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April 28, 2000
REG 00-032
BYR 2000-041

United States Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555

References: (a) License No. DPR-3 (Docket No. 50-29)

Subject: 1999 ANNUAL RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT

Enclosed is the 1999 Annual Radiological Environmental Operating Report. This report summarizes the findings of the Radiological Environmental Monitoring Program (REMP) conducted by Yankee Atomic Electric Company (YAEC) in the vicinity of the Yankee Nuclear Power Station (YNPS) in Rowe, Massachusetts. This information is submitted in accordance with YNPS Defueled Technical Specification 6.8.2.a.

We trust this information is satisfactory; however, if you have any questions, please contact us.

Very truly yours,

YANKEE ATOMIC ELECTRIC COMPANY

Merrill J. Atkins,
Regulatory Affairs Manager

Enclosure

c: P. Ray, USNRC, Project Manager
R. B. Bellamy, USNRC, Region I

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YANKEE NUCLEAR POWER STATION

ANNUAL RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT

January - December 1999

April 2000

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1. INTRODUCTION

This report summarizes the findings of the Radiological Environmental Monitoring Program (REMP) conducted by Yankee Atomic Electric Company in the vicinity of the Yankee Nuclear Power Station (YNPS) in Rowe, Massachusetts during the calendar year 1999. It is submitted annually in compliance with plant Technical Specification 6.8.2.a. and is organized as follows.

Section 2: Provides an introductory explanation to the background radioactivity and radiation that is detected in the YNPS environs.

Section 3: Provides a brief description of the YNPS site and its environs.

Section 4: Provides a description of the overall REMP program design. Included is a summary of the Offsite Dose Calculation Manual (ODCM) Requirements for REMP sampling, tables listing all locations sampled or monitored in 1999, with compass sectors and distances from the plant, and maps showing each REMP location. Tables listing Lower Limit of Detection requirements and Reporting Levels are also included.

Section 5: Consists of the summarized data as required by the ODCM. The tables are in the format specified by the NRC Branch Technical Position on Environmental Monitoring (Reference 1). Also included is a summary of environmental TLD measurements for 1999.

Section 6: Provides the results of the 1999 monitoring program. The performance of the program in meeting regulatory requirements as given in the Technical Specifications and ODCM is discussed, and the data acquired during the year are analyzed.

Section 7: Provides an overview of the Quality Assurance programs used at the Duke Engineering and Services Environmental Laboratory (DESEL). As required by the ODCM, the results of the Intercomparison Programs are given.

Section 8: Summarizes the requirements and the results of the 1999 Land Use Census.

Section 9: Gives an overall summary of the results of the 1999 Radiological Environmental Monitoring Program.

2. NATURALLY OCCURRING AND MAN-MADE BACKGROUND RADIOACTIVITY

Radiation or radioactivity potentially detected in the YNPS environment can be grouped into three categories. The first is "naturally-occurring" radiation and radioactivity. The second is "man-made" radioactivity from sources other than YNPS. The third potential source of radioactivity is due to emissions from YNPS. For the purposes of the YNPS REMP, the first two categories are classified as "background" radiation, and are the subject of discussion in this section of the report. The third category, radioactivity from plant emissions, is the one that the REMP is primarily designed to detect and evaluate.

2.1 Naturally Occurring Background Radioactivity

Natural radiation and radioactivity in the environment, which provide the major source of human radiation exposure, may be subdivided into three separate sub-categories: "primordial radioactivity," "cosmogenic radioactivity," and "cosmic radiation." "Primordial radioactivity" is made up of those radionuclides that were created with the universe and that have a sufficiently long half-life to be still present on the earth. Included in this category are the radionuclides that these elements have decayed into. A few of the more important radionuclides in this category are Uranium-238 (U-238), Thorium-232 (Th-232), Potassium-40 (K-40), Radium-226 (Ra-226), and Radon-222 (Rn-222). Uranium-238 and Thorium-232 are readily detected in soil and rock, whether through direct field measurements or through laboratory analysis of samples. Radium-226 in the earth can find its way from the soil into ground water, and is often detectable there. Radon-222 is one of the components of natural background in the air we breath, and its daughter products are detectable on air sampling filters. Potassium-40 comprises about 0.01 percent of all natural potassium in the earth, and is consequently detectable in most biological substances, including the human body. There are many more primordial radionuclides found in the environment in addition to the major ones discussed above (Reference 2).

The second sub-category of naturally-occurring radiation and radioactivity is "cosmogenic radioactivity." This is produced through the nuclear interaction of high energy cosmic radiation with elements in the earth's atmosphere, and to a much lesser degree in the earth's crust. These radioactive elements are then incorporated into the entire geosphere and atmosphere, including the earth's soil, surface rock, biosphere, sediments, ocean floors, polar ice and atmosphere. The major radionuclides in this category are Carbon-14 (C-14), Hydrogen-3 (H-3 or Tritium), Sodium-22 (Na-22), and Beryllium-7 (Be-7). Beryllium-7 is the one most readily detected, and is found on air sampling filters and occasionally in biological media (Reference 2).

The third sub-category of naturally-occurring radiation and radioactivity is "cosmic radiation." This consists of high energy atomic and sub-atomic particles of extra-terrestrial origin and the secondary particles and radiation that are produced through their interaction in the earth's atmosphere. The primary radiation comes mostly from outside of our solar system, and to a lesser degree from the sun. We are protected from most of this radiation by the earth's atmosphere, which absorbs the radiation. Consequently, one can see that with increasing elevation one would be exposed to more cosmic radiation as a direct result of a thinner layer of air for protection. This "direct radiation" is best detected in the field with high pressure ion chambers.

2.2 Man-Made Background Radioactivity

The second source of "background" radioactivity in the YNPS environment is from "man-made" sources not related to the power plant. The most recent contributor to this category was the fallout from the Chernobyl accident in April of 1986, which was detected in the YNPS environment and other parts of the world. A much greater contributor to this category, however, has been fallout from atmospheric nuclear weapons tests. Tests were conducted from 1945 through 1980 by the United States, the Soviet Union, the United Kingdom, China and France, with the large majority of testing occurring during the periods 1954-1958 and 1961-1962. A test ban treaty was signed in 1963 by the United States, Soviet Union and United Kingdom, but not by France and China. Atmospheric testing was conducted by the People's Republic of China last in October 1980. Much of the fallout detected today is due to this explosion and the last large scale test, done in November of 1976 (Reference 3).

The radioactivity produced by these detonations was deposited worldwide. The amount of fallout deposited in any given area is dependent on many factors, such as the explosive yield of the device, the latitude and altitude of the detonation, the season in which it occurred, and the timing of subsequent rainfall which washes fallout from the troposphere (Reference 4). Most of this fallout has decayed into stable elements, but the residual radioactivity is still readily detectable in environmental samples worldwide. The two predominant radionuclides are Cesium-137 (Cs-137) and Strontium-90 (Sr-90). They are found in soil and in vegetation, and since cows and goats graze large areas of vegetation, these radionuclides are also readily detected in milk.

Other potential "man-made" sources of environmental "background" radioactivity include other nuclear power plants, coal-fired power plants, national defense installations, hospitals, research laboratories and industry. These collectively are insignificant on a global scale when compared to the sources discussed above (natural and fallout).

3.0 GENERAL PLANT AND SITE INFORMATION

The Yankee Nuclear Power Station (YNPS) is located on a 2200 acre site in a predominantly rural area of northwestern Massachusetts, three-quarters of a mile south of the Vermont border. The plant resides in the town of Rowe, Massachusetts, approximately 9 miles east-northeast of North Adams, Massachusetts. The surrounding area is heavily forested and lightly populated. Hills bounding the river valley rise 500 to 1000 feet above the site, reaching elevations of 2100 feet.

The Deerfield River is used extensively for hydroelectric power generation both upstream and downstream of YNPS. Sherman Dam, immediately adjacent to YNPS, operates as a hydroelectric generating station. Sherman Pond, the impoundment behind this dam, had been used as a source of cooling water for YNPS.

YNPS was voluntarily shut down on October 1, 1991 and ceased power operation on February 26, 1992 after 32 years of operation. The plant is in the process of decommissioning which involves the disassembly and removal of the plant components and structures. This process is taking place in strict conformance with USNRC regulations. Oversight will also continue from the U.S. Environmental Protection Agency, the Massachusetts Department of Environmental Protection, Massachusetts Department of Public Health, and Massachusetts Emergency Management Administration.

The radiological environmental monitoring program for YNPS continued during 1999 at the reduced scale set forth by an ODCM change made to reflect the change in the physical configurations at the plant and the removal of radionuclide source terms and production. The radiological environmental monitoring program will continue throughout the decommissioning period.

4. PROGRAM DESIGN

The Radiological Environmental Monitoring Program for the YNPS was designed with specific objectives in mind. These were:

- To provide an early indication of the appearance or accumulation of any radioactive material in the environment caused by YNPS activities.

- To provide assurance to regulatory agencies and the public that the environmental impact from YNPS is known and within anticipated limits.

- To verify the adequacy and proper functioning of station effluent controls and monitoring systems.

- To provide standby monitoring capability for rapid assessment of risk to the general public in the event of unanticipated or accidental releases of radioactive material.

These objectives will continue to be in force, to varying degrees, throughout decommissioning activities at the YNPS site. Due to the shutdown status of the plant, and due to the relatively low quantities of radioactive material now on the site, some of the objectives have a different degree of importance than in the past.

The radiological environmental monitoring program was initiated in 1958, approximately two years before the plant began operation in 1960. It has been in operation continuously since that time, with improvements made periodically over those years. The program continued without modification following the shutdown of the plant in 1991 and was reduced in scope beginning in 1997 primarily to reflect the absence of short lived radionuclides in various pathways resulting from the plant shutdown (no source of production) and the individual radionuclides short half-life (long decay time since the shutdown).

The program was designed to meet the intent of NRC Regulatory Guide 4.1, *Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants*; NRC Regulatory Guide 4.8, *Environmental Technical Specifications for Nuclear Power Plants*; the NRC Branch Technical Position of November 1979 entitled, *An Acceptable Radiological Environmental Monitoring Program*; and NRC NUREG-0472, *Radiological Effluent Technical Specifications for PWR's*.

The environmental TLD program was designed and tested around NRC Regulatory Guide 4.13, *Performance, Testing and Procedural Specifications for Thermoluminescence Dosimetry: Environmental Applications.* The quality assurance program was designed around the guidance given in NRC Regulatory Guide 4.15, *Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment.*

Prior to August 1992, the requirements for the Radiological Environmental Monitoring Program (REMP) were given in the YNPS Technical Specifications. In August 1992, the REMP requirements were removed from the Technical Specifications and placed in the Offsite Dose Calculation Manual (ODCM) (Reference 5) pursuant to NRC Generic Letter 89-01 (Reference 6). ODCM controls are cited in this report when specific REMP requirements are discussed.

The sampling requirements of the REMP are given in Table 4.1 of the ODCM and in Table 4.1 of this report. The identification of the required sampling locations is given in Table 4.4 of the ODCM and in Tables 4.2 and 4.3 of this report. The sampling and monitoring locations are shown graphically on the maps in Figures 4.1 through 4.7.

4.1 Monitoring Zones

The REMP is designed to allow comparison of levels of radioactivity in samples from the area possibly influenced by the plant to levels found in areas not influenced by the plant. The first area is called Zone 1, and its monitoring locations are called "indicators." The second area is called Zone 2, and its monitoring locations are called "controls." The distinction between the two zones, depending on the type of sample or sample pathway, is based on one or more of several factors, such as site meteorological history, meteorological dispersion calculations, relative direction from the plant, river flow, and distance. Analysis of survey data from the two zones aids in determining if there is a significant difference between the two areas. It can also help in differentiating between radioactivity or radiation due to plant activities and that due to other fluctuations in the environment, such as atmospheric nuclear weapons test fallout or seasonal variations in the natural background.

4.2 Pathways Monitored

Four pathway categories are monitored by the REMP. They are the direct radiation, airborne, waterborne, and ingestion pathways. Each of these four categories is monitored by the collection of one or more sample media, which are listed below, and are described in more detail in this section:

Airborne Pathway
- Air Particulate Sampling

Waterborne Pathways
- River Water Sampling
- Ground Water Sampling
- Storm Drain Water Sampling
- Sediment Sampling

Ingestion Pathways
- Milk Sampling
- Fish Sampling
- Food Product and Maple Syrup Sampling

Direct Radiation Pathway
- TLD Monitoring

4.3 Descriptions of Monitoring Programs

4.3.1 Air Sampling

Continuous air samplers are installed at six locations, five of which are required by the YNPS ODCM. The sampling pumps at these locations operate continuously at a flow rate of approximately one cubic foot per minute. Airborne particulates are collected by passing air through a 47 mm glass-fiber filter. A dry gas meter is incorporated into the sampling stream to measure the total volume of air sampled in a given interval. The entire system is housed in a weatherproof structure. The filters are collected biweekly, and to allow for the decay of radon daughter products, they are held for at least 100 hours at the DESEL before being analyzed for gross-beta radioactivity (indicated as GR-B in the data tables). The biweekly filters are composited by location at the DESEL for a quarterly gamma spectroscopy analysis.

4.3.2 River Water Sampling

An automatic compositing sampler is located at one downstream sampling location. The sampler is controlled by timers that collect an aliquot of river water at least every two hours over a period of one month. Grab samples are collected monthly at Sherman Pond and at one upstream location. All river water samples are preserved with HCl and $NaHSO_3$, or HNO_3, to prevent the plate out of potentially-present radionuclides on the container walls. Each sample is analyzed for gross-beta and gamma-emitting radionuclides. The monthly samples are composited quarterly by location at the DESEL for an H-3 analysis.

4.3.3 Ground Water Sampling

Grab samples are collected monthly from two on-site locations. The ODCM requires samples to be collected at least once per quarter. All ground water samples are preserved with HCl and $NaHSO_3$ or HNO_3 to prevent the plate out of potentially-present radionuclides on the container walls. Each sample is required by the ODCM to be analyzed for gamma-emitting radionuclides and H-3. Samples are also analyzed for gross beta activity which is not an ODCM requirement.

4.3.4 Storm Drain Water Sampling

Grab samples are collected monthly from the West Storm Drain. This is not an ODCM required sampling location. This water is comprised of non-radioactive secondary side plant effluents, as well as groundwater and precipitation (including snow melt) draining from the west side of the plant facility. All storm drain water samples are preserved with HCl and $NaHSO_3$, or HNO_3, to prevent the plate out of potentially-present radionuclides on the container walls. Each sample is analyzed for gross-beta and gamma-emitting radionuclides and H-3.

4.3.5 Sediment Sampling

Shoreline sediment cores are collected semiannually from two locations, one upstream and one downstream of the plant. At each location, six two-inch inner diameter plastic coring tubes are driven into the sediment at least six inches deep. The cores are carefully extracted and kept in an upright position and frozen prior to delivery to the DESEL. At the DESEL, the frozen cores are cut into 5 cm (two-inch) segments. For each location, the 0-5 cm segments are blended into a single sample, as are the 5-10 cm and 10-15 cm segments. These composite samples are then analyzed for gamma-emitting radionuclides.

An additional bottom sediment core is collected semiannually in Sherman Pond near the

plant discharge. A Wildco K. B. Core Sampler is dropped from a boat. Six cores are collected here, and are processed and analyzed as described above.

4.3.6 Milk Sampling

Milk samples are supposed to be collected monthly from one indicator and one control location. However, the most recent Land Use Census finds no location within five miles from which milk samples can be collected. If a future Land Use Census identifies an available sampling location within five miles, it will be included. Immediately after collection, each milk sample is preserved with an appropriate amount of formaldehyde or is shipped to the laboratory in a cooler packed with ice. Each sample is analyzed for gamma-emitting radionuclides. Although not required by the ODCM, Sr-89 and Sr-90 analyses are also performed on quarterly composited samples.

4.3.7 Fish Sampling

Fish samples are collected semiannually at two locations (upstream of the plant and in Sherman Pond). A gill net is set overnight from a boat, and mixed species of fish are removed the following day. The species typically collected are yellow perch, smelt, pickerel, trout, bullheads or suckers. The fish samples are frozen and delivered to the DESEL where the edible portions are analyzed for gamma-emitting radionuclides.

4.3.8 Food Product Sampling

Food products are collected annually (at harvest) at three locations. The samples are either tuberous vegetables, above-ground vegetables, or fruit. Two indicator locations are chosen as a result of the annual Land Use Census, based on meteorological dispersion calculations. The third location is a control, which is located sufficiently far away from the plant to be outside any potential influence from it. The edible portions of the samples are then analyzed at the DESEL for gamma-emitting radionuclides.

4.3.9 Maple Syrup Sampling

Maple syrup is an important commercial product in northern New England, including the YNPS plant environs. Consequently, samples are collected annually from two or three locations although there is no ODCM requirement. These samples are collected from the syrup manufacturer as a finished product, that is, following the boiling down of the maple sap. Since the samples have already been boiled down as part of the syrup production process, no preservatives are needed in the samples. Following collection, the samples are analyzed at the

DESEL for gamma-emitting radionuclides. It should be noted that because of the boiling down and filtering of the sap, the resulting radionuclide measurements do not represent actual environmental concentrations. It is estimated that the resulting syrup has been concentrated by a factor of from 15 to 120 times the original sap, depending mostly on the time of the season and sugar content of the sap collected.

4.3.10 TLD Monitoring

Direct gamma radiation exposure was continuously monitored with the use of thermoluminescent dosimeters (TLDs). Specifically, Panasonic UD-801AS1 and UD-814AS1 calcium sulfate dosimeters were used, with a total of five elements in place at each monitoring location. Each pair of dosimeters is sealed in a plastic bag, which is in turn housed in a plastic-screened container. This container is attached to an object such as a tree, fence or utility pole. TLDs are posted at 33 locations, with 24 of these stations required by the ODCM. All the TLD's are read out quarterly. The plant staff posts and retrieves all TLDs, while the DESEL processes them.

TABLE 4.1

Radiological Environmental Monitoring Program
(as required by ODCM Table 4.1)

Exposure Pathway and/or Sample Media	Collection			Analysis	
	Number of Sample Locations	Routine Sampling Mode	Collection Frequency	Analysis Type	Analysis Frequency
1. Direct Radiation (TLDs)	24	Continuous	Quarterly	Gamma Dose	Each TLD
2. Airborne: Particulates	5	Continuous	Once per two weeks	Gross Beta Gamma Isotopic	Each Sample Quarterly Composite by Location
3. Waterborne					
a. Surface Water	2	Composite at two hour intervals-Downstream	Monthly	Gross Beta Gamma Isotopic Tritium (H-3)	Each Sample Each Sample Quarterly Composite
		Grab -Upstream	Monthly		
b. Ground Water	2	Grab	Quarterly	Gamma Isotopic Tritium (H-3)	Each Sample Each Sample
c. Shoreline Sediment	1	Grab	Semiannually	Gamma Isotopic	Each Sample

TABLE 4.1
(continued)

Radiological Environmental Monitoring Program
(as required by ODCM Table 4.1)

Exposure Pathway and/or Sample Media	Collection			Analysis	
	Nominal Number of Sample Locations	Routine Sampling Mode	Nominal Collection Frequency	Analysis Type	Analysis Frequency
4. Ingestion					
a. Milk*	2	Grab	Monthly	Gamma Isotopic	Each sample
b. Fish	2	Grab	Semiannually (or seasonal if appropriate)	Gamma Isotopic on edible portions	Each sample
c. Food Products					
Tuberous or above-ground vegetables, or fruit	3	Grab	At harvest	Gamma Isotopic on edible portion	Each sample

* A total of two locations are included (one indicator location and one control). However, the most recent Land Use Census finds no locations within five miles from which milk samples can be collected. If a future Land Use Census indentifies an available sampling location within five miles, it will be included in the REMP.

TABLE 4.2

Radiological Environmental Monitoring Locations (non-TLD) in 1999
Yankee Nuclear Power Station

Exposure pathway	Station Code	Station Description	Zone*	Distance From Plant (km)	Direction From Plant
1. Airborne					
	AP-11	Observation Stand	1	0.5	NW
	AP-12	Monroe Bridge	1	1.1	SW
	AP-13	Rowe School	1	4.2	SE
	AP-14	Harriman Station	1	3.2	N
	AP-21	Williamstown, MA	2	22.2	W
	AP-31	YAEC Visitor's Center	1	0.8	SW
2. Waterborne					
a. Surface	WR-11	Bear Swamp Lower Reservoir	1	6.3	Down-river
	WR-21	Harriman Reservoir	2	10.1	Up-river
	WR-31	Sherman Pond	1	0.1	N
b. Ground	WG-11	Plant Potable	1	On-site	--
	WG-12	Sherman Spring	1	0.2	NW
c. Storm Drain	WW-52	West Storm Drain	1	On-site	--
d. Sediment	SE-11	No. 4 Station	1	36.2	Down-river
	SE-21	Harriman Reservoir	2	10.1	Up-river
	SE-91	Sherman Pond	1	0.1	N
3. Ingestion					
a. Milk	*				
	TM-21	Williamstown, MA	2	21	WSW
b. Fish	FH-11	Sherman Pond	1	1.5	Near Dischg.
	FH-21	Harriman Reservoir	2	10.1	Up-river

* A total of two locations are included (one indicator location and one control). However, the most recent Land Use Census finds no locations within five miles from which milk samples can be collected. If a future Land Use Census indentifies an available sampling location within five miles, it will be included in the REMP.

TABLE 4.2
(continued)

Radiological Environmental Monitoring Locations (non-TLD) in 1999
Yankee Nuclear Power Station

Exposure pathway	Station Code	Station Description	Zone*	Distance From Plant (km)	Direction From Plant
3. Ingestion, (continued)					
c. Food Products	TF-11	Monroe Bridge, MA	1	1.3 (2.0)+	SW (WSW)+
	TF-13	Monroe, MA	1	1.9	WNW
	TF-21	Williamstown, MA	2	21.0	WSW
	MS-33	Rowe, MA (Maple syrup)	1	1.0	S
	MS-45	Florida, MA (Maple syrup)	2	10.5	WSW

* 1 = Indicator Stations; 2 = Control Stations
\+ First distance/sector as listed in ODCM Table 4.4, second as corrected in 1999 Land Use Census

TABLE 4.3

Radiological Environmental Monitoring Locations (TLD) in 1999
Yankee Nuclear Power Station

Station Code	Station Description	Zone*	Distance From Plant (km)	Direction From Plant
GM-1	YAEC Visitors' Center	1	0.8	SW
GM-2	Observation Stand	1	0.5	NW
GM-3	Rowe School	1	4.2	SE
GM-4	Harriman Station	1	3.2	N
GM-5	Monroe Bridge	1	1.1	SW
GM-6	Readsboro Road Barrier	1	1.3	N
GM-7	Whitingham Line	1	3.5	NE
GM-8	Monroe Hill Barrier	1	1.8	S
GM-9	Dunbar Brook	1	3.2	SW
GM-10	Cross Road	1	3.5	E
GM-11	Adams High Line	1	2.1	WNW
GM-12	Readsboro, VT	1	5.5	NNW
GM-13	Restricted Area Fence	F	0.08	WSW
GM-14	Restricted Area Fence	F	0.11	WNW
GM-15	Restricted Area Fence	F	0.08	NNW
GM-16	Restricted Area Fence	F	0.13	NNE
GM-17	Restricted Area Fence	F	0.14	ENE
GM-18	Restricted Area Fence	F	0.14	ESE
GM-19	Restricted Area Fence	F	0.16	SE
GM-20	Restricted Area Fence	F	0.16	SSE
GM-21	Restricted Area Fence	F	0.11	SSW
GM-22	Heartwellville, VT	2	12.6	NNW
GM-23	Williamstown Substation	2	22.2	W
GM-25	Whitingham, VT	O	7.7	NNE
GM-27	Number 9 Road	O	7.6	ENE
GM-29	Route 8A	O	8.2	ESE

TABLE 4.3
(continued)

Radiological Environmental Monitoring Locations (TLD) in 1999
Yankee Nuclear Power Station

Station Code	Station Description	Zone*	Distance From Plant (km)	Direction From Plant
GM-31	Legate Hill Road	O	7.6	SSE
GM-32	Rowe Road	O	7.9	S
GM-33	Zoar Road	O	6.9	SSW
GM-35	Whitcomb Summit	O	8.6	WSW
GM-36	Tilda Road	O	6.6	W
GM-38	West Hill Road	O	6.6	NW
GM-40	Readsboro Road	1	0.5	W

* 1 = Indicator TLD; 2 = Control TLD; O = Outer Ring TLD;
F = Fenceline TLD.

TABLE 4.4

Environmental Lower Limit of Detection (LLD) Sensitivity Requirements

Analysis	Water (pCi/l)	Airborne Particulates or Gases (pCi/m3)	Fish (pCi/kg)	Milk (pCi/l)	Food Product (pCi/kg)	Sediment (pCi/kg -dry)
Gross-Beta	4	0.01				
H-3	2000					
Mn-54	15		130			
Co-58,60	15		130			
Zn-65	30		260			
Zr-Nb-95	15					
Cs-134	15	0.05	130	15	60	150
Cs-137	18	0.06	150	18	80	180

Additional explanatory footnotes are given in ODCM Table 4.3.

TABLE 4.5

Reporting Levels for Radioactivity Concentrations In Environmental Samples

Analysis	Water (pCi/l)*	Airborne Particulates or Gases (pCi/m3)	Fish (pCi/kg)	Milk (pCi/l)	Food Product (pCi/kg)
H-3	30000				
Mn-54	1000		30000		
Co-58	1000		30000		
Co-60	300		10000		
Zn-65	300		20000		
Zr-Nb-95	400				
Cs-134	30	10	1000	60	1000
Cs-137	50	20	2000	70	2000

* Reporting Level for non-drinking water pathways.

Figure 4.1 Radiological Environmental Sampling Locations Within 1 Mile of YNPS

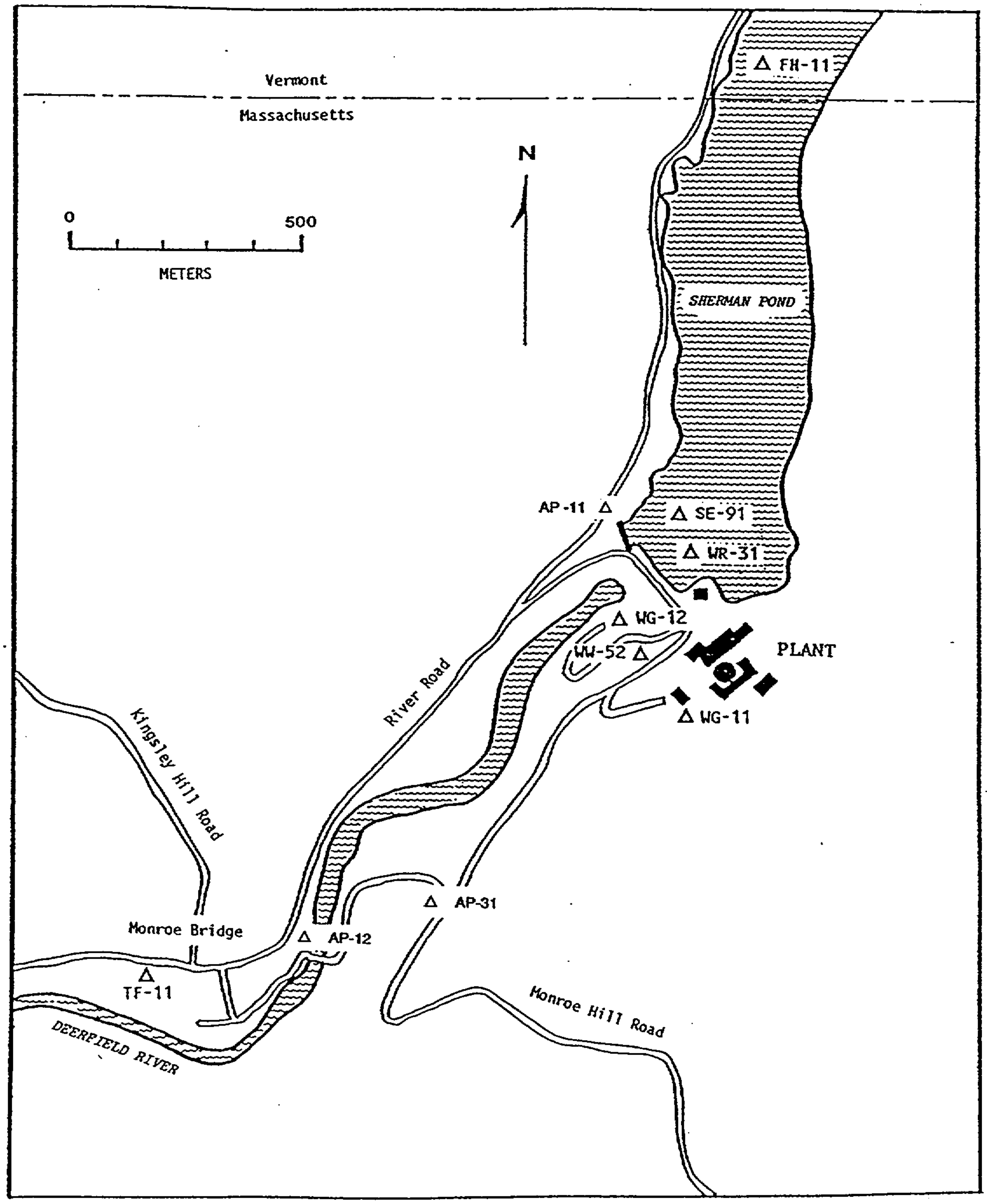


Figure 4.2 Radiological Environmental Sampling Locations Within 12 Miles of YNPS

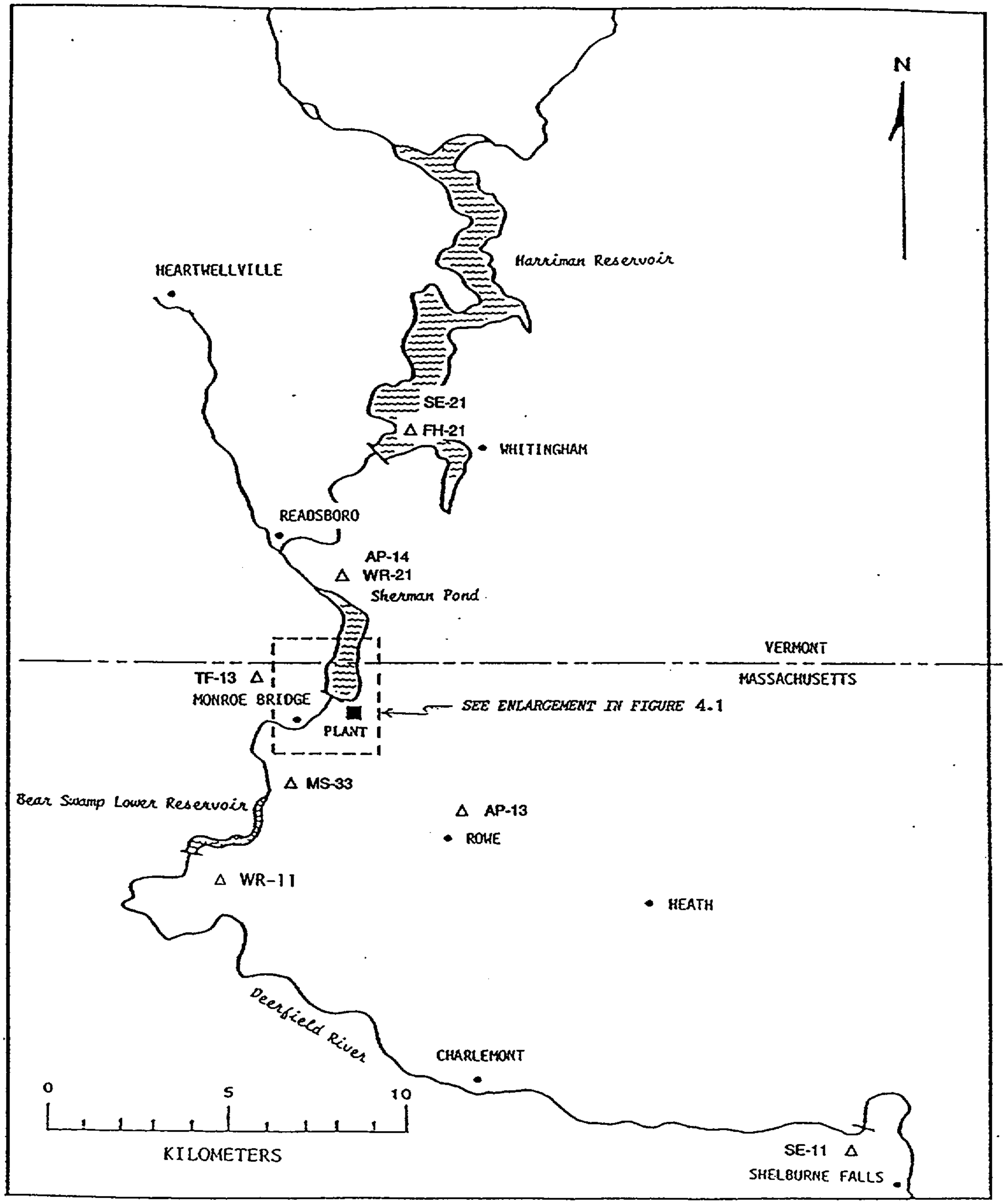


Figure 4.3 Radiological Environmental Sampling Locations Outside 12 Miles of YNPS

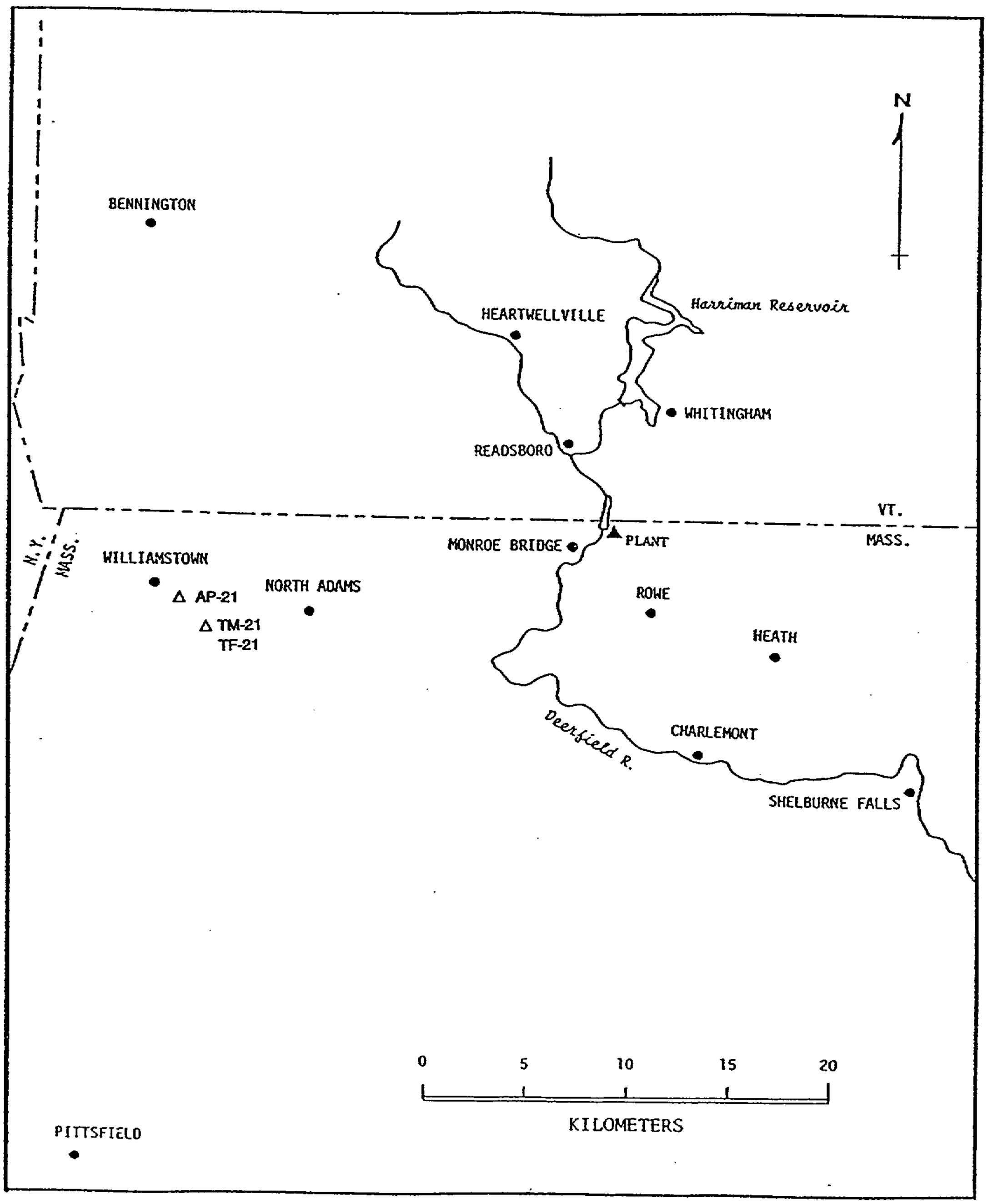


Figure 4.4 Environmental TLD Monitoring Locations at the YNPS Restricted Area Fence

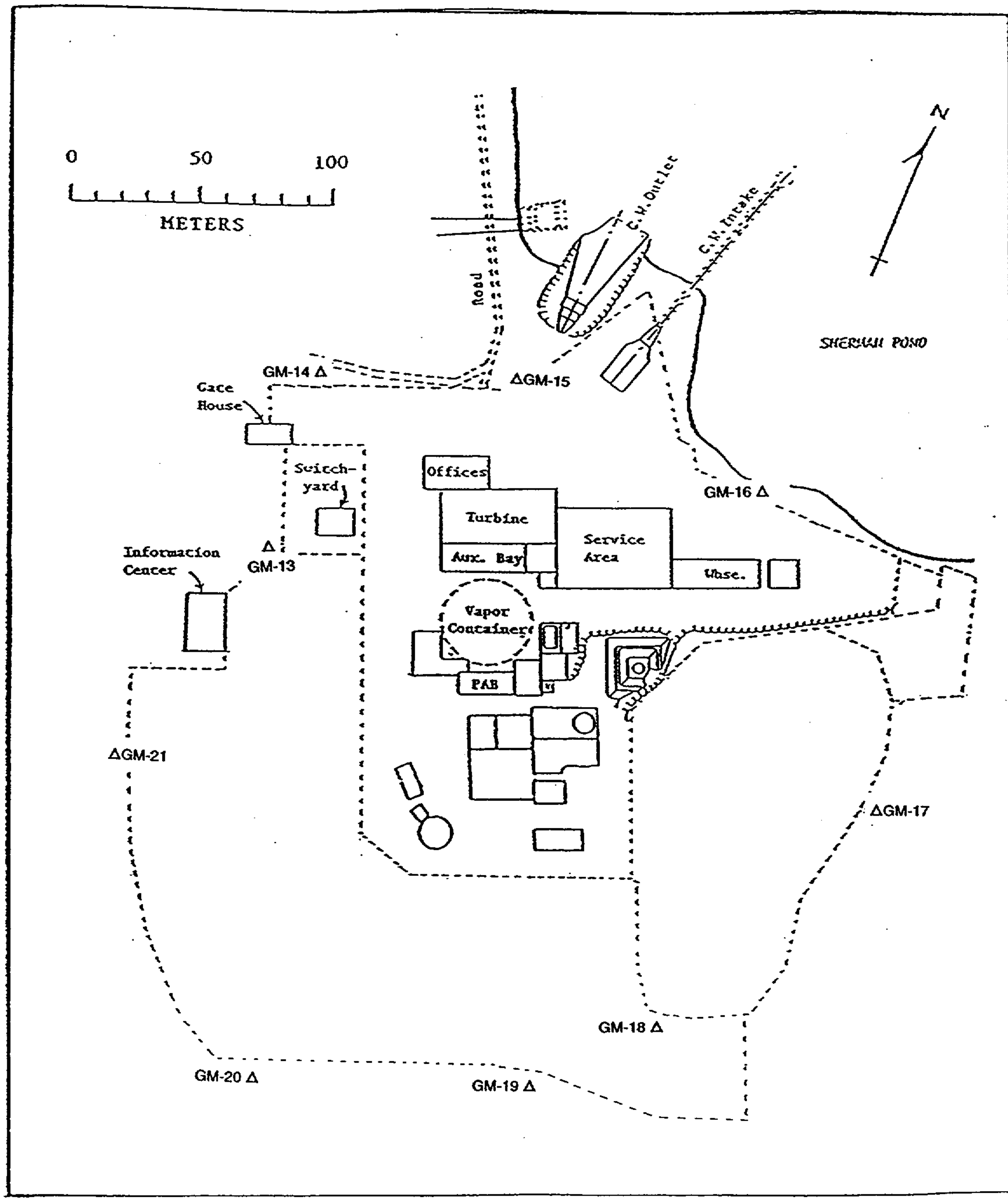


Figure 4.5 Environmental TLD Monitoring Locations Within 1 Mile of YNPS

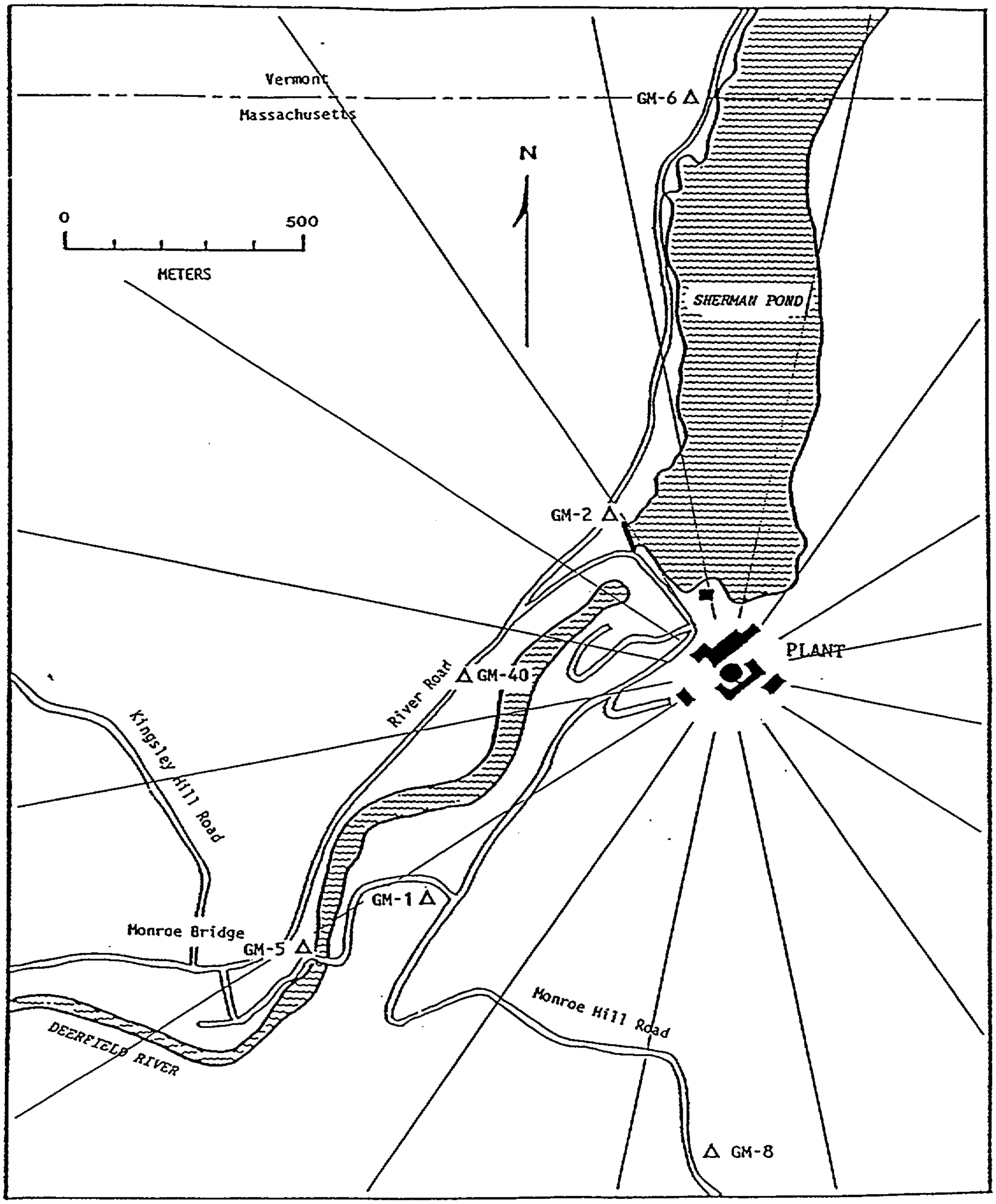


Figure 4.6 Environmental TLD Monitoring Locations Within 12 Miles of YNPS

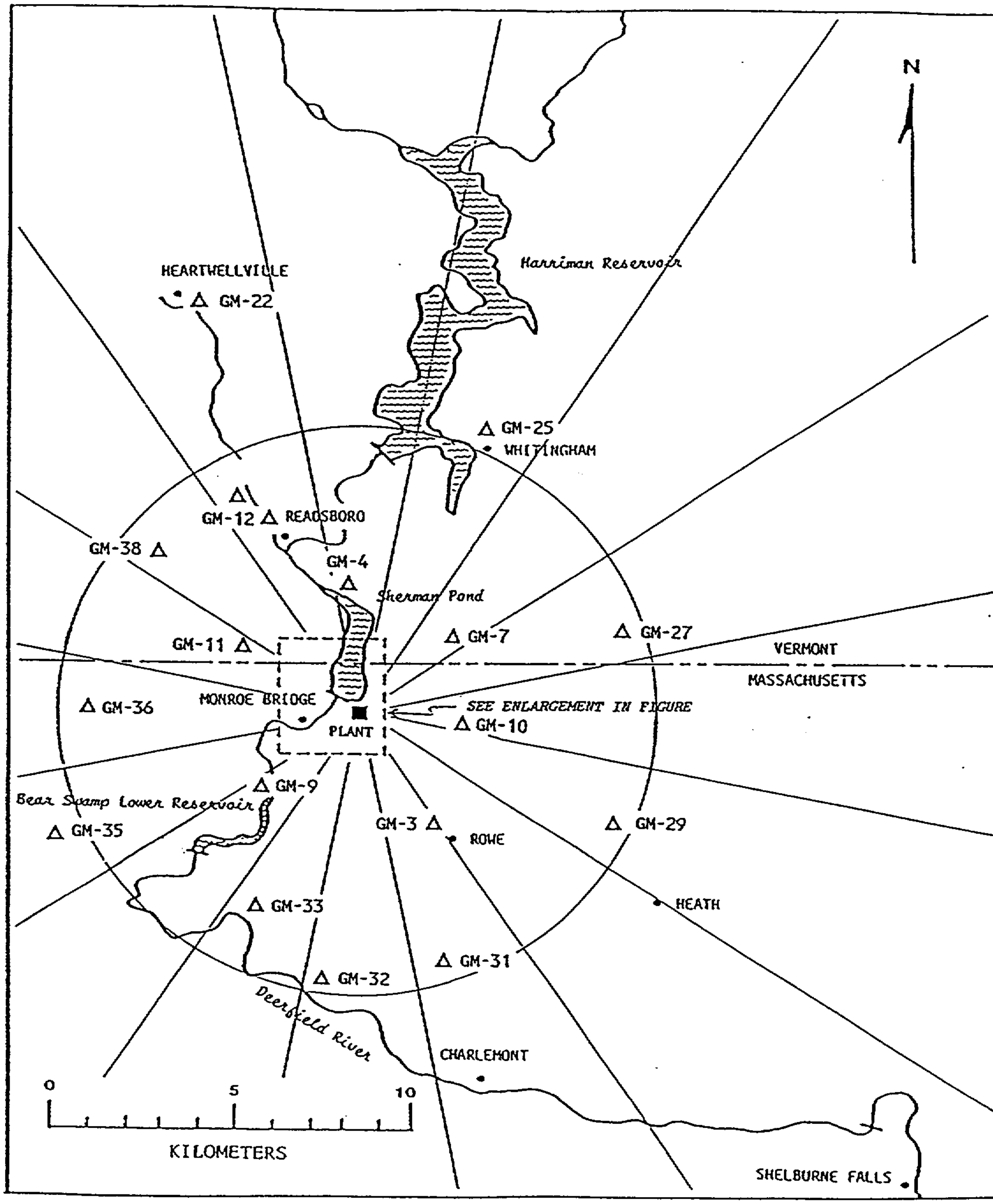
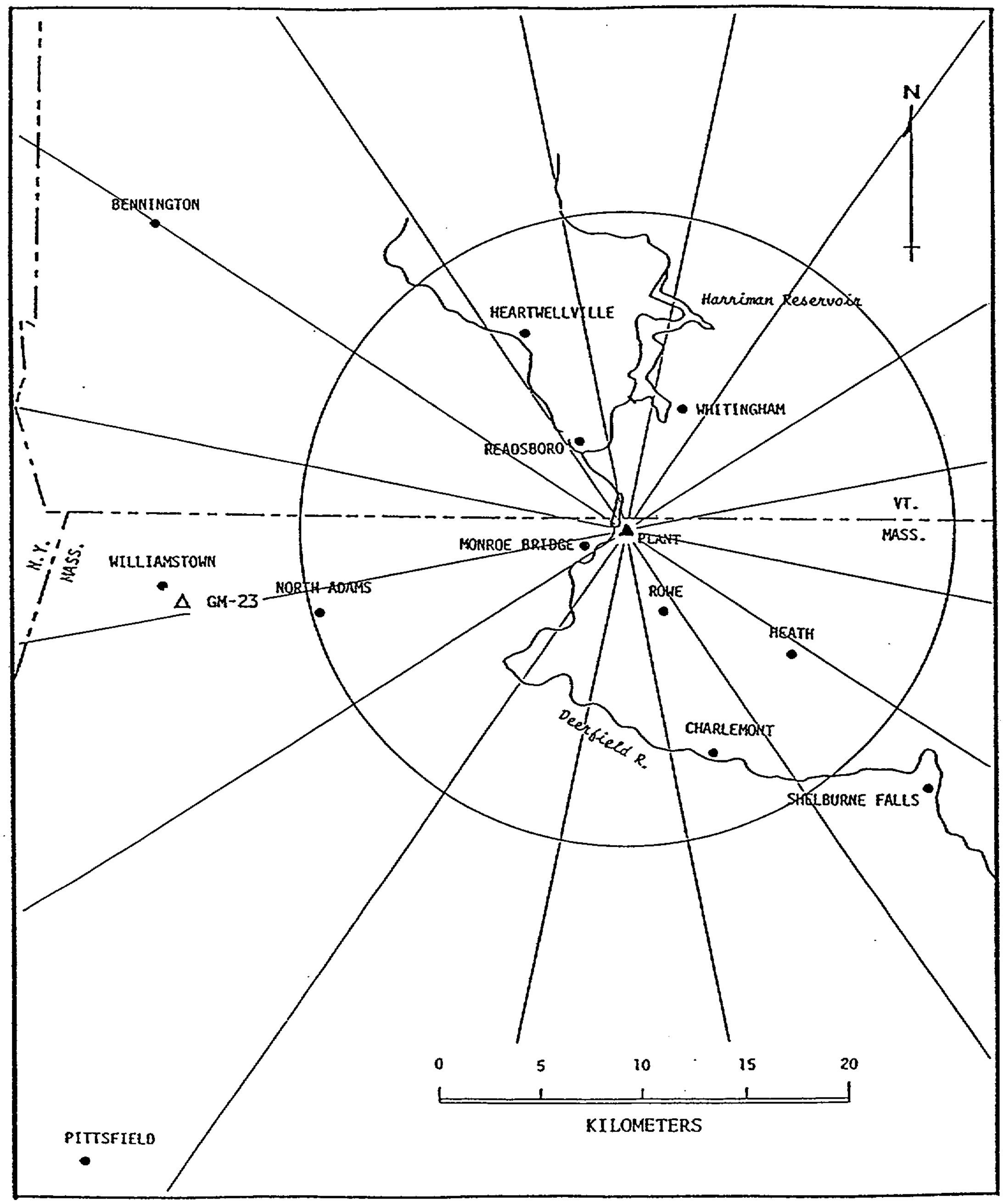


Figure 4.7 Environmental TLD Monitoring Locations Outside of 12 Miles from YNPS



5. RADIOLOGICAL DATA SUMMARY TABLES

This section summarizes the analytical results of the environmental samples that were collected during 1999. These results, shown in Table 5.1, are presented in a format similar to that prescribed in the NRC's Radiological Assessment Branch Technical Position on Environmental Monitoring (Reference 1). The results are ordered by sample media type and then by radionuclide for the pathways described in Section 4.2 and 4.3. The units for each media type are also given. Table 5.2 provides the same information for TLD direct radiation measurements.

The left-most column contains the radionuclide of interest, the total number of analyses for that radionuclide in 1999, and the number of measurements which exceeded the Reporting Levels found in Table 4.2 of the YNPS ODCM. The latter are classified as "Non-routine" measurements. The second column lists the required Lower Limit of Detection (LLD) for those radionuclides which have detection capability requirements as specified in the ODCM Table 4.3. The absence of a value in this column indicates that no LLD is specified in the ODCM for that radionuclide in that media. The laboratory aims to meet the LLD for any analysis. Occasionally the required LLD is not met. This is usually due to malfunctions in sampling equipment, which result in low sample volume. Such cases are addressed in Section 6.2.

For each radionuclide and media type, the remaining three columns summarize the data for the following categories of monitoring locations: (1) the Indicator or Zone 1 stations, which are within the range of influence of the plant and which could conceivably be affected by plant activities; (2) the station which had the highest mean concentration during 1999 for that radionuclide; and (3) the Control or Zone 2 stations, which are beyond the influence of the plant. Direct radiation monitoring stations (using TLDs) are grouped into Indicator, Outer Ring, Fenceline and Control stations.

In each of these columns, for each radionuclide, the following are given:

- The mean value of all concentrations including negative values and values that are not considered "detectable"
- The lowest and highest concentration.

- The number of detectable measurements divided by the total number of measurements.

A sample is considered to yield a "detectable measurement" when the concentration exceeds three times its associated standard deviation. The standard deviation on each measurement represents only the random uncertainty associated with the radioactive decay process (counting statistics), and not the propagation of all possible uncertainties in the analytical procedure.

The radionuclides reported in this section represent those that: 1) had a Reporting Level listed in Table 4.2 of the ODCM or, a LLD requirement in Table 4.3 of the ODCM or 2) had a positive measurement of radioactivity, whether it was naturally-occurring or man-made; or 3) were of specific interest for any other reason. The radionuclides that are routinely analyzed and reported by the DESEL in a gamma spectroscopy analysis are: Th-232, Ag-110m, Ba-140, Be-7, Ce-141, Ce-144, Co-57, Co-58, Co-60, Cr-51, Cs-134, Cs-137, Fe-59, I-131, I-133, K-40, Mn-54, Mo-99, Np-239, Ru-103, Ru-106, Sb-124, Se-75, TeI-132, Zn-65 and Zr-95. In no case did a radionuclide not shown in Table 5.1 appear as a "detectable measurement" during 1999.

Data from direct radiation measurements made by TLDs are provided in Table 5.2 in a format essentially the same as above. The complete listing of quarterly TLD data is provided in Table 5.3.

Table 5.1
Radiological Environmental Program Summary
Yankee Nuclear Power Station, Rowe, MA
(January - December 1999)

MEDIUM: Air Particulates (AP)   UNITS: pCi/cubic meter

Radionuclides* (No. Analyses) Non-Routine**		Required LLD	Indicator Stations: Mean / Range / No. Detected***	Station With Highest Mean: Sta.	Station With Highest Mean: Mean / Range / No. Detected***	Control Stations: Mean / Range / No. Detected***
GR-B	(168) (0)	0.01	2.2E -2 (1.2 - 4.2)E -2 (140/ 140)	12	2.6E -2 (1.4 - 4.2)E -2 (28/ 28)	2.3E -2 (1.4 - 3.3)E -2 (28/ 28)
Be-7	(24) (0)		9.5E -2 (4.3 - 15.5)E -2 (20/ 20)	21	1.1E -1 (8.2 - 14.9)E -2 (4/ 4)	1.1E -1 (8.2 - 14.9)E -2 (4/ 4)
Co-58	(24) (0)		-1.6E -4 (-1.3 - 1.4)E -3 (0/ 20)	21	2.2E -4 (-1.9 - 5.6)E -4 (0/ 4)	2.2E -4 (-1.9 - 5.6)E -4 (0/ 4)
Co-60	(24) (0)		1.8E -4 (-2.2 - 17.7)E -4 (0/ 20)	12	5.0E -4 (0.0 - 1.8)E -3 (0/ 4)	1.3E -5 (-1.5 - 2.7)E -4 (0/ 4)
Cs-134	(24) (0)	0.05	-6.4E -5 (-7.2 - 6.7)E -4 (0/ 20)	13	5.9E -5 (-4.1 - 6.7)E -4 (0/ 4)	1.2E -5 (-7.1 - 13.5)E -5 (0/ 4)
Cs-137	(24) (0)	0.06	-1.4E -4 (-7.1 - 2.9)E -4 (0/ 20)	13	4.9E -5 (-1.6 - 2.9)E -4 (0/ 4)	-4.1E -5 (-2.4 - 1.8)E -4 (0/ 4)

Table 5.1
Radiological Environmental Program Summary
Yankee Nuclear Power Station, Rowe, MA
(January - December 1999)

MEDIUM: River Water (WR) UNITS: pCi/kg

Radionuclides* (No. Analyses) Non-Routine**		Required LLD	Indicator Stations Mean Range No. Detected***	Station With Highest Mean Sta.	Mean Range No. Detected***	Control Stations Mean Range No. Detected***
GR-B	(36) (0)	4	1.4E 0 (-3.6 - 46.7)E -1 (9/ 24)	11	1.8E 0 (7.0 - 466.8)E -2 (6/ 12)	8.6E -1 (-5.1 - 21.1)E -1 (1/ 12)
H-3	(12) (0)	2000	1.1E 2 (-3.0 - 3.1)E 2 (0/ 8)	11	1.6E 2 (2.7 - 26.1)E 1 (0/ 4)	2.4E 1 (-1.5 - 2.1)E 2 (0/ 4)
Mn-54	(36) (0)	15	2.6E -1 (-2.4 - 2.3)E 0 (0/ 24)	31	6.3E -1 (-1.7 - 2.3)E 0 (0/ 12)	-7.3E -1 (-4.0 - 0.9)E 0 (0/ 12)
Co-58	(36) (0)	15	-4.6E -1 (-2.7 - 0.9)E 0 (0/ 24)	21	-3.4E -1 (-2.5 - 1.9)E 0 (0/ 12)	-3.4E -1 (-2.5 - 1.9)E 0 (0/ 12)
Fe-59	(36) (0)		7.2E -1 (-7.9 - 8.1)E 0 (0/ 24)	31	2.0E 0 (-7.9 - 8.1)E 0 (0/ 12)	-1.1E 0 (-3.2 - 1.0)E 0 (0/ 12)
Co-60	(36) (0)	15	5.8E -1 (-2.4 - 4.1)E 0 (0/ 24)	21	1.4E 0 (-1.3 - 5.8)E 0 (0/ 12)	1.4E 0 (-1.3 - 5.8)E 0 (0/ 12)
Zn-65	(36) (0)	30	7.7E -2 (-1.7 - 1.5)E 1 (0/ 24)	31	5.1E -1 (-1.7 - 1.5)E 1 (0/ 12)	-3.0E -1 (-4.4 - 5.3)E 0 (0/ 12)
Zr-95	(36) (0)	15	4.9E -1 (-3.2 - 3.9)E 0 (0/ 24)	31	9.5E -1 (-2.0 - 3.9)E 0 (0/ 12)	1.3E -1 (-4.2 - 3.4)E 0 (0/ 12)
I-131	(36) (0)		-7.4E -1 (-1.7 - 0.3)E 1 (0/ 24)	31	6.4E -1 (-2.1 - 3.0)E 0 (0/ 12)	3.5E -1 (-3.4 - 4.2)E 0 (0/ 12)
Cs-134	(36) (0)	15	-7.9E -2 (-2.3 - 2.2)E 0 (0/ 24)	11	2.4E -1 (-1.3 - 2.1)E 0 (0/ 12)	-1.7E -1 (-1.6 - 1.5)E 0 (0/ 12)
Cs-137	(36) (0)	18	1.8E -2 (-2.3 - 4.2)E 0 (0/ 24)	11	9.2E -2 (-1.8 - 2.7)E 0 (0/ 12)	-5.0E -1 (-3.0 - 1.7)E 0 (0/ 12)
Ba-140	(36) (0)		-1.6E -1 (-3.4 - 7.9)E 0 (0/ 24)	21	4.3E -1 (-1.2 - 3.1)E 0 (0/ 12)	4.3E -1 (-1.2 - 3.1)E 0 (0/ 12)

Table 5.1
Radiological Environmental Program Summary
Yankee Nuclear Power Station, Rowe, MA
(January - December 1999)

MEDIUM: Ground Water (WG) UNITS: pCi/kg

Radionuclides* (No. Analyses) Non-Routine**		Required LLD	Indicator Stations: Mean, Range, No. Detected***	Station With Highest Mean: Sta.	Mean, Range, No. Detected***	Control Stations: Mean, Range, No. Detected***
GR-B	(24) (0)	4	5.0E 0 (5.8 - 127.9)E -1 (22/ 24)	11	5.3E 0 (5.8 - 127.9)E -1 (11/ 12)	NO DATA
H-3	(24) (0)	2000	1.1E 2 (-1.3 - 3.8)E 2 (2/ 24)	12	1.8E 2 (-2.7 - 37.8)E 1 (2/ 12)	NO DATA
Mn-54	(24) (0)	15	-4.9E -1 (-2.0 - 1.6)E 0 (0/ 24)	11	-4.4E -1 (-2.0 - 1.6)E 0 (0/ 12)	NO DATA
Co-58	(24) (0)	15	-6.7E -1 (-2.9 - 1.9)E 0 (0/ 24)	12	-4.9E -1 (-2.9 - 1.9)E 0 (0/ 12)	NO DATA
Fe-59	(24) (0)		-1.2E 0 (-1.3 - 0.6)E 1 (0/ 24)	12	-8.9E -1 (-9.6 - 3.9)E 0 (0/ 12)	NO DATA
Co-60	(24) (0)	15	4.2E -1 (-2.3 - 2.2)E 0 (0/ 24)	12	7.1E -1 (-3.7 - 22.4)E -1 (0/ 12)	NO DATA
Zn-65	(24) (0)	30	4.4E -1 (-9.7 - 8.8)E 0 (0/ 24)	11	1.1E 0 (-1.9 - 8.8)E 0 (0/ 12)	NO DATA
Zr-95	(24) (0)	15	-7.3E -1 (-4.1 - 3.5)E 0 (0/ 24)	11	-3.6E -1 (-4.1 - 3.5)E 0 (0/ 12)	NO DATA
I-131	(24) (0)		-1.8E 1 (-4.3 - 0.1)E 2 (0/ 24)	11	1.8E -1 (-5.5 - 5.6)E 0 (0/ 12)	NO DATA
Cs-134	(24) (0)	15	-5.2E -1 (-8.1 - 2.4)E 0 (0/ 24)	12	-5.0E -1 (-8.1 - 1.7)E 0 (0/ 12)	NO DATA
Cs-137	(24) (0)	18	-2.6E -1 (-3.1 - 2.7)E 0 (0/ 24)	11	-2.5E -1 (-2.6 - 2.7)E 0 (0/ 12)	NO DATA
Ba-140	(24) (0)		-5.6E -1 (-2.1 - 0.5)E 1 (0/ 24)	11	3.0E -1 (-3.8 - 3.6)E 0 (0/ 12)	NO DATA

Table 5.1
Radiological Environmental Program Summary
Yankee Nuclear Power Station, Rowe, MA
(January - December 1999)

MEDIUM: Storm Drain Water (WW) UNITS: pCi/kg

Radionuclides* (No. Analyses) Non-Routine**		Required LLD	Indicator Stations Mean Range No. Detected***	Station With Highest Mean Sta.	Station With Highest Mean Mean Range No. Detected***	Control Stations Mean Range No. Detected***
GR-B	(12) (0)	4	4.7E 0 (5.1 - 109.6)E -1 (11/ 12)	52	4.7E 0 (5.1 - 109.6)E -1 (11/ 12)	NO DATA
H-3	(12) (0)	2000	5.8E 1 (-4.2 - 3.6)E 2 (0/ 12)	52	5.8E 1 (-4.2 - 3.6)E 2 (0/ 12)	NO DATA
Mn-54	(11) (0)	15	-4.9E -1 (-3.0 - 2.4)E 0 (0/ 11)	52	-4.9E -1 (-3.0 - 2.4)E 0 (0/ 11)	NO DATA
Co-58	(11) (0)	15	1.8E -1 (-1.8 - 1.4)E 0 (0/ 11)	52	1.8E -1 (-1.8 - 1.4)E 0 (0/ 11)	NO DATA
Fe-59	(11) (0)		6.4E -1 (-3.9 - 7.1)E 0 (0/ 11)	52	6.4E -1 (-3.9 - 7.1)E 0 (0/ 11)	NO DATA
Co-60	(11) (0)	15	-4.3E -1 (-1.4 - 0.7)E 0 (0/ 11)	52	-4.3E -1 (-1.4 - 0.7)E 0 (0/ 11)	NO DATA
Zn-65	(11) (0)	30	9.6E -1 (-2.9 - 6.0)E 0 (0/ 11)	52	9.6E -1 (-2.9 - 6.0)E 0 (0/ 11)	NO DATA
Zr-95	(11) (0)	15	5.5E -1 (-3.7 - 3.0)E 0 (0/ 11)	52	5.5E -1 (-3.7 - 3.0)E 0 (0/ 11)	NO DATA
I-131	(11) (0)		5.0E -1 (-1.6 - 4.9)E 0 (0/ 11)	52	5.0E -1 (-1.6 - 4.9)E 0 (0/ 11)	NO DATA
Cs-134	(11) (0)	15	-4.9E -1 (-4.4 - 1.2)E 0 (0/ 11)	52	-4.9E -1 (-4.4 - 1.2)E 0 (0/ 11)	NO DATA
Cs-137	(11) (0)	18	-5.3E -1 (-3.4 - 2.0)E 0 (0/ 11)	52	-5.3E -1 (-3.4 - 2.0)E 0 (0/ 11)	NO DATA
Ba-140	(11) (0)		2.6E -2 (-2.8 - 1.9)E 0 (0/ 11)	52	2.6E -2 (-2.8 - 1.9)E 0 (0/ 11)	NO DATA

Table 5.1
Radiological Environmental Program Summary
Yankee Nuclear Power Station, Rowe, MA
(January - December 1999)

MEDIUM: Sediment (SE) UNITS: pCi/kg dry

Radionuclides* (No. Analyses) Non-Routine**		Required LLD	Indicator Stations: Mean / Range / No. Detected***	Station With Highest Mean: Sta.	Station With Highest Mean: Mean / Range / No. Detected***	Control Stations: Mean / Range / No. Detected***
Be-7	(18) (0)		2.4E 1 (-5.6 - 9.9)E 2 (0/ 12)	11	1.6E 2 (-2.2 - 9.9)E 2 (0/ 6)	-1.1E 2 (-4.8 - 1.2)E 2 (0/ 6)
K-40	(18) (0)		2.1E 4 (1.3 - 3.0)E 4 (12/ 12)	91	2.6E 4 (2.4 - 3.0)E 4 (6/ 6)	1.8E 4 (1.5 - 2.3)E 4 (6/ 6)
Co-58	(18) (0)		-2.6E 0 (-5.8 - 10.1)E 1 (0/ 12)	91	3.7E 0 (-5.8 - 10.1)E 1 (0/ 6)	-1.1E 1 (-4.0 - 0.3)E 1 (0/ 6)
Co-60	(18) (0)		3.0E 1 (-8.1 - 11.3)E 1 (1/ 12)	91	5.4E 1 (-8.1 - 11.3)E 1 (1/ 6)	-2.5E 1 (-5.5 - 0.0)E 1 (0/ 6)
Cs-134	(18) (0)	150	-8.4E 0 (-8.8 - 3.3)E 1 (0/ 12)	21	1.3E 1 (-3.3 - 3.9)E 1 (0/ 6)	1.3E 1 (-3.3 - 3.9)E 1 (0/ 6)
Cs-137	(18) (0)	180	1.0E 3 (-5.2 - 302.9)E 1 (8/ 12)	91	2.0E 3 (1.3 - 3.0)E 3 (6/ 6)	1.9E 2 (-4.3 - 43.9)E 1 (3/ 6)
Th-232	(18) (0)		1.6E 3 (4.3 - 26.0)E 2 (12/ 12)	91	2.3E 3 (2.0 - 2.6)E 3 (6/ 6)	6.3E 2 (4.8 - 8.9)E 2 (6/ 6)

Table 5.1
Radiological Environmental Program Summary
Yankee Nuclear Power Station, Rowe, MA
(January - December 1999)

MEDIUM: Milk (TM) UNITS: pCi/kg

Radionuclides* (No. Analyses) Non-Routine**	Required LLD	Indicator Stations: Mean, Range, No. Detected***	Station With Highest Mean: Sta.	Station With Highest Mean: Mean, Range, No. Detected***	Control Stations: Mean, Range, No. Detected***
K-40 (12) (0)		NO DATA	21	1.4E 3 (1.3 - 1.5)E 3 (12/ 12)	1.4E 3 (1.3 - 1.5)E 3 (12/ 12)
Sr-89 (4) (0)		NO DATA	21	-3.0E 0 (-4.4 - -0.4)E 0 (0/ 4)	-3.0E 0 (-4.4 - -0.4)E 0 (0/ 4)
Sr-90 (4) (0)		NO DATA	21	1.2E 0 (5.5 - 17.1)E -1 (2/ 4)	1.2E 0 (5.5 - 17.1)E -1 (2/ 4)
I-131 (12) (0)		NO DATA	21	-7.9E -1 (-3.9 - 1.6)E 0 (0/ 12)	-7.9E -1 (-3.9 - 1.6)E 0 (0/ 12)
Cs-134 (12) (0)	15	NO DATA	21	-2.7E -1 (-2.6 - 1.6)E 0 (0/ 12)	-2.7E -1 (-2.6 - 1.6)E 0 (0/ 12)
Cs-137 (12) (0)	18	NO DATA	21	8.8E -2 (-3.4 - 2.9)E 0 (0/ 12)	8.8E -2 (-3.4 - 2.9)E 0 (0/ 12)
Ba-140 (12) (0)		NO DATA	21	9.0E -1 (-2.9 - 4.6)E 0 (0/ 12)	9.0E -1 (-2.9 - 4.6)E 0 (0/ 12)

Table 5.1
Radiological Environmental Program Summary
Yankee Nuclear Power Station, Rowe, MA
(January - December 1999)

MEDIUM: Fish (FH) UNITS: pCi/kg

Radionuclides* (No. Analyses) Non-Routine**		Required LLD	Indicator Stations: Mean / Range / No. Detected***	Station With Highest Mean: Sta.	Station With Highest Mean: Mean / Range / No. Detected***	Control Stations: Mean / Range / No. Detected***
K-40	(4) (0)		2.5E 3 (2.2 - 2.8)E 3 (2/ 2)	21	2.9E 3 (2.6 - 3.2)E 3 (2/ 2)	2.9E 3 (2.6 - 3.2)E 3 (2/ 2)
Mn-54	(4) (0)	130	3.1E 0 (-3.9 - 10.1)E 0 (0/ 2)	21	6.4E 0 (-1.3 - 14.0)E 0 (0/ 2)	6.4E 0 (-1.3 - 14.0)E 0 (0/ 2)
Co-58	(4) (0)	130	5.6E 0 (4.7 - 6.5)E 0 (0/ 2)	11	5.6E 0 (4.7 - 6.5)E 0 (0/ 2)	2.1E 0 (9.4 - 32.3)E -1 (0/ 2)
Fe-59	(4) (0)		-6.3E 1 (-1.2 - -0.1)E 2 (0/ 2)	21	-5.6E 0 (-1.7 - 0.6)E 1 (0/ 2)	-5.6E 0 (-1.7 - 0.6)E 1 (0/ 2)
Co-60	(4) (0)	130	-1.3E 1 (-1.4 - -1.2)E 1 (0/ 2)	21	2.0E 0 (-4.2 - 8.1)E 0 (0/ 2)	2.0E 0 (-4.2 - 8.1)E 0 (0/ 2)
Zn-65	(4) (0)	260	-1.7E 1 (-2.2 - -1.1)E 1 (0/ 2)	11	-1.7E 1 (-2.2 - -1.1)E 1 (0/ 2)	-3.2E 1 (-4.6 - -1.7)E 1 (0/ 2)
Cs-134	(4) (0)	130	1.7E 0 (-5.2 - 39.3)E -1 (0/ 2)	11	1.7E 0 (-5.2 - 39.3)E -1 (0/ 2)	-6.7E 0 (-7.1 - -6.3)E 0 (0/ 2)
Cs-137	(4) (0)	150	5.3E 1 (4.7 - 6.0)E 1 (1/ 2)	11	5.3E 1 (4.7 - 6.0)E 1 (1/ 2)	1.2E 1 (5.0 - 19.6)E 0 (0/ 2)

Table 5.1
Radiological Environmental Program Summary
Yankee Nuclear Power Station, Rowe, MA
(January - December 1999)

MEDIUM: Food Crop (TF) UNITS: pCi/kg

Radionuclides* (No. Analyses) Non-Routine**		Required LLD	Indicator Stations: Mean, Range, No. Detected***	Station With Highest Mean: Sta.	Mean, Range, No. Detected***	Control Stations: Mean, Range, No. Detected***
K-40	(3) (0)		2.9E 3 (8.2 - 49.9)E 2 (2/ 2)	11	5.0E 3 (1/ 1)	2.2E 3 (1/ 1)
Co-58	(3) (0)		6.2E 0 (-2.6 - 14.9)E 0 (0/ 2)	11	1.5E 1 (0/ 1)	-1.1E 1 (0/ 1)
Co-60	(3) (0)		1.3E 0 (-4.6 - 7.1)E 0 (0/ 2)	21	1.8E 1 (0/ 1)	1.8E 1 (0/ 1)
I-131	(3) (0)		1.3E 1 (6.2 - 19.8)E 0 (0/ 2)	11	2.0E 1 (0/ 1)	1.4E 1 (0/ 1)
Cs-134	(3) (0)		1.3E 0 (-3.1 - 5.8)E 0 (0/ 2)	21	8.6E 0 (0/ 1)	8.6E 0 (0/ 1)
Cs-137	(3) (0)		1.3E 1 (-2.4 - 28.4)E 0 (0/ 2)	13	2.8E 1 (0/ 1)	-1.4E 0 (0/ 1)

Table 5.1
Radiological Environmental Program Summary
Yankee Nuclear Power Station, Rowe, MA
(January - December 1999)

MEDIUM: Maple Syrup (MS) UNITS: pCi/kg

Radionuclides* (No. Analyses) Non-Routine**		Required LLD	Indicator Stations: Mean / Range / No. Detected***	Station With Highest Mean: Sta.	Station With Highest Mean: Mean / Range / No. Detected***	Control Stations: Mean / Range / No. Detected***
K-40	(2) (0)		1.8E 3 (1/ 1)	33	1.8E 3 (1/ 1)	1.6E 3 (1/ 1)
Co-58	(2) (0)		-1.3E 0 (0/ 1)	33	-1.3E 0 (0/ 1)	-3.5E 0 (0/ 1)
Co-60	(2) (0)		2.5E -1 (0/ 1)	45	1.4E 0 (0/ 1)	1.4E 0 (0/ 1)
I-131	(2) (0)		-6.3E -1 (0/ 1)	33	-6.3E -1 (0/ 1)	-6.5E -1 (0/ 1)
Cs-134	(2) (0)	60	-1.7E 0 (0/ 1)	45	6.5E -1 (0/ 1)	6.5E -1 (0/ 1)
Cs-137	(2) (0)	80	1.2E 1 (1/ 1)	45	1.5E 1 (1/ 1)	1.5E 1 (1/ 1)

Footnotes to Table 5.1:

* The only radionuclides reported in this table are those with Reporting Level or LLD requirements, those for which positive radioactivity was detected, and those which may be of interest for some other specific reason. See Section 5 of this report for a discussion of other radionuclides that were analyzed.

** Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 4.2.

*** The fraction of sample analyses yielding detectable measurements (i.e. > 3 standard deviations) is shown in parentheses.

TABLE 5.2

ENVIRONMENTAL TLD DATA SUMMARY
YANKEE NUCLEAR POWER STATION, ROWE, MA
(JANUARY - DECEMBER 1999)

INDICATOR TLDs	OUTER RING TLDs	FENCELINE TLDs	CONTROL TLDs
MEAN RANGE (NO. MEASUREMENTS)*	MEAN RANGE (NO. MEASUREMENTS)*	MEAN RANGE NO. MEASUREMENTS)*	MEAN RANGE (NO. MEASUREMENTS)*
6.4 ± 0.8 4.9 - 8.4 (51)	6.5 ± 1.0 4.6 - 8.5 (36)	7.6 ± 1.1 5.8 - 9.4 (35)	7.0 ± 0.9 5.3 – 8.1 (8)

OFFSITE STATION WITH HIGHEST MEAN

STA. NO.	MEAN RANGE (NO. MEASUREMENTS)*
GM-38	7.7 ± 1.2 5.9 - 8.5 (4)

* Each "measurement" is based on quarterly readings from five TLD elements.

TABLE 5.3

ENVIRONMENTAL TLD MEASUREMENTS

1999

(Micro-R/hour)

Sta. No.	Description	1ST QUARTER EXP.	S.D.	2ND QUARTER EXP.	S.D.	3RD QUARTER EXP.	S.D.	4TH QUARTER EXP.	S.D.	ANNUAL AVE. EXP.
GM-01	YNPS Visitor's Center	6.2	± 0.3	7.0	± 0.5	6.9	± 0.3	7.1	± 0.4	6.8
GM-02	Observation Stand	5.3	± 0.3	6.5	± 0.5	6.6	± 0.3	6.5	± 0.4	6.2
GM-03	Rowe School	4.9	± 0.2	5.9	± 0.4	5.5	± 0.5	5.7	± 0.3	5.5
GM-04	Harriman Station	5.1	± 0.2	5.9	± 0.6	6.0	± 0.3	5.8	± 0.3	5.7
GM-05	Monroe Bridge	6.1	± 0.2	7.1	± 0.4	6.9	± 0.3	7.0	± 0.4	6.8
GM-06	Readsboro Rd. Barrier	5.5	± 0.2	7.3	± 0.5	7.8	± 0.4	7.3	± 0.5	7.0
GM-07	Whitingham Line	5.4	± 0.3	7.5	± 0.5	8.4	± 0.7	7.2	± 0.4	7.1
GM-08	Monroe Hill Barrier	5.0	± 0.2	6.0	± 0.6	6.0	± 0.3	5.9	± 0.3	5.7
GM-09	Dunbar Brook	5.6	± 0.2	7.9	± 0.7	7.2	± 0.3	7.1	± 0.4	7.0
GM-10	Cross Rd.	5.3	± 0.2	6.5	± 0.4	6.8	± 0.4	6.6	± 0.3	6.3
GM-11	Adams High Line	4.9	± 0.2	6.2	± 0.4	6.6	± 0.4	6.4	± 0.4	6.0
GM-12	Readsboro, VT	6.4	± 0.2	7.1	± 0.3	6.7	± 0.3	*		6.7
GM-13	Indust. Area Fence	6.0	± 0.3	8.5	± 0.5	8.4	± 0.4	8.3	± 0.4	7.8
GM-14	Indust. Area Fence	5.8	± 0.3	7.4	± 0.5	7.2	± 0.4	7.1	± 0.4	6.9
GM-15	Indust. Area Fence	6.0	± 0.2	7.5	± 0.5	7.2	± 0.4	7.5	± 0.5	7.1
GM-16	Indust. Area Fence	5.8	± 0.2	7.7	± 0.8	7.1	± 0.3	7.3	± 0.4	7.0
GM-17	Indust. Area Fence	5.8	± 0.3	7.6	± 0.4	7.6	± 0.4	7.2	± 0.4	7.1
GM-18	Indust. Area Fence	7.1	± 0.3	9.4	± 0.8	9.2	± 0.5	8.9	± 0.4	8.7
GM-19	Indust. Area Fence	6.6	± 0.3	9.3	± 0.6	9.2	± 0.6	8.9	± 0.4	8.5
GM-20	Indust. Area Fence	6.3	± 0.3	8.6	± 0.4	8.8	± 0.4	8.9	± 0.5	8.2
GM-21	Indust. Area Fence	5.9	± 0.3	8.0	± 0.4	*		6.6	± 0.3	6.9
GM-22	Heartwellville, VT	5.3	± 0.2	7.9	± 0.5	7.5	± 0.4	6.8	± 0.4	6.9
GM-23	Williamstown Subst.	6.8	± 0.2	8.1	± 0.5	6.8	± 0.4	7.1	± 0.4	7.2
GM-25	Whitingham, VT	5.0	± 0.2	6.3	± 0.3	6.4	± 0.3	6.2	± 0.5	6.0
GM-27	Number 9 Rd.	4.8	± 0.2	6.3	± 0.4	6.3	± 0.4	6.3	± 0.3	5.9
GM-29	Route 8A	4.6	± 0.6	5.2	± 0.4	5.1	± 0.3	4.9	± 0.4	4.9
GM-31	Legate Hill Rd.	5.5	± 0.2	6.6	± 0.5	6.6	± 0.3	6.3	± 0.4	6.3
GM-32	Rowe Rd.	5.6	± 0.2	7.0	± 0.4	6.8	± 0.3	7.2	± 0.9	6.6
GM-33	Zoar Rd.	6.0	± 0.3	7.2	± 0.3	6.8	± 0.4	6.8	± 0.4	6.7
GM-35	Whitcomb Summit	5.4	± 0.2	7.7	± 0.4	7.8	± 0.3	7.5	± 0.4	7.1
GM-36	Tilda Rd.	5.4	± 0.2	7.4	± 0.4	7.4	± 0.4	7.1	± 0.4	6.8
GM-38	West Hill Rd.	5.9	± 0.2	8.4	± 0.6	8.5	± 0.5	8.0	± 0.5	7.7
GM-40	Readsboro Rd.	5.6	± 0.4	7.2	± 0.3	7.6	± 0.3	7.0	± 0.4	6.8

* TLD MISSING

6. ANALYSIS OF ENVIRONMENTAL RESULTS

6.1 Sampling Program Deviations

ODCM Control 4.1 allows for deviations "if specimens are unobtainable due to hazardous conditions, seasonal unavailability or malfunction of automatic sampling equipment." Some minor deviations were noted in the REMP during 1999. These deviations did not compromise the program's effectiveness and in fact are considered insignificant with respect to what is normally anticipated for any radiological environmental monitoring program. These specific deviations were:

1. Air Samplers
   a). The pumps at air sampling stations AP-11 and AP-31 seized resulting in a loss of about 16.5 hours of sample time on 09-28-99 (due to Hurricane Floyd).

2. TLDs
   a) The TLD at Station GM-21 was missing in the Third Quarter of 1999.
   b) The TLD at Station GM-12 was missing in the Fourth Quarter of 1999.

3. Milk
   a) The most recent Land Use Census finds no locations within five miles from which milk samples can be collected. If a future Land Use Census identifies an available sampling location within five miles, it will be included in the REMP.

6.2 Comparison of Achieved LLDs with Requirements

Table 4.3 of the ODCM (Table 4.4 in this report) gives the required Lower Limits of Detection (LLDs) for environmental sample analyses. On occasion, an LLD is not achieved due to situations such as a low sample volume caused by sampling equipment malfunction. In such a case, Control 7.1 of the ODCM requires a discussion of the situation in the Annual Radiological Environmental Operating Report. At the DESEL, the target LLD for any analysis is typically 30-40 percent of the most restrictive required LLD. Expressed differently, the typical sensitivities achieved for each analysis are at least 2.5 to 3 times better than that required by the YNPS ODCM.

For each analysis having an LLD requirement in ODCM Table 4.3, the *a posteriori* or after the fact LLD calculated for that analysis was compared with the required LLD. Of the several hundred analyses performed with a specified LLD requirement, only five failed to meet the requirements of Table 4.3 of the ODCM in 1999. Four of the five were gamma spectroscopic analyses on sediment samples, the fifth was a beta analysis on a storm drain water sample; all failed to meet the required LLD due to low sample volume.

6.3 Results Compared Against Reporting Levels

ODCM Control 4.1.a. requires the written notification to the NRC within 30 days whenever a Reporting Level in ODCM Table 4.2 is exceeded. Reporting Levels are the environmental concentrations that relate to the ALARA design dose objectives of 10 CFR 50, Appendix I. It should be noted that environmental concentrations are averaged over calendar quarters for the purposes of this comparison, and that Reporting Levels apply only to measured levels of radioactivity due to plant effluents. During 1999, no Reporting Levels were exceeded.

6.4 Data Analysis by Media Type

The 1999 REMP data for each media type are discussed below. These are arranged in the same order as in Table 5.1, and are further categorized by pathway. Graphical plots of monitoring data are shown at the end of this section in Figures 6.1 to 6.26. With respect to data plots, all values are plotted, whether they are "detectable" or "non-detectable."

6.4.1 Airborne Pathways

6.4.1.1 Air Particulates

The biweekly air particulate filters from each of the six operating sampling sites were analyzed for gross-beta radioactivity. At the end of each quarter, the individual filters collected during the quarter from each sampling site were composited for a gamma analysis. The results of the biweekly air particulate sampling program are shown in Table 5.1 and Figures 6.1 through 6.6.

As shown in Figure 6.1, there has been no significant difference between the quarterly average concentration at the indicator (near-plant) stations and the control (distant from plant) stations. Also notable is a distinct annual cycle, with the minimum concentration in the second quarter, and the maximum concentration in the first quarter.

Figures 6.2 through 6.6 show the biweekly gross beta concentration at each air particulate sampling location required by the ODCM along with the control air particulate sampling location at AP-21 (Williamstown, MA). It can be readily seen that the gross-beta measurements on air particulate filters

fluctuate significantly over the course of a year. The measurements from control station AP-21 vary similarly, indicating that these fluctuations are due to regional changes in naturally-occurring airborne radioactive materials, and not due to YNPS operations. Table 5.1 shows that the mean concentration from indicator stations, on the average, are similar to those from control locations, further supporting this conclusion.

The only radionuclide detected on the quarterly gamma isotopic analysis of the composited air particulate filters was Be-7, a naturally-occurring cosmogenic radionuclide.

6.4.2 Waterborne Pathways

6.4.2.1 Ground Water

Monthly ground water samples were collected from two on-site locations during 1999. (Only quarterly samples are required by ODCM Table 4.1.) Table 5.1 shows that gross-beta measurements were positive in most samples. This is due to naturally-occurring radionuclides in the water.

The elevated first half semiannual average gross-beta concentration in 1992 at WG-11, as seen in Figure 6.7, was due to naturally occurring radionuclides in water which was trucked in from an off-site source. A detailed discussion can be found in the Annual Radiological Environmental Operating Reports for 1992 and 1993. An elevated gross-beta concentration of 12.8 pCi/kg at WG-11 was found in 1999. A confirmatory gamma spectroscopic analysis was peformed and no gamma-emitting radionuclides were detected. Note that the location of WG-11 is 525 feet up-gradient of the Vapor Container area, so it is unlikely that plant related beta activity migrated up-gradient to this well.

A steadily decreasing concentration of H-3 has been detected in previous years in WG-12 (Sherman Spring) samples, as shown in Figure 6.8. The water from Sherman Spring leaves the ground on YNPS property and flows into the Deerfield River. Neither the Deerfield River nor Sherman Spring are used for drinking water. H-3 was detected in two of twenty-four samples from the two ground water stations in 1999.

No gamma-emitting radionuclides were detected in any of the ground water samples.

6.4.2.2 River Water

Aliquots of river water were automatically collected every two hours from the Deerfield River downstream from the plant. These composited samples were collected monthly and sent to the DESEL for analysis. Monthly grab samples were also collected at the Harriman Reservoir control location and at Sherman Pond near the discharge area.

Table 5.1 shows that gross-beta measurements were positive in some samples, as would be expected, due to naturally-occurring radionuclides in the water. The historical concentrations at the indicator and control locations have not been significantly different, as shown in Figure 6.9, except during the last half of 1992 when the levels at WR-11 were slightly elevated relative to the control, and during the last half of 1998 through 1999 when the levels at WR-21 were slightly depressed relative to the indicator. The 1992 occurrence was attributed to naturally occurring radioactivity and is discussed in the 1992 and 1993 Annual Radiological Environmental Operating Reports. The 1998 – 1999 occurrence is attributed to naturally occurring radioactivity. Note that all but one of the values used in the semi-annual averages for station WR-21 are not statistically positive since the concentrations are less than three times the standard deviations of the measurements.

No gamma-emitting radionuclides attributable to activities at YNPS were detected in any of the samples. For each sampling site, the monthly samples were composited into quarterly samples for H-3 analyses. No H-3 was detected in river water samples during 1999.

Beginning in July 1994, a split sampling program was undertaken in cooperation with the Massachusetts Department of Public Health (MDPH). Water samples were collected at the discharge point and then split with the MDPH, at their discretion. During 1999, five samples were split and analyzed by the DESEL and the MDPH laboratory. A gamma spectroscopy and H-3 analyses were performed on each sample. No radioactivity was detected in any of the 1999 samples, as analyzed at the DESEL. In Figure 4.1 and Table 4.2, this sample location is in the same vicinity as WR-31. In the data of Table 5.1, this location is labeled as WR-91 to distinguish it from routine REMP samples collected from WR-31.

6.4.2.3 Storm Drain Water

Monthly grab samples were collected from the West Storm Drain (WW-52) when available during 1999. Each sample was analyzed for gross-beta and gamma-emitting radionuclides and H-3. Gross-beta measurements were positive in 11 out of 12 samples taken, as would be expected. An elevated gross-beta concentration of 11 pCi/kg was found in 1999. A confirmatory gamma spectroscopic analysis was peformed and no gamma-emitting radionuclides were detected. No gamma-emitting radionuclides or H-3 were detected in any of the samples.

6.4.2.4 Sediment

Semiannual sediment core samples were collected from three locations during 1999. Each set of samples was segmented by depth (0-5, 5-10, 10-15 cm) and analyzed for gamma-emitting radionuclides. As would be expected, naturally-occurring K-40 and Th-232 were detected in the samples.

In addition to the naturally-occurring radionuclides, Cs-137 was detected in most segments. The results from the 0-5 cm depth segment from downstream location SE-11 are consistent with what has been measured in previous years (see Figure 6.10) and is attributed to nuclear weapons testing fallout. The Cs-137 in the 5-10 cm and 10-15 cm depth segments at SE-11 are bounded by levels previously reported at the control location (SE-21). The levels and the distribution of the Cs-137 in the core segments indicate nuclear weapons testing fallout as the origin. At both the indicator and the control location, the character of the sediment is highly dependent on the specific location sampled, which in turn is dependent on the water level in Harriman Reservoir or on the Deerfield River shoreline at the time of sampling. The diverse character of the sediment at either location and the fact that Cs-137 tends to bind more to sediment containing organic matter than to sandy and rocky sediment leads to a wide range of Cs-137 concentrations, as shown in Figure 6.10 and 6.11.

Table 5.1 and Figure 6.12 show the levels of Cs-137 at station SE-91. These samples were collected from a deep water location near the plant discharge in Sherman Pond. Although much of the Cs-137 in this sediment is due to global nuclear weapons testing fallout, some of the Cs-137 in these samples is likely due to effluents released from monitored plant discharges. It is believed that the higher Cs-137 levels at SE-91, whether due to fallout or plant effluents, are related to the physical make-up of the sediment (rich organic benthic layer) at the bottom of Sherman Pond. As would be expected, naturally-occurring K-40 and Th-232 were detected in the samples.

Co-60 has been detected in the past in the deep water sediment at SE-91. With respect to 1999 samples, the 0-5 cm segment from the core taken in November 1999 at SE-91 showed a Co-60 concentration of 71 ± 16 pCi/kg-dry. The 5-10 cm and 10-15 cm segments and the sample collected in May contained no detectable Co-60. This sample, as all others at SE-91, were collected in deep water, well away from the shoreline and is attributed to licensed plant discharges in past years. None of this radioactivity is involved in any significant pathway of exposure to man.

6.4.3 Ingestion Pathways

6.4.3.1 Milk

Milk samples from cows at one control farm were collected monthly (when available) during the year. The indicator farm, however, sold it's milking cows in August of 1998, making indicator milk samples

unavailable. Each sample was analyzed for gamma-emitting radionuclides. Quarterly composites, by location, were analyzed for Sr-89 and Sr-90.

As expected, naturally-occurring K-40 was detected in all samples. Also expected was Cs-137 and Sr-90. Cs-137 was not detected, however, in any samples in 1999. It should be noted that the annual average Cs-137 concentration in Figure 6.13 was calculated using all the measured concentrations regardless of whether they were considered "detectable" or not, or whether the measured concentration was positive or negative. Sr-90 was detected in two out of four control samples.

Although both Cs-137 and Sr-90 are a by-product of plant operations, the levels detected in milk are due to worldwide fallout from nuclear weapons tests, and to a much lesser degree from fallout from the Chernobyl incident. These two radionuclides are present throughout the natural environment as a result of atmospheric nuclear weapons testing that started primarily in the late 1950's and continued through 1980. They may be found in soil and vegetation, as well as anything that feeds upon vegetation, directly or indirectly. The Cs-137 and Sr-90 levels shown in Table 5.1 and Figures 6.13 and 6.14 are consistent with those detected in previous years near YNPS and is indicative of the residual Cs-137 and Sr-90 levels due to weapons testing fallout.

6.4.3.2 Fish

Semiannual samples of fish were collected from two locations during 1999. The edible portions of each of these were analyzed for gamma-emitting radionuclides. As expected in biological matter, naturally-occurring K-40 was detected in all samples. Cs-137 was detected in one of the two indicator samples. No other gamma emitting radionuclides were detected in 1999 fish samples. The average Cs-137 concentrations shown on Figure 6.15 for 1999 and many of the previous years contain both "positive" and "non-positive" measurements. The radioactivity detected in 1999 and in previous years at both the indicator and control locations shown on Figure 6.15 is attributed to global nuclear weapons testing fallout.

6.4.3.3 Food

The food crops collected in 1999 consisted of samples of blackberries, kale, and tomatoes. Each was analyzed for gamma-emitting radionuclides. K-40 was detected in all three samples. No other gamma emitting radionuclides were detected.

6.4.3.4 Maple Syrup

Processed maple syrup samples were collected from an indicator and control location in April of 1999. These samples had been concentrated, relative to the original tree sap, by boiling (see Section 4.3.9). Naturally occurring K-40 and Cs-137 were detected in both samples. The concentrations of Cs-137 in 1999 samples are consistent with that detected in both indicator and control samples in previous years, and is attributed to global nuclear weapons testing fallout.

6.4.4 Direct Radiation Pathway

Direct radiation is continuously measured at 33 locations surrounding YNPS with the use of thermoluminescent dosimeters (TLDs). These are collected every calendar quarter for readout at the DESEL.

As can be seen in Figures 6.16 to 6.26, there is a distinct annual cycle at both indicator and control locations. The lowest point of the cycle occurs during the winter months. This is due primarily to the attenuating effect of the snow cover on radon emissions and on direct irradiation by naturally-occurring radionuclides in the soil. Differing amounts of these radionuclides in the underlying soil, rock or nearby building materials result in different radiation levels between one field site and another.

From Table 5.2 and 5.3, it can be seen that the mean exposure rates for the Indicator, Outer Ring, and Control categories were not significantly different in 1999. This indicates that there was no significant overall increase in direct radiation exposure rates in the plant vicinity. As shown in Figures 6.16 to 6.26, the levels in 1999 are consistent with or bounded by levels in previous years.

The Fenceline TLDs shown in Figures 6.24 and 6.25 and summarized in Tables 5.2 and 5.3 are located on the fence surrounding the Radiation Control Area within the YNPS property bounds, and are influenced by licensed plant activities. The Fenceline exposure rates have shown a declining trend as the decommissioning of the site has progressed.

FIGURE 6.1

GROSS-BETA MEASUREMENTS ON AIR PARTICULATE FILTERS
QUARTERLY AVERAGES

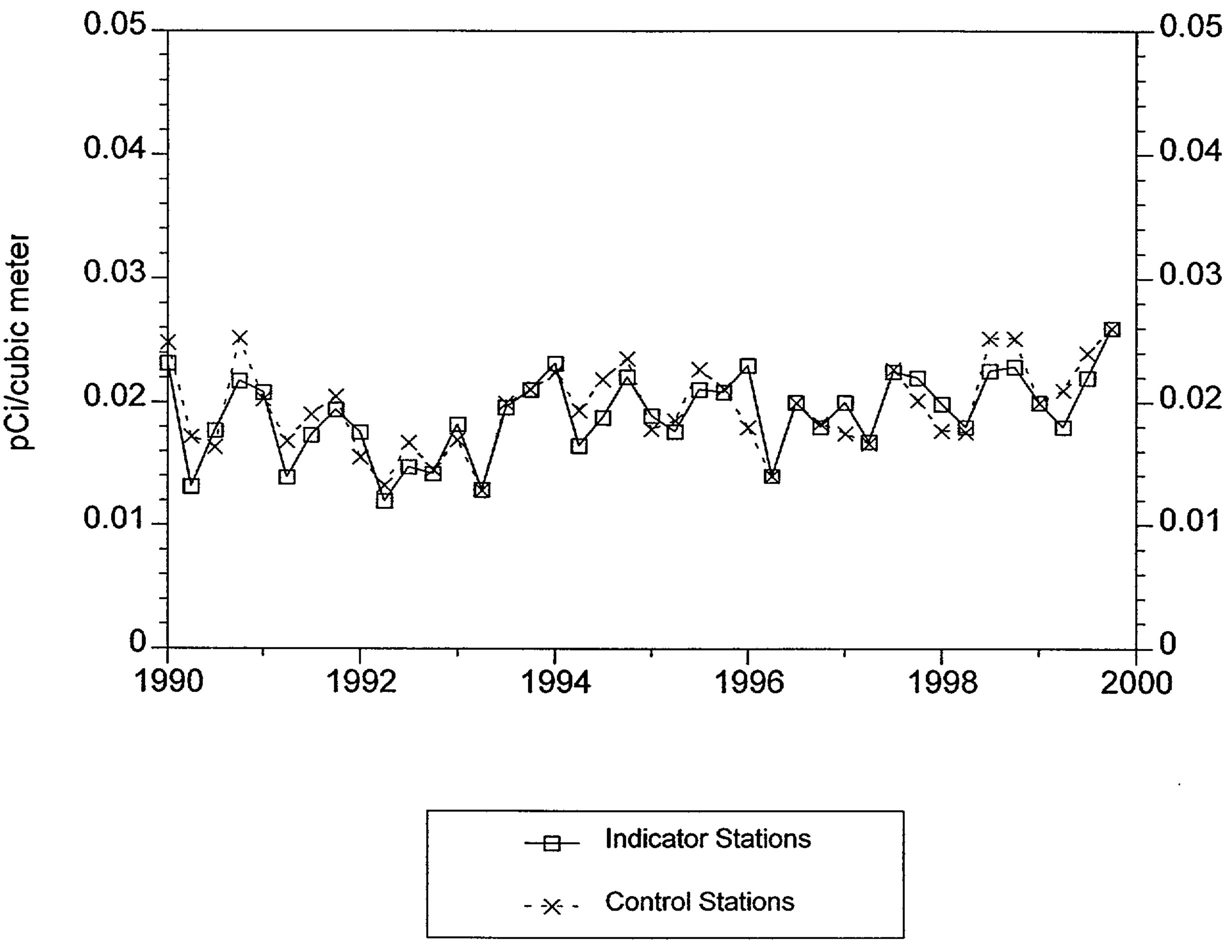


FIGURE 6.2

GROSS-BETA MEASUREMENTS ON AIR PARTICULATE FILTERS

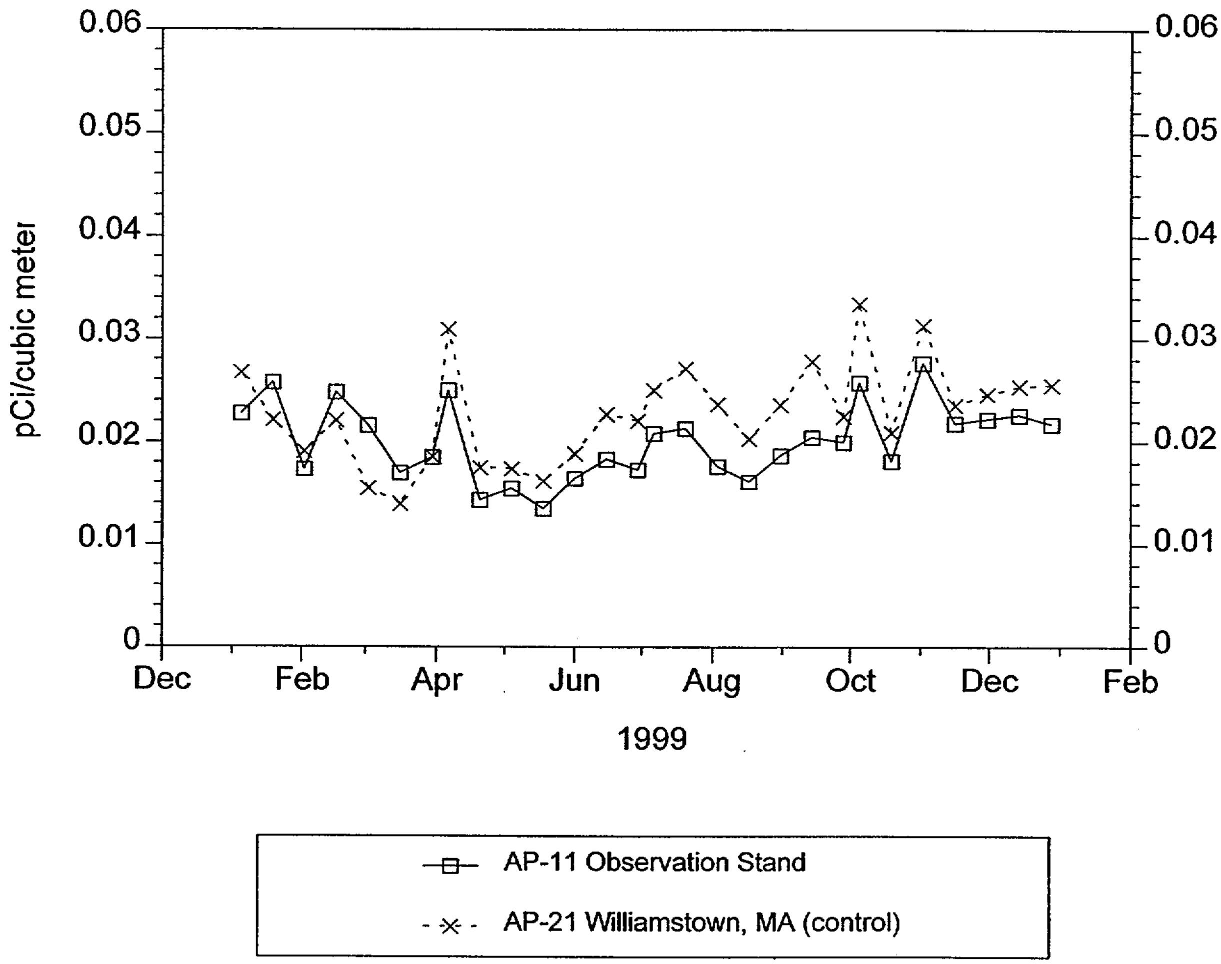


FIGURE 6.3

GROSS-BETA MEASUREMENTS ON AIR PARTICULATE FILTERS

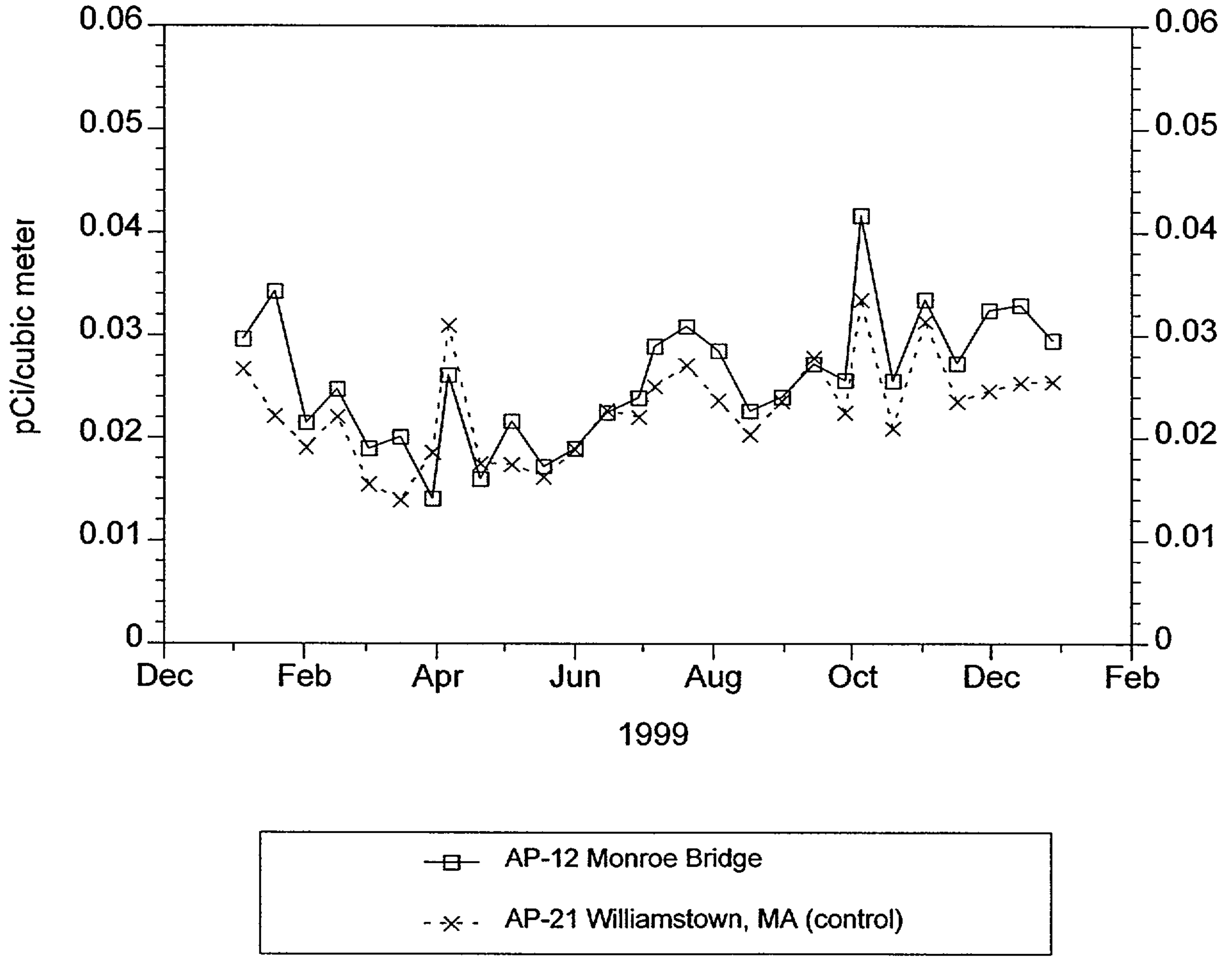


FIGURE 6.4

GROSS-BETA MEASUREMENTS ON AIR PARTICULATE FILTERS

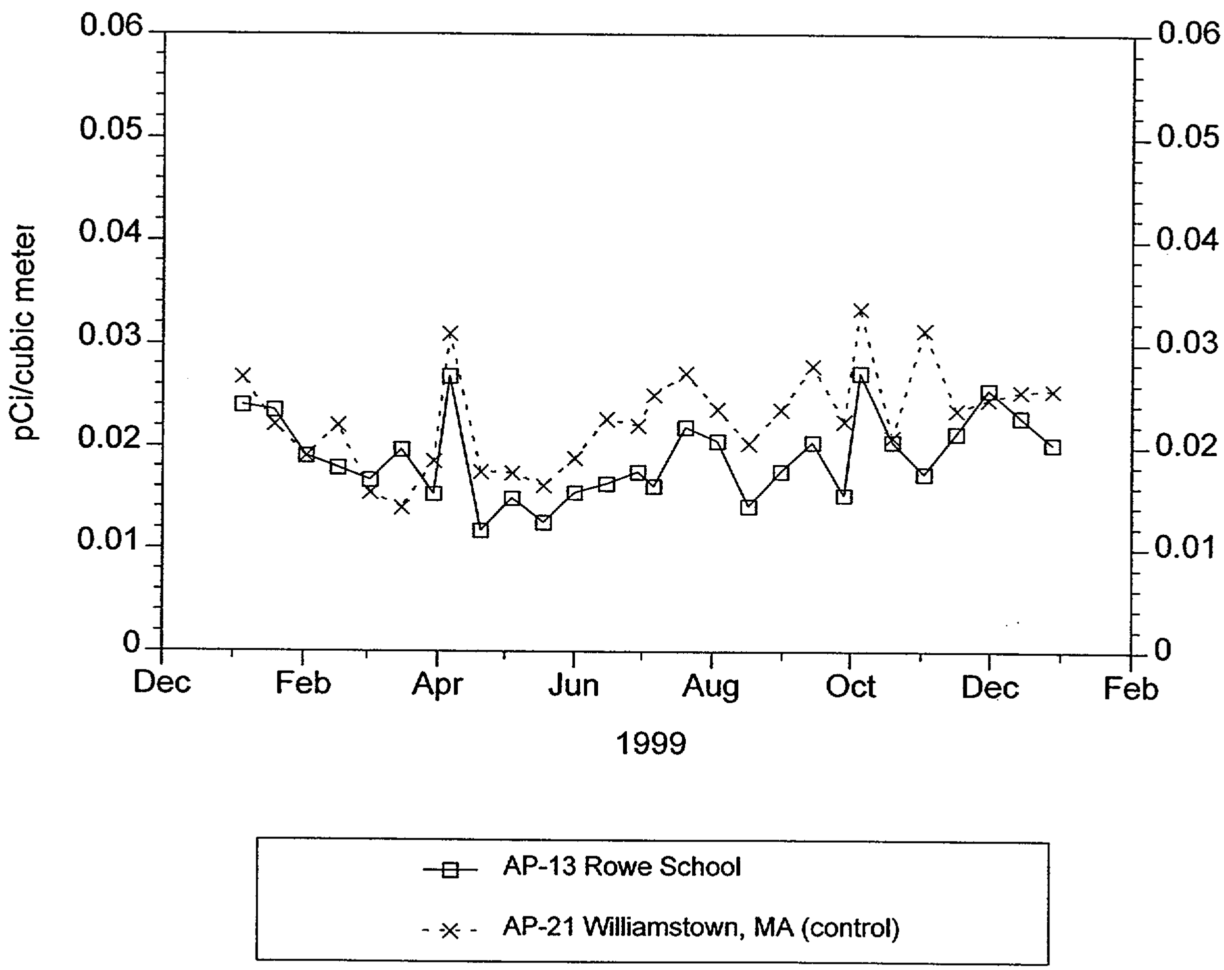


FIGURE 6.5

GROSS-BETA MEASUREMENTS ON AIR PARTICULATE FILTERS

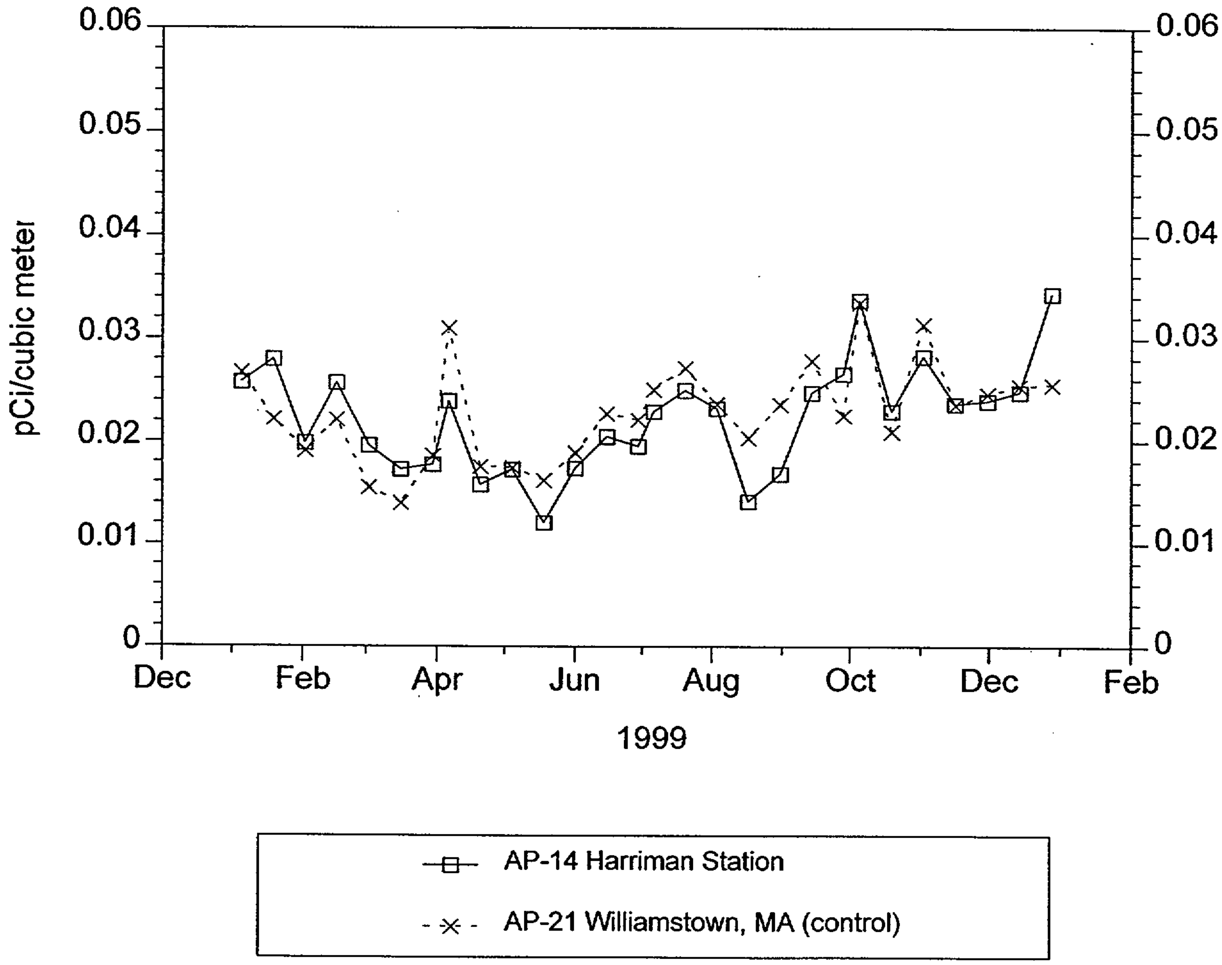


FIGURE 6.6

GROSS-BETA MEASUREMENTS ON AIR PARTICULATE FILTERS

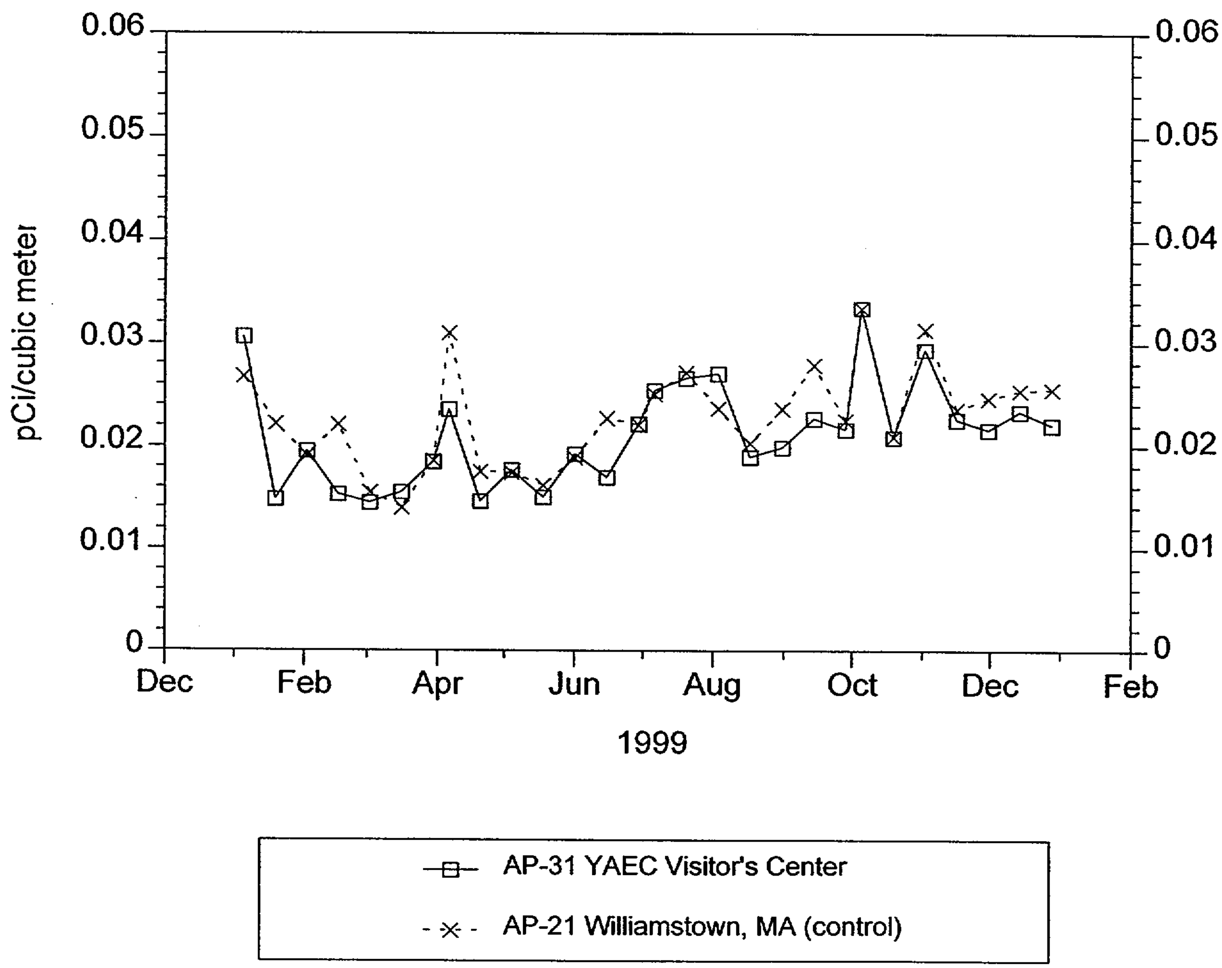


FIGURE 6.7

GROSS-BETA MEASUREMENTS OF GROUND WATER
SEMI-ANNUAL AVERAGES

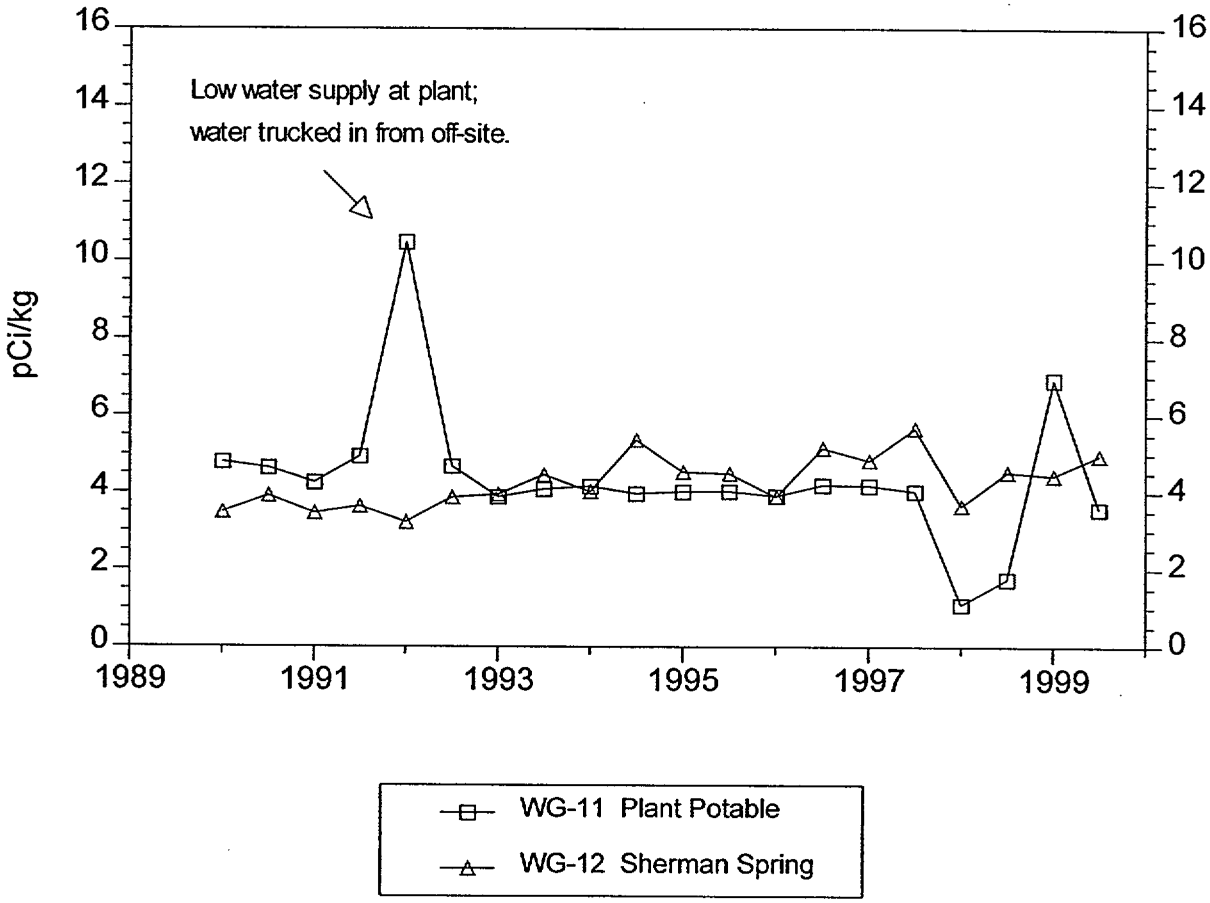


FIGURE 6.8

H-3 IN GROUND WATER
STATION WG-12, SHERMAN SPRING

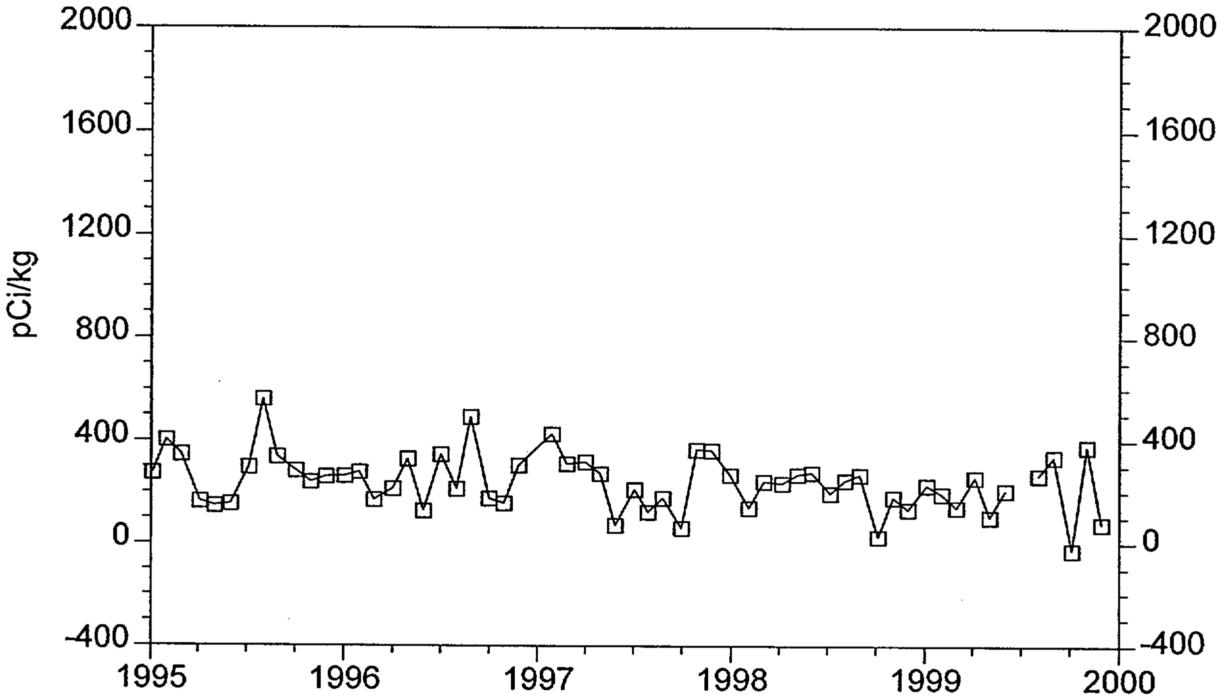


FIGURE 6.9

GROSS-BETA MEASUREMENTS OF RIVER WATER
SEMI-ANNUAL AVERAGES

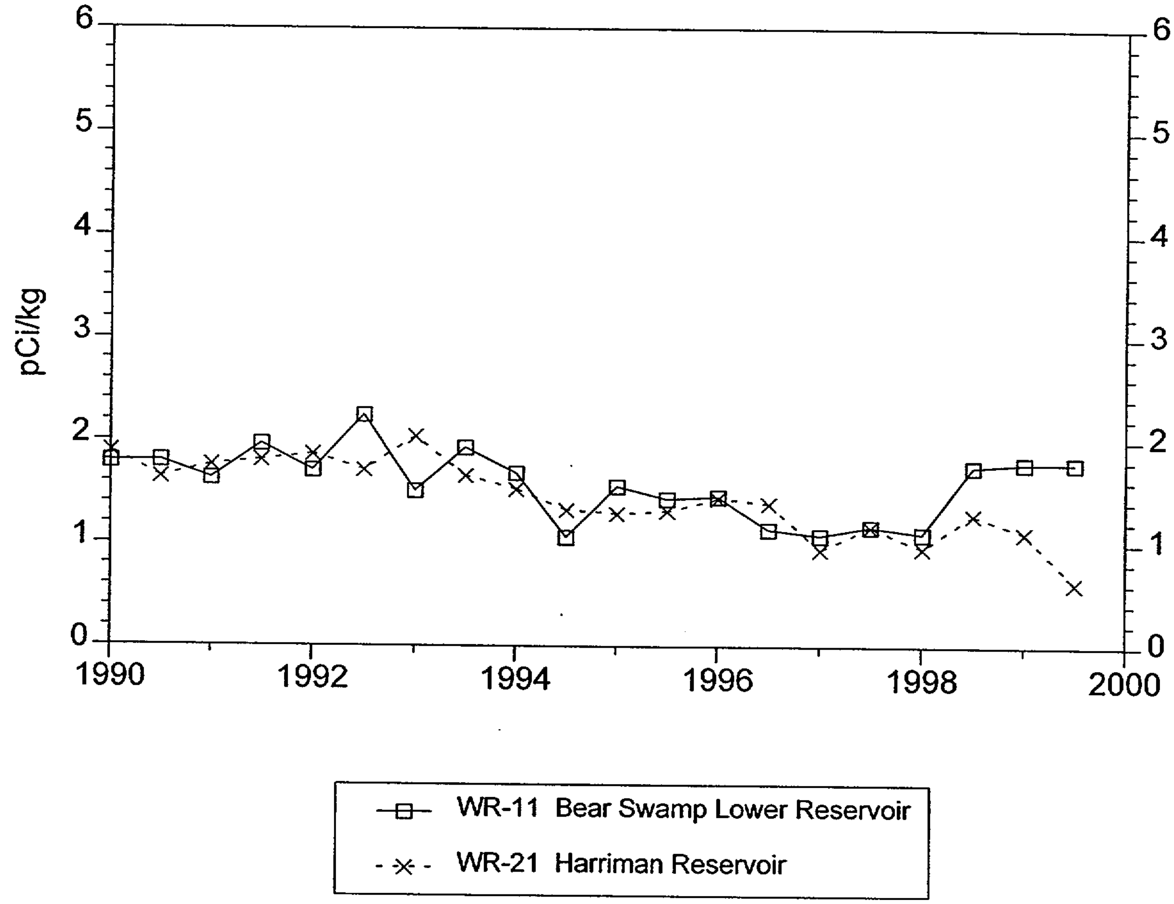


FIGURE 6.10

CESIUM -137 IN SHORELINE SEDIMENT
STATION SE-11, NO.4 STATION

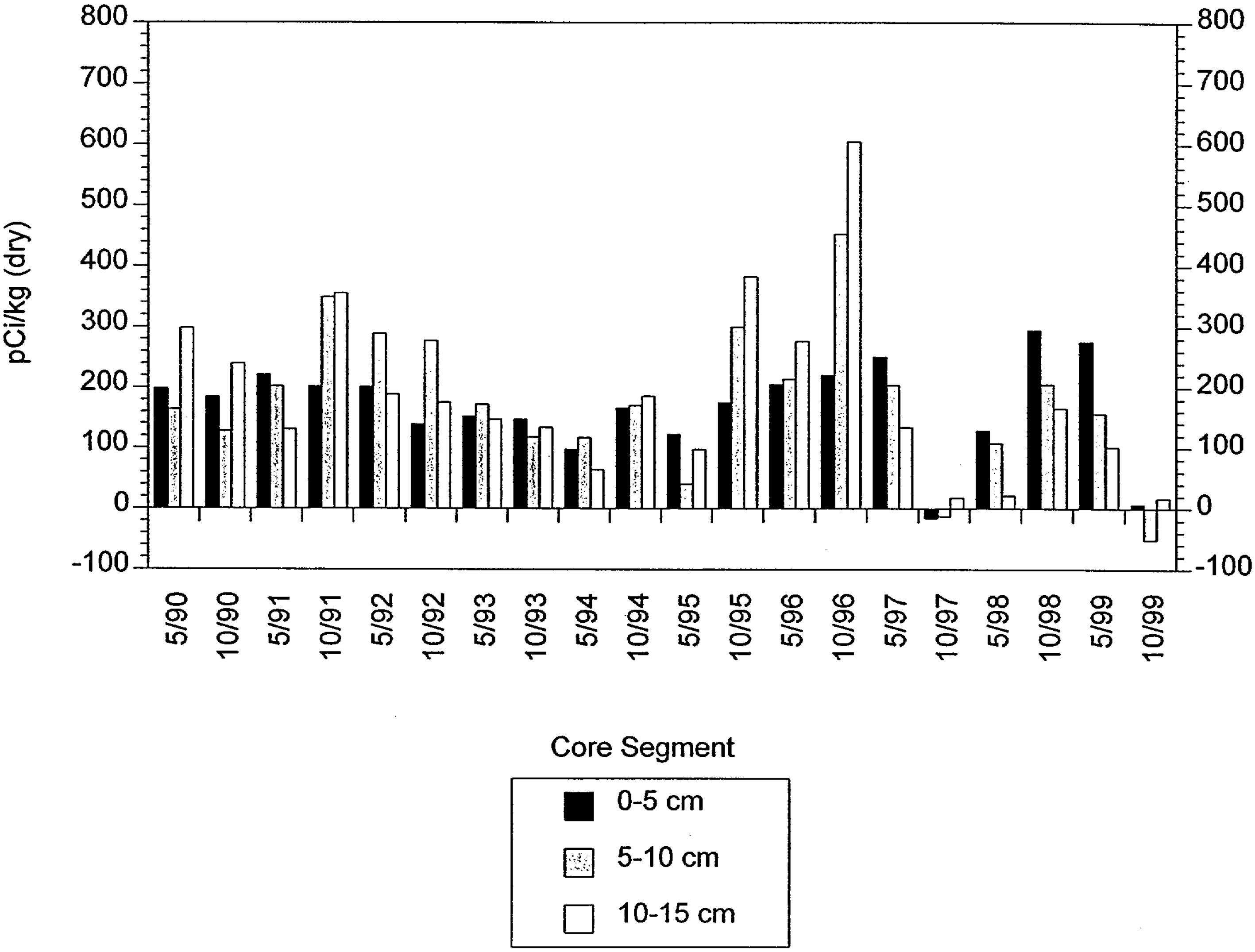


FIGURE 6.11

CESIUM - 137 IN SHORELINE SEDIMENT
STATION SE - 21, HARRIMAN RESERVOIR

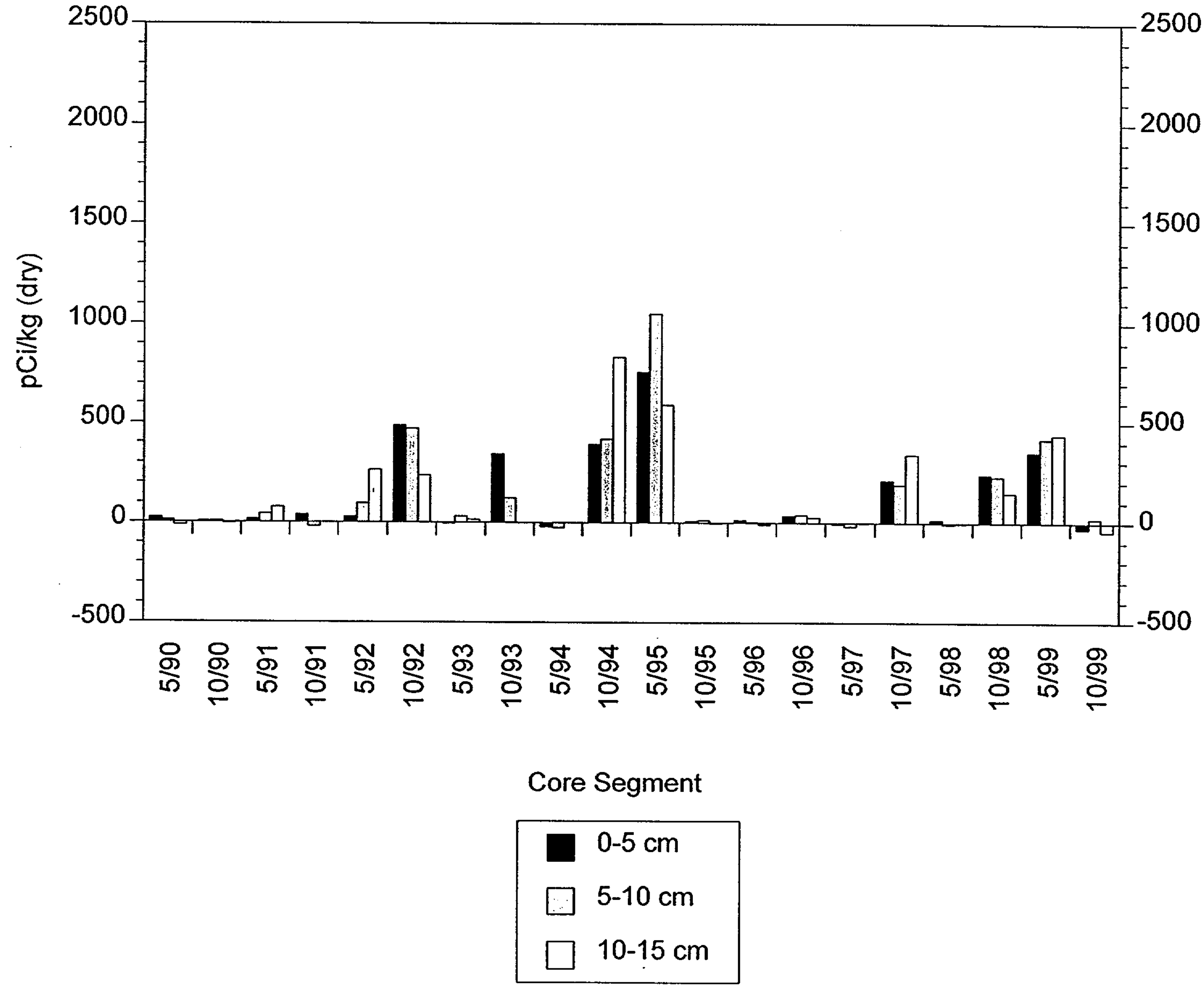


FIGURE 6.12

CESIUM - 137 IN BOTTOM SEDIMENT
STATION SE - 91, SHERMAN POND

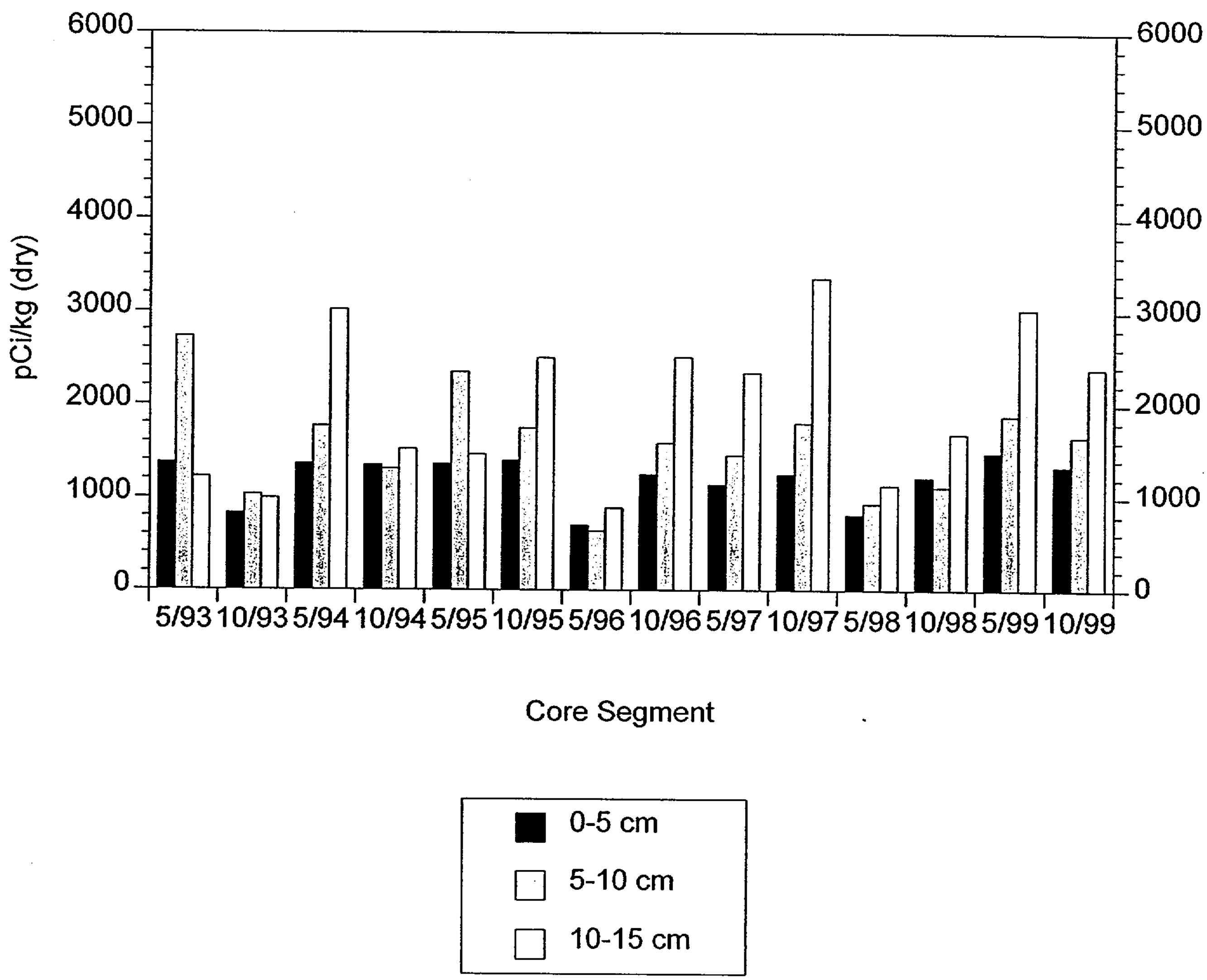
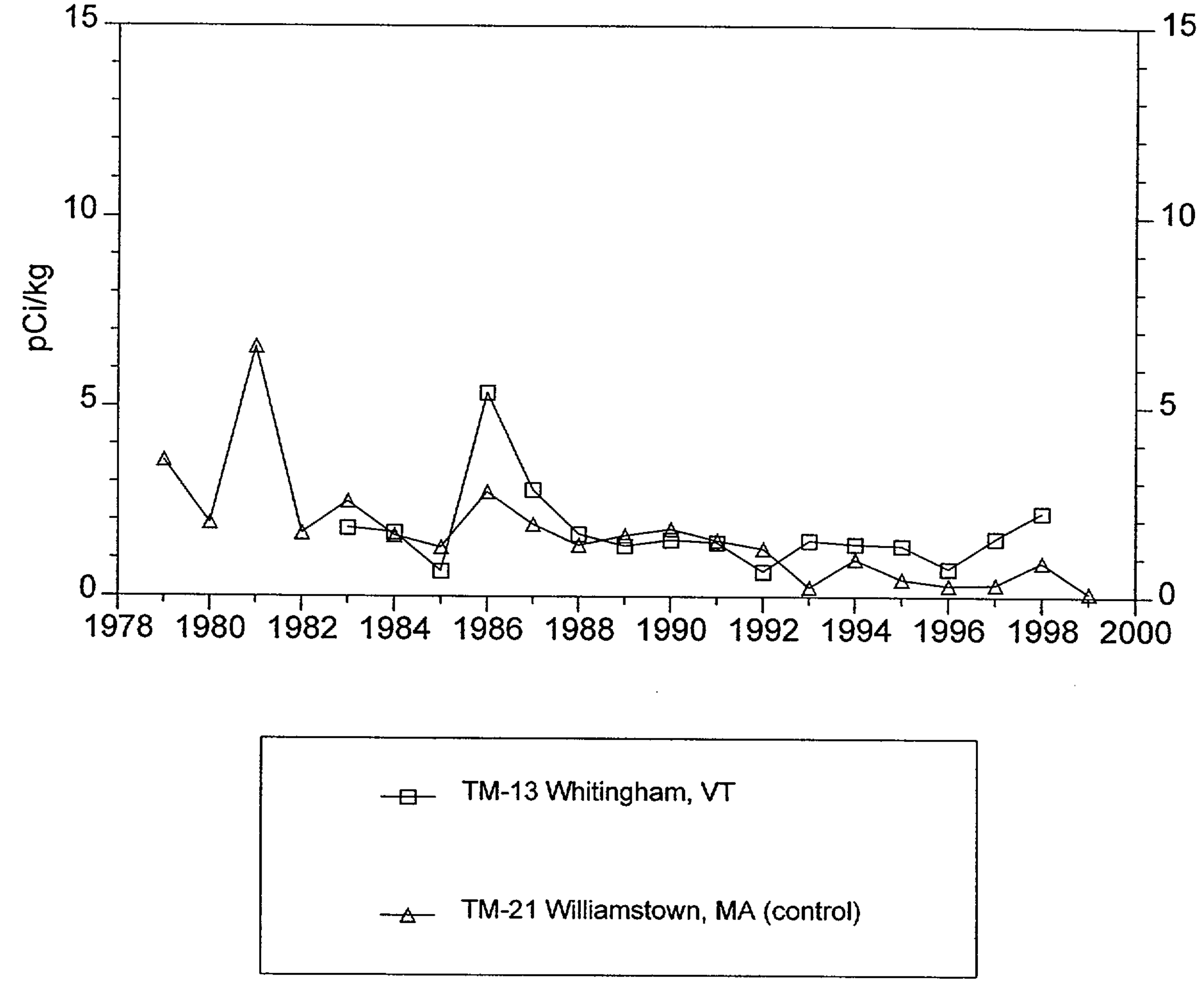


FIGURE 6.13

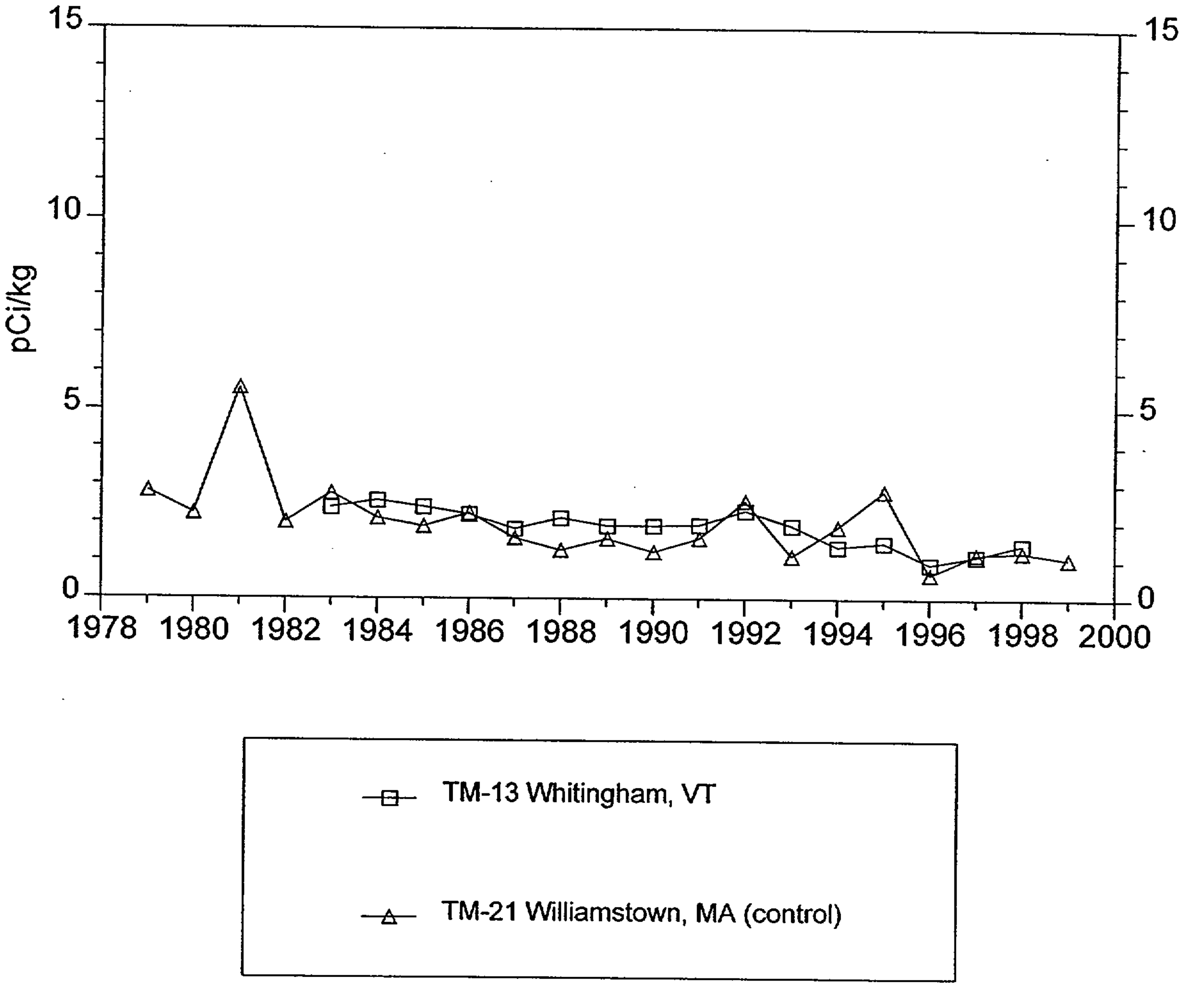
CESIUM - 137 IN MILK
ANNUAL AVERAGES



-No milk sampling location available within 5 miles

FIGURE 6.14

STRONTIUM - 90 IN MILK
ANNUAL AVERAGES



-No milk sampling location is available within 5 miles

FIGURE 6.15

CESIUM - 137 IN FISH
ANNUAL AVERAGE CONCENTRATIONS

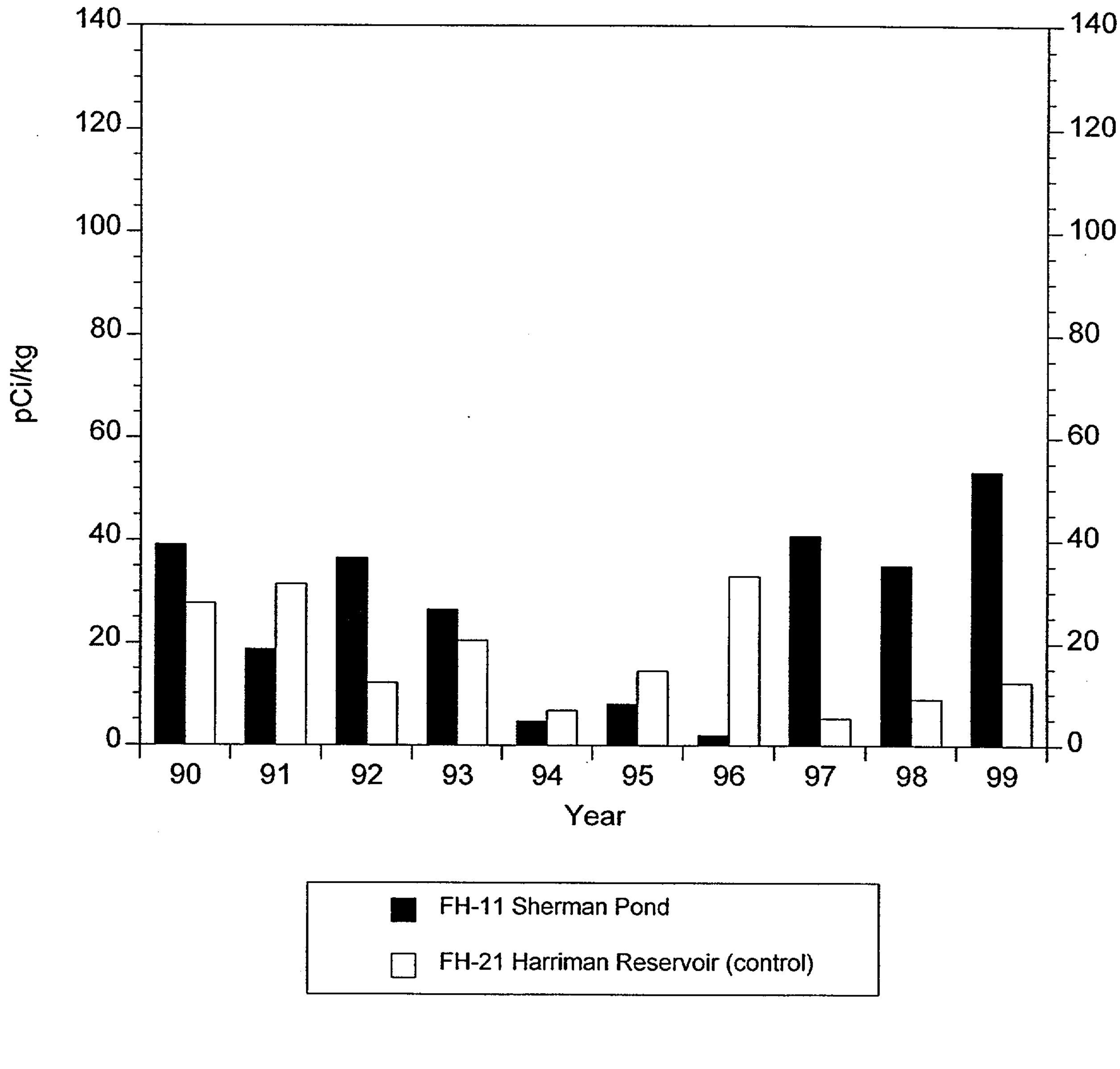


FIGURE 6.16

EXPOSURE RATE AT INDICATOR, OUTER RING AND CONTROL TLDS

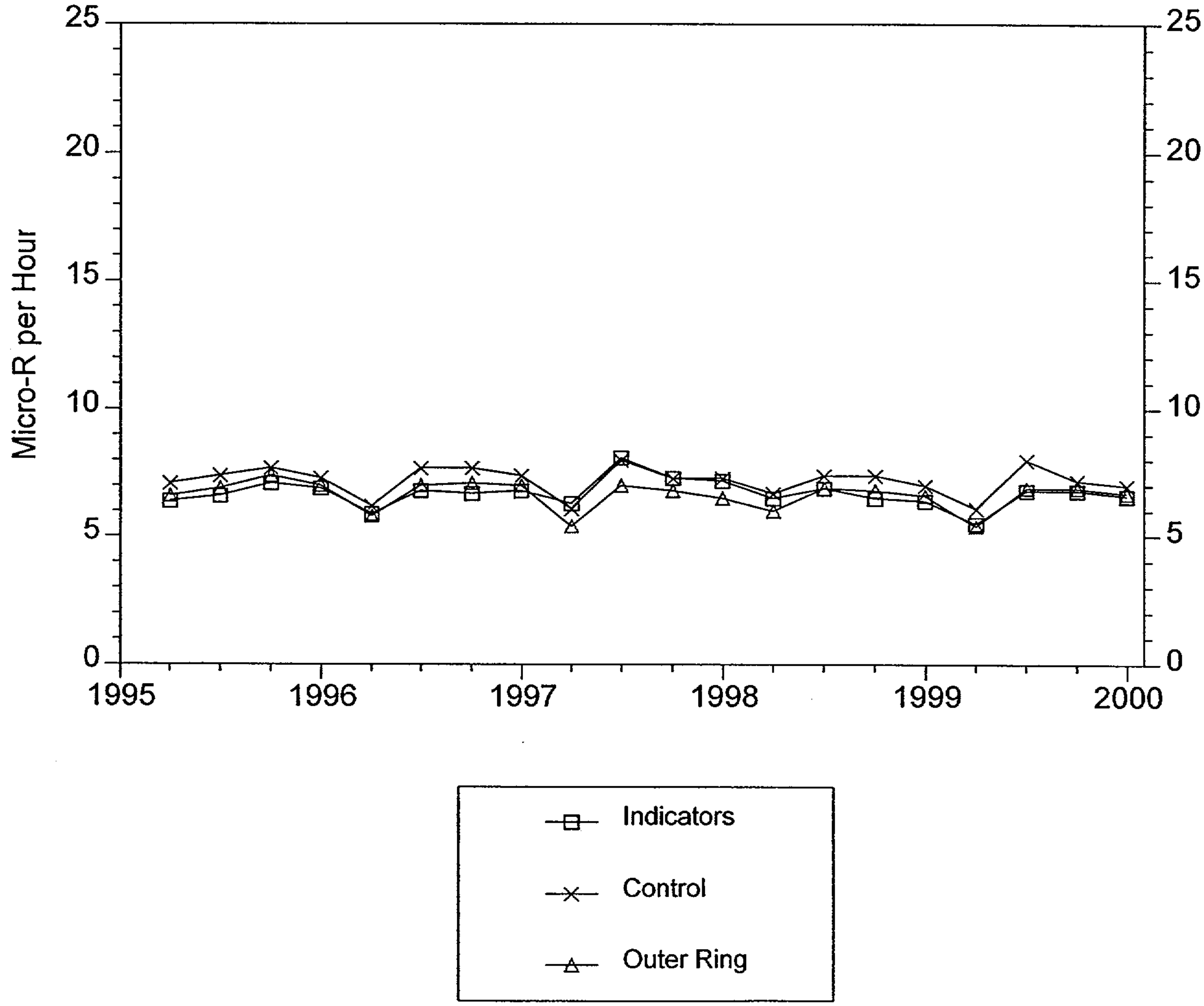


FIGURE 6.17

EXPOSURE RATE AT INDICATOR TLDS, GM 01 - 04

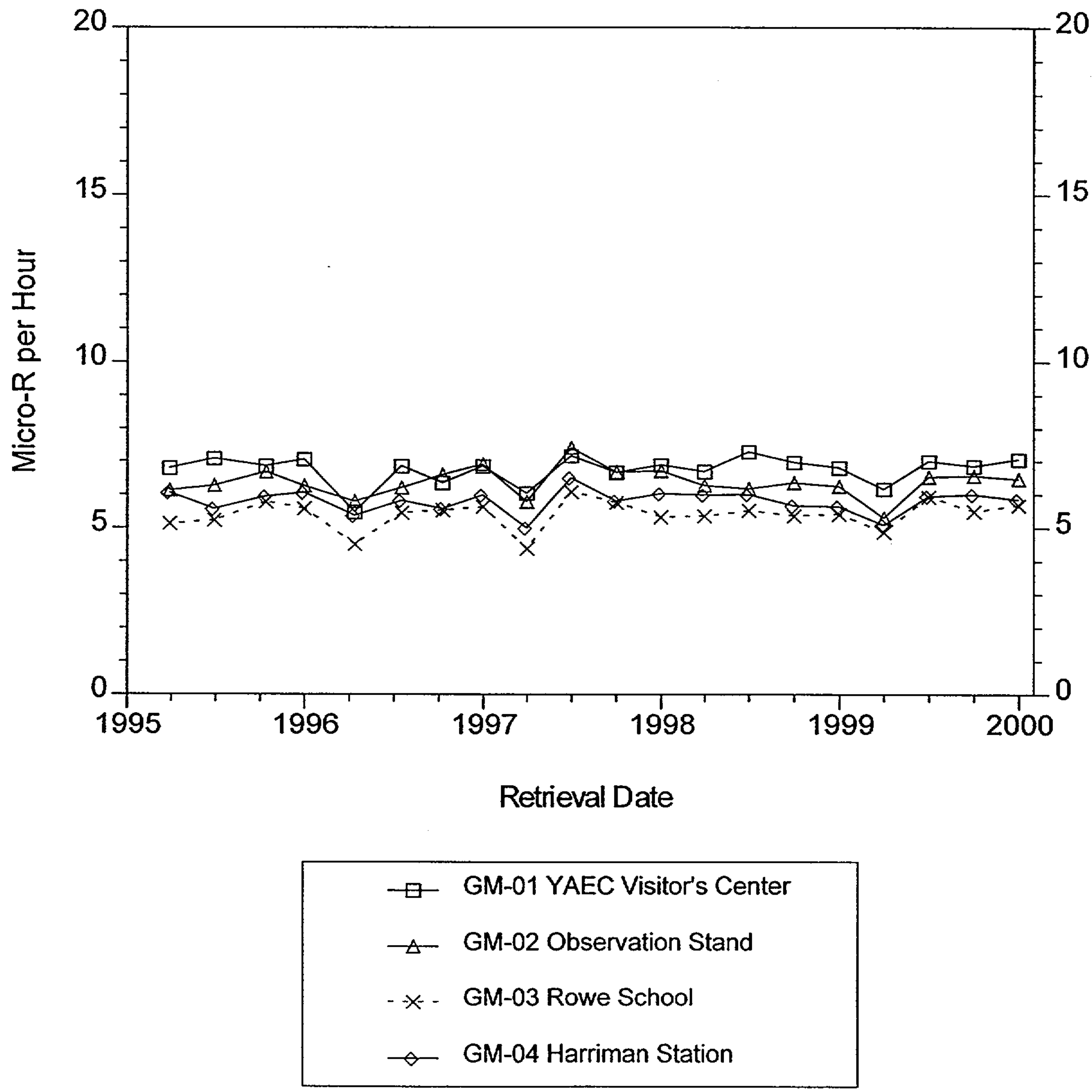


FIGURE 6.18

EXPOSURE RATE AT INDICATOR TLDS, GM 05 - 08

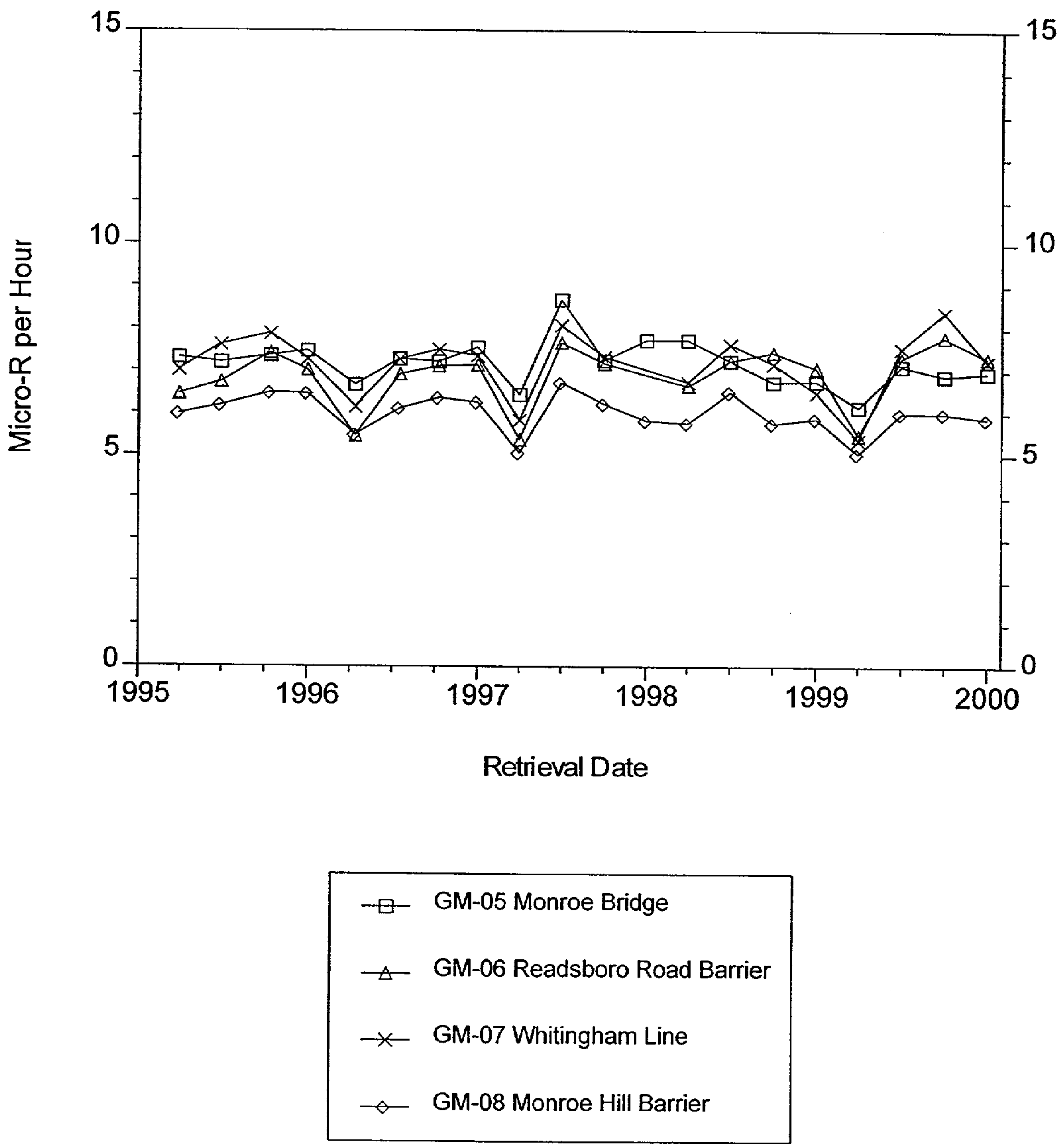


FIGURE 6.19

EXPOSURE RATE AT INDICATOR TLDS, GM 09 - 12, 40

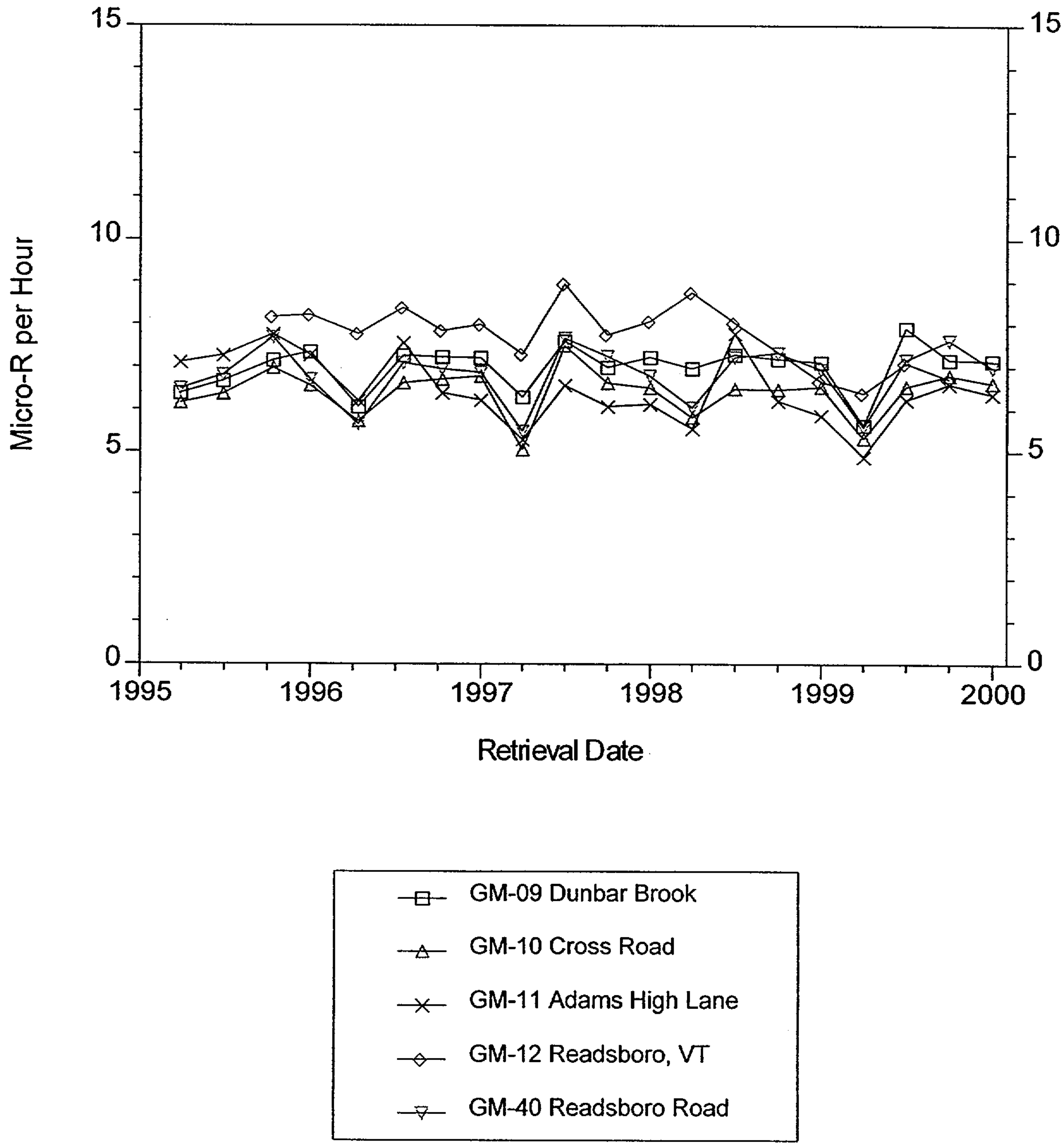


FIGURE 6.20

EXPOSURE RATE AT OUTER RING TLDS, GM 25 & 27

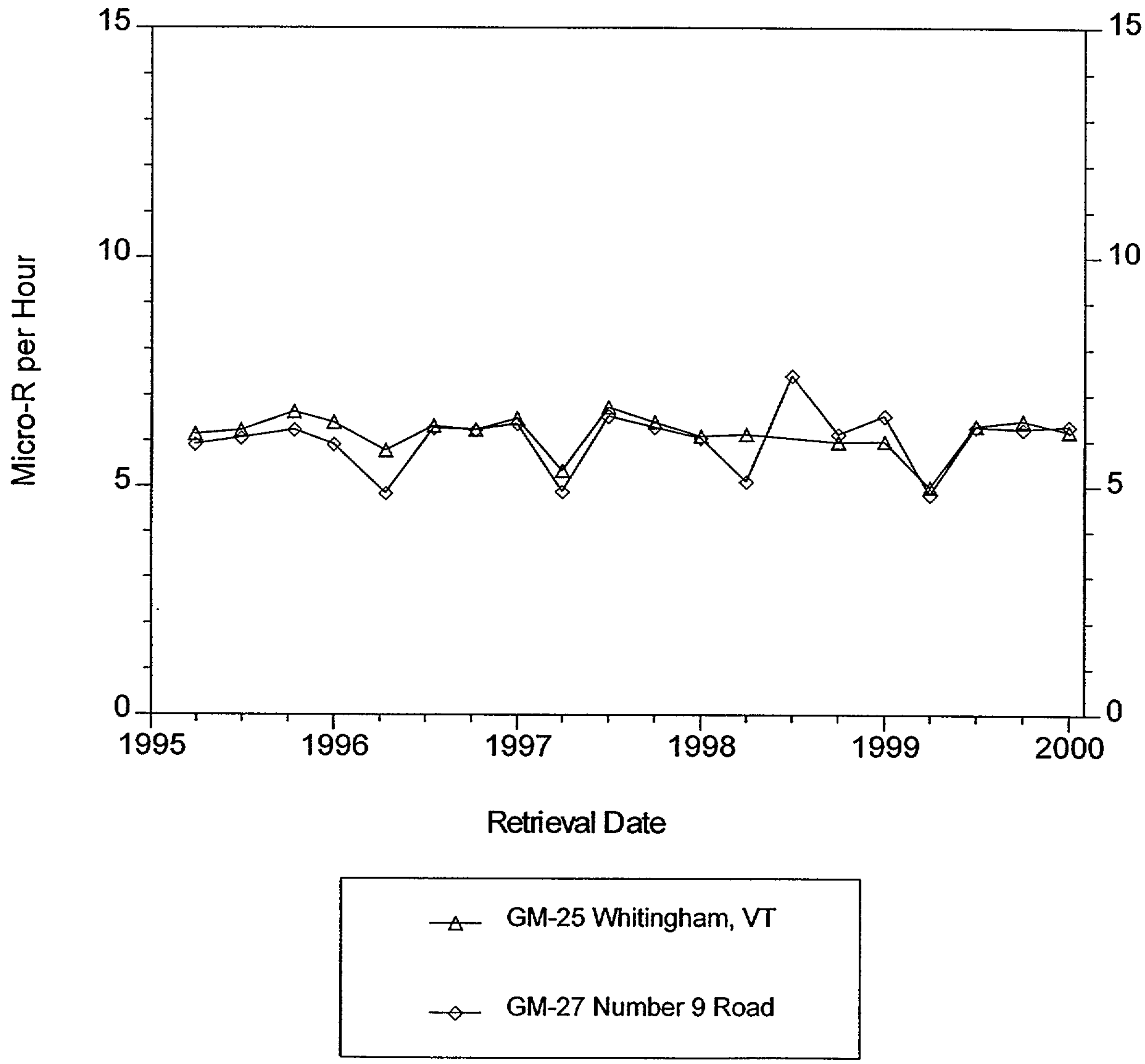


FIGURE 6.21

EXPOSURE RATE AT INDICATOR TLDS, GM 29 - 31

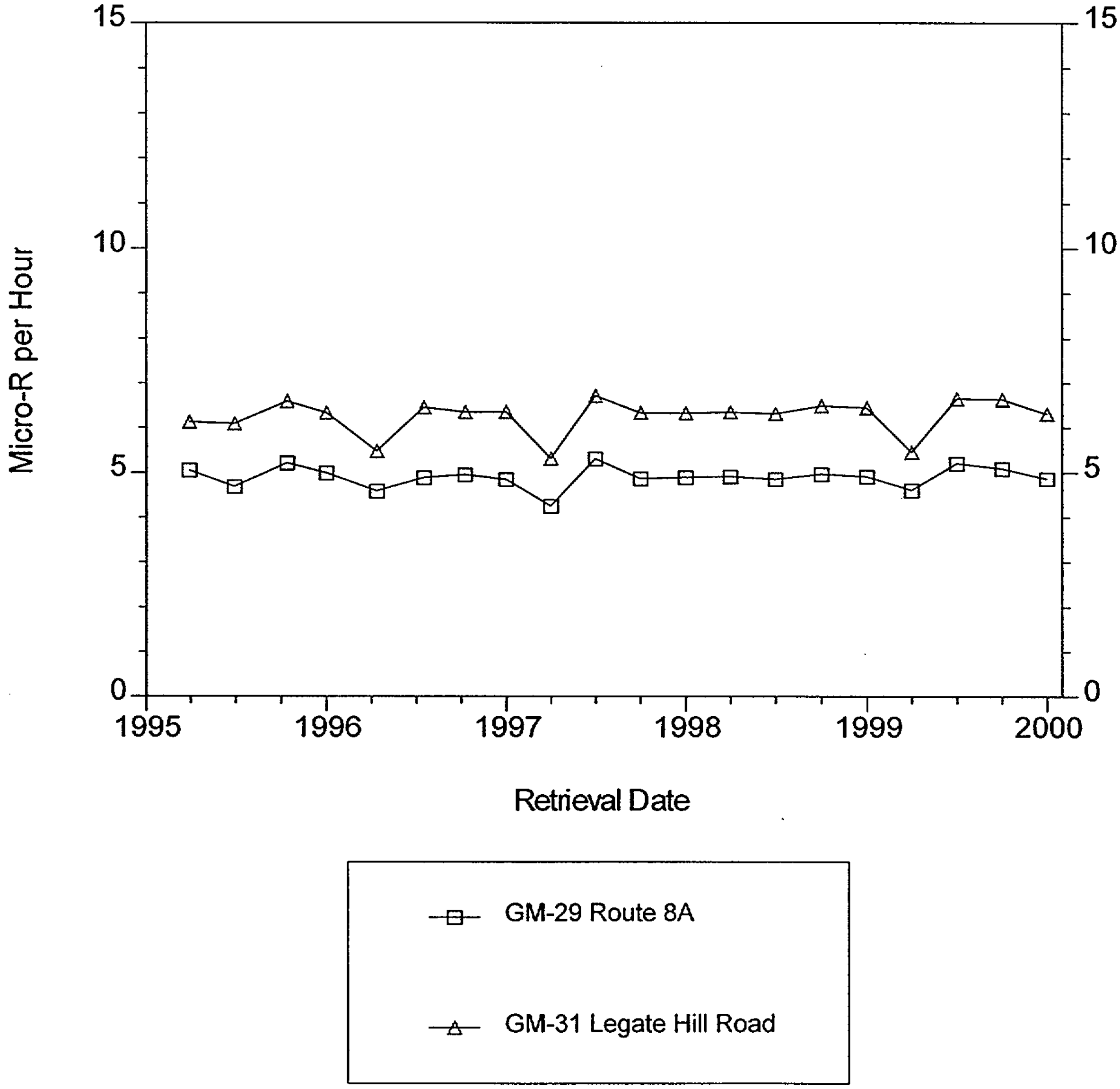


FIGURE 6.22

EXPOSURE RATE AT OUTER RING TLDS, GM 32, 33 & 35

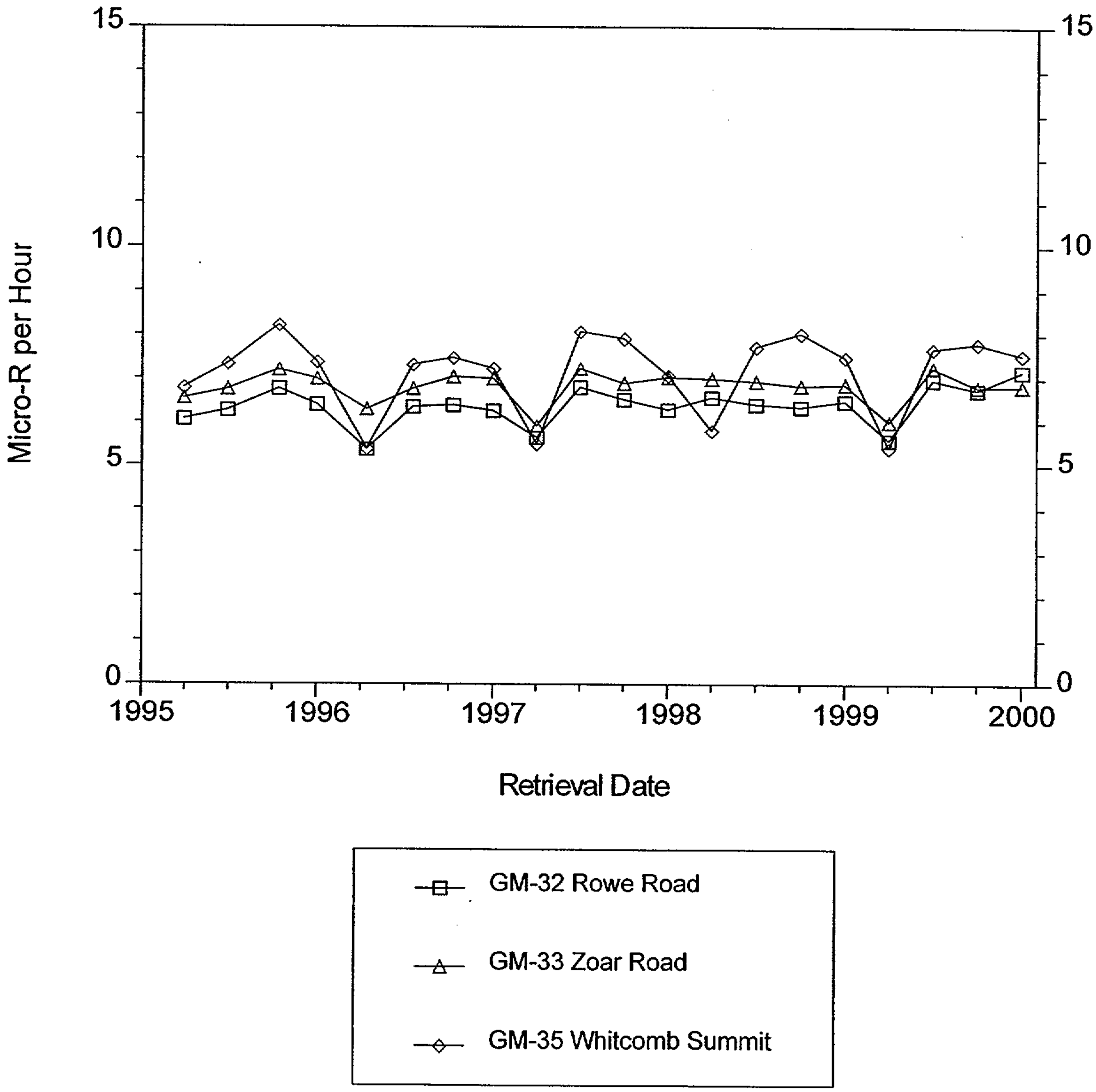


FIGURE 6.23

EXPOSURE RATE AT OUTER RING TLDS, GM 36, 38

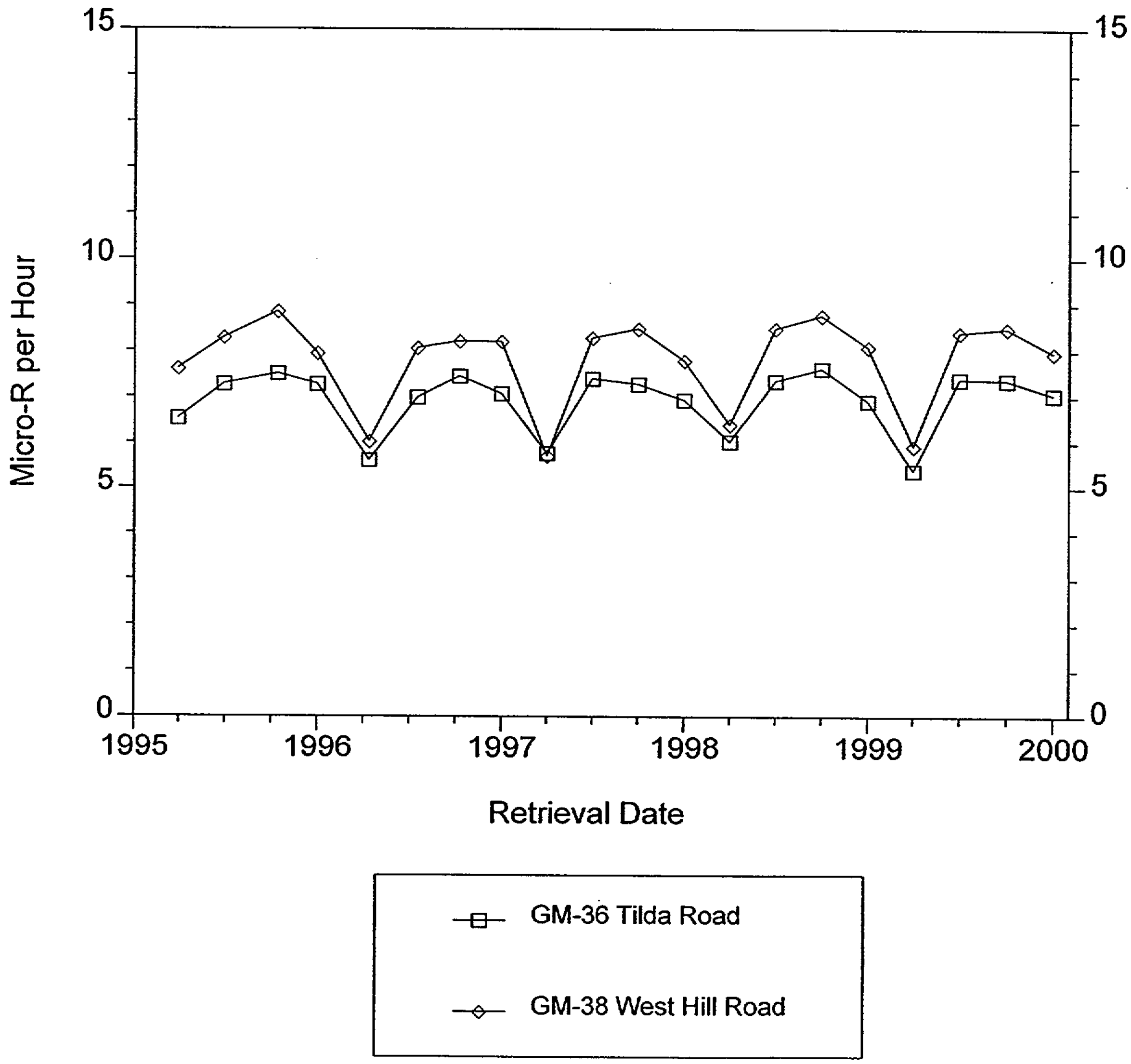


FIGURE 6.24

EXPOSURE RATE AT INDICATOR TLDS, GM 13 - 16

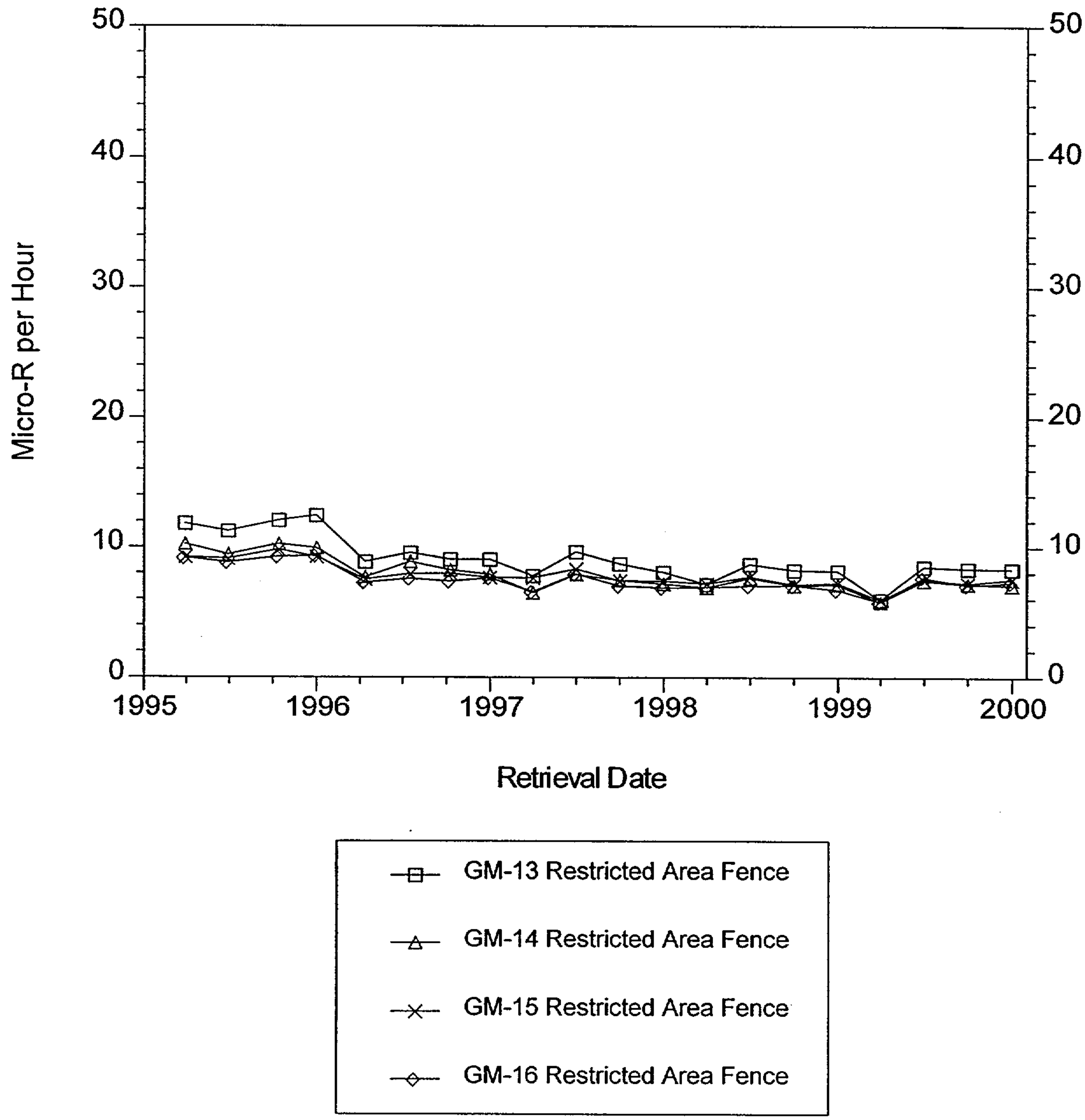


FIGURE 6.25

EXPOSURE RATE AT INDICATOR TLDS, GM 17-21

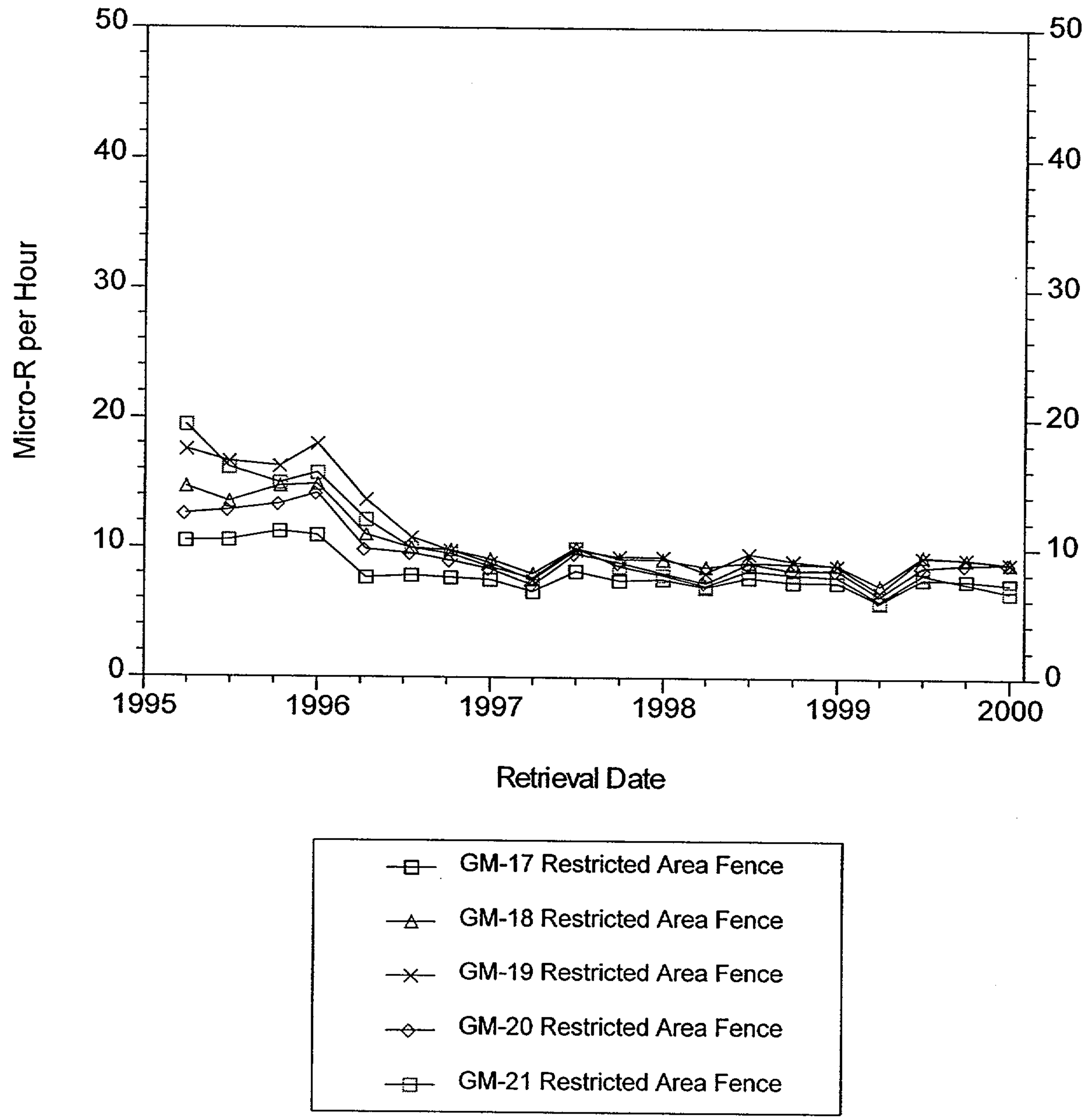
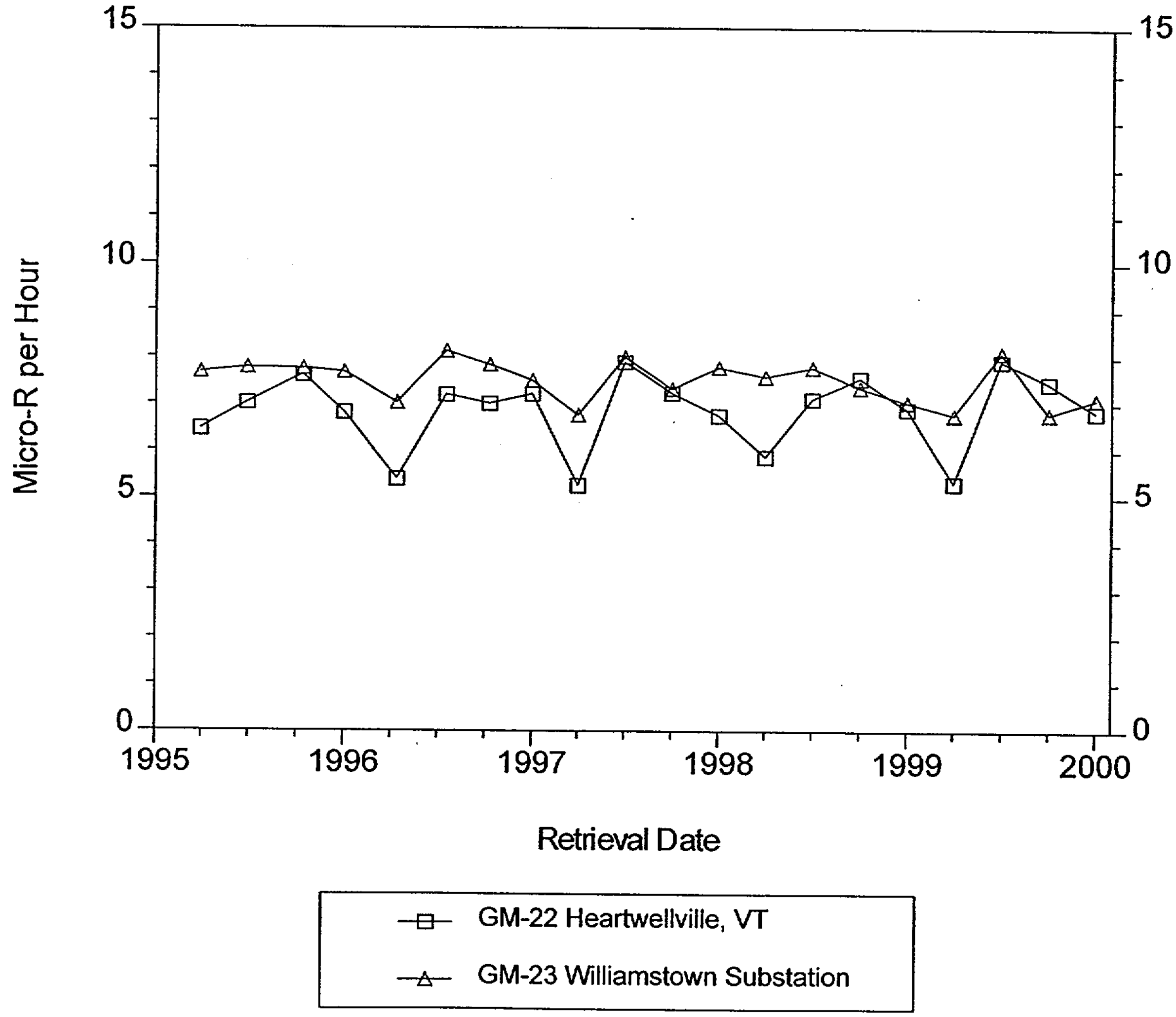


FIGURE 6.26

EXPOSURE RATE AT CONTROL TLDS, GM 22-23



7. QUALITY ASSURANCE PROGRAM

The quality assurance program at the Duke Engineering & Services Environmental Laboratory (DESEL) is designed to serve two overall purposes: 1) Establish a measure of confidence in the measurement process to assure the licensee, regulatory agencies and the public that analytical results are accurate and precise; and 2) Identify deficiencies in the sampling and/or measurement process to those responsible for these operations so that corrective action can be taken. Quality assurance is applied to all steps of the measurement process, including the collection, measurement and reporting of data, as well as the record keeping of the final results. Quality control, as part of the quality assurance program, provides a means to control and measure the characteristics of the measurement equipment and processes, relative to established requirements.

The DESEL employs a comprehensive quality assurance program designed to monitor the quality of analytical processing to ensure reliable environmental monitoring data. The program includes the use of controlled procedures for all work activities, a nonconformance and corrective action tracking system, systematic internal audits, audits by external groups, a laboratory quality control program, and a staff training program. Monitoring programs include the Intralaboratory Quality Control Program administered by the Laboratory QA Officer (used in conjunction with the National Institute of Standards and Technology's Measurement Assurance Program, NIST MAP) and a third party interlaboratory program administered by Analytics, Inc. Together these programs are targeted to supply QC/QA sources at 5% of the client sample analysis load. In addition the Laboratory Quality Control Audit Committee administers a blind duplicate program conducted through client environmental monitoring programs.

This summary reports all interlaboratory known values or intralaboratory results received by DESEL on or before February 28, 2000.

7.1 Intralaboratory Quality Control Program

The DESEL conducts an extensive intralaboratory quality control program. Process check samples are either samples submitted in duplicate to evaluate the precision of a measurement process or are "spiked" with a known amount of radioactive material to assess the bias in the measurement. The laboratory QA Officer administers the program. A summary of the process check results may be found in Table 7.1.

- One gross alpha in water result was outside the acceptance criteria for bias. However, since the mean bias of 11.2% is within the DESEL tolerance range of ± 25% for gross alpha analyses no further action was required.
- Two sets of gross beta in water results failed to meet the acceptance criteria for bias.
- DESEL CR99-05 was issued and then cancelled due to improper preservation of the spiked sample and no addition action was required.
- The failure of a second set of samples resulted in DESEL CR99-06. The investigation indicated that the problem was in a recent gross beta calibration. The unit was recalibrated and the calibration was evaluated against the bias and precision criteria gross

beta analyses. The memo EL 171/99 closed CR99-06.

7.2 Third Party Intercomparison Program

This report includes the results for the last set of samples submitted in the 4th quarter 1998 under the EPA Performance Evaluation Program. The EPA PE Program officially ended in 1998. The lab results are compared to the control limits determined by the EPA and an investigation is conducted if the mean of three results is outside the EPA control limits. Table 7.2 provides a summary of the results for the 1998 EPA Intercomparison Program. The analyses of two sample sets in a water matrix included gamma-emitting radionuclides, Sr-89, Sr-90, Ra-226, Ra-228 and Natural Uranium. All results were within the EPA Control Limits.

The DESEL participates in an independent third party intercomparison program managed by Analytics Inc. Initially, this program augmented the EPA program which it now replaces. The scope of the QA program with Analytics is designed to be comparable to the pre-1996 EPA PE Program in terms of the number of samples, matrices and nuclides. Each sample is analyzed in triplicate and the results are evaluated against the acceptance criteria described in the DESL Manual 100-Laboratory QA and is summarized at the end of Table 7.3. This is the protocol for all interlaboratory programs with no pre-set acceptance criteria. When the results of the cross-check analysis fall outside of the acceptance criteria, an investigation is initiated to determine the cause of the problem and if appropriate, corrective measures are taken.

Three Analytics results failed to meet the criteria for acceptance (Table 7.3) and the DESEL has issued Condition Reports (CR) to investigate the failures.

- DESEL CR98-09 was issued to investigate the occurrence of imprecise results among I-131 low level analyses in milk. The cause of the precision failure was found to be an instrumentation problem and the unit was placed "out of service" following the issuance of the CR. The problem was resolved by optimizing the electronics and is addressed in the memo EL 83-99 dated June 14, 1999. CR98-09 was closed on September 1999.
- DESEL CR99-11 was issued to investigate the -27% mean bias for gross alpha and analysis in water. This investigation is in progress.
- DESEL CR99-11 was also issued to investigate the 28% mean bias for Ra-226 analysis in water. This investigation is in progress.

7.3 Environmental TLD Quality Assurance Program

Performance documentation of the routine processing of the Panasonic environmental TLDs (thermoluminescent dosimeter) program at the DESEL is provided by the dosimetry quality assurance testing program. This program includes the National Voluntary Laboratory Accreditation Program, independent third party performance testing by Battelle Pacific Northwest Labs and internal performance testing conducted by the Laboratory QA Officer. Under these programs, dosimeters are irradiated to ANSI specified testing criteria and submitted for processing to the Dosimetry Services Group as "unknowns". The bias and precision of TLD processing is measured against this standard and is used to indicate trends and changes in performance. Instrumentation checks, although routinely performed by the Dosimetry Services

Group and representing between 5-10% of the TLDs processed, are not presented in this report because they do not represent a true process check sample since the doses are known to the processor.

Ninety-six independent performance tests were conducted during 1999. Of these, 72 were submitted to the Dosimetry Services Group by the QA Officer and 24 were submitted as part of Battelle Pacific Northwest Laboratories testing program. All of the dosimeter evaluations met the acceptance criteria for accuracy and precision and are summarized below.

Test Organization	No. of Dosimeters	Bias ± Std Dev %	Precision (Std Dev) %
Battelle 1st half 1999	12	-3.9 ± 5.1	1.7
Battelle 2nd half 1999	12	-5.2 ± 10.8	2.4
DESEL 1st half 1999	36	0.0 ± 2.3	0.7
DESEL 2nd half 1999	36	0.8 ± 2.3	1.2

7.4 Blind Duplicate Quality Assurance Program

The Laboratory Quality Control Audit Committee (LQCAC) is comprised of a representative from each of five New England power plants that are serviced by the DESEL. Two of the primary functions of the LQCAC have been to conduct an annual audit of Laboratory operations and to coordinate the Blind Duplicate Quality Assurance Program. Under the Blind Duplicate Quality Assurance Program, paired samples are submitted by the five clients. Samples are split from homogeneous environmental media by the client and sent to the DESEL for analysis. They are "blind" in that the identification of the matching sample is not identified to the Laboratory. The LQCAC analyses the results of the paired analyses to evaluate precision in Laboratory measurements.

A total of fifty-five paired samples was submitted under this program by the participating clients during 1999. The measurements were evaluated for twenty-five gamma emitting radionuclides, H-3, Sr-89, Sr-90, I-131 and gross-beta. All measurements are evaluated, whether the results are statistically positive or not, and whether the net concentration is positive or negative. Of the 1447 paired measurements evaluated in 1999, 1432 or 98.9% fell within the established acceptance criteria.

The samples submitted as part of this program are listed in Table 7.4.

TABLE 7.1
DESEL RESULTS IN THE INTRALABORATORY PROCESS CONTROL PROGRAM
January - December 1999

Media Analysis	Bias Criteria (1)				Precision Criteria (2)			
	1	2	3	4	1	2	3	4
I. Air Charcoal								
Gamma	40	6						
II. Air Filter								
Beta	91	9	4					
Gamma	9				9			
III. Milk								
Gamma	6				6			
Iodine-LL	6				6			
IV. Water								
Gross Alpha	1	3	1	1	4		2	
Gross Beta	3	3	2	6	6	4		2
Gamma	2	1			6	2		
Iodine-LL								
Radium	1				1			
Tritium	3	1	2		6			
Strontium								
V. Sediment/Soil								
Gamma					12	4		
VI. Vegetation								
Gamma								
Total Number in Range	162	23	9	7	56	10	2	2
% of Total Processed	80	11	4	3	80	14	3	3
Sum of Analyses	201				70			

(1) Percent Bias Criteria by Bias Category
Bias Category = 1 > 0% and < = 5%
Bias Category = 2 > 5% and < = 10%
Bias Category = 3 > 10% and < = 15%
Gross alpha, Sr89/90 > 10% and < = 25%
Transuranics > 10% and < = 20%
Bias Category = 4 Outside Criteria

(2) Percent Precision Criteria by Precision Category
Precision Category = 1 > 0% and < = 5%
Precision Category = 2 > 5% and < = 10%
Precision Category = 3 > 10% and < = 15%
Gross alpha, Sr89/90 > 10% and < = 25%
Transuranics > 10% and < = 20%
Precision Category = 4 Outside Criteria

TABLE 7.2
DESEL RESULTS IN THE EPA PERFORMANCE EVALUATION PROGRAM
Quarter 4, 1998

Nuclide	Media	Reference Date	DESL Mean	Lower Control Limit *	Upper Control Limit *
Co-60	Water	10/20/1998	20.9	12.3	29.7
Cs-134	Water	10/20/1998	4.3	0.0	14.7
Cs-137	Water	10/20/1998	49.9	41.3	58.7
Natural U	Water	10/20/1998	13.8	12.9	23.3
Ra-226	Water	10/20/1998	4.6	3.3	5.7
Ra-228	Water	10/20/1998	1.3	0.8	2.2
Sr-89	Water	10/20/1998	18.1	10.3	27.7
Sr-90	Water	10/20/1998	7.3	0.0	16.7
Co-60	Water	11/06/1998	36.8	29.3	46.7
Ba-133	Water	11/06/1998	53.2	45.6	66.4
Cs-134	Water	11/06/1998	102.8	96.3	113.7
Cs-137	Water	11/06/1998	111.2	100.6	121.4
Zn-65	Water	11/06/1998	131.3	108.4	153.6

*** Units in pCi/Liter**

TABLE 7.3
DESEL RESULTS IN THE ANALYTICS INC. CROSS CHECK PROGRAM
Quarter 4, 1998 - Quarter 3, 1999

Sample	Quarter Year	Sample Media	Nuclide	Reported Value *	Known Value *	Ratio DESEL/ Analytics	Evaluation
E1606-162	4th/98	Filter	Sr-89	193	210	0.96	Agreement
			Sr-90	63.5	64	0.99	Agreement
E1607-162	4th/98	Filter	Gross alpha	45	49	0.92	Agreement
			Gross beta	76	69	1.10	Agreement
E1608-162	4th/98	Water	H-3	5947	5980	0.99	Agreement
E1609-162	4th/98	Milk	I-131LL	59	71	0.83	Non-agreement
			I-131	77	71	1.08	Agreement
			Ce-141	750	746	1.01	Agreement
			Cr-51	1006	979	1.03	Agreement
			Cs-134	217	220	0.99	Agreement
			Cs-137	186	183	1.02	Agreement
			Mn-54	148	142	1.04	Agreement
			Fe-59	161	148	1.09	Agreement
			Zn-65	157	140	1.12	Agreement
			Co-60	175	178	0.98	Agreement
E1677-162	1st/99	Water	I-131LL	89	91	0.98	Agreement
			I-131	93	91	1.02	Agreement
			Ce-141	173	177	0.98	Agreement
			Cr-51	390	398	0.98	Agreement
			Cs-134	109	114	0.96	Agreement
			Cs-137	240	240	1.00	Agreement
			Mn-54	157	152	1.03	Agreement
			Fe-59	80	79	1.01	Agreement
			Zn-65	190	195	0.97	Agreement
			Co-60	178	181	0.98	Agreement
E1678-162	1st/99	Water	Gross alpha	37	51	0.73	Non-agreement
			Gross beta	180	201	0.90	Agreement
E1679-162	1st/99	Water	U-234	43	39	1.10	Agreement
			U-235	2	2	1.00	Agreement
			U-238	45	41	1.10	Agreement
			Pu-238	53	54	0.98	Agreement
			Pu-239	30	29	1.03	Agreement
			Ra-226	74	58	1.28	Non-agreement
			Ra-228	36	36	1.00	Agreement

*** Units in pCi/Liter**

TABLE 7.3
DESEL RESULTS IN THE ANALYTICS INC. CROSS CHECK PROGRAM
Quarter 4, 1998 - Quarter 3, 1999

Sample	Quarter Year	Sample Media	Nuclide	Reported Value *	Known Value *	Ratio DESEL/ Analytics	Evaluation
E1680-162	1st/99	Milk	I-131LL	99	96	1.03	Agreement
			I-131	89	96	0.93	Agreement
			Ce-141	142	136	1.04	Agreement
			Cr-51	314	306	1.03	Agreement
			Cs-134	83	88	0.94	Agreement
			Cs-137	185	185	1.00	Agreement
			Mn-54	123	117	1.05	Agreement
			Fe-59	61	61	1.00	Agreement
			Zn-65	157	150	1.05	Agreement
			Co-60	139	139	1.00	Agreement
E1681-162	1st/99	Milk	Sr-89	68	70	0.97	Agreement
			Sr-90	44	43	1.02	Agreement
E1773-162	2nd/99	Filter	Alpha	71	68	1.04	Agreement
			Beta	218	221	1.00	Agreement
E1775-162	2nd / 99	Milk	Ce-141	163	168	0.97	Agreement
			Cr-51	194	215	0.90	Agreement
			Cs-134	111	115	0.96	Agreement
			Cs-137	189	188	1.00	Agreement
			Mn-54	85	85	1.00	Agreement
			Fe-59	46	48	0.96	Agreement
			Zn-65	119	122	0.98	Agreement
			Co-60	205	214	0.96	Agreement
			I-131	85	72	1.18**	Agreement
			I-131LL	83	72	1.15	Agreement
E1771-162	2nd / 99	Filter	Ce-141	155	161	0.96	Agreement
			Cr-51	203	206	0.98	Agreement
			Cs-134	101	110	0.92	Agreement
			Cs-137	192	180	1.06	Agreement
			Mn-54	88	81	1.08	Agreement
			Fe-59	50	46	1.09	Agreement
			Zn-65	122	117	1.04	Agreement
			Co-60	192	205	1.94	Agreement
E1772-162	2nd/99	Filter	Sr-89	177	176	1.00	Agreement
			Sr-90	54	54	1.00	Agreement

***Units in pCi/Liter**
**** Meets 2 sigma range criteria for agreement**

TABLE 7.3
DESEL RESULTS IN THE ANALYTICS INC. CROSS CHECK PROGRAM
Quarter 4, 1998 - Quarter 3, 1999

Sample	Quarter Year	Sample Media	Nuclide	Reported Value *	Known Value *	Ratio DESEL/ Analytics	Evaluation
E1875-162	3rd/99	Water	Alpha	44	51	0.85	Agreement
			Beta	247	271	0.91	Agreement
E1874-162	3rd/99	Water	Ce-141	247	244	1.01	Agreement
			Cr-51	189	184	1.03	Agreement
			I-131	81	77	1.05	Agreement
			Cs-134	114	119	0.95	Agreement
			Cs-137	281	268	1.05	Agreement
			Mn-54	218	210	1.04	Agreement
			Fe-59	96	94	1.02	Agreement
			Zn-65	203	202	1.01	Agreement
			Co-60	160	159	1.01	Agreement
			I-131LL	77	77	1.00	Agreement
E1876-162	3rd/ 99	Water	Sr-89	75	77	0.98	Agreement
			Sr-90	37	38	0.96	Agreement
E1877-162	3rd/99	Milk	Ce-141	194	197	0.99	Agreement
			Cr-51	154	149	1.03	Agreement
			I-131	90	91	0.99	Agreement
			I-131LL	98	91	1.08	Agreement
			Cs-134	87	96	0.90	Agreement
			Cs-137	217	217	1.00	Agreement
			Mn-54	169	170	0.99	Agreement
			Fe-59	74	76	0.97	Agreement
			Zn-65	160	164	0.97	Agreement
			Co-60	132	129	1.02	Agreement
E1878-162	3rd/99	Milk	Sr-89	46	48	0.95	Agreement
			Sr-90	80	80	1.00	Agreement

Bias Acceptance Criteria ± 15%, or as noted below:
Gross alpha, Sr89/90 ± 25%
Transuranics and Radium ± 20% or,
If known value falls within 2 sigma range acceptance criteria is met

Precision Acceptance Criteria ± 15%, or as noted below:
Gross alpha, Sr89/90 ± 25%
Transuranics and Radium ± 20%

TABLE 7.4
SUMMARY OF BLIND DUPLICATE SAMPLES SUBMITTED TO THE DESEL
January - December 1999

TYPE OF SAMPLE	NUMBER OF PAIRED SAMPLES SUBMITTED
Cow Milk	26
Ground Water	8
Surface Water	14
Irish Moss	2
Mussels	4
Food Product - Cranberries	1
TOTAL	55

8. LAND USE CENSUS

A Land Use Census is conducted annually between the dates of June 1 and October 1 to identify the locations of the nearest milk animal, the nearest residence, and the nearest garden of greater than 500 square feet producing fresh leafy vegetables in each of the 16 meteorological sectors within a distance of five miles of the plant.

Immediately following the collection of field data, in compliance with ODCM Control 4.2, a dosimetric analysis is performed to compare the census locations to the "Critical Receptor" identified in the ODCM. This Critical Receptor is the location that is used in the conservative Method 1 dose calculations found in the ODCM (i.e. the dose calculations done in compliance with ODCM Surveillance Requirement 3.4). If a Census location has a 20% greater potential dose than that of the Critical Receptor, this fact must be announced in the Semiannual Effluent Release Report for that period. A re-evaluation of which location to use as a Critical Receptor would also be done at that time. For the 1999 Census, no such location was identified.

Pursuant to ODCM Control 4.2, a dosimetric analysis is then performed, using site specific meteorological data, to determine which milk and food product census locations would provide the optimal sampling locations. If any location has a 20% greater potential dose commitment than at a currently-sampled location, the new location is added to the routine environmental sampling program in replacement of the location with the lowest calculated dose (which is later eliminated from the program). For the 1999 Census, no such garden location was identified, and consequently no changes were mandated for the food product sampling program. Also, there were no milk animal locations that could provide milk samples for the REMP identified in the 1999 census.

The Land Use Census was carried out and completed between the dates of June 1 and October 1, as required. The results of the 1999 Land Use Census are included in this report in compliance with ODCM Surveillance Requirement 4.2. The locations identified during the Census may be found in Table 8.1. Note that a recommendation was made to revise ODCM Table 4.4 to reflect the proper distance and sector for TF-11 (the Passardi garden on River Road in Monroe Bridge, MA). Current listing in the ODCM is 1.30 km SW and actual is 2.00 km WSW. This arose from a discrepancy between the plant's transmitted Land Use Census information and ODCM Table 4.4.

TABLE 8.1
1999 LAND USE CENSUS LOCATIONS

SECTOR	NEAREST RESIDENCE Km (Mi)	NEAREST GARDEN Km (Mi)	NEAREST MILK ANIMAL Km (Mi)
N	4.4 (2.8)	6.1 (3.8)	*
NNE	4.3 (2.7)**	4.7 (2.9)	*
NE	3.2 (2.0)	3.2 (2.0)	*
ENE	3.9 (2.4)	5.8 (3.6)	*
E	3.0 (1.9)	3.4 (2.1)	*
ESE	3.4 (2.1)**	3.4 (2.1)**	*
SE	2.3 (1.4)	3.5 (2.2)	*
SSE	2.1 (1.3)	3.0 (1.9)**	*
S	2.3 (1.4)	2.9 (1.8)	*
SSW	*	*	*
SW	1.3 (0.8)	7.2 (4.5)**	*
WSW	1.3 (0.8)	2.0 (1.2)	*
W	1.9 (1.2)	2.7 (1.7)	*
WNW	1.9 (1.2)	1.9 (1.2)	*
NW	2.4 (1.5)	2.4 (1.5)	*
NNW	2.9 (1.8)	3.9 (2.4)	*

* No location was identified within 5 miles of the plant.

** New location in 1999

9. SUMMARY

During 1999, as in all previous years since 1958, an environmental monitoring program was conducted to assess the levels of radiation or radioactivity in the Yankee Nuclear Power Station environment. Over 400 samples were collected (including TLDs) over the course of the year, with a total of over 2,000 radionuclide or exposure rate analyses being performed on them. The samples included ground water, river water, storm drain water, sediment, fish, locally grown food products, mixed vegetation, maple syrup and milk. In addition to these samples, the air surrounding the plant was sampled continuously and the radiation levels were measured continuously with environmental TLDs.

Low levels of radioactivity from three sources (described below) were detected. Most samples had measurable levels of naturally-occurring K-40, Be-7, Th-232 or radon daughter products. Many samples (milk, sediment and maple syrup) had fallout radioactivity from atmospheric nuclear weapons tests conducted primarily from the late 1950's through 1980. Several samples contained detectable levels of Cs-137. Although much of the Cs-137 in these samples is due to global nuclear weapons testing fallout, some of the Cs-137 is likely due to effluents released from previous monitored plant discharges. One sample contained a detectable level of Co-60 from previous emissions from YNPS. These were all collected in the immediate vicinity of the plant or from on-site locations. No other plant related radionuclides were detected in the 1999 REMP sampling program. In all cases, the possible radiological impact was negligible with respect to exposure from natural background radiation. In no case did the detected levels approach or exceed the most restrictive federal regulatory or plant license limits for radionuclides in the environment.

10. REFERENCES

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3. Ionizing Radiation: Sources and Biological Effects, United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), 1982 Report to the General Assembly.

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5. Letter, "Issuance of Amendment No. 146 to Facility Possession Only License No. DPR-3-Yankee Nuclear Power Station," M. Fairtile, NRC to J. Grant, Yankee Atomic Electric Company, dated November 5, 1992.

6. NRC Generic Letter 89-01, Subject: Implementation of Programmatic Controls for Radiological Effluent Technical Specifications in the Administrative Controls Section of the Technical Specifications and the Relocation of Procedural Details of RETS to the Offsite Dose Calculation Manual or to the Process Control Program. Dated January 31, 1989.