	Cs-137	Other Activity
7G1	01/06/87 to 04/07/87	0.98 ± 0.60	3.0 ± 0.7	LT 60				
12G1	01/06/87 to 04/07/87	0.79 ± 0.53	8.7 ± 1.0	LT 70				
2S2	01/06/87 to 04/07/87	LT 0.8	3.0 ± 0.7	71 ± 44				
5S4	01/06/87 to 04/07/87	1.3 ± 0.7	3.1 ± 0.7	LT 60				
11S2	01/06/87 to 04/07/87	LT 0.5	1.2 ± 0.6	71 ± 40				
15S4	01/06/87 to 04/07/87	LT 0.8	3.4 ± 0.8	LT 50				
9B1	01/06/87 to 04/07/87	1.5 ± 0.5	3.8 ± 0.8	LT 60				
1D2	01/06/87 to 04/07/87	0.50 ± 0.43	3.3 ± 0.7	LT 60		53 ± 26		
3D1	01/06/87 to 04/07/87	0.86 ± 0.52	7.2 ± 0.9	LT 60		77 ± 30		
12E1	01/06/87 to 04/07/87	0.80 ± 0.50	3.3 ± 0.7	LT 50				
7G1	04/07/87 to 07/07/87	0.47 ± 0.44	5.0 ± 0.8	LT 80				
12G1	04/07/87 to 07/07/87	2.4 ± 0.8	5.0 ± 0.8	LT 80			3.9 ± 3.1	
2S2	04/07/87 to 07/07/87	1.9 ± 0.8	6.1 ± 0.9	LT 90				
5S4	04/07/87 to 07/07/87	1.3 ± 0.7	5.3 ± 0.8	LT 80		132 ± 34		
11S2	04/07/87 to 07/07/87	3.4 ± 1.1	6.0 ± 0.9	210 ± 110				
15S4	04/07/87 to 07/07/87	1.6 ± 0.7	6.0 ± 0.9	LT 80				
9B1	04/07/87 to 07/07/87	1.9 ± 0.8	5.2 ± 0.8	LT 70				
1D2	04/07/87 to 07/07/87	0.81 ± 0.54	3.9 ± 0.7	87 ± 50				
3D1	04/07/87 to 07/07/87	1.4 ± 0.7	4.4 ± 0.8	LT 70				
12E1	04/07/87 to 07/07/87	1.3 ± 0.6	4.7 ± 0.8	LT 100				
7G1	07/07/87 to 10/06/87	LT 0.6	3.8 ± 0.8	LT 80				
12G1	07/07/87 to 10/06/87	LT 0.6	4.0 ± 0.8	73 ± 45				
2S2	07/07/87 to 10/06/87	LT 0.6	3.3 ± 0.7	LT 70				
5S4	07/07/87 to 10/06/87	1.4 ± 0.7	3.3 ± 0.7	77 ± 48				
11S2	07/07/87 to 10/06/87	LT 0.7	2.4 ± 0.7	LT 70				
15S4	07/07/87 to 10/06/87	LT 0.6	3.4 ± 0.7	LT 80				
9B1	07/07/87 to 10/06/87	LT 0.6	3.5 ± 0.8	LT 80				
1D2	07/07/87 to 10/06/87	LT 0.7	4.0 ± 0.8	LT 70				
3D1	07/07/87 to 10/06/87	LT 0.6	3.2 ± 0.7	260 ± 50				
12E1	07/07/87 to 10/06/87	LT 0.6	3.3 ± 0.7	LT 80				
7G1	10/06/87 to 01/05/88	0.9 ± 0.3	5.5 ± 0.9	130 ± 50				
12G1	10/06/87 to 01/05/88	1.1 ± 0.3	6.3 ± 0.9	190 ± 40				
2S2	10/06/87 to 01/05/88	1.2 ± 0.3	5.6 ± 0.9	180 ± 50				
5S4	10/06/87 to 01/05/88	0.85 ± 0.30	5.8 ± 0.9	93 ± 26				
11S2	10/06/87 to 01/05/88	0.50 ± 0.30	4.5 ± 0.9	140 ± 50				
15S4	10/06/87 to 01/05/88	1.0 ± 0.3	7.3 ± 1.0	170 ± 50				
9B1	10/06/87 to 01/05/88	1.5 ± 0.4	5.1 ± 0.9	250 ± 50				
1D2	10/06/87 to 01/05/88	0.6 ± 0.3	3.7 ± 0.8	150 ± 40				
3D1	10/06/87 to 01/05/88	0.8 ± 0.3	5.6 ± 0.9	93 ± 26				
12E1	10/06/87 to 01/05/88	1.5 ± 0.4	5.1 ± 0.9	100 ± 30				

* Only gamma emitters detected are reported; typical LLD values are found on Table 20.

TABLE 15
(Page 1 of 4)
GROSS BETA MINUS K-40, IODINE-131 AND GAMMA* SPECTROMETRY OF MILK
SSES 1987
(Results in pCi/l ± 2 s)

LOCATION	COLLECTION DATE	Gr-B minus K-40	I-131	K-40	Cs-137	Other Activity	
10G1	01/05/87	13 ± 2		1280 ± 130			
12B2	01/05/87	8.0 ± 1.9		1280 ± 130			
12B3	01/05/87	14 ± 2		1080 ± 110			
6C1	01/05/87	8.5 ± 2.4		1310 ± 130			
10D1	01/05/87	9.8 ± 3.8		1230 ± 120			
12D2	01/05/87	7.2 ± 2.2		1300 ± 130			
5E1	01/05/87	4.7 ± 1.6		1220 ± 120			
13E3	01/05/87	7.0 ± 1.8		1410 ± 140			
14B1	01/05/87	8.6 ± 2.1		1280 ± 130			
10G1	02/09/87	13 ± 2		1390 ± 140	4.2 ± 3.3		
12B2	02/10/87	5.0 ± 1.6		1300 ± 130			
12B3 (1)	02/09/87	15 ± 2		1220 ± 120		Sr-90	3.7 ± 0.9
6C1	02/09/87	7.6 ± 1.9		1350 ± 140			
10D1	02/09/87	13 ± 2		1160 ± 120	7.9 ± 5.0		
12D2	02/09/87	4.4 ± 1.6		1170 ± 120			
5E1	02/09/87	7.9 ± 1.9		1310 ± 130			
13E3	02/09/87	7.5 ± 1.8		1360 ± 140	5.9 ± 3.6		
14B1	02/09/87	7.0 ± 1.9		1330 ± 130	4.3 ± 3.6		
10G1	03/09/87	14 ± 2		1390 ± 140	3.7 ± 3.5		
12B2	03/10/87	3.9 ± 1.7		1290 ± 130			
12B3	03/09/87	12 ± 2		1290 ± 130			
6C1	03/09/87	7.4 ± 1.9		1300 ± 130			
10D1	03/09/87	12 ± 2		1340 ± 130			
12D2	03/10/87	7.2 ± 2.0		1310 ± 130			
5E1	03/09/87	5.5 ± 1.9		1390 ± 140			
13E3	03/09/87	6.7 ± 2.0		1330 ± 130			
14B1	03/09/87	5.8 ± 2.0		1200 ± 120			
10G1	04/06/87	12 ± 2		1330 ± 130			
12B2	04/07/87	4.6 ± 1.8		1270 ± 130			
12B3 (1)	04/06/87	16 ± 2		1350 ± 140	4.8 ± 3.1	Sr-90	6.8 ± 1.0
6C1 (1)	04/06/87	9.5 ± 2.2		1430 ± 140	7.5 ± 4.6	Sr-90	3.1 ± 0.9
10D1	04/06/87	12 ± 2		1290 ± 130	3.1 ± 3.1		
12D2	04/07/87	5.5 ± 1.9		1280 ± 130			
5E1	04/06/87	8.0 ± 1.9		1180 ± 120			
13E3	04/06/87	5.9 ± 1.8		1260 ± 130	9.3 ± 5.7		
14B1	04/06/87	6.3 ± 1.8		1300 ± 130	7.2 ± 4.4		
10G1 (2)	04/20/87	11 ± 2		1280 ± 130			
12B2 (2)	04/21/87	5.0 ± 1.9		1200 ± 120			
10D1 (2)	04/20/87	11 ± 2		1120 ± 110			
5E1 (2)	04/20/87	6.8 ± 2.0		1110 ± 110			
13E3 (2)	04/20/87	6.3 ± 1.9		1020 ± 100	12 ± 5		
14B1 (2)	04/20/87	5.2 ± 1.7		1210 ± 120	4.2 ± 4.7		

See Footnotes

TABLE 15
(Page 2 of 4)
GROSS BETA MINUS K-40, IODINE-131 AND GAMMA* SPECTROMETRY OF MILK
SSES 1987
(Results in pCi/l ± 2 s)

LOCATION	COLLECTION DATE	Gr-B minus K-40	I-131	K-40	Cs-137	Other Activity	
10G1	05/11/87	12 ± 2		1200 ± 120			
12B2	05/11/87	3.5 ± 1.6		1230 ± 120	6.3 ± 3.1		
12B3 (1)	05/12/87	19 ± 2		1260 ± 130	20 ± 5	Sr-90	7.6 ± 0.8
6C1	05/11/87	8.6 ± 1.8		1340 ± 130			
10D1	05/11/87	7.9 ± 1.7		1320 ± 130			
12D2	05/12/87	7.1 ± 1.8		1200 ± 120			
5E1	05/11/87	5.9 ± 1.7		1270 ± 130			
13E3	05/11/87	5.6 ± 1.7		1270 ± 130			
14B1	05/11/87	7.6 ± 1.8		1340 ± 130			
10G1	05/26/87	10 ± 2		1330 ± 130			
12B2	05/27/87	3.9 ± 1.8		1290 ± 130			
10D1	05/26/87	8.8 ± 1.9		1300 ± 130			
5E1	05/26/87	5.9 ± 1.8		1160 ± 120			
13E3	05/26/87	5.2 ± 1.8		1360 ± 140			
14B1	05/26/87	11 ± 2		1180 ± 120			
10G1	06/08/87	5.6 ± 1.9		1150 ± 120	4 ± 3		
12B2	06/08/87	3.8 ± 2.3		1310 ± 130	11 ± 4		
12B3	06/08/87	14 ± 3		1080 ± 110			
6C1	06/08/87	4.0 ± 2.2		1320 ± 130			
10D1	06/08/87	4.3 ± 2.3		1280 ± 130			
12D2	06/09/87	7.8 ± 2.0		1240 ± 120			
5E1	06/08/87	4.0 ± 2.2		1280 ± 130	5 ± 4		
13E3	06/08/87	4.6 ± 2.4		1440 ± 140			
14B1	06/08/87	8.1 ± 2.6		1200 ± 120	4 ± 3		
10G1	06/22/87	11 ± 2		1350 ± 140			
12B2	06/22/87	4.5 ± 2.2		1260 ± 130			
10D1	06/22/87	8.8 ± 2.2		1100 ± 110			
5E1	06/22/87	6.3 ± 2.3		1180 ± 120			
13E3	06/22/87	8.6 ± 1.9		1420 ± 140			
14B1	06/22/87	7.9 ± 2.4		1290 ± 130			
10G1	07/06/87	12 ± 2		1330 ± 130	6.3 ± 4.6		
12B2	07/06/87	4.8 ± 2.2		1190 ± 120			
12B3	07/06/87	12 ± 2		992 ± 99			
6C1	07/06/87	8.4 ± 2.3		1300 ± 130			
10D1	07/06/87	7.6 ± 2.2		1170 ± 120			
12D2	07/07/87	5.8 ± 2.2		1340 ± 130			
5E1	07/06/87	3.3 ± 2.1		1260 ± 130			
13E3	07/06/87	4.8 ± 2.2		1110 ± 110			
14B1	07/06/87	4.9 ± 2.2		1160 ± 120			
10G1	07/20/87	9.0 ± 2.0		1310 ± 130			
12B2	07/20/87	4.4 ± 1.8		1270 ± 130			
10D1	07/20/87	7.5 ± 2.0		1320 ± 130			
5E1	07/20/87	4.7 ± 1.7		1350 ± 140			
13E3	07/20/87	5.2 ± 1.8		1480 ± 150			
14B1	07/20/87	8.6 ± 2.1		1170 ± 120			

See footnotes

TABLE 15
(Page 3 of 4)
GROSS BETA MINUS K-40, IODINE-131 AND GAMMA* SPECTROMETRY OF MILK
SSES 1987
(Results in pCi/l ± 2 s)

LOCATION	COLLECTION DATE	Gr-B minus K-40	I-131	K-40	Cs-137	Other Activity	
10G1	08/10/87	10 ± 2		1420 ± 140	4.2 ± 3.5		
12B2	08/11/87	3.2 ± 1.9		1270 ± 130			
12B3	08/10/87	17 ± 2		1280 ± 130	8.5 ± 3.9	Sr-90	9.3 ± 1.0
6C1	08/10/87	6.9 ± 2.0		1280 ± 130			
10D1	08/10/87	6.8 ± 2.0		1380 ± 140			
12D2	08/11/87	4.3 ± 1.9		1260 ± 130			
5E1	08/10/87	4.2 ± 1.9		1230 ± 120			
13E3	08/10/87	5.9 ± 2.0		1410 ± 140			
14B1	08/10/87	8.4 ± 2.1		1300 ± 130	4.1 ± 3.5		
10G1	08/24/87	8.4 ± 1.9		1310 ± 130			
12B2	08/25/87	3.5 ± 1.8		1490 ± 150			
10D1	08/24/87	5.8 ± 1.8		1180 ± 120			
5E1	08/24/87	4.4 ± 1.7		1190 ± 120			
13E3	08/24/87	6.8 ± 1.9		1280 ± 130			
14B1	08/24/87	6.0 ± 1.9		1250 ± 130			
10G1	09/08/87	6.6± 1.6		1370 ± 140			
12B2	09/08/87	2.9 ± 1.4		1350 ± 130	3.2 ± 3.3		
12B3 (1)	09/09/87	16 ± 2		1200 ± 120		Sr-90	10 ± 1
6C1	09/08/87	3.3 ± 1.6		1260 ± 130			
10D1	09/08/87	5.0 ± 1.6		1170 ± 120			
12D2	09/09/87	2.6 ± 1.6		1370 ± 140			
5E1	09/08/87	3.2 ± 1.5		1170 ± 120			
13E3	09/08/87	3.9 ± 1.5		1360 ± 140			
14B1	09/08/87	2.6 ± 1.6		1210 ± 120			
10G1	09/21/87	9.7 ± 2.5		1340 ± 130			
12B2	09/22/87	5.1 ± 2.0		1260 ± 130			
10D1	09/21/87	6.6 ± 2.0		1300 ± 130			
5E1	09/21/87	6.3 ± 2.4		1270 ± 130			
13E3	09/21/87	6.4 ± 2.5		1280 ± 130	3.8 ± 3.4		
14B1	09/21/87	12 ± 3		1220 ± 120			
10G1	10/05/87	13 ± 2		1230 ± 120			
12B2	10/06/87	6.7 ± 2.1		1190 ± 120			
12B3	10/05/87	13 ± 2		1270 ± 130			
6C1	10/05/87	6.0 ± 1.7		1170 ± 120			
10D1	10/05/87	11 ± 2		928 ± 93			
12D2	10/05/87	4.4 ± 1.7		1410 ± 120			
5E1	10/05/87	6.4 ± 1.7		1230 ± 120			
13E3	10/05/87	13 ± 2		1250 ± 120			
14B1	10/05/87	5.6 ± 1.6		1260 ± 130			
10G1	10/19/87	6.9 ± 1.7		1330 ± 130			
12B2	10/19/87	5.4 ± 1.6		1300 ± 130			
10D1	10/19/87	5.0 ± 1.7		1120 ± 110	5.4 ± 4.8		
5E1	10/19/87	4.4 ± 1.7		1300 ± 130			
13E3	10/19/87	6.0 ± 1.7		1430 ± 140			
14B1	10/19/87	9.0 ± 2.0		1330 ± 130			

See footnotes

TABLE 15
(Page 4 of 4)
GROSS BETA MINUS K-40, IODINE-131 AND GAMMA* SPECTROMETRY OF MILK
SSES 1987
(Results in pCi/l ± 2 s)

LOCATION	COLLECTION DATE	Gr-B minus K-40	I-131	K-40	Cs-137	Other Activity
10G1	11/09/87	5.3 ± 1.6		1350 ± 140		
12B2	11/09/87	LT 2		1470 ± 150		
12B3	11/10/87	14 ± 2		1130 ± 110		
6C1	11/09/87	11 ± 2		1340 ± 130		
10D1	11/09/87	LT 3		1180 ± 120		
12D2	11/10/87	LT 3		1170 ± 120		
5E1	11/09/87	4.4 ± 1.8		1140 ± 110		
13E3	11/09/87	LT 3		1340 ± 130		
14B1	11/09/87	8.6 ± 2.2		1120 ± 110		
10G1	12/07/87	7.1 ± 1.7		988 ± 99		
12B2	12/07/87	3.7 ± 1.6		1230 ± 120		
12B3	12/07/87	11 ± 2		1110 ± 110		
6C1	12/07/87	5.7 ± 1.7		1190 ± 120		
10D1	12/07/87	5.9 ± 1.6		1370 ± 140		
12D2	12/08/87	2.9 ± 1.6		1220 ± 120		
5E1	12/07/87	5.2 ± 1.7		1230 ± 120		
13E3	12/08/87	4.3 ± 1.6		1030 ± 100		
14B1	12/07/87	3.5 ± 1.5		1250 ± 130		

(1) Sr-89 and Sr-90 analysis were performed; detected results are reported.
(2) Location sampled biweekly from April through October.

TABLE 16
GAMMA* SPECTROMETRY OF SOIL
SSES 1987
Results in pCi/g (dry) ± 2 s

LOCATION	COLLECTION DATE	Be-7	K-40	Cs-137	Ra-226	Th-228	Other Activity
7G1 BOT	9/17/87	LT 0.4	7.7 ± 0.8	0.51 ± 0.05	1.7 ± 0.5	0.94 ± 0.09	
7G1 TOP	9/17/87	LT 0.4	7.9 ± 0.8	1.7 ± 0.2	2.4 ± 0.6	0.99 ± 0.10	
12G3 BOT	9/17/87	LT 0.2	10 ± 1	0.19 ± .019	1.6 ± 0.3	1.0 ± 0.1	
12G3 TOP	9/17/87	LT 0.2	9.2 ± 0.9	0.14 ± 0.01	1.9 ± 0.3	1.2 ± 0.1	
2S4 BOT	9/16/87	LT 0.2	11 ± 1	0.08 ± 0.02	1.4 ± 0.3	1.0 ± 0.1	
2S4 TOP	9/16/87	LT 0.3	13 ± 1	0.18 ± 0.03	1.1 ± 0.3	0.81 ± 0.08	
5S5 BOT	9/16/87	LT 0.2	10 ± 1	0.17 ± 0.02	1.4 ± 0.3	0.87 ± 0.09	Mn-54 0.02 ± 0.02
5S5 TOP	9/16/87	LT 0.3	11 ± 1	0.11 ± 0.03	1.3 ± 0.5	1.0 ± 0.1	
11S4 BOT	9/16/87	LT 0.3	9.4 ± 0.9	0.43 ± 0.04	1.0 ± 0.5	0.76 ± 0.08	
11S4 TOP	9/16/87	LT 0.2	7.7 ± 0.8	0.63 ± 0.06	1.3 ± 0.4	0.66 ± 0.07	
15S4 BOT	9/16/87	LT 0.2	16 ± 2	0.04 ± 0.02	2.1 ± 0.3	1.2 ± 0.1	
15S4 TOP	9/16/87	LT 0.2	14 ± 1	0.07 ± 0.03	2.1 ± 0.4	1.1 ± 0.1	
9B2 BOT	9/16/87	LT 0.2	8.0 ± 0.8	0.24 ± 0.02	1.5 ± 0.3	0.62 ± 0.06	
9B2 TOP	9/16/87	LT 0.2	7.9 ± 0.1	0.23 ± 0.02	1.2 ± 0.4	0.56 ± 0.06	
1D4 BOT	9/16/87	LT 0.3	8.0 ± 0.8	0.25± 0.04	1.5± 0.5	0.96 ± 0.10	
1D4 TOP	9/16/87	LT 0.3	9.3 ± 0.9	0.30± 0.03	1.6 ± 0.5	1.0 ± 0.1	
3D2 BOT	9/17/87	LT 0.2	11 ± 1	0.49± 0.05	2.6± 0.5	1.7± 0.2	
3D2 TOP	9/17/87	LT 0.4	10 ± 1	0.76± 0.08	3.1 ± 0.6	2.1± 0.2	
12E2 BOT	9/17/87	LT 0.2	11 ± 1	0.20± 0.02	1.4± 0.3	0.97± 0.97	
12E2 TOP	9/17/87	LT 0.9	41 ± 4	0.76± 0.08	2.8± 0.8	2.5± 0.3	

* Only gamma emitters detected are reported; typical LLD values are found on Table 20.

TABLE17
GAMMA* SPECTROMETRY OF VEGETATION
SSES 1987
Results in pCi/g (dry) ± 2 s

LOCATION	COLLECTION DATE	Be-7	K-40	I-131	Cs-137	Other Activity
7G1	9/17/87	1.6 ± 0.2	6.1 ± 0.6	LT 0.05	0.026 ± 0.013	
12G3	9/17/87	2.4 ± 0.2	8.2 ± 0.8	LT 0.06	LT 0.02	
2S4	9/17/87	0.68 ± 0.15	5.1 ± 0.5	LT 0.05	LT 0.02	
5S5	9/17/87	2.6 ± 0.3	7.1 ± 0.7	LT 0.05	LT 0.02	
11S4	9/17/87	1.3 ± 0.2	6.1 ± 0.6	LT 0.05	LT 0.02	
15S4	9/17/87	4.3 ± 0.4	7.2 ± 0.7	LT 0.05	LT 0.02	
9B2	9/17/87	5.3 ± 0.5	7.2 ± 0.7	LT 0.05	LT 0.02	
1D4	9/17/87	1.6 ± 0.2	4.5 ± 0.5	LT 0.05	LT 0.01	
3D2	9/17/87	1.5 ± 0.2	5.9 ± 0.6	LT 0.04	0.060 ± 0.009	
12E2	9/17/87	3.5 ± 0.4	6.6 ± 0.7	LT 0.05	LT 0.01	

* Only gamma emitters detected are reported; typical LLD values are found on Table 21.

TABLE 18
GAMMA* SPECTROMETRY OF FOOD PRODUCTS (FRUITS, VEGETABLES AND HONEY)
SSES 1987
Results in pCi/g (wet) ± 2 s

LOCATION	COLLECTION DATE	Be-7	K-40	C	s-137	Other Activity
2H1 STRAWBERRIES	06/09/87		1.4 ± 0.1			
12H STRAWBERRIES	06/10/87		0.9 ± 0.1			
2H1 LETTUCE	07/06/87		3.9 ± 0.4			
2H1 GREEN BEANS	07/06/87		2 ± 0.2			
11D1 LETTUCE	07/07/87	0.25 ± 0.09	4.7 ± 0.5			
11D1 GREEN BEANS	07/07/87		2 ± 0.2			
2H1 RED BEETS	07/20/87		4.3 ± 0.4			
11D1 RED BEETS	07/20/87		5.1 ± 0.5			
2H1 CABBAGE	08/11/87		1.1 ± 0.1	0.014 ± 0.009		
11D1 SWEET CORN	08/10/87		2.9 ± 0.3			
2H1 TOMATO	08/11/87		1.3 ± 0.1			
2H1 SWEET CORN	08/11/87		2.6 ± 0.3			
11D1 CABBAGE	08/10/87		2.9 ± 0.3			
11D1 TOMATO	08/10/87		2.6 ± 0.3			
11D1 CANTOLOPE	08/11/87		2 ± 0.2	0.009 ± 0.008		
2H1 POTATO	09/09/87		4.9 ± 0.5			
11D1 POTATO	09/09/87		2.8 ± 0.3		C-14(1)	7 ± 0.2
7B2 HONEY	10/06/87		1.2 ± 0.1	0.14 ± 0.01		
2H1 MCNTSH APPLES	10/05/87		0.8 ± 0.1			
2H1 CRTLND APPLES	10/05/87		0.7 ± 0.1			
7B2 MCNTSH APPLES	10/06/87		1.1 ± 0.1			
7B2 CRTLND APPLES	10/06/87		0.8 ± 0.1			
12B1 MCNTSH APPLES	10/06/87		0.9 ± 0.2			
12B1 CRLND APPLES	10/06/87		0.8 ± 0.1			

* Only gamma emitters detected are reported; typical LLD values are found on Table 21.
(1) Results reported in pCi/gram (carbon)

TABLE 19
GAMMA* SPECTROMETRY OF GAME, POULTRY, AND EGGS
SSES 1987
Results in pCi/g (wet) ± 2 s

SAMPLE TYPE	LOCATION	COLLECTION DATE	K-40	Cs-137	Other Activity
DEER	9B	09/25/87	3.12 ± 0.3	0.017 ± 0.004	
DEER	16B	11/30/87	2.5 ± 0.25	0.09 ± 0.009	
DEER	10B	01/04/88	2.45 ± 0.24		
DUCK	10D1	10/06/87	3.39 ± 0.34		
EGG	12B1	10/06/87	1.05 ± 0.1		
SQUIRREL	16S1	10/19/87	3.24 ± 0.32	1.21 ± 0.12	
SQUIRREL	15S4	10/19/87	3.11 ± 0.31	0.77 ± 0.08	
SQUIRREL	1S2	10/23/87	3.35 ± 0.33	0.33 ± 0.03	

* Only gamma emitters detected are reported; typical values found in table 20.

TABLE 20

TYPICAL * LOWER LIMITS OF DETECTION OF NUCLIDES SEARCHED FOR BUT NOT FOUND BY GAMMA SPECTROMETRY

IN THE VICINITY OF SUSQUEHANNA STEAM ELECTRIC STATION, 1987

NUCLIDE	FISH (pCi/g wet)	SEDIMENT (pCi/g dry)	SURFACE WATER (pCi/ℓ)	GROUND WATER (pCi/ℓ)	POTABLE WATER (pCi/ℓ)	RAIN WATER (pCi/ℓ)
Mn-54	0.019	0.072	6.2	5.4	6.1	4.8
Co-58	0.026	0.079	6.4	6.0	6.3	5.2
Fe-59	0.058	0.21	10	10	12	10
Co-60	0.019	0.071	6.2	6.0	6.2	5.3
Zn-65	0.042	0.18	11	12	9	10
Zr-95	0.051	0.18	12	10	12	9
Nb-95	0.036	0.93	7.1	6.8	7.0	5.9
I-131**	0.75	0.11	0.28	20	0.33	23
Cs-134	0.024	0.085	6.4	6.0	7.2	5.2
Cs-137	0.024	0.082	6.3	6.0	6.8	5.3
Ba-140	0.40	0.79	30	31	31	30
La-140	0.15	0.50	9	9	10	10

NUCLIDE	AIR PARTICULATES (10-3 pCi/m3)	MILK (pCi/ℓ)	FRUITS/VEG. (pCi/g wet)	ALGAE (pCi/g dry)	GAME, POULTRY AND EGGS (pCi/g wet)	SOIL (pCi/g dry)
Mn-54	0.42	6.9	0.020	0.30	0.022	0.080
Co-58	0.49	6.9	0.018	0.29	0.031	0.090
Fe-59	0.66	14	0.048	0.71	0.081	0.26
Co-60	0.48	9	0.020	0.40	0.020	0.076
Zn-65	0.96	17	0.050	0.74	0.048	0.16
Zr-95	0.96	16	0.049	0.58	0.072	0.19
Nb-95	0.51	7.7	0.020	0.31	0.040	0.096
I-131**	4.1	0.13	0.028	0.52	0.29	0.51
Cs-134	0.42	8.0	0.021	0.35	0.024	0.091
Cs-137	0.42	7.8	0.021	0.36	0.024	0.093
Ba-140	3.5	32	0.070	0.91	0.86	0.64
La-140	1.6	9	0.038	0.56	0.29	0.28

* Typical refers to mean plus two standard deviations.
** Iodine-131 in surface water, potable water and milk is determined by radiochemical methods. See appendix B-5.

APPENDIX A

US EPA INTERCOMPARISON PROGRAM RESULTS

1. Introduction

The quality assurance program of the Radiological Laboratory of Teledyne Isotopes (TI) is briefly described in this appendix.

Information on each incoming sample is entered in a permanent log book. A sample number is assigned to each sample at the time of receipt. This sample number uniquely identifies each sample.

Laboratory counting instruments are calibrated, using radionuclide standards obtained from the National Bureau of Standards, the EPA, and reliable commercial suppliers, such as Amersham-Searle. Calibration of counting instruments is maintained by regular counting of radioactive reference sources. Background counting rates are measured regularly on all counting instruments. Additional performance checks for the gamma-ray scintillation spectrometer include regular checks and adjustment, when necessary, of energy calibration.

Blank, spiked (known quantities of radioactivity added), and replicate samples are processed periodically to determine analytical precision and accuracy.

2. Laboratory Analyses for Quality Assurance

Quality control samples amounted to about 7.7% of all samples analyzed. Teledyne Isotopes participates in the U.S. Environmental Protection Agency Radioactivity Intercomparison Studies (Cross-check) Program. The TI results of analyses performed on samples and the known values are listed in Table A-1.

TABLE A-1

INTER-LABORATORY COMPARISONS, 1987

TELEDYNE ISOTOPES

Collection Date	Media	Nuclide	EPA-Results(a)	Teledyne Isotopes Results(b)	All Participants Mean ± 2 s.d.
10/22/86	Water (Sample A)	Gross Alpha	40.00 ± 17.32	51.00 ± 6.00	35.76 ± 18.50
10/22/86	Water (Sample B)	Gross Beta	51.00 ± 8.66	48.00 ± 3.00	46.63 ± 12.16
		Sr-89	10.00 ± 8.66	11.33 ± 1.74	9.14 ± 5.16
		Sr-90	4.00 ± 2.60	4.00 ± 0.00	3.84 ± 1.80
		Co-60	24.00 ± 8.66	29.33 ± 12.12	24.45 ± 4.46
		Cs-134	12.00 ± 8.66	12.00 ± 3.00	11.30 ± 3.72
		Cs-137	8.00 ± 8.66	7.67 ± 1.74	8.83 ± 3.78
01/09/87	Water	Sr-89	25.00 ± 8.66	22.66 ± 1.74	23.28 ± 6.34
		Sr-90	25.00 ± 2.60	26.00 ± 0.00	23.33 ± 5.66
01/23/87	Water	Gross Alpha	11.00 ± 8.66	18.33 ± 3.45 (d)	10.15 ± 5.26
		Gross Beta	10.00 ± 8.66	11.66 ± 1.74	11.19 ± 4.60
01/30/87	Food (c)	Sr-90	49.00 ± 17.32	50.00 ± 8.49	43.06 ± 20.34
		I-131	78.00 ± 13.85	74.00 ± 4.23	80.90 ± 12.46
		Cs-137	84.00 ± 8.66	91.00 ± 16.98	87.86 ± 10.08
		K	980.00 ± 84.87	984.00 ±201.30	984.23 ±141.50
02/06/87	Water	Co-60	50.00 ± 8.66	50.33 ± 4.56	50.40 ± 8.04
		Zn-65	91.00 ± 8.66	108.33 ± 7.53 (e)	93.88 ± 16.28
		Ru-106	100.00 ± 8.66	100.33 ± 33.45	95.01 ± 31.02
		Cs-134	59.00 ± 8.66	62.00 ± 16.71	54.77 ± 6.90
		Cs-137	87.00 ± 8.66	92.00 ± 10.80	87.31 ± 10.84
02/13/87	Water	H-3	4209.00 ±729.19	4100.00 ±600.00	4155.66 ±835.40
02/27/87	Water	I-131	9.00 ± 1.55	8.67 ± 1.75	8.58 ± 3.00
03/20/87	Water	Gross Alpha	3.00 ± 8.66	3.33 ± 1.74	3.91 ± 2.68
		Gross Beta	13.00 ± 8.66	14.33 ± 1.74	12.83 ± 4.72
04/03/87	Water	I-131	7.00 ± 1.21	6.67 ± 1.74	7.26 ± 2.16

TABLE A

INTER-LABORATORY COMPARISONS, 1987

TELEDYNE ISOTOPES

Collection Date	Media	Nuclide	EPA-Results(a)	Teledyne Isotopes Results(b)	All Participants Mean ± 2 s.d.
04/10/87	Air Filter	Gross Alpha	14.00 ± 8.66	18.33 ± 3.45	15.49 ± 6.08
		Gross Beta	43.00 ± 8.66	42.00 ± 7.92	45.31 ± 10.04
		Sr-90	17.00 ± 2.60	15.66 ± 1.74	17.52 ± 3.66
		Cs-137	8.00 ± 8.66	8.00 ± 3.00	9.27 ± 4.20
04/17/87	Water	Gross Alpha	30.00 ± 13.86	33.66 ± 3.45	28.38 ± 16.52
		Gross Beta	66.00 ± 8.66	56.00 ± 5.19 (f)	64.51 ± 14.62
		Sr-89	19.00 ± 8.66	16.33 ± 1.74	17.38 ± 8.70
		Sr-90	10.00 ± 2.60	9.33 ± 1.74	9.98 ± 3.12
		Co-60	8.00 ± 8.66	8.00 ± 3.00	9.04 ± 3.90
		Cs-134	20.00 ± 8.66	15.33 ± 4.56	18.19 ± 5.14
		Cs-137	15.00 ± 8.66	12.33 ± 3.45	15.68 ± 4.34
05/08/87	Water	Sr-89	41.00 ± 8.66	40.33 ± 6.93	38.96 ± 14.20
		Sr-90	20.00 ± 2.60	21.33 ± 1.74	19.57 ± 5.72
05/22/87	Water	Gross Alpha	11.00 ± 8.66	9.67 ± 1.74	9.70 ± 6.10
		Gross Beta	7.00 ± 8.66	8.33 ± 1.74	7.89 ± 4.32
06/05/87	Water	Cr-51	41.00 ± 8.66	LT 53.33	39.25 ± 27.60
		Co-60	64.00 ± 8.66	63.00 ± 13.08	64.80 ± 4.25
		Zn-65	10.00 ± 8.66	LT 9.67	10.93 ± 4.64
		Ru-103	75.00 ± 8.66	72.00 ± 35.37	72.58 ± 21.42
		Cs-134	40.00 ± 8.66	34.66 ± 4.56	36.71 ± 6.72
		Cs-137	80.00 ± 8.60	79.00 ± 13.08	79.59 ± 10.38
06/12/87	Water	H-3	2895.00 ±618.34	2800.00 ±300.00	2784.00 ±585.66
06/26/87	Milk	Sr-89	69.00 ± 8.66	63.67 ± 7.53	63.67 ± 28.42
		Sr-90	35.00 ± 2.60	39.66 ± 3.45 (g)	34.29 ± 10.18
		I-131	59.00 ± 10.39	49.33 ± 9.63 (h)	61.98 ± 11.82
		Cs-137	74.00 ± 8.66	77.00 ± 15.60	75.22 ± 11.42
		K	1525.00 ±131.64	1533.00 ±294.45	1576.61 ±225.18
07/24/87	Water	Gross Alpha	5.00 ± 8.66	6.33 ± 1.74	4.71 ± 2.88
		Gross Beta	5.00 ± 8.66	6.33 ± 1.74	6.05 ± 3.58

TABLE A-1

INTER-LABORATORY COMPARISONS, 1987

TELEDYNE ISOTOPES

Collection Date	Media	Nuclide	EPA-Results(a)	Teledyne Isotopes Results(b)	All Participants Mean ± 2 s.d.
07/31/87	Food	Sr-89	20.00 ± 8.66	18.67 ± 3.45	20.36 ± 13.94
		Sr-90	30.00 ± 2.60	31.00 ± 3.00	27.58 ± 7.85
		I-131	80.00 ± 13.86	88.00 ± 31.74	81.11 ± 14.58
		Cs-137	50.00 ± 8.66	57.33 ± 16.53 (i)	52.07 ± 9.30
		K	1680.00 ±145.49	1603.33 ±603.24	1730.28 ±297.36
08/07/87	Water	I-131	48.00 ± 10.39	58.67 ± 1.74 (j)	47.19 ± 9.74
08/28/87	Air Filter	Gross Alpha	10.00 ± 8.66	11.00 ± 3.00	10.47 ± 4.36
		Gross Beta	30.00 ± 8.66	26.00 ± 5.78	30.31 ± 8.64
		Sr-90	10.00 ± 2.60	9.33 ± 1.74	9.55 ± 3.90
		Cs-137	10.00 ± 8.66	9.00 ± 3.00	10.66 ± 3.72
09/18/87	Water	Gross Alpha	4.00 ± 8.66	2.67 ± 1.74	3.85 ± 2.90
		Gross Beta	12.00 ± 8.66	13.00 ± 3.00	12.00 ± 4.46
10/09/87	Water	Cr-51	70.00 ± 8.66	90.67 ± 34.77 (k)	68.82 ± 17.74
		Co-60	15.00 ± 8.66	16.33 ± 1.74	16.39 ± 4.00
		Zn-65	46.01 ± 8.66	50.67 ± 1.74	47.24 ± 9.32
		Ru-106	61.00 ± 8.66	55.67 ± 12.12	60.12 ± 19.36
		Cs-134	25.00 ± 8.66	25.67 ± 1.74	24.44 ± 4.90
		Cs-137	51.00 ± 8.66	54.67 ± 6.24	51.78 ± 5.98
10/16/87	Water	H-3	4492.00 ±778.04	4300.00 ±300.00	4386.34 ±598.32
10/21/87	Water	Gross Alpha	28.00 ± 12.12	40.67 ± 6.24 (l)	27.96 ± 15.04
		Gross Beta	72.00 ± 8.66	72.67 ± 4.59	75.22 ± 18.56
		Sr-89	16.00 ± 8.66	14.67 ± 1.74	15.21 ± 7.26
		Sr-90	10.00 ± 2.60	9.67 ± 1.74	9.85 ± 2.58
		Co-60	16.00 ± 8.66	19.33 ± 7.56	16.57 ± 4.46
		Cs-134	16.00 ± 8.66	14.33 ± 7.56	15.67 ± 5.18
		Cs-137	24.00 ± 8.66	25.00 ± 10.83	24.29 ± 4.40
11/20/87	Water	Gross Alpha	7.00 ± 8.66	L.T. 1.0 (m)	6.34 ± 4.22
		Gross Beta	19.00 ± 8.66	L.T. 1.0 (m)	18.55 ± 7.32
12/04/87	Water	I-131	26.00 ± 10.39	26.33 ± 4.59	26.61 ± 6.28

TABLE A

INTER-LABORATORY COMPARISONS, 1987

TELEDYNE ISOTOPES

Collection Date	Media	Nuclide	EPA-Results(a)	Teledyne Isotopes Results(b)	All Participants Mean ± 2 s.d.

Notes:

(a) EPA Results-Expected laboratory precision (3 sigma). Units are pCi/ℓ for water, and milk except K is in mg/ℓ. Units are total pCi for air particulate filters.

(b) Teledyne Results - Average ± three sigma. Units are pCi/ℓ for water and milk except K is in mg/ℓ. Units are total pCi for air particulate filters.

(c) Units for food analysis are pCi/kg except K which is mg/kg.

(d) No aerosol solution was added to the planchets in the final stages of preparation leading to a more efficient counting geometry. The technicians in the alpha beta laboratory have been instructed to add the aerosol in accordance with Procedure PRO-031-1.

(e) No reason could be ascertained for the high result for Zn-65. Previous results had a normalized deviation from the known of -0.34 (10/10/86) and 0.58 (06/06/86). Therefore this does not appear to be a trend. Further cross-checks will be studied for any problems.

(f) The previous two EPA beta results are 6 percent low, and our in-house beta spikes are low by about the same percentage. The analysts have been re-trained in transferring all sample residue into the planchets.

(g) The reported high result was due to small aliquot available for the Sr-90 analysis. Inadvertently a larger aliquot was used for another analysis leaving 40% of the normal volume for Sr-90. Additionally, the narrow acceptance limits defined by EPA is particularly difficult to meet. For this analysis 63% of the participants were beyond the ± 3 sigma limit.

(h) The low result is attributed to the application of the resin method rather than the hydroxide method to this analysis. The resin method is inefficient at absorbing protien-bound iodine thus leading to low results. The results obtained by GeLi were higher.

(i) The Cs-137 results in EPA foods have typically been biased high. We are in the process of performing our annual calibrations. We are using a new Amersham mixed gamma standard rather than the most recently prepared NBS standard which is now several years old. Based on preliminary results the three Cs-137 values would be 52.1, 50.3, and 50.9, which average 51.1.

(j) Erroneously high electrode reading of stable iodide in sample (possibly because of interfering species such as S--) leading to erroneously low chemical yields. After repeating the electrode reading, the calculated average I-131 is 49.6 pCi/ℓ. Technicians have been made aware to be suspicious of high electrode readings. When unusually high readings occur samples will be diluted and/or oxidized and remeasured.

(k) The data for the Cr-51 results were reviewed. The detector efficiencies appear to be correct. The other five isotopes measured in this sample were within two standard deviations indicating there is no systematic error. Chromium-51 is difficult to measure at this activity level because of the low branching intensity of the gamma ray and being in the high background region of the spectrum since Cr-51 has a low energy ray.

TABLE A-1

INTER-LABORATORY COMPARISONS, 1987

TELEDYNE ISOTOPES

Collection Date	Media	Nuclide	EPA-Results(a)	Teledyne Isotopes Results(b)	All Participants Mean ± 2 s.d.

Notes:

(l) The reason for deviation is due to uneven distribution of residue on planchet. The residue from the original planchets was dissolved, evaporated and remounted The counting results then became accurate (29±3, 30±3, 26±3).

(m) The EPA sample was not analyzed. The technician misinterpreted the dilution instructions sent by the EPA and proceeded to dilute and analyze instead an in-house blank of deionized water. The EPA sample was analyzed and the results were 5.4 ± 1.6, 5.2 ± 1.6 and 6.2 ± 1.7 for gross alpha and 21 ± 2, 21 ± 2 and 20 ± 2 for gross beta. In the future, all dilutions will be performed by the laboratory supervisor or the laboratory manager to ensure accuracy.

APPENDIX B

SUMMARY OF ANALYTICAL METHODS

The following section contains brief descriptions of the analytical laboratory procedures along with explanations of the calculational methods used by Teledyne Isotopes for sample analysis. These are considered proprietary and are published for informational purposes only.

A further discussion on data reporting conventions can be found in Appendix C.

TLD MEASUREMENTS

During the four quarters of 1986, a PP&L dosimetry system was used which consists of a Panasonic UD-710 reader and UD-801 badges. The UD-801 badges have two elements of lithium borate (Cu) and two elements of calcium sulfate (Tm). Only the calcium sulfate (Tm) elements are used for environmental measurements. This phosphor was chosen for its characteristic high light output, minimal thermally induced signal loss (fading) and negligible self-dosing.

In handling, the badges are kept clean, and the element phosphors are not touched. The badges are stored and transported in plastic bags or other containers.

Before going to the field, the dosimeters are read twice (separated by one hour) in which the second reading is used as an inherent (background) reading for each element. After the inherent read, the badges are placed in sealed plastic bags, to aid in preventing moisture contacting the TLDs, labeled with the sampling location and taken immediately out to the field. Upon removal from the field, the TLDs are inspected for any damage and readout immediately. In-transit TLDs are not used because of the short time period between the inherent reading and field placement.

An element correction factor has been calculated for each element, and the reader is calibrated using a cesium-137 source.

DETERMINATION OF GROSS ALPHA AND/OR GROSS BETA ACTIVITY IN WATER SAMPLES, AIR PARTICULATE FILTERS, COMPOSITED AIR PARTICULATE FILTERS OR SEDIMENTS

TELEDYNE ISOTOPES

This described the process used to measure the overall alpha and/or beta radioactivity of water samples, air particulate filters, composited air particulate filters or sediments without identifying the radioactive species present. No chemical separation techniques are involved. One liter of the water sample is evaporated on a hotplate. The evaporated sample is rinsed into a 2-inch diameter stainless steel planchet which is stamped with a concentric ring pattern to distribute residue evenly. Final evaporation to dryness takes place under heat lamps. Residue mass is determined by weighing the planchet before and after mounting the sample. In the case of an air particulate sample, the filter is mounted directly on a 2-inch stainless steel planchet. Composited air filter samples are leached with nitric acid to bring the deposit into solution. The solution is filtered and an aliquot is evaporated and then mounted on a 2-inch stainless steel planchet. Sediment samples are dried and a 1-gram aliquot is mounted directly on a 2-inch stainless steel planchet.

The planchets are then counted for alpha and/or beta activity in a low-background gas flow proportional counter. Calculation of activity includes an empirical self-absorption correction curve which allows for the change in effective counting efficiency caused by the residue mass. Self absorption is not considered in the case of air particulate filters because of the impracticality of accurately weighing the deposit, and because the penetration depth of the deposit into the filter is unknown.

CALCULATION OF THE SAMPLE ACTIVITY

$$\frac{\text{Net pCi on collection date}}{\text{unit volume or wt.}} = \frac{\left[\frac{N}{t} - B\right] \pm 2\sqrt{\frac{\frac{N}{t} + B}{t}}}{2.22(V)(E)}$$

net activity

random uncertainty

where: N = total counts for sample (counts)

t = counting time for sample (min)

B = background rate of counter (cpm)

2.22 = $\frac{\text{dpm}}{\text{pCi}}$

V(w) = volume or weight of sample analyzed

E = efficiency of the counter

Calculation of the L.T. Value

A "less than" (LT) value is reported if no activity is found. If net activity, as calculated above, is less than or is equal to 4.66 times the standard deviation of the background counting rate, then the LT value is reported.

$$\text{Thus LT} = \frac{4.66\sqrt{\frac{B}{t}}}{2.22\,(V)(E)}$$

DETERMINATION OF I-131 IN MILK AND WATER SAMPLES

BY RADIOCHEMISTRY

TELEDYNE ISOTOPES

This described the radiochemical methods for determining I-131 activity in milk and water samples.

Two liters of sample are first equilibrated with stable iodide carrier. A batch treatment with anion exchange resin is used to remove iodide from the sample. The iodide is then stripped from the resin with sodium hypochlorite solution, is reduced with hydroxylamine hydrochloride, and is extracted into carbon tetrachloride as free iodine. It is then back-extracted as iodide into sodium bisulfite solution and is precipitated as palladium iodide. The precipitate is weighed for chemical yield and is mounted on a nylon planchet which is then analyzed on a low level beta counting system. The chemical yield is corrected by measuring a stable iodide content of the milk with a specific ion electrode.

CALCULATION OF THE SAMPLE ACTIVITY

$$\text{Net pCi on collection date} = \frac{\left[\frac{N}{t} - B\right]}{2.22(V)(y)(DF)(E)} \pm \frac{2\sqrt{\frac{\frac{N}{t} + B}{t}}}{2.22(V)(y)(DF)(E)}$$

liter — net activity — Random uncertainty

where:
- N = total counts from sample (counts)
- t = counting time for sample (min)
- B = background rate of counter (cpm)
- 2.22 = $\frac{\text{dpm}}{\text{pCi}}$
- V = volume of sample analyzed (liters)
- y = chemical yield of the mount or sample counted
- DF = decay factor from the collection to the mid count time
- E = efficiency of the counter for the I-131 betas.

Note: Efficiency is determined by counting an I-131 standard.

Calculation of the L.T. Value

If the net activity, $\frac{N}{t} - B$, is equal to or is less than 4.66 times the standard deviation of the background counting rate the activity on the collection date is below the limit of detection and is called "less than" (L.T.).

$$\text{L.T.} = \frac{4.66\sqrt{\frac{B}{t}}}{2.22(V)(y)(DF)(E)}$$

DETERMINATION OF TRITIUM BY GAS COUNTING

TELEDYNE ISOTOPES

A 2 ml aliquot is reduced into hydrogen gas and collected in an activated charcoal trap. The hydrogen is then transferred into a previously evacuated one liter proportional counter. Non tritiated hydrogen and ultra-high purity methane is added and the mixture is counted. Backgrounds and standards are counted in the same gas mixture as the samples.

Calculation of the sample activity:

$$\frac{\text{Net pCi}}{\text{unit vol.}} = \frac{3.234 \times (TU)_N \times V_N}{CPM_N \times V_S} \quad (CPM)_G - BKG \pm 2\sqrt{S_G^2 + S_B^2}$$

where: $(TU)_N$ = the tritium units of the standard

V_N = volume of the standard used to calibrate the efficiency of the detector - in psia

V_S = volume of the sample loaded into the detector - in psia

$(CPM)_N$ = the cpm activity of the standard of volume V_N

$(CPM)_G$ = the gross activity of the sample of volume V_S and the detector background

BKG = the background of the detector in cpm

3.234 = conversion factor changing TU to pCi/l

t = counting time for the sample

s_G = standard deviation of the gross activity of the sample and the detector background, in cpm

s_B = standard deviation of the background, in cpm

Calculation of the L.T. Value

If the net activity, $[(CPM)_G - BKG]$, is equal to or less than 3.3 times the standard deviation of the net counting rate the activity on the collection date is below the limits of detection and is called "less than" (L.T.).

$$\text{thus L.T.} = \frac{3.3 \times 3.234 \times (TU)n \times Vn \times \sqrt{s_G^2 + s_B^2}}{(CPM)_N \times V_s}$$

where: s_G = standard deviation of the gross activity of the sample and the detector background, in cpm

s_B = standard deviation of the background, in cpm

Determination of Tritium in Water by Electrolytic Enrichment and Liquid Scintillation Counting

Teledyne Isotopes

Approximately 55 milliliters of the sample undergoes enrichment by electrolysis. The electrolysis decomposes the water into elemental hydrogen and oxygen. Water molecules containing only protium (hydrogen with a mass number of one) decompose electrolytically at a faster rate than those tritiated water molecules. The nonelectrolyzed water remaining becomes enriched in tritium as a result. Electrolytic enrichment typically produces 3 to 5 millititers of water in which the tritium is concentrated. After the enriched water is distilled for purification purposes, three milliliters is mixed with liquid scintillation material and counted for its activity.

CALCULATION OF THE SAMPLE ACTIVITY FOR TRITIUM

$$\frac{\text{Net pCi}}{\text{unit vol.}} = \frac{\left[\frac{N}{t} - B\right]}{2.22(V)(EF)(E)} \pm \frac{2\sqrt{\frac{N}{t} + B}}{2.22(V)(EF)(E)}$$

net activity

random uncertainty

where: N = total counts from sample (counts)

t = counting time for sample (min)

B = background rate of counter (cpm)

2.22 = $\frac{\text{dpm}}{\text{pCi}}$

EF = enrichment factor

E = efficiency of the counter for tritium

Calculation of the L.T. Value

If the net activity, $\frac{N}{t} - B$, is equal to or less than 4.66 times the standard deviation of the background counting rate, the activity on the collection date is below the limit of detection and is called "less than" (L.T.)

$$L.T. = \frac{4.66\sqrt{\frac{B}{t}}}{(2.22)(V)(EF)(E)\left(\frac{Vc}{Vf}\right)}$$

Where Vc = Volume counted by liquid scintillation

Vf = Final volume at the end of enrichment

DETERMINATION OF GAMMA EMITTING RADIOISOTOPES

TELEDYNE ISOTOPES

Gamma emitting radioisotopes are determined with the use of a lithium-drifted germanium (Ge(Li)) and high purity germanium detectors with high resolution spectrometry in specific media, for example, air particulate filters, charcoal filters, milk, water, vegetation, soil/sediments, biological media, etc. Each sample to be assayed is prepared and counted in standard geometries such as one-liter wrap-around Marinelli containers, 300 ml or 150 ml bottles, or two-inch filter paper source geometries.

Samples are counted on large (55 cc volume) germanium detectors connected to Nuclear Data 6620 data acquisition and computation systems. All resultant spectra are stored on magnetic tape.

The analysis of each sample consists of calculating the specific activities of all detected radionuclides or the detection limits from a standard list of nuclides. The germanium detection systems are calibrated for each standard geometry using certified radionuclide standards traceable to the National Bureau of Standards

CALCULATION OF THE SAMPLE ACTIVITY AND RANDOM UNCERTAINTY

$$\text{Net pCi/vol or mass} = \underbrace{\frac{[N-B]}{2.22\,(V)(E)(GA)(DF)(t)}}_{\text{net activity}} \pm \underbrace{\frac{2\sqrt{N+B}}{2.22\,(V)(E)(GA)(DF)(t)}}_{\text{random uncertainty}}$$

where: N = area, in counts, of a spectral region containing a gamma emission of the nuclide of interest

Note: if the detector exhibits a peak in this region when counting a blank this background (BB) is subtracted from N before using the above equations. BB is the count rate of the blank in the background peak.

B = background counts in the region of interest, calculated by fitting a straight line across the region connecting the two adjacent regions.

t = counting interval of sample, minutes

2.22 = dpm/pCi

V = volume or mass of sample analysed

E = efficiency of counter at the energy region of interest

GA = gamma abundance of the nuclide at the gamma emission energy under consideration

DF = decay factor from sample collection time to midpoint of the counting interval

6A-> CALCULATION OF THE L.T. VALVE

$$\text{L.T. (pCi/vol or mass)} = \frac{4.66\ \sqrt{N}}{2.22\ (V)(E)(GA)(DF)(t)}$$

The width of the spectral band around the emission energy is calculated differently from the case of an identified peak, so that the value of N used in the two equations may differ.

A detection limit or "less than" (LT) value is reported if no activity is found. If no spectral lines are identified at the energies appropriate to a nuclide, the LT value is calculated by the above equation. If spectral lines for man-made radionuclides are identified but the random uncertainty in the first equation is greater than 60% of the net activity, then a LT value is also assigned by the second equation. When the random uncertainty exceeds only 30% for naturally-occurring radionuclides, the LT value is assigned.

The analyst's judgement is exercised in the decision to report an activity or a L.T. The agreement between various spectral lines of the same nuclide, and possible interference from other nuclides, are considered in this decision.

DETERMINATION OF GROSS BETA MINUS K-40 ACTIVITY IN MILK SAMPLES

TELEDYNE ISOTOPES

This procedure describes a radiochemical method for measuring the gross beta activity of milk after removing natural K-40.

One fourth liter of milk sample is curdled by adding trichloroacetic acid (TCA) solution. The curd is removed by vacuum filtration. Radioactive species are co-precipitated with natural calcium as oxalates by addition of oxalic acid and ammonia (leaving potassium in solution). The precipitate is collected by vacuum filtration on a polycarbonate (Millipore) filter, then is ashed in a muffle furnace to remove organic material. The ash is dissolved in hydrochloric acid and solids are removed by filtration. Oxalates are again precipitated and collected on a polycarbonate filter. After drying, the precipitate is removed from the filter and crushed to a powder, the placed in a 2-inch stainless steel counting planchet.

Precipitate mass is determined by weighing the planchet before and after mounting the sample. The planchet is counted for beta activity on an automatic proportional counter. Results are calculated using an empirical self-absorption curve which allows for the change in effective counting efficiency caused by the residue mass.

CALCULATION OF THE SAMPLE ACTIVITY

TELEDYNE ISOTOPES

$$\frac{\text{Net pCi}}{\text{unit volume}} = \frac{\left[\frac{N}{t} - B\right]}{2.22(V)(E)} \pm \frac{2\sqrt{\frac{N}{t} + B}}{2.22\ (V)(E)}$$

net activity — random uncertainty

where: N = total counts from sample (counts)

t = counting time for sample (min)

B = background rate of counter (cpm)

$2.22 = \frac{\text{dpm}}{\text{pCi}}$

V = volume of sample analyzed

E = efficiency of the counter

Establishing and reporting activities that are equal to or less than the detection limit:

If the net activity, $\frac{\left[\frac{N}{t} - B\right]}{2.22(V)(E)}$, is equal to or is less than 4.66 times the standard deviation of the background counting rate, the activity is below the limits of detection and is called "less than" (L.T.).

$$\text{L.T.} = \frac{4.66\sqrt{\frac{B}{t}}}{2.22\ (V)(E)}$$

APPENDIX C

DATA REPORTING CONVENTIONS

The results from Teledyne Isotope's analyses are generally reported to two significant figures. Random uncertainties of counting are reported to the same decimal place as the result. If the uncertainty has no digit before the third figure in the result, the uncertainty is rounded up to the second significant figure. If the uncertainty is less than 10% of the result, an uncertainty of 10% of the result is reported. Detection limits are rounded to one significant figure.

In the tables presenting analytical measurements, a calculated value is reported with the random uncertainty of counting at 2 standard deviations (2s) calculated by considering both the sample and background count rates. The uncertainty of an activity is influenced by the volume or mass of the sample, the background count rate, the count times, the method used to round off the value obtained to reflect its degree of significance,and other factors. The uncertainties of activities determined by gamma spectrometric analyses are also influenced by the relative concentrations of the radionuclides in the sample, the energies and intensities of the gammas emitted by those radionuclides, and the assumptions used in selecting the radionuclides to be quantitatively determined.

Results reported as less than (LT) are below the lower limit of detection (LLD). The LLD is defined as the smallest concentration of a specific radioactive material in a sample that will yield a net count (above system background) with a 95 percent probability of detection and with only a 5 percent probability of falsely concluding that a fluctation in background represents sample activity.