AmerGen Energy Company, LLC
Three Mile Island Unit 1
Route 441 South, P.O. Box 480
Middletown, PA 17057

Telephone: 717-944-7621

AmerGen SM

An Exelon/British Energy Company

April 17, 2002
5928-02-20107

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

THREE MILE ISLAND NUCLEAR STATION
UNITS 1 AND 2 (TMI-1 & TMI-2)
OPERATING LICENSE NO. DPR-50 AND POSSESSION ONLY LICENSE NO. DPR-73
DOCKET NOS. 50-289 AND 50-320

SUBJECT: 2001 RADIOLOGICAL ENVIRONMENTAL MONITORING REPORT

In accordance with TMI-1 Technical Specification 6.9.3.1 and TMI-2 Technical Specification 6.8.1.1, enclosed is the 2001 Radiological Environmental Monitoring Report for the Three Mile Island Nuclear Station.

Please contact Adam Miller of TMI-1 Regulatory Assurance at (717) 948-8128 if you have any questions regarding this submittal.

Sincerely,

George H. Gellrich
Plant Manager

GHG/awm

Enclosure

cc: Region I Administrator
TMI-1 Senior Project Manager
TMI-2 Project Manager
TMI Senior Resident Inspector
GPU Nuclear TMI-2 Cognizant Officer
File 02011

IE25

Radiological Environmental Monitoring Report 2001

Prepared by
Three Mile Island
Rad, Health & Safety

AmerGen SM
An Exelon/British Energy Company

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS, SYMBOLS AND ACRONYMS

ABBREVIATIONS

cubic feet per second	cfs
cubic meter(s)	m^3
curie(s)	Ci
curie(s) per year	Ci/yr
east	E
east-northeast	ENE
east-southeast	ESE
gram(s)	g
hour(s)	h
liter(s)	L
meter(s)	m
microroentgen(s) per hour	µR/h
mile per hour	mph
millirem(s)	mrem
millirem(s) per hour	mrem/h
millirem(s) per standard month	mrem/std month
millirem(s) per year	mrem/yr
milliroentgen(s)	mR
milliroentgen(s) per hour	mR/h
milliroentgen(s) per standard month	mR/std month
north	N
northeast	NE
northwest	NW
north-northeast	NNE
north-northwest	NNW
percent	%
picocurie(s)	pCi
picocurie(s) per cubic meter	pCi/m^3
picocurie(s) per gram	pCi/g
picocurie(s) per liter	pCi/L
reference(s)	Ref. (Refs.)
rem(s) per year	rem/yr
Roentgen(s)	R
Roentgen(s) equivalent man	rem
south	S
southeast	SE
southwest	SW
south-southeast	SSE
south-southwest	SSW
standard deviation	std dev
standard month	std month
west	W
west-northwest	WNW
west-southwest	WSW
year(s)	yr

ELEMENT SYMBOLS

actinium	Ac
americium	Am
antimony	Sb
argon	Ar
barium	Ba
beryllium	Be
carbon	C
cesium	Cs
chromium	Cr
cobalt	Co
curium	Cm
hydrogen (tritium)	H-3
iodine	I
iron	Fe
krypton	Kr
lanthanum	La
manganese	Mn
niobium	Nb
nitrogen	N
oxygen	O
plutonium	Pu
potassium	K
radium	Ra
radon	Rn
silver	Ag
strontium	Sr
thorium	Th
tritiated water vapor	HTO
uranium	U
xenon	Xe
zinc	Zn
zirconium	Zr

ACRONYMS

aboveground tank monitoring program ..... ATMP
accident generated water ..... AGW
AmerGen Energy Company, LLC ..... AmerGen
American National Standards Institute ..... ANSI
annual land use census ..... ALUC
as low as reasonably achievable ..... ALARA
biological effects of atomic radiation ..... BEAR
biological effects of ionizing radiation ..... BEIR
borated water storage tank ..... BWST
building 48 ..... 48S
Department of Energy ..... DOE
east dike catch basin ..... EDCB
Environmental Measurement Laboratory ..... EML
Environmental Radioactivity Laboratory ..... ERL
Federal Radiation Council ..... FRC
final safety analysis report ..... FSAR
GPU Inc. ..... GPU
groundwater monitoring program ..... GMP
high efficiency particulate air ..... HEPA
International Committee on Radiation Protection ..... ICRP
lower limit of detection ..... LLD
maximum permissible concentration ..... MPC
mean sea level ..... msl
Milton Hershey School ..... MHS
minimum detectable concentration ..... MDC
National Academy of Sciences ..... NAS
National Council on Radiation Protection and Measurements ..... NCRP
National Institute of Standards and Technology ..... NIST
National Voluntary Laboratory Accreditation Program ..... NVLAP
offsite dose calculation manual ..... ODCM
operations support facility ..... OSF
Pennsylvania State Bureau of Radiation Protection ..... PaBRP
Post Defueling Monitored Storage ..... PDMS
pressurized water reactor ..... PWR
quality assurance ..... QA
quality control ..... QC
radiological environmental monitoring program ..... REMP
Red Hill Dam ..... RHD
Safe Harbor Dam ..... SHD
simplified environmental effluent dosimetry system ..... SEEDS
Teledyne Brown Engineering ..... TBE
thermoluminescent dosimeter ..... TLD
Three Mile Island ..... TMI
Three Mile Island Environmental Affairs ..... TMIEA
Three Mile Island Nuclear Station ..... TMINS
Three Mile Island - Unit 1 ..... TMI-1
Three Mile Island - Unit 2 ..... TMI-2
Title 10 of the Code of Federal Regulations, Part 20 ..... 10 CFR 20
Title 10 of the Code of Federal Regulations, Part 50, Appendix I ..... 10 CFR 50 App. I
Title 40 of the Code of Federal Regulations, Part 190 ..... 40 CFR 190
United Nations Scientific Committee on the Effects of Atomic Radiation ..... UNSCEAR
United States Environmental Protection Agency ..... USEPA
United States Nuclear Regulatory Commission ..... USNRC
York Haven Generating Station ..... YHGS
York Haven Dam ..... YHD
York Haven Pond ..... YHP

SUMMARY AND CONCLUSIONS

The radiological environmental monitoring performed in 2001 by AmerGen for the Three Mile Island Nuclear Station (TMINS) is discussed in this report. The environmental sample results and the doses calculated from measured effluents indicated that TMINS operations in 2001 had no adverse effect on the health of the public or the environment.

The operation of a nuclear power station results in the release of small amounts of radioactive materials to the environment. A radiological environmental monitoring program (REMP) has been established to monitor radiation and radioactive materials in the environment around TMINS. The results of environmental measurements are used to assess the impact of TMINS operations, to demonstrate compliance with the TMI-1 and TMI-2 Technical Specifications (Refs. 1 and 2) and applicable Federal and State regulations, and to verify the adequacy of containment and radioactive effluent control systems. The program also evaluates the estimated radiation doses to individuals due to radioactive effluents.

Summaries and interpretations of the data are published annually in the Radiological Environmental Monitoring Report. Previous reports in this series are referenced at the end of the report (Refs. 3 through 30 and 41). Additional information concerning releases of radioactive materials to the environment is contained in the Radiological Effluent Release Reports. These reports are submitted annually to the United States Nuclear Regulatory Commission (USNRC).

Many of the radioactive materials discussed in this report are typically present in the environment, either from natural processes or as a result of non-TMINS activities such as past atmospheric nuclear weapon tests and medical industry activities. To determine the impact of TMINS operations, if any, on the environment and the public, results from samples collected close to TMINS (indicator stations) are compared to results from samples obtained at distant sites (control or background stations). Comparisons with historical data also are performed, as appropriate.

During 2001, samples of air, surface, effluent, drinking and storm water, sediments, fruits, vegetables, grains, fish, groundwater and milk were collected. Direct radiation exposures also were measured in the vicinity of TMINS. Samples were analyzed for gross beta radioactivity, tritium (H-3), strontium-89 (Sr-89) and strontium-90 (Sr-90), iodine-131 (I-131) and/or gamma-emitting radionuclides. The results are discussed in the various sections of this report. Additionally, radiological impacts in terms of radiation dose as a result of TMINS radioactive releases were calculated and are discussed in this report **(Radiological Impact of TMINS Operations)**.

The results provided in this report are summarized in the following highlights:

- In 2001, 1059 samples were collected from the aquatic, atmospheric and terrestrial environments around TMINS. There were 1291 analyses performed on these samples. Also, 2160 radiation exposure measurements were taken using thermoluminescent dosimeters (TLDs). Finally, 93 groundwater samples were collected and 117 analyses were performed on these samples. The monitoring performed in 2001 met or exceeded the sample collection and analysis requirements of the TMI-1 and TMI-2 Technical Specifications.

- In addition to natural radioactivity, low concentrations of radionuclides such as H-3, Sr-90, cesium-137 (Cs-137) and I-131 were detected in some media and were attributed to either fallout from prior nuclear weapon tests, the medical industry or TMINS operations.

- As a result of routine TMINS operations, the raw surface water collected downstream of the TMINS liquid discharge outfall occasionally had H-3 concentrations greater than those detected in control samples. This was expected because H-3 was released in liquid effluents and the samples were collected at a location where mixing of liquid effluents with Susquehanna River water was incomplete. All but one of the measured concentrations were below the

United States Environmental Protection Agency's (USEPA) Primary Drinking Water Standard of 20,000 picocuries per liter (pCi/L). The exception was biased as a result of using semiweekly grab samples (rather than hourly aliquots) to represent the collection period.

- Several indicator drinking water samples contained H-3 at concentrations above those detected in control samples. A portion of the H-3 measured in the indicator samples was attributed to routine operations at TMINS. The measured concentrations were a small fraction of the USEPA Primary Drinking Water Standard.

- Low concentrations of TMINS-related Cs-137 were detected in aquatic sediments collected proximal to or just downstream of the TMINS liquid discharge outfall. During 2001, as well as in previous years, this material was routinely released in TMINS liquid effluents. Additionally, Cs-137 is readily adsorbed by suspended particles in the water column and bottom sediments. Since Cs-137 also was detected in the control samples, a portion of the Cs-137 measured in the indicator samples was attributed to fallout from prior nuclear weapon tests.

- Groundwater samples collected from the onsite monitoring wells and the industrial wells contained H-3 above ambient concentrations as a result of current operations at TMI-1 and/or various non-routine TMI-1 and TMI-2 events. All H-3 concentrations detected in onsite groundwater were below the effluent concentration specified in USNRC 10 CFR 20 (Appendix B, Table 2).

- Tritium was detected in onsite groundwater used for drinking. The presence of H-3 in these samples was attributed to current or past TMI-1 operations and possibly past TMI-2 operations. All of the H-3 concentrations measured in onsite drinking water were a small fraction of the USEPA Primary Drinking Water Standard.

- Gamma radiation exposure rates recorded at the offsite indicator TLD stations averaged 61 milliroentgens per year (mR/yr). Offsite controls were similar, averaging 66 mR/yr. The exposure rates were consistent with those presented by the National Council on Radiation Protection and Measurements (Ref. 31). No significant increase in ambient gamma radiation levels was detected.

- During 2001, small amounts of radioactive materials were released in TMI-1 and TMI-2 liquid and gaseous effluents. Release amounts were minimized due to good fuel integrity, minimal leakage in the steam generators and improved efficiency of the waste processing systems.

- The calculated doses to the public from TMINS operations in 2001 were well below all applicable regulatory limits and significantly less than doses received from other common sources of radiation. The maximum hypothetical whole body dose received by an individual from 2001

TMI-1 and TMI-2 liquid and airborne effluents combined was conservatively calculated to be 0.2 mrem. This dose is equivalent to 0.07 percent of the dose that an individual living in the TMI area receives each year from natural background radiation.

- The maximum hypothetical whole body dose to the surrounding population from all 2001 liquid and airborne effluents was calculated to be 11 person-rem. This dose is equivalent to 0.002 percent of the dose that the total population living within 50 miles of TMI receives each year from natural background radiation.

In conclusion, radioactive materials related to TMINS operations were detected in environmental samples, but the measured concentrations were low and consistent with measured effluents. The environmental sample results verified that the doses received by the public from TMINS effluents in 2001 were well below applicable dose limits and only a small fraction of the doses received from natural background radiation. Additionally, the results indicated that there was no permanent buildup of radioactive materials in the environment and no significant increase in background radiation levels.

Therefore, based on the results of the radiological environmental monitoring program (REMP) and the doses calculated from measured effluents, TMINS operations in 2001 did not have any adverse effects on the health of the public or on the environment.

RADIOLOGICAL ENVIRONMENTAL MONITORING

Three Mile Island (TMI) is located about 2.5 miles south of Middletown in Londonderry Township, Dauphin County, Pennsylvania. Approximately 2.1 miles long and 0.3 miles wide, TMI is one of the largest of a group of several islands in the Susquehanna River. Three Mile Island Nuclear Station (TMINS) is situated on the northern one-half of TMI. The station consists of two pressurized water reactors (PWR), TMI-1 and TMI-2. Only TMI-1 is an operating reactor. The TMI-2 reactor was shut down in 1979. At the end of 1993, TMI-2 was placed in a condition called Post-Defueling Monitored Storage (PDMS). Both reactors are expected to be decommissioned when TMI-1 ceases operations.

Comprehensive radiological environmental monitoring is conducted by AmerGen at TMINS to measure levels of radiation and radioactive materials in the environment. The information obtained from the radiological environmental monitoring program (REMP) is then used to determine the effect of TMINS operations, if any, on the environment and the public.

The USNRC has established regulatory guides which contain acceptable monitoring practices. The TMINS REMP was designed on the basis of these regulatory guides along with the guidance provided by the USNRC Radiological Assessment Branch Technical Position for an acceptable radiological environmental monitoring program (Ref. 32). The TMINS REMP meets or exceeds the monitoring requirements set forth by the USNRC.

The important objectives of the REMP are:

- To assess dose impacts to the public from TMINS operations.
- To verify inplant controls for the containment of radioactive materials.
- To determine buildup of long-lived radionuclides in the environment and changes in background radiation levels.
- To provide reassurance to the public that the program is capable of adequately assessing impacts and identifying noteworthy changes in the radiological status of the environment.
- To fulfill the requirements of the TMI-1 and TMI-2 Technical Specifications.

Environmental Exposure Pathways to Humans from Airborne and Liquid Effluents

Small amounts of radioactive materials are released to the environment as a result of operating a commercial nuclear power station. Once released, these materials move through the environment in a variety of ways and may eventually reach humans via breathing, drinking, eating and direct exposure. These routes of exposure are referred to as environmental exposure pathways. Figure 13 illustrates the important exposure pathways. As can be seen from this figure, these exposure pathways are both numerous and varied. While some pathways are relatively simple, such as inhalation of airborne radioactive materials, others may be complex. For example, radioactive airborne particulates may deposit on grass and when eaten by cows may be transferred into milk. The milk may then be consumed by humans. This route of exposure is referred to as the air-grass-cow-milk-human pathway.

Although radionuclides can reach humans by a number of pathways, some are more important than others. The critical pathway for a given radionuclide is the one that produces the greatest dose to a population, or to a specific segment of the population. This segment of the population is called the critical group, and may be defined by age, diet, or other cultural factors. The dose may be delivered to the whole body or confined to a specific organ. The organ receiving the greatest fraction of the dose is called the critical organ. This information was used to develop the TMINS REMP.

Sampling

The TMINS REMP consists of two phases -- the preoperational and the operational. Data gathered in the preoperational phase is used as a basis for evaluating radiation levels and radioactivity in the vicinity of the plant after the plant becomes operational. The

operational phase began in 1974 at the time TMI-1 became operational.

The program consists of taking radiation measurements and collecting samples from the environment, analyzing them for radioactivity content, and then interpreting the results. With emphasis on the critical exposure pathways to humans, samples from the aquatic, atmospheric, and terrestrial environments are collected. These samples include, but are not limited to, air, water, sediment, fish, milk, fruits, vegetables and groundwater. Thermoluminescent dosimeters (TLDs) are placed in the environment to measure gamma radiation levels.

The Offsite Dose Calculation Manual, ODCM, (Ref. 33) implements the TMI-1 and TMI-2 Technical Specifications and defines the sample types to be collected and the analyses to be performed. As appropriate, changes to the REMP are initiated by recommendations from staff scientists. However, the minimum sampling and analysis requirements specified in the ODCM are maintained.

Sampling locations were established by considering topography, meteorology, population distribution, hydrology, areas of public interest and land use characteristics of the local area. The sampling locations are divided into two classes, indicator and control. Indicator locations are those that are expected to show effects from TMINS operations, if any exist. These locations were selected primarily on the basis of where the highest predicted environmental concentrations would occur. The indicator locations are typically downstream or within a few miles of TMINS. Control stations are located generally upstream or at distances greater than 10 miles from TMINS. The samples collected at these sites are expected to be unaffected by TMINS operations. Data from control locations provide a basis for evaluating indicator data relative to natural background radioactivity and fallout from prior nuclear weapon tests.

Figures 1, 2 and 3 show the current sampling locations around TMI. Table A-1 in Appendix A describes the sampling locations by distance and azimuth along with the type(s) of samples collected at each sampling location.

Analysis

In addition to specifying the media to be collected and the number of sampling locations, the ODCM also specifies the frequency of sample collection and the types and frequency of analyses to be performed. Also specified are analytical sensitivities (detection limits) and reporting levels. Table A-2 in Appendix A provides a synopsis of the sample types, number of sampling locations, collection frequencies, number of samples collected, types and frequencies of analyses, and number of samples analyzed. Table A-3 in Appendix A lists samples which were not collected or analyzed per the requirements of the ODCM. Sample analyses which did not meet the required analytical sensitivities are presented in Appendix B. Changes in sample collection and analysis are described in Appendix C.

Measurement of low radionuclide concentrations in environmental media requires special analysis techniques.

Analytical laboratories use state-of-the-art laboratory equipment designed to detect all three types of radiation emitted (alpha, beta, and gamma). This equipment must meet the analytical sensitivities required by the ODCM. Examples of the specialized laboratory equipment used are germanium detectors with multichannel analyzers for determining specific gamma-emitting radionuclides, liquid scintillation counters for detecting H-3 and low level proportional counters for detecting gross beta radioactivity.

Calibrations of the counting equipment are performed by using standards traceable to the National Institute of Standards and Technology (NIST). Computer hardware and software used in conjunction with the counting equipment perform calculations and provide data management.

Data Review

The analytical results are routinely reviewed by a staff scientist to assure that sensitivities have been achieved and that the proper analyses have been performed. Investigations are conducted when action levels or USNRC reporting levels are reached or when anomalous values are discovered. The action levels were established by staff scientists and are typically 10 percent of the USNRC reporting levels specified in the ODCM. These levels are purposely set low so that corrective action can be initiated before a USNRC reporting level is reached.

Table 1 provides a summary of radionuclide concentrations detected in the environmental samples analyzed by the primary (main) laboratory. Statistical methods used to derive this table along with other statistical conclusions are detailed in Appendix F. The sample results from the quality control (QC) laboratory were used mainly to verify the sample results reported by the primary laboratories. Therefore, the QC results were excluded from Table 1 and the main text of this report to avoid biasing the results.

Quality Assurance Program

A quality assurance (QA) program is conducted in accordance with guidelines provided in Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs" (Ref. 34) and as required by the Technical Specifications. It is documented by written policies, procedures, and records. These documents encompass all aspects of the REMP including sample collection, equipment calibration, laboratory analysis and data review.

The QA program is designed to identify possible deficiencies so that corrective action can be taken. It also provides a measure of confidence in the results of the monitoring program in order to assure the regulatory agencies and the public that the results are valid. The QA program for the measurement of radioactivity in environmental samples is implemented by:

- Auditing all REMP-related activities including analytical laboratories.
- Requiring analytical laboratories to participate in a cross check program(s).
- Requiring analytical laboratories to split samples for separate analysis (recounts are performed when samples cannot be split).

- Splitting samples, having the samples analyzed by independent laboratories, and then comparing the results for agreement.

- Reviewing QC results of the analytical laboratories including spike and blank sample results and duplicate analysis results.

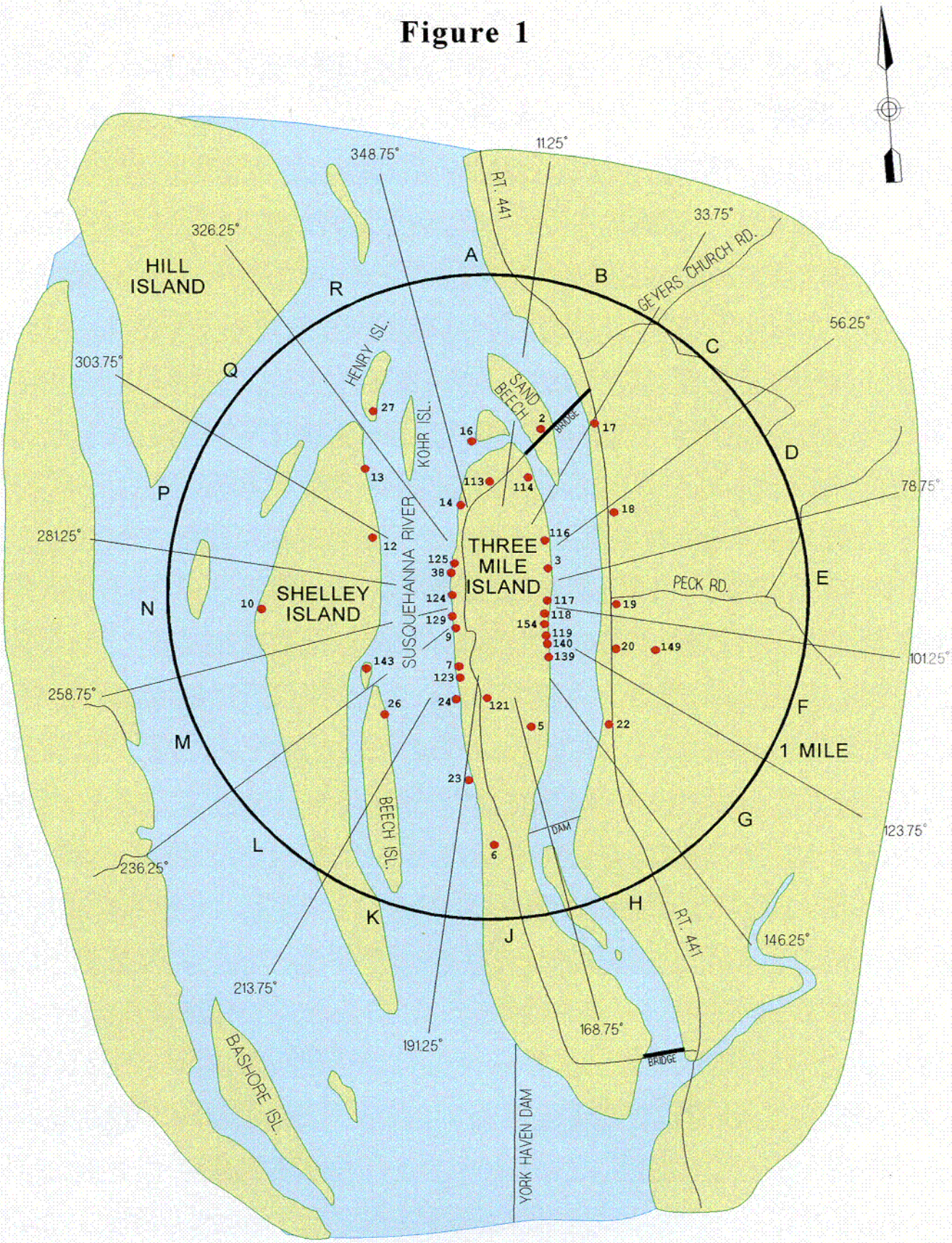
The cross-check program results for the primary laboratories are outlined in Appendix D.

The TLD readers are calibrated on a routine basis against recognized standards. Also, control TLDs are processed with each group of TLDs. The accuracy and variability of the control TLD results are examined to assure the reader is functioning properly. In addition, each element (TLD) has an individual correction factor based on its response to a known exposure. Other cross checks, calibrations, and certifications are in-place to assure the accuracy of the TLD program. The environmental dosimeters were tested and qualified to the American National Standard Institutes (ANSI) publication N545-1975 and the USNRC Regulatory Guide 4.13 (Refs. 35 and 36). The results for some of these tests were published in the Health Physics Journal (Ref. 37).

In addition to the TMINS REMP, the Pennsylvania State Bureau of Radiation Protection (PáBRP) also maintains a surveillance program in the TMI area. This program provides an independent assessment of radioactive releases and the radiological impact on the surrounding environment. The results from this program have compared favorably with those from the TMINS program.

Samples of the TMINS liquid discharge are collected and analyzed as a QC check for the inplant effluent monitoring program. For 2001, the results obtained by the REMP were consistent with those reported for the inplant effluent monitoring program.

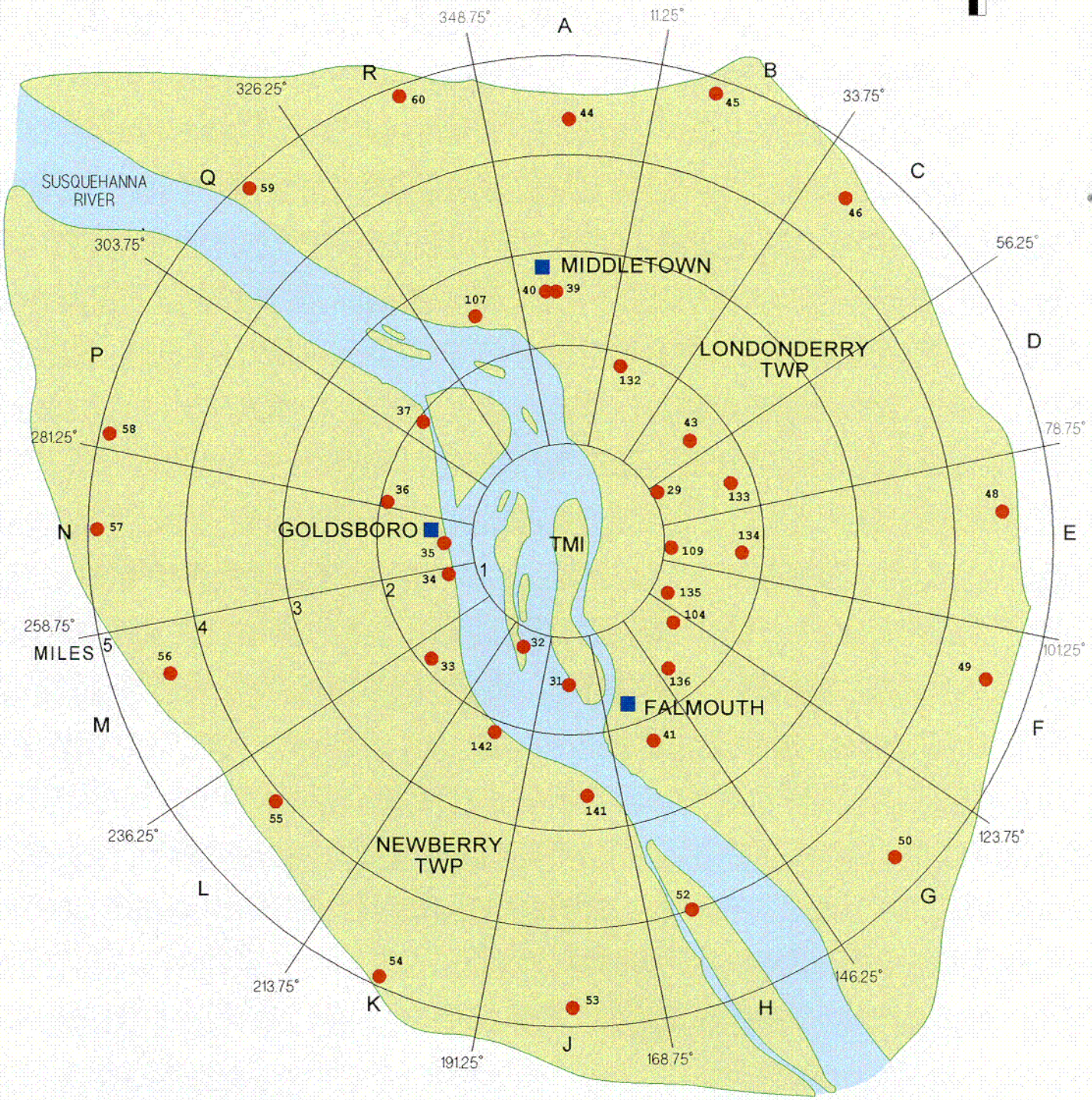
Figure 1



Locations of REMP Stations Within 1 Mile of TMINS

C01

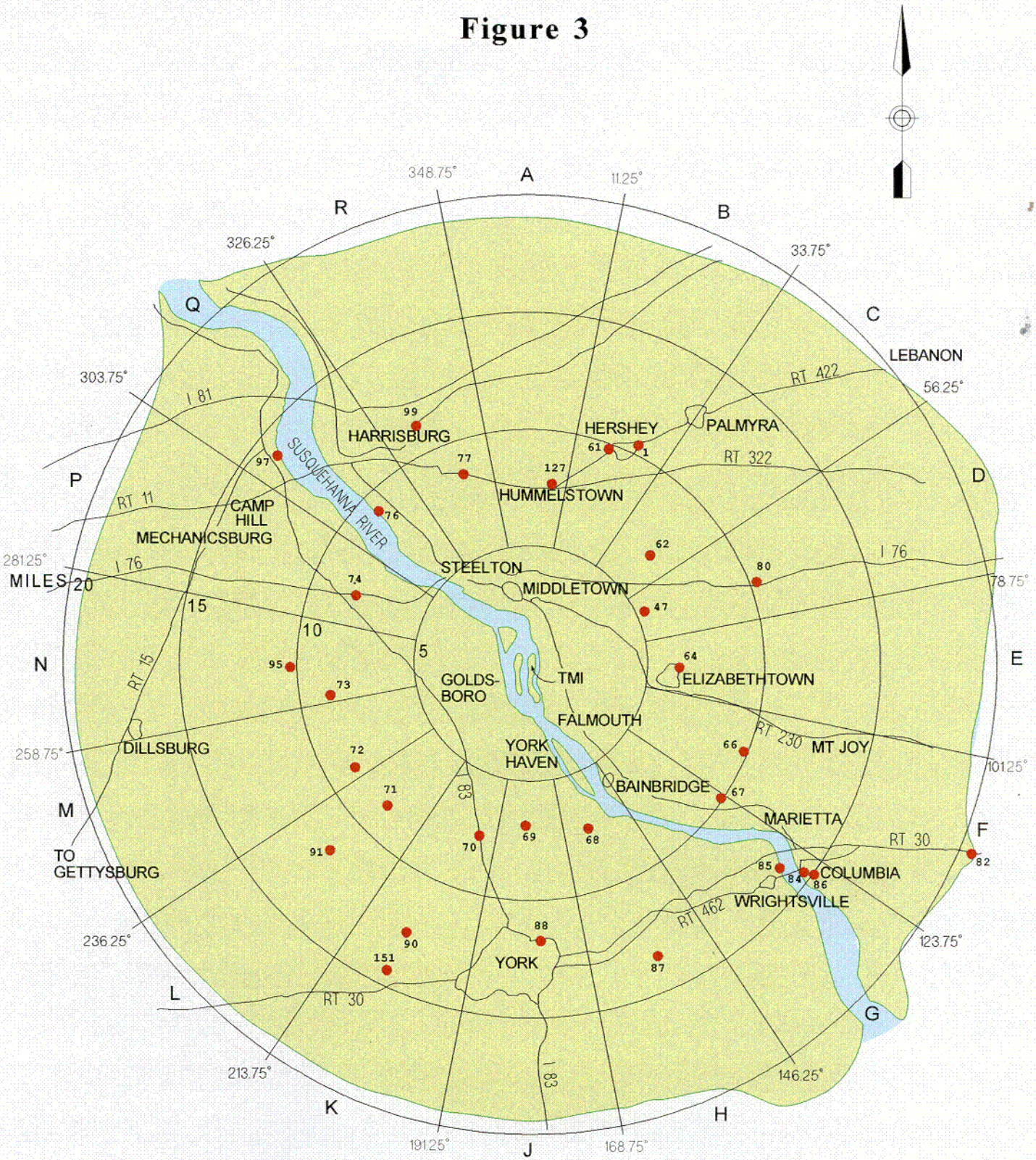
Figure 2



Locations of REMP Stations
1 to 5 Miles from TMINS

C02

Figure 3



Locations of REMP Stations Greater Than 5 Miles From TMINS

C03

2001
RADIOLOGICAL ENVIRONMENTAL MONITORING REPORT

TABLE 1
Summary of Radionuclide Concentrations in 2001 Environmental Samples
Three Mile Island Nuclear Station[1]

Media or Pathway Sampled (Unit of Measurement)	Analyses	Total Number of Analyses Performed[2]	Lower Limit of Detection (LLD)[3]	Indicator Locations Mean (F)[4] (Range)	Location with Highest Mean[9], Station Name, Distance, Direction, and Description[6]	Mean (F)[4] (Range)	Control Locations Mean (F)[4] (Range)	Number of Reportable Results[7]
Air Iodine (pCi/m3)	*Gamma Spec*							
	I-131	362	7.0E-02	ND[8]	---	---	ND	0
Air Particulates (pCi/m3)	Gross Beta	362	1.0E-02	2.2E-02 (311/311) (8.7E-03 - 4.5E-02)	Q15-1, 13.5 mi NW West Fairview	2.2E-02 (51/51) (9.7E-03 - 4.0E-02)	2.2E-02 (51/51) (9.7E-03 - 4.0E-02)	0
	Gamma Spec							
	Be-7	28	5.0E-02	6.5E-02 (24/24) (4.8E-02 - 8.1E-02)	H3-1, 2.3 mi SSE Falmouth	6.7E-02 (4/4) (5.8E-02 - 7.8E-02)	6.2E-02 (4/4) (4.9E-02 - 7.2E-02)	0
	Cs-134	28	5.0E-02	ND	---	---	ND	0
	Cs-137	28	6.0E-02	ND	---	---	ND	0
	K-40	28	2.0E-02	1.4E-02 (1/24)	M2-1, 1.3 mi WSW Goldsboro	1.4E-02 (1/4)	ND	0
Fish (pCi/g,wet)	Sr-89	8	2.5E-02	ND	---	---	ND	0
	Sr-90	8	1.0E-02	ND	---	---	ND	0
	Gamma Spec							
	Co-58	8	1.3E-01	ND	---	---	ND	0
	Co-60	8	1.3E-01	ND	---	---	ND	0
	Cs-134	8	1.3E-01	ND	---	---	ND	0
	Cs-137	8	1.5E-01	ND	---	---	ND	0
	Fe-59	8	2.6E-01	ND	---	---	ND	0

2001
RADIOLOGICAL ENVIRONMENTAL MONITORING REPORT

TABLE 1
Summary of Radionuclide Concentrations in 2001 Environmental Samples
Three Mile Island Nuclear Station[1]

Media or Pathway Sampled (Unit of Measurement)	Analyses	Total Number of Analyses Performed[2]	Lower Limit of Detection (LLD)[3]	Indicator Locations Mean (F)[4] (Range)	Location with Highest Mean[9], Station Name, Distance, Direction, and Description[6]	Mean (F)[4] (Range)	Control Locations Mean (F)[4] (Range)	Number of Reportable Results[7]
Fish (pCi/g,wet)	K-40	8	5.0E-01	2.7E+00 (4/4) (2.4E+00 - 3.2E+00)	BKGP, Control Predators Above Discharge	2.9E+00 (2/2) (2.7E+00 - 3.1E+00)	2.8E+00 (4/4) (2.7E+00 - 3.1E+00)	0
	Mn-54	8	1.3E-01	ND	---	---	ND	0
	Zn-65	8	2.6E-01	ND	---	---	ND	0
Aquatic Sediments (pCi/g,dry)	*Gamma Spec*							
	Ac-228	6	2.0E-01	1.2E+00 (4/4) (8.0E-01 - 1.5E+00)	J2-1, 1.5 mi S Above York Haven Dam	1.5E+00 (2/2) (1.5E+00 - 1.5E+00)	1.1E+00 (2/2) (1.0E+00 - 1.1E+00)	0
	Be-7	6	2.0E-01	1.3E+00 (2/4) (5.3E-01 - 2.0E+00)	J2-1, 1.5 mi S Above York Haven Dam	2.0E+00 (1/2)	6.2E-01 (1/2)	0
	Cs-134	6	1.5E-01	ND	---	---	ND	0
	Cs-137	6	1.8E-01	1.5E-01 (4/4) (1.4E-01 - 2.0E-01)	J2-1, 1.5 mi S Above York Haven Dam	1.7E-01 (2/2) (1.4E-01 - 2.0E-01)	7.6E-02 (2/2) (6.8E-02 - 8.4E-02)	0
	K-40	6	2.0E-01	1.2E+01 (4/4) (7.7E+00 - 1.7E+01)	J2-1, 1.5 mi S Above York Haven Dam	1.6E+01 (2/2) (1.4E+01 - 1.7E+01)	1.0E+01 (2/2) (9.8E+00 - 1.1E+01)	0
	Ra-226	6	2.0E-01	1.9E+00 (4/4) (1.3E+00 - 2.5E+00)	J2-1, 1.5 mi S Above York Haven Dam	2.4E+00 (2/2) (2.3E+00 - 2.5E+00)	1.9E+00 (2/2) (1.8E+00 - 1.9E+00)	0
Drinking Water (pCi/L)	Gross Beta	36	4.0E+00	2.7E+00 (24/24) (1.6E+00 - 3.7E+00)	G15-2, 13.6 mi SE Wrightsville Water Supply, Wrightsville	3.0E+00 (12/12) (2.3E+00 - 3.7E+00)	1.9E+00 (9/12) (1.4E+00 - 2.4E+00)	0
	Tritium	36	2.0E+03	2.8E+02 (4/24) (1.8E+02 - 4.4E+02)	G15-3, 14.8 mi SE Lancaster Water Authority, Columbia	3.1E+02 (3/12) (2.2E+02 - 4.4E+02)	ND	0

2001
RADIOLOGICAL ENVIRONMENTAL MONITORING REPORT

TABLE 1
Summary of Radionuclide Concentrations in 2001 Environmental Samples
Three Mile Island Nuclear Station[1]

Media or Pathway Sampled (Unit of Measurement)	Analyses	Total Number of Analyses Performed[2]	Lower Limit of Detection (LLD)[3]	Indicator Locations Mean (F)[4] (Range)	Location with Highest Mean[9], Station Name, Distance, Direction, and Description[6]	Mean (F)[4] (Range)	Control Locations Mean (F)[4] (Range)	Number of Reportable Results[7]
Drinking Water (pCi/L)	I-131 (low level)	36	1.0E+00	ND	---	---	ND	0
	Gamma Spec							
	Ba-140	36	6.0E+01	ND	---	---	ND	0
	Co-58	36	1.5E+01	ND	---	---	ND	0
	Co-60	36	1.5E+01	ND	---	---	ND	0
	Cs-134	36	1.5E+01	ND	---	---	ND	0
	Cs-137	36	1.8E+01	ND	---	---	ND	0
	Fe-59	36	3.0E+01	ND	---	---	ND	0
	K-40	36	5.0E+01	1.4E+02 (1/24)	G15-3, 14.8 mi SE Lancaster Water Authority, Columbia	1.4E+02 (1/12)	1.4E+02 (1/12)	0
	La-140	36	1.5E+01	ND	---	---	ND	0
	Mn-54	36	1.5E+01	ND	---	---	ND	0
	Nb-95	36	1.5E+01	ND	---	---	ND	0
	Zn-65	36	3.0E+01	ND	---	---	ND	0
	Zr-95	36	3.0E+01	ND	---	---	ND	0
Fruits (pCi/g,wet)	*Gamma Spec*							
	Cs-134	2	6.0E-02	ND	---	---	ND	0

2001
RADIOLOGICAL ENVIRONMENTAL MONITORING REPORT

TABLE 1
Summary of Radionuclide Concentrations in 2001 Environmental Samples
Three Mile Island Nuclear Station[1]

Media or Pathway Sampled (Unit of Measurement)	Analyses	Total Number of Analyses Performed[2]	Lower Limit of Detection (LLD)[3]	Indicator Locations Mean (F)[4] (Range)	Location with Highest Mean[9], Station Name, Distance, Direction, and Description[6]	Mean (F)[4] (Range)	Control Locations Mean (F)[4] (Range)	Number of Reportable Results[7]
Fruits (pCi/g,wet)	Cs-137	2	8.0E-02	ND	---	---	ND	0
	I-131	2	6.0E-02	ND	---	---	ND	0
	K-40	2	4.0E-01	2.7E+00 (1/1)	E1-2, 0.4 mi E TMI Visitors Center	2.7E+00 (1/1)	2.1E+00 (1/1)	0
Grains (pCi/g,wet)	*Gamma Spec*							
	Cs-134	2	6.0E-02	ND	---	---	ND	0
	Cs-137	2	8.0E-02	ND	---	---	ND	0
	I-131	2	6.0E-02	ND	---	---	ND	0
	K-40	2	4.0E-01	1.9E+00 (1/1)	B10-2, 10.1 mi NNE Milton Hershey School, Hershey	1.9E+00 (1/1)	1.9E+00 (1/1)	0
Broad Leaf Vegetables (pCi/g,wet)	Sr-89	2	2.5E-02	ND	---	---	ND	0
	Sr-90	2	1.0E-02	2.4E-03 (1/1)	E1-2, 0.4 mi E TMI Visitors Center	2.4E-03 (1/1)	1.5E-03 (1/1)	0
	Gamma Spec							
	Cs-134	2	6.0E-02	ND	---	---	ND	0
	Cs-137	2	8.0E-02	ND	---	---	ND	0
	I-131	2	6.0E-02	ND	---	---	ND	0

2001
RADIOLOGICAL ENVIRONMENTAL MONITORING REPORT

TABLE 1
Summary of Radionuclide Concentrations in 2001 Environmental Samples
Three Mile Island Nuclear Station[1]

Media or Pathway Sampled (Unit of Measurement)	Analyses	Total Number of Analyses Performed[2]	Lower Limit of Detection (LLD)[3]	Indicator Locations Mean (F)[4] (Range)	Location with Highest Mean[9], Station Name, Distance, Direction, and Description[6]	Mean (F)[4] (Range)	Control Locations Mean (F)[4] (Range)	Number of Reportable Results[7]
Broad Leaf Vegetables (pCi/g,wet)	K-40	2	4.0E-01	2.5E+00 (1/1)	E1-2, 0.4 mi E TMI Visitors Center	2.5E+00 (1/1)	1.8E+00 (1/1)	0
Vegetables (pCi/g,wet)	*Gamma Spec*							
	Cs-134	2	6.0E-02	ND	---	---	ND	0
	Cs-137	2	8.0E-02	ND	---	---	ND	0
	I-131	2	6.0E-02	ND	---	---	ND	0
	K-40	2	4.0E-01	4.3E+00 (1/1)	E1-2, 0.4 mi E TMI Visitors Center	4.3E+00 (1/1)	3.0E+00 (1/1)	0
Milk (pCi/L)	I-131 (low level)	100	1.0E+00	ND	---	---	ND	0
	Sr-89	16	5.0E+00	ND	---	---	ND	0
	Sr-90	16	2.0E+00	1.1E+00 (11/12) (5.4E-01 - 2.0E+00)	D2-1, 1.1 mi ENE Dairy Farm	1.6E+00 (3/4) (1.2E+00 - 2.0E+00)	1.3E+00 (3/4) (7.6E-01 - 2.2E+00)	0
	Gamma Spec							
	Ba-140	100	6.0E+01	ND	---	---	ND	0
	Cs-134	100	1.5E+01	ND	---	---	ND	0
	Cs-137	100	1.8E+01	ND	---	---	ND	0
	K-40	100	5.0E+01	1.4E+03 (75/75) (9.6E+02 - 1.6E+03)	K15-3, 14.5 mi SSW Dairy Farm	1.5E+03 (25/25) (1.1E+03 - 1.7E+03)	1.5E+03 (25/25) (1.1E+03 - 1.7E+03)	0
	La-140	100	1.5E+01	ND	---	---	ND	0

2001
RADIOLOGICAL ENVIRONMENTAL MONITORING REPORT

TABLE 1
Summary of Radionuclide Concentrations in 2001 Environmental Samples
Three Mile Island Nuclear Station[1]

Media or Pathway Sampled (Unit of Measurement)	Analyses	Total Number of Analyses Performed[2]	Lower Limit of Detection (LLD)[3]	Indicator Locations Mean (F)[4] (Range)	Location with Highest Mean[9], Station Name, Distance, Direction, and Description[6]	Mean (F)[4] (Range)	Control Locations Mean (F)[4] (Range)	Number of Reportable Results[7]
Surface Water[10] (pCi/L)	Tritium	24	2.0E+03	5.5E+03 (8/12) (5.4E+02 - 3.0E+04)	J1-2, 0.5 mi S West Shore of TMI	5.5E+03 (8/12) (5.4E+02 - 3.0E+04)	ND	0
	I-131 (low level)	12	1.0E+00	[11]	A3-2, 2.5 mi N Swatara Creek, Middletown	6.7E-01 (4/12) (3.7E-01 - 9.8E-01)	6.7E-01 (4/12) (3.7E-01 - 9.8E-01)	0
	Gamma Spec							
	Ba-140	24	6.0E+01	ND	---	---	ND	0
	Co-58	24	1.5E+01	ND	---	---	ND	0
	Co-60	24	1.5E+01	ND	---	---	ND	0
	Cs-134	24	1.5E+01	ND	---	---	ND	0
	Cs-137	24	1.8E+01	ND	---	---	ND	0
	Fe-59	24	3.0E+01	ND	---	---	ND	0
	K-40	24	5.0E+01	ND	Q9-1, 8.5 mi NW Steelton Water Authority, Steelton	1.1E+02 (3/12) (6.5E+01 - 1.6E+02)	1.1E+02 (3/12) (6.5E+01 - 1.6E+02)	0
	La-140	24	1.5E+01	ND	---	---	ND	0
	Mn-54	24	1.5E+01	ND	---	---	ND	0
	Nb-95	24	1.5E+01	ND	---	---	ND	0
	Zn-65	24	3.0E+01	ND	---	---	ND	0
	Zr-95	24	3.0E+01	ND	---	---	ND	0
Direct Radiation (mR/std month)	*Gamma*	2107[5]		4.9E+00 (1843/1843) (3.5E+00 - 8.1E+00)	H8-1, 7.4 mi SSE Saginaw Road, Starview	7.5E+00 (24/24) (6.7E+00 - 8.1E+00)	5.5E+00 (264/264) (4.2E+00 - 8.0E+00)	0

2001
RADIOLOGICAL ENVIRONMENTAL MONITORING REPORT

TABLE 1
Summary of Radionuclide Concentrations in 2001 Environmental Samples
Three Mile Island Nuclear Station[1]

Media or Pathway Sampled (Unit of Measurement)	Analyses	Total Number of Analyses Performed[2]	Lower Limit of Detection (LLD)[3]	Indicator Locations Mean (F)[4] (Range)	Location with Highest Mean[9], Station Name, Distance, Direction, and Description[6]	Mean (F)[4] (Range)	Control Locations Mean (F)[4] (Range)	Number of Reportable Results[7]

[1]This table presents primary program results in exponential form (i.e., 1.2E-2 = 0.012) > minimum detectable concentration (MDC). It does not include duplicate analysis results or results from the quality control (QC) program, the rodent monitoring program or the groundwater monitoring program. Additionally, results from recounts supercede original results; reanalysis results supercede both original and/or recount results.

[2]The total number of analyses does not include duplicate analyses, recounts or reanalyses.

[3]The ODCM LLD (or MDC) is given when applicable. It should be noted that, in some cases, the TMINS REMP achieves LLDs that are lower than those required by the ODCM.

[4](F) is the ratio of results > MDC to the number of samples analyzed. Means and ranges are based on results > MDC.

[5]The total number of elements (TLDs) that were used for data analysis.

[6]All distances are measured from a point that is midway between the TMI-1 and TMI-2 reactor buildings.

[7]The total number of results that exceeded USNRC reporting levels as specified in the ODCM.

[8]ND = Not Detected (i.e. all net sample concentrations were equal to or less than the MDC).

[9]The location with the highest mean was determined using more than two significant figure.

[10]Sample results from Station K1-1 (TMINS liquid discharge) were used as a check for the inplant effluent sampling program and, therefore, were not included in this table.

[11]This analysis was not performed on this medium.

DIRECT RADIATION MONITORING

Radiation is a normal component of the environment resulting primarily from natural sources, such as cosmic radiation and naturally-occurring radionuclides, and to a lesser extent from manmade sources, such as fallout from prior nuclear weapon tests. The cessation of atmospheric nuclear weapon tests and the decay of fallout products have resulted in a gradual decrease in environmental radiation levels. Direct radiation monitoring measures ionizing radiation primarily from cosmic and terrestrial sources.

Gamma radiation exposure rates near TMINS were measured using thermoluminescent dosimeters (TLDs). TLD stations were arranged in roughly concentric rings around TMINS, generally with one station in each of the 16 compass sectors, at the site boundary and 1, 2, 5, 8 and 10 or more miles from the site. Those TLD stations approximately 10 or more miles from the site were control (or background) stations while those less than 10 miles from the site were indicator stations. Indicator stations were located to detect any potential effect of TMINS operations on environmental radiation levels. Control stations were located at sites that should be unaffected by TMINS operations.

The TLDs were processed each calendar quarter. All gamma radiation exposure rates recorded during 2001 were within normal ranges and were consistent with previous results.

No relationship between TMINS operations and offsite exposure rates was indicated. The 2001 quarterly exposure rates for the individual TLD stations and a map showing onsite TLD station locations are contained in Appendix H. Offsite TLD stations are depicted on Figures 1, 2 and 3.

Sample Collection and Analysis

A thermoluminescent dosimeter (TLD) is a crystal (phosphor) which absorbs and stores energy in traps when exposed to ionizing radiation. These traps are so stable that they do not decay appreciably over time. When heated, the crystal emits light proportional to the amount of radiation received, and the light is measured to determine the integrated exposure. This process is referred to as thermoluminescence. The reading process 'rezeros' (anneals) the TLD and prepares it for reuse. The TLDs in use for environmental monitoring at TMINS are capable of accurately measuring exposures between 1 mR (well below normal environmental exposures for the quarterly monitoring periods) and 200 R.

Each TLD station consists of 2 primary program TLD badges, each of which has 4 phosphors or elements. Since each TLD responds to radiation independently, this provides 8 independent detectors at each station. In addition, 10 stations have a vendor-supplied quality control TLD badge which has 4 independent detectors, for a total of 12 detectors at each station. The quality control badges are used as an independent check on the accuracy of the primary program TLD results.

Of the 4 elements in the primary program's TLDs, 3 are composed of calcium sulfate and 1 is composed of lithium borate. The calcium sulfate elements are shielded with a thin layer of lead making the response to different energies of gamma radiation more linear. The lead also shields the elements from beta radiation, making them sensitive to gamma radiation only. The lithium borate element is shielded differently to permit the detection of beta radiation as well as gamma. The combination of different phosphor materials, shielding, and multiple phosphors per badge permit quantification of both gamma and beta radiation. Only the calcium sulfate phosphors are used for environmental monitoring; however, the lithium borate elements can be used to evaluate beta exposures or as a backup to the calcium sulfate elements should more data be required.

Data from the TLDs were evaluated by obtaining the average of the usable element results at each station, and comparing the result to historical averages and ranges for the period of TMINS shutdown between the first quarter of 1980 and the third quarter of 1985. The averages and overall trends of the indicator and control stations were also compared with each other and with averages and trends obtained for the five-year shutdown period.

All TLD exposure rate data presented in this report were normalized to a standard month (std month) to adjust for variable field exposure periods. A std month is 30.4 days. Several badges were used to quantify transit

exposure during storage and handling of TLDs. Transit exposures were subtracted from gross field exposures to produce net field exposures.

Direct Radiation Results

In 2001, the average annual exposure rate for offsite indicator stations, which excludes stations located on the TMINS site boundary fence, was 5.1 ± 1.6 mR/std month. Quarterly exposure rates at offsite indicator stations ranged from 3.6 to 8.1 mR/std month. The average annual exposure rate for all control stations, those stations approximately 10 miles or more from TMINS, was 5.5 ± 1.5 mR/std month. Quarterly exposure rates at control stations ranged from 4.2 to 8.0 mR/std month. Similar exposure rates were measured in 2000 when offsite indicators and controls averaged 4.7 ± 1.4 mR/std month and 5.1 ± 1.4 mR/std month, respectively.

Typically, average exposure rates at control stations have been higher than those at offsite indicator stations. This is a result of variation in the natural radioactive characteristics of rock and soil near the stations. The historical average exposure rate (for the period from 1980 to 1985, when TMINS did not operate) was 5.2 mR/std month for indicator stations and 5.7 mR/std month for control stations. Generally, exposure rates at both indicator and control stations have decreased gradually due to the cessation of atmospheric nuclear weapon testing and the decay of fallout products. This trend is depicted in Figure 4.

In 2001, the average annual exposure rate for all indicator stations, including those stations located on the TMINS site boundary fence, was 4.9 ± 1.5 mR/std month. Quarterly average exposure rates ranged from 3.5 to 8.1 mR/std month. Similar exposure rates were measured in 2000 when all indicator stations averaged 4.6 ± 1.7 mR/std month and ranged from 3.2 to 8.5 mR/std month.

Exposure rates at some indicator stations located on the site boundary fence were slightly elevated. This was not unexpected because these stations were located close to radioactive material transport routes or storage areas.

The average onsite exposure rates including those from stations located on the site boundary fence were typically lower than exposure rates for offsite stations. This is consistent with previous results and is a function of the differing characteristics of the land surface and geology in the immediate vicinity of the TLD stations. Many onsite stations are located on or above manmade surfaces or structures, which may shield the TLDs from terrestrial sources of radiation.

Exposure rates at stations on the site boundary fence vary with the movement and storage of onsite radioactive materials and with the number and placement of stations on the fence. Occasionally, stations on the fence may be moved or added to ensure comprehensive coverage of some areas. For these reasons, year-to-year comparisons between stations on the site boundary fence and other indicator or control stations usually are not appropriate.

In 2001, the highest annual average exposure rate for an offsite location was 7.5 ± 1.3 mR/std month at indicator Station H8-1. This annual average exposure rate is typical for Station H8-1, and is lower than the historical (1980-1985) exposure rate of 7.9 ± 1.4 mR/std month for Station H8-1.

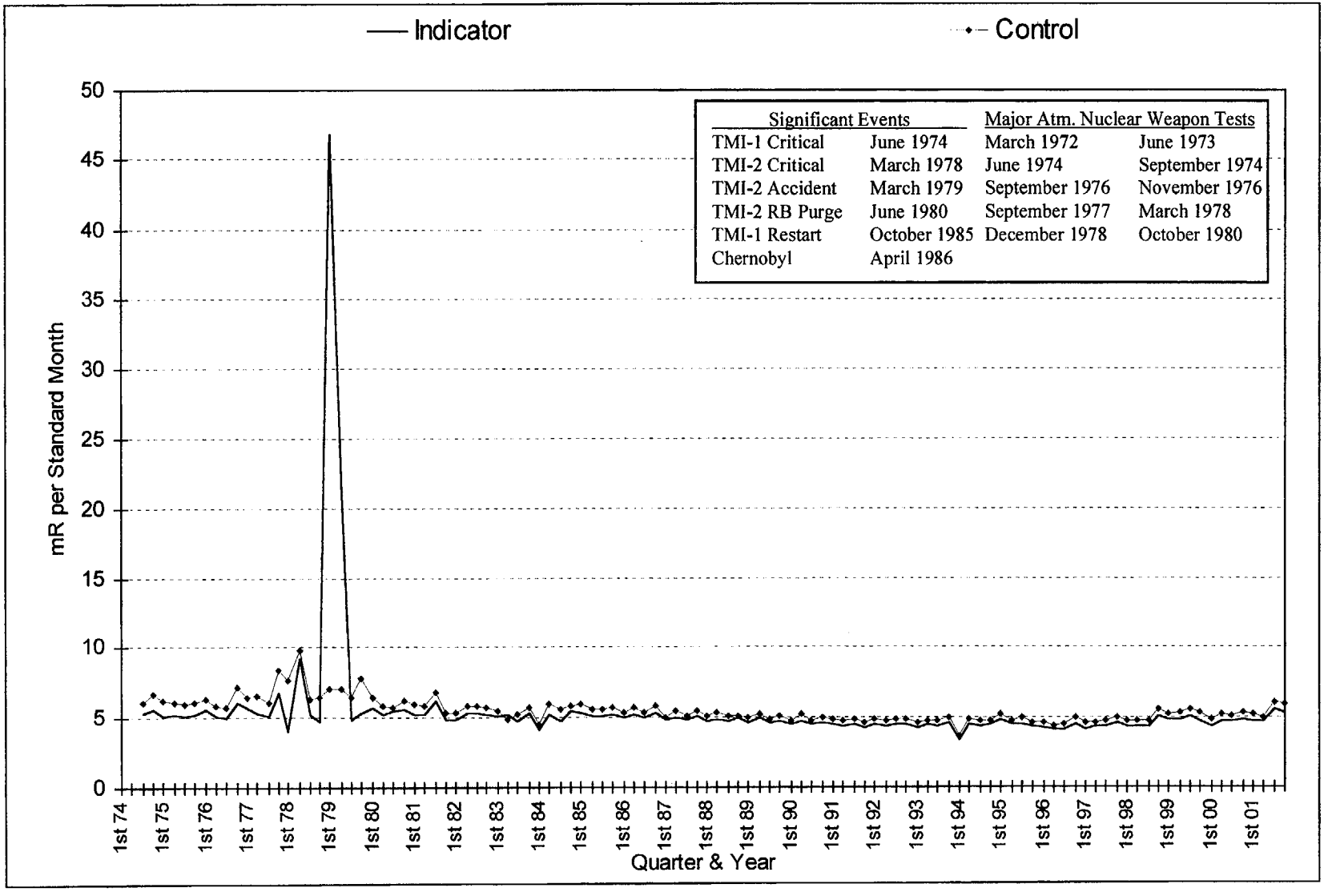
During 2001, average quarterly exposure rates for offsite indicators and controls were slightly higher in the third and fourth quarters due to lower transit exposures. The average exposure rates observed at offsite indicator stations for the first, second, third and fourth quarters of 2001 were 4.7, 4.7, 5.6 and 5.3 mR/std month. With slightly higher quarterly exposure rates, the controls trended similarly. Average exposure rates at control stations for the first, second, third and fourth quarters of 2001 were 5.2, 5.0, 6.0 and 5.9 mR/std month. The fact that both indicators and controls trended similarly suggested that TMINS operation did not change offsite exposure rates.

Figure 4 is a plot of gamma exposure rates (as measured by TLDs) in the vicinity of TMINS from 1974 through 2001. Data from stations located on the TMINS site boundary fence are excluded from the graph. Based on Figure 4, the trends in exposure rates at indicator stations were similar to those of control stations with the exception of 1979. As a result of the TMI-2 accident, a transitory increase in exposure rates from the release of noble gases was observed. Increases also were observed in both indicator and control stations in 1976, 1977, and 1978 as a result of nuclear weapon tests.

No elevated exposure rates as a result of TMINS operations were observed at any offsite TLD station in 2001. The annual average gamma radiation exposure rate recorded at all offsite indicator TLD monitoring stations was 5.1 mR/std month. This equates to an annual exposure rate of 61 mR/yr. An exposure of this magnitude is consistent with the annual average radiation dose a person receives from cosmic and terrestrial sources (Ref. 31).

Historical Gamma Exposure Rates

mR per Standard Month by Quarter



Significant Events		Major Atm. Nuclear Weapon Tests	
TMI-1 Critical	June 1974	March 1972	June 1973
TMI-2 Critical	March 1978	June 1974	September 1974
TMI-2 Accident	March 1979	September 1976	November 1976
TMI-2 RB Purge	June 1980	September 1977	March 1978
TMI-1 Restart	October 1985	December 1978	October 1980
Chernobyl	April 1986		

Figure 4

ATMOSPHERIC MONITORING

A potential exposure pathway to humans is inhalation of airborne radioactive materials. To monitor this exposure pathway, ambient air was sampled by a network of continuously operating samplers and then analyzed for radioactivity content. Based on the analytical results, no contribution to the general levels of airborne radioactivity was attributed to TMINS operations during 2001.

Sample Collection and Analysis

The indicator air sampling stations were located primarily in the prevailing downwind directions to the east (TMINS Visitors Center, Station E1-2), the east-southeast (500 kV Substation, Station F1-3), the southeast (dairy farm near Falmouth, Station G2-1), and the south-southeast (Falmouth, Station H3-1) of TMINS and in the nearby communities of Goldsboro (Station M2-1) and Middletown (Station A3-1). The control air sampling station was located in West Fairview (Station Q15-1), a community situated more than 13 miles from TMINS. This station provided background data for comparison.

Mechanical air samplers were used to continuously draw air through glass fiber filters and charcoal cartridges. To maintain a constant flow rate throughout the collection period, each sampler was equipped with an electronic mass flow controller. This device automatically adjusted the flow rate to compensate for dust loading and changes in atmospheric pressure and temperature.

Total air volumes were measured and recorded with dry gas meters. Air volumes were then adjusted based on vacuum readings over the collection period. All air samplers were calibrated semiannually and maintained by instrumentation technicians.

The glass fiber filters were used to collect airborne particulate matter. The filters were collected weekly and analyzed for gross beta radioactivity. The filters were then combined quarterly by individual station locations and analyzed for gamma-emitting radionuclides.

During the year, two glass fiber filters had sampling periods of less than two days. These filters were not analyzed for gross beta radioactivity because the particulate matter collected was not representative of the weekly sampling period. The filters were, however, included in the quarterly composite samples that were analyzed for gamma-emitting radionuclides.

Cartridges containing activated charcoal were used for monitoring gaseous radioiodines. These cartridges were placed downstream of the particulate filter at each of the air sampling stations. Charcoal cartridges were collected weekly and analyzed separately from the particulate filters for I-131.

Two of the charcoal cartridges collected during 2001 had sampling periods of two days or less. These samples were not analyzed for gaseous radioiodines because they did not adequately represent the weekly collection period.

Air Particulate Results

During 2001, more than 350 air particulate samples (filters) were collected weekly from seven locations and analyzed for gross beta radioactivity. The particulate matter (dust particles) collected on all indicator and control filters contained gross beta radioactivity above the minimum detectable concentration (MDC).

The gross beta concentrations measured on the filters collected from indicator sites ranged from 0.0087 ± 0.0017 pCi/m^3 to 0.045 ± 0.003 pCi/m^3 and averaged 0.022 ± 0.013 pCi/m^3. The air particulate samples collected from the control location had gross beta concentrations that ranged from 0.0097 ± 0.0018 pCi/m^3 to 0.040 ± 0.003 pCi/m^3 and averaged 0.022 ± 0.013 pCi/m^3. For comparison, the 2000 average gross beta concentrations were 0.017 ± 0.014 pCi/m^3 and 0.017 ± 0.014 pCi/m^3 for indicators and controls, respectively.

The air sampling location with the highest annual average gross beta concentration (based on more than two significant figures) was control Station Q15-1 (West Fairview). The average gross beta concentration for airborne particulates collected at this station was 0.022 ± 0.013 pCi/m^3. This average concentration was well below the preoperational average concentration of

0.15 ± 0.16 pCi/m^3 and, as shown on Table 2, was similar to the annual average gross beta concentrations calculated for particulate samples collected at the other air sampling sites.

As depicted in Figure 5, average weekly gross beta concentrations at indicator and control air monitoring locations were somewhat variable, but trended similarly throughout the monitoring period. The weekly gross beta concentrations and trends at individual air sampling sites also were similar.

The similarity of indicator and control data suggested that gross beta radioactivity levels did not change in 2001 as a result of TMINS operations. Additionally, the gross beta radioactivity associated with airborne particulates was due primarily to naturally-occurring radionuclides.

Historical trends of average quarterly gross beta concentrations associated with airborne particulates from 1972 to 2001 are depicted in Figure 6. Generally, the gross beta concentrations have decreased with time. The 2001 average gross beta concentration of 0.022 pCi/m^3, for indicators and controls combined, is approximately 15% of the 1974 preoperational average concentration (0.15 pCi/m^3).

The overall diminution in gross beta concentrations is a direct result of the ban on atmospheric nuclear weapon tests and the radioactive decay of fallout products from previous detonations. Elevated concentrations at both indicator and control air monitoring stations were noted after each major nuclear weapon test, the TMI-2 accident, and the Chernobyl accident. The trends for indicator and control stations were similar for the entire TMINS operational period.

Gamma-emitting radionuclides related to TMINS operations were not detected on any of the quarterly composites that were analyzed in 2001. As expected, all of the quarterly composite samples contained naturally-occurring beryllium-7 (Be-7). Concentrations detected on indicator samples were similar to those detected on control filters. Also, naturally-occurring potassium-40 (K-40) was detected on one sample.

Air Iodine Results

During 2001, more than 350 charcoal cartridges were collected weekly and analyzed for I-131. None of the weekly samples contained I-131 (or any other isotope of iodine) above the MDC.

TABLE 2

2001 Average Gross Beta Concentrations in Airborne Particulates (pCi/m^3)

Station	Description	Average +/- 2 std dev*
A3-1(I)	Middletown	0.022 ± 0.013
E1-2(I)	TMINS Visitors Center	0.022 ± 0.013
F1-3 (I)	500 kV Substation	0.022 ± 0.014
G2-1(I)	Dairy Farm (Near Falmouth)	0.022 ± 0.013
H3-1(I)	Falmouth	0.022 ± 0.013
M2-1(I)	Goldsboro	0.022 ± 0.014
Q15-1(C)	West Fairview	0.022 ± 0.013

* Averages and standard deviations are based on concentrations > MDC.

(I) = Indicator Station (C) = Control Station

2001 Gross Beta Concentrations in Air Particulates

Picocuries per Cubic Meter by Week

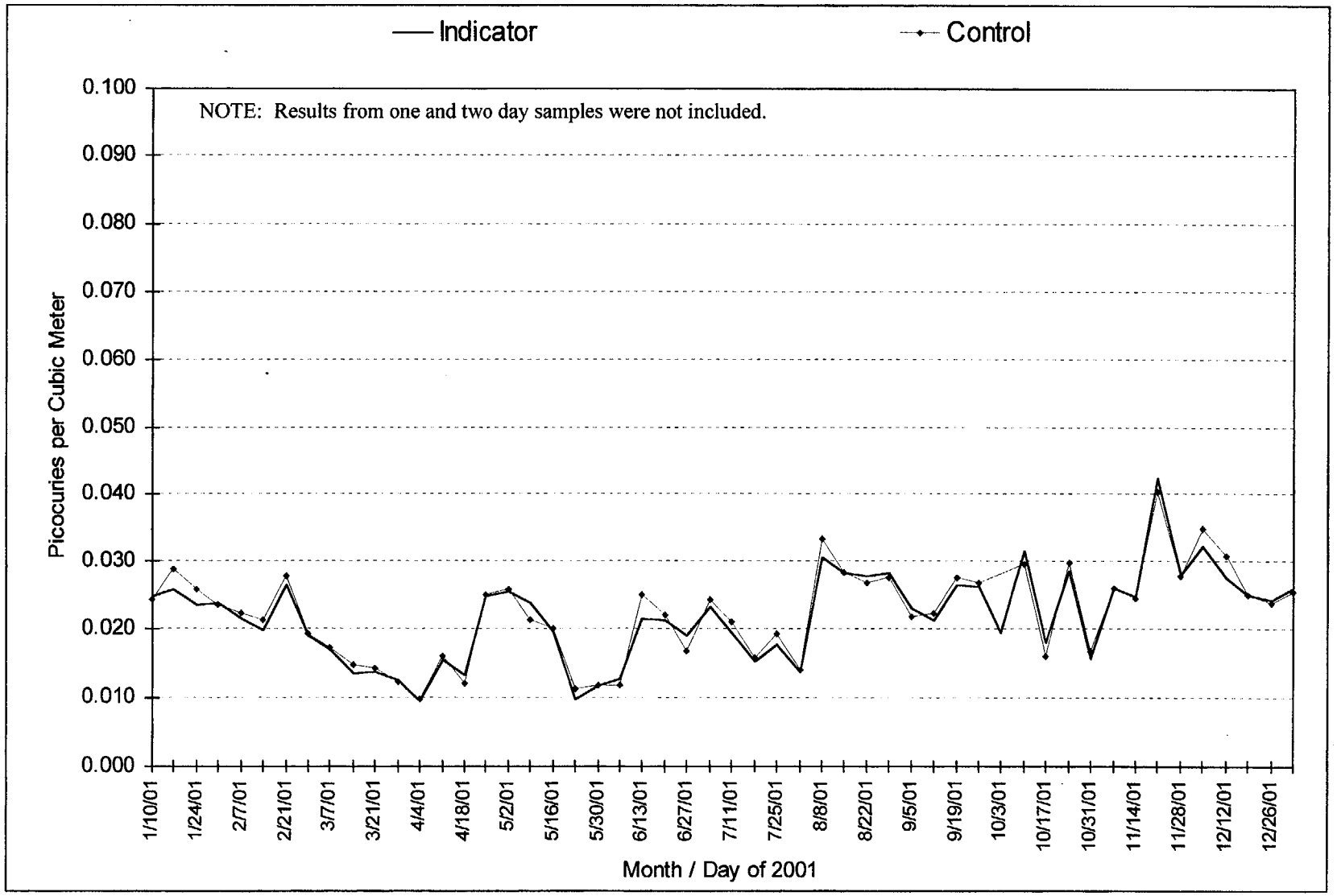


Figure 5

Historical Gross Beta Concentrations in Air Particulates

Picocuries per Cubic Meter by Quarter

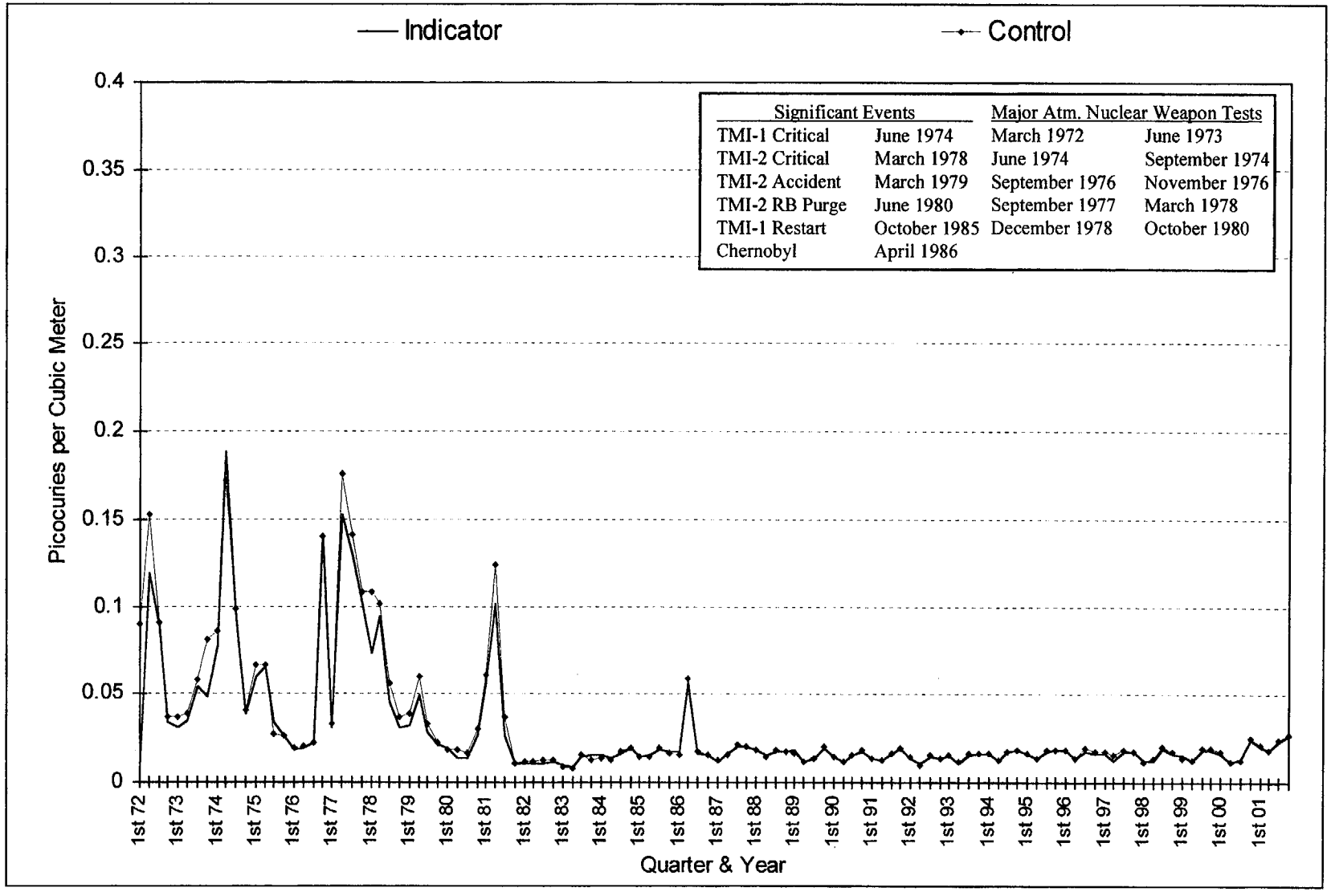


Figure 6

AQUATIC MONITORING

Since radioactive materials are released to the Susquehanna River from routine operations at TMINS and this watershed is used as a source for drinking water and recreational activities, the aquatic environment is monitored extensively for radionuclides of potential TMINS origin. Recreational activities in the TMI reach of the Susquehanna River include fishing, boating, swimming and other water sports.

Monitoring of the aquatic environment in the vicinity of TMINS was accomplished by collecting and analyzing samples of surface water, drinking water, fish and river sediments. The indicator (downstream) sampling sites were chosen based on studies of travel time and mixing characteristics for the Susquehanna River. Control samples were collected from locations which were not expected to be affected by TMINS operations. The impact of TMINS operations was assessed by comparing control sample concentrations to those measured in indicator samples. As applicable, comparisons with results from previous years also were performed.

During 2001, samples from the aquatic environment were found to contain low concentrations of radioactive materials attributable to routine TMINS operations. They included Cs-137 in sediments and H-3 in surface water and drinking water. The concentrations found in these samples, however, were too low to adversely impact humans or the environment. Naturally-occurring radionuclides and those attributed to the medical industry and to fallout from prior nuclear weapon tests also were identified in various aquatic media.

Sample Collection and Analysis

Surface (raw/unfinished) and drinking (treated/finished) water samples were collected at six stations (three indicators and three controls) and analyzed during 2001. Indicator samples were collected from locations along the Susquehanna River which were downstream of the TMINS liquid discharge outfall. Indicator surface water samples were collected at one location, Station J1-2 (west shore of TMI). Indicator drinking water samples were collected at two water treatment facilities -- Station G15-2 (Wrightsville Water Supply, Wrightsville, PA) and Station G15-3 (Lancaster Water Authority, Columbia, PA).

Control samples were collected from the Susquehanna River upstream of the TMINS liquid discharge outfall or from its tributaries. Control surface water samples were collected from two locations -- Station A3-2 (Swatara Creek, Middletown, PA), and Station Q9-1 (Steelton Water Authority, Steelton, PA).

Control drinking water samples were obtained at one water treatment facility -- Station Q9-1 (Steelton Water Authority, Steelton, PA).

Samples of the TMINS liquid discharge (Station K1-1) also were collected and analyzed. The liquid discharge samples were collected from a location where the water was not yet mixed with the Susquehanna River. As appropriate, data from the liquid discharge samples were compared with data obtained from samples collected as part of the TMINS Effluent Monitoring Program.

Water samples normally were obtained by an automatic water compositor. Grab samples were collected when sufficient sample volumes were not available. The compositors collected a measured volume of water (i.e. aliquot) at a preset interval of time (30 or 60 minutes). These samplers were maintained and calibrated by instrumentation technicians.

The samples normally were retrieved biweekly (every two weeks). To verify that the compositors were operating properly, a surveillance was performed weekly. Occasionally, samples were retrieved weekly to close out a calendar month or quarter. All water samples retrieved weekly and biweekly were then combined monthly by station.

The monthly samples from indicator drinking water Stations G15-3 and G15-2 along with those collected from control drinking water Station Q9-1 and control surface water Station A3-2 were analyzed for low-level I-131 using a chemical separation (concentration) technique. Samples of the

TMINS liquid discharge also were analyzed for low-level I-131 employing the same technique.

Except for those collected from control surface water Station A3-2, all monthly water samples were analyzed for H-3 and gamma-emitting radionuclides, including I-131. Monthly gross beta analyses also were performed on all drinking water samples and the samples collected from Station K1-1. Semiannual samples were prepared from monthly samples collected at Station K1-1 and analyzed for Sr-89 and Sr-90.

Electro-shocking equipment were used to collect fish samples in the spring (May and June) and fall (October and December) of 2001. To monitor the progression of radionuclides through the food chain, bottom feeding fish as well as predator species were collected. Indicator samples were collected from zones or areas immediately at or downstream of the TMINS liquid discharge outfall, while control specimens were gathered from locations greater than ten miles upstream of TMI. The edible portions were analyzed for Sr-89, Sr-90 and gamma-emitting radionuclides.

As part of the routine REMP, river sediments from three locations (two indicators and one control) were collected in the spring (June) and fall (October) of 2001. Indicator sediment samples were collected at a site just downstream of the TMINS liquid discharge outfall (Station K1-3), and at the York Haven Dam, YHD, (Station J2-1). The control samples were obtained from the Susquehanna River just upstream of TMI (Station A1-3).

All sediment samples were collected using a dredge designed for this purpose. They were dried and then analyzed for gamma-emitting radionuclides.

Water Results

Iodine-131 is produced during the fission process and may be a constituent of TMI-1 liquid effluents. This radionuclide also may be discharged to the Susquehanna River and its tributaries by medical facilities and their patients via the municipal sewage system. Institutions such as hospitals utilize this material for diagnostic studies of the thyroid and thyroid therapy. Iodine-131 from medical facilities and their patients is commonly detected in REMP samples because the methods used to treat sewage do not remove this material.

During 2001, low-level I-131 using the chemical separation/concentration technique was detected above the minimum detectable concentration (MDC) in 4 of 12 control surface water samples and in 4 of 12 samples collected from Station K1-1, the TMINS liquid discharge. Iodine-131 above the MDC was not detected in any of the indicator or control drinking water samples. Indicator surface water samples were not analyzed using the chemical separation/concentration technique.

The I-131 concentrations measured in control surface water samples ranged from 0.37 ± 0.21 pCi/L to 0.98 ± 0.22 pCi/L and averaged 0.67 ± 0.50 pCi/L. For comparison, the average I-131 concentration for 2000 control surface water samples was 1.5 ± 2.5 pCi/L.

Four of twelve TMINS liquid discharge samples collected in 2001 contained I-131 above the MDC. The I-131 concentrations ranged from 0.35 ± 0.18 pCi/L to 1.4 ± 0.2 pCi/L and averaged 0.81 ± 0.95 pCi/L. The 2000 results were similar, ranging from 0.31 ± 0.26 pCi/L to 2.1 ± 0.2 pCi/L and averaging 1.0 ± 1.2 pCi/L.

For three of the four times I-131 was detected in a liquid discharge sample, a similar concentration of this material was measured in a control sample. On one occasion, however, I-131 was not detected concurrently in a control sample. This may have been caused by the process used to cool water at TMINS.

Water is continually withdrawn from the Susquehanna River for cooling. During one of the cooling processes, a large amount of water is evaporated. The suspended and dissolved materials remain in the water and, therefore, are concentrated. One of these materials may be medically-related I-131 (i.e. I-131 released by upstream medical facilities and/or their patients). To prevent a buildup of these concentrated materials, some of the water is diluted and then returned or discharged to the Susquehanna River. It is possible that the dilution water also contains medically-related I-131.

The similarity of the control and discharge results along with the possibility that I-131 may be concentrated during the cooling process suggested that medical facilities and their patients, and not TMINS, was the source of the I-131 detected in both the control surface water and the liquid discharge samples. The absence of I-131 in 2001 liquid effluent samples supported this conclusion.

In 2001, H-3 above the MDC was measured in 8 of 12 monthly indicator surface water samples. This material was not detected in control surface water. Table 3 lists the annual average H-3 concentrations and the ranges for the samples collected at each surface water station. Also included in the table are the annual average concentrations and ranges based on actual sample concentrations, whether positive, negative or zero.

As expected, H-3, a major component of 2001 TMINS liquid effluents, was detected above the MDC in 67% of the monthly surface water samples collected at indicator Station J1-2. This station is located just downstream of the TMINS liquid discharge outfall where mixing of liquid effluents with river water is incomplete. More complete mixing is not achieved until liquid effluents pass over the York Haven Dam (YHD).

The annual average H-3 concentration for the samples collected at Station J1-2 was 5000 ± 20000 pCi/L. The results ranged from 540 ± 100 pCi/L to 30000 ± 500 pCi/L. Some of the monthly concentrations as well as the annual average concentration were biased by missed aliquots or by using grabs. Missed aliquots were caused by sampler malfunctions, AC power failures or freezing temperatures. Grabs were taken and used when sufficient sample volumes were not available.

For comparison, H-3 was detected in 5 of 12 2000 monthly samples collected at Station

J1-2. The concentrations ranged from 83 ± 50 pCi/L to 1400 ± 100 pCi/L and averaged 400 ± 1100 pCi/L. Like some of the 2001 H-3 concentrations, some of the 2000 concentrations were biased when the sampler was inoperable.

A higher average concentration was expected in 2001 because a higher amount of H-3 was released in 2001 liquid effluents. Approximately 490 Ci of H-3 were released in liquid effluents in 2001, whereas, about 280 Ci were released in 2000. Higher amounts of H-3 were released in 2001 because more wastewater was processed in preparation for the refueling of TMI-1. The TMI-1 refueling outage began in October and ended in December.

Figure 7 depicts the 2001 monthly trends of H-3 concentrations in surface water samples collected at Station J1-2. Actual concentrations (whether positive, negative or zero) were plotted. For comparison, the actual monthly H-3 concentrations measured in the TMINS liquid discharge samples also are depicted in Figure 7. This figure shows that the H-3 concentrations measured in the samples obtained from Station J1-2 were directly related to those detected in the TMINS liquid discharge samples (Station K1-1). Historical trends of H-3 concentrations in surface water are shown in Figure 8.

A dose estimate was not performed for H-3 in surface water because this medium normally is not consumed by humans. All but one of the H-3 concentrations measured in surface water during 2001 were below the USEPA Primary Drinking Water Standard of 20,000 pCi/L. The lone exception was biased high by collecting and using grab samples to represent the monthly period. Grab samples provide only a snapshot of the collection period; they do not adequately represent the entire collection period.

In 2001, H-3 above the MDC was measured in 4 indicator drinking water samples. This material was not detected in any of the control drinking water samples. Table 3 lists the annual average H-3 concentrations for the samples collected at each drinking water station. Also included are the annual average concentrations based on actual sample concentrations, whether positive, negative or zero.

One monthly drinking water sample from indicator Station G15-2 (Wrightsville Water Supply, Wrightsville, PA) and three monthly drinking water samples from indicator Station G15-3 (Lancaster Water Authority, Columbia, PA) contained H-3 above the MDC. The H-3 concentrations averaged 280 ± 230 pCi/L and ranged from 180 ± 80 pCi/L to 440 ± 110 pCi/L.

The H-3 concentrations measured in the 2001 indicator drinking water samples were similar to those measured in 2000, when 4 samples contained H-3 above the MDC. The measured concentrations averaged 180 ± 180 pCi/L and ranged from 91 ± 55 pCi/L to 290 ± 100 pCi/L. The 2001 results also were consistent with those measured in other years.

Figure 9 (upper) displays the average monthly H-3 concentrations measured in the 2001 indicator and control drinking water samples. Instead of only using concentrations above the MDC, actual concentrations (whether

positive, negative or zero) were used for the graph. This method eliminated biases in the data and missing data points. For comparison, the actual H-3 concentrations obtained from samples collected at Station K1-1 also were included in Figure 9 (lower).

Generally, Figure 9 shows that the highest average indicator concentrations occurred when the highest amounts of H-3 were released in TMINS liquid effluents. The concentrations measured in the indicator samples were consistent with data gathered from travel time and mixing studies. There were a number of months when the indicator average was similar to or less than the control sample concentration. This indicated that the H-3 measured in both indicator and control drinking water samples was most likely due to fallout from prior nuclear weapon tests or natural production of this material in the atmosphere.

To put the 2001 H-3 results into perspective, the highest monthly indicator concentration of 440 ± 110 pCi/L represented only slightly more than 2% of the USEPA Primary Drinking Water Standard (20,000 pCi/L). Furthermore, if an individual drank water at this concentration for an entire year, the maximum hypothetical whole body dose would be 0.05 mrem. This calculated dose is equivalent to less than 0.02% of the whole body dose that an individual living in the TMI area receives each year from natural background radiation (300 mrem).

Generally, the H-3 concentrations detected in samples collected at Station K1-1 (TMINS liquid discharge) agreed well with those obtained from the TMINS Effluent Monitoring Program.

The monthly composites of all drinking water samples were analyzed for gross beta activity. Table 4 lists, by station, the annual averages and ranges for gross beta concentrations above the MDC. Averages and ranges based on actual concentrations are included for comparison. The monthly (composite) TMINS liquid discharge samples from Station K1-1 also were analyzed for gross beta.

Most of the drinking water samples collected in 2001 contained gross beta radioactivity concentrations above the MDC. Indicator results ranged from 1.6 ± 0.8 pCi/L to 3.7 ± 0.7 pCi/L and averaged 2.7 ± 1.1 pCi/L. Similarly, the controls ranged from 1.4 ± 0.8 pCi/L to 2.4 ± 1.0 pCi/L and averaged 1.9 ± 0.7 pCi/L. The 2001 averages were consistent with the 2000 averages of 2.2 ± 1.2 pCi/L and 2.1 ± 1.1 pCi/L for indicators and controls, respectively.

The monthly gross beta averages for indicator and control drinking water are plotted in Figure 10. Actual concentrations were used for this graph. Generally, indicator and control sample concentrations trended similarly throughout the year. Minor differences were evident, but expected.

The variability in the gross beta concentrations was directly related to the type of treatment and the overall contaminant removal efficiency of each water treatment facility. For example, suspended solids with adsorbed man-made or naturally-occurring

radioactive materials are removed from raw river water by common treatment processes such as filtration and sedimentation. The amount removed by these processes will vary as a function of the individual system design and operation.

All of the drinking water results for 2001 were well below the Federal and State Primary Drinking Water Standard of 50 pCi/L for gross beta radioactivity. The results indicated that gross beta radioactivity detected in all drinking water samples was attributed to naturally-occurring radioactive materials.

In 2001, all of the monthly composite samples from Station K1-1 (TMINS liquid discharge) had gross beta radioactivity concentrations above the MDC. The gross beta concentrations ranged from 2.0 ± 0.9 pCi/L to 8.8 ± 1.3 pCi/L and averaged 4.3 ± 4.4 pCi/L. The 2001 results were consistent with those reported in previous years for Station K1-1 samples. All TMINS liquid discharge samples, like drinking water samples, had gross beta concentrations well below the Federal and State Primary Drinking Water Standard of 50 pCi/L.

Monthly composite samples of surface and drinking water were analyzed for the presence of gamma-emitting radionuclides. None of the samples collected in 2001 contained detectable levels of reactor-produced, gamma-emitting radionuclides. Naturally-occurring K-40 was detected in 5 samples.

Semiannual composite samples were prepared from the monthly TMINS liquid discharge samples and then analyzed for the presence of Sr-89 and Sr-90. None of the 2001 semiannual composites contained Sr-89 or Sr-90 above the MDC.

Fish Results

During 2001, fish samples were collected at one indicator and one control location in the spring (May and June) and fall (October and December). They included recreationally important predators (smallmouth and largemouth bass) and bottom feeders (carp). All samples were analyzed for gamma-emitting radionuclides, Sr-89, and Sr-90.

None of the fish samples collected in 2001 contained detectable levels of reactor-produced, gamma-emitting radionuclides. As expected, naturally-occurring K-40 was detected in all fish samples. Indicator concentrations were similar to those measured in the controls.

All fish samples were analyzed for Sr-89 and Sr-90. Neither of these radioactive materials was detected above the MDC in any of the 2001 fish samples.

Sediment Results

In June and October of 2001, routine REMP sediment samples were collected from three sites in the Susquehanna River. Control samples were collected from a location upstream of the TMINS liquid discharge outfall. Indicators were collected from two sites in the York Haven Pond (YHP) between TMINS liquid discharge outfall and the York Haven Dam (YHD). All samples were analyzed for gamma-emitting radionuclides.

Naturally-occurring K-40, Ra-226 and Actinium-228 (Ac-228) as well as fallout and/or reactor-produced Cs-137 were identified in all indicator and control samples. Additionally, the samples collected in June contained naturally-occurring Be-7. No other reactor-produced, gamma-emitting radionuclides were detected above the MDC.

Indicator Cs-137 concentrations ranged from 0.14 ± 0.04 pCi/g (dry) to 0.20 ± 0.06 pCi/g (dry) and averaged 0.15 ± 0.06 pCi/g (dry). Control sample concentrations were slightly lower, ranging from 0.068 ± 0.025 pCi/g (dry) to 0.084 ± 0.046 pCi/g (dry) and averaging 0.076 ± 0.022 pCi/g (dry). For comparison, 2000 average Cs-137 concentrations were 0.17 ± 0.08 pCi/g (dry) and 0.099 ± 0.061 pCi/g (dry), for indicators and controls, respectively.

The sediment samples collected from Indicator Station J2-1, a location just upstream of the York Haven Dam, had the highest annual average Cs-137 concentration. The concentrations ranged from 0.14 ± 0.04 pCi/g (dry) to 0.20 ± 0.06 pCi/g (dry) and averaged 0.17 ± 0.09 pCi/g (dry).

As mentioned previously, Cs-137 is a fallout product of weapons testing as well as a constituent of TMINS liquid effluents. Since indicator sample concentrations were generally higher than those measured in 2001 control samples, it is reasonable to conclude that an increment of the Cs-137 detected in the indicator samples was due to TMINS operations. The presence of this material in the control samples indicated that a portion of the Cs-137 detected in the indicator samples also was due to fallout from prior atmospheric nuclear weapon tests.

Figure 11 depicts Cs-137 concentrations in river sediments from 1984 through 2001. As shown in this figure, no discernible buildup of Cs-137 occurred at indicator locations prior to and after 1995. This was primarily due to periodic scouring or removal of bottom sediments during high river flows.

A temporary buildup of Cs-137 in sediments was noted in 1995. This was caused by lower than normal river flows during the year and especially in the spring months when most scouring occurs. In 1996, the average Cs-137 concentrations in indicator samples trended downward. The reduction was due to releasing lower amounts of Cs-137 and having higher than average river flows which increase dilution of liquid effluents and promote scouring.

Based on the annual average concentration of Cs-137 in samples collected from Station J2-1, an estimate of the shoreline whole body dose to the maximally exposed individual was calculated. For this calculation, the annual average Cs-137 control concentration was subtracted to account for fallout Cs-137. The calculated whole body dose (0.0002 mrem/yr) was insignificant and a small percentage (0.00007%) of the whole body dose received by an individual from natural background radiation (300 mrem/yr).

TABLE 3

2001 Average Tritium Concentrations in Surface and Drinking Water (pCi/L)

Station	Description	Sample Concentrations > MDC [1] Average +/- 2 std dev	Range	Actual Sample Concentrations [2] Average +/- 2 std dev	Range
		Surface Water			
Q9-1 (C)	Steelton Water Authority (Steelton, PA)	---	---	50 ± 100	(-44) - 130
J1-2 (I)	West Shore of TMI	5000 ± 20000	540 - 30000	4000 ± 17000	10 - 30000
		Drinking Water			
Q9-1 (C)	Steelton Water Authority (Steelton, PA)	---	---	20 ± 100	(-75) - 100
G15-2 (I)	Wrightsville Water Supply (Wrightsville, PA)	180	---	80 ± 110	(-20) - 180
G15-3 (I)	Lancaster Water Authority (Columbia, PA)	310 ± 230	220 - 440	130 ± 260	(-14) - 440

(1) Averages and ranges are based on sample results above the minimum detectable concentration (MDC). Duplicate analysis results and quality control sample results are not included.

(2) Averages and ranges are based on actual sample concentrations (whether positive, negative or zero). Negative sample concentrations are enclosed in parentheses. Using actual sample concentrations (sample count rate minus background or blank count rate) to calculate annual averages eliminates biases such as those caused by averaging only sample concentrations above the MDC. Negative sample concentrations are important to the overall average, but have no physical significance. Duplicate analysis results and quality control sample results are not included.

(I) = Indicator Station (C) = Control Station

TABLE 4

2001 Average Gross Beta Concentrations in Drinking Water (pCi/L)

Station	Description	Sample Concentrations > MDC [1]		Actual Sample Concentrations [2]	
		Average +/- 2 std dev	Range	Average +/- 2 std dev	Range
Q9-1 (C)	Steelton Water Authority (Steelton, PA)	1.9 ± 0.7	1.4 - 2.4	1.7 ± 0.9	0.96 - 2.4
G15-2 (I)	Wrightsville Water Supply (Wrightsville, PA)	3.0 ± 0.9	2.3 - 3.7	3.0 ± 0.9	2.3 - 3.7
G15-3 (I)	Lancaster Water Authority (Columbia, PA)	2.5 ± 1.1	1.6 - 3.4	2.5 ± 1.1	1.6 - 3.4

(1) Averages and ranges are based on sample results above the minimum detectable concentration (MDC). Duplicate analysis results and quality control sample results are not included.

(2) Averages and ranges are based on actual sample concentrations (whether positive, negative or zero). Negative sample concentrations are enclosed in parentheses. Using actual sample concentrations (sample count rate minus background or blank count rate) to calculate annual averages eliminates biases such as those caused by averaging only sample concentrations above the MDC. Negative sample concentrations are important to the overall average, but have no physical significance. Duplicate analysis results and quality control sample results are not included.

(I) = Indicator Station (C) = Control Station

2001 Tritium Concentrations in Surface Water

Picocuries per Liter by Month

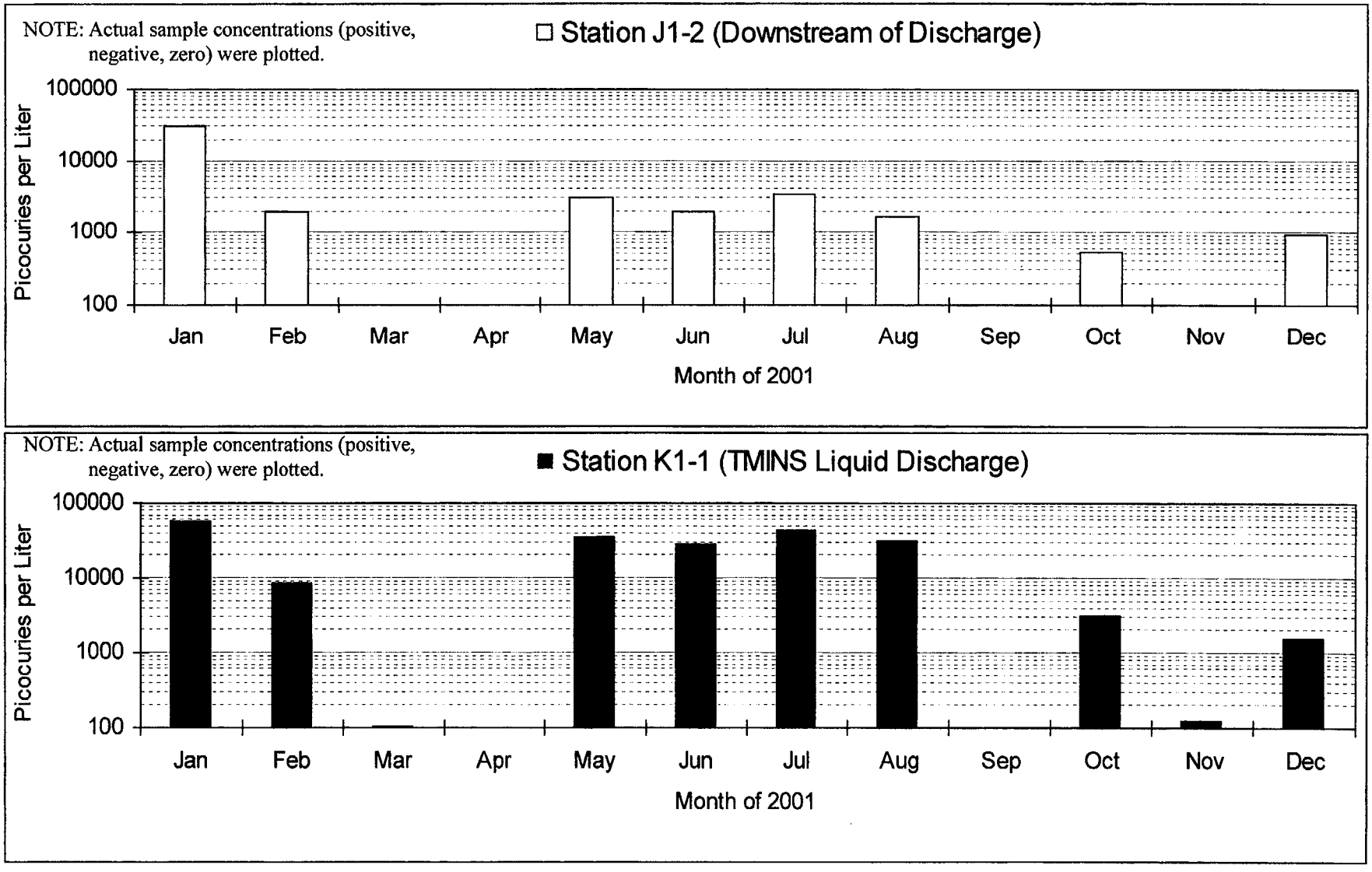


Figure 7

Historical Tritium Concentrations in Surface Water

Picocuries per Liter by Quarter

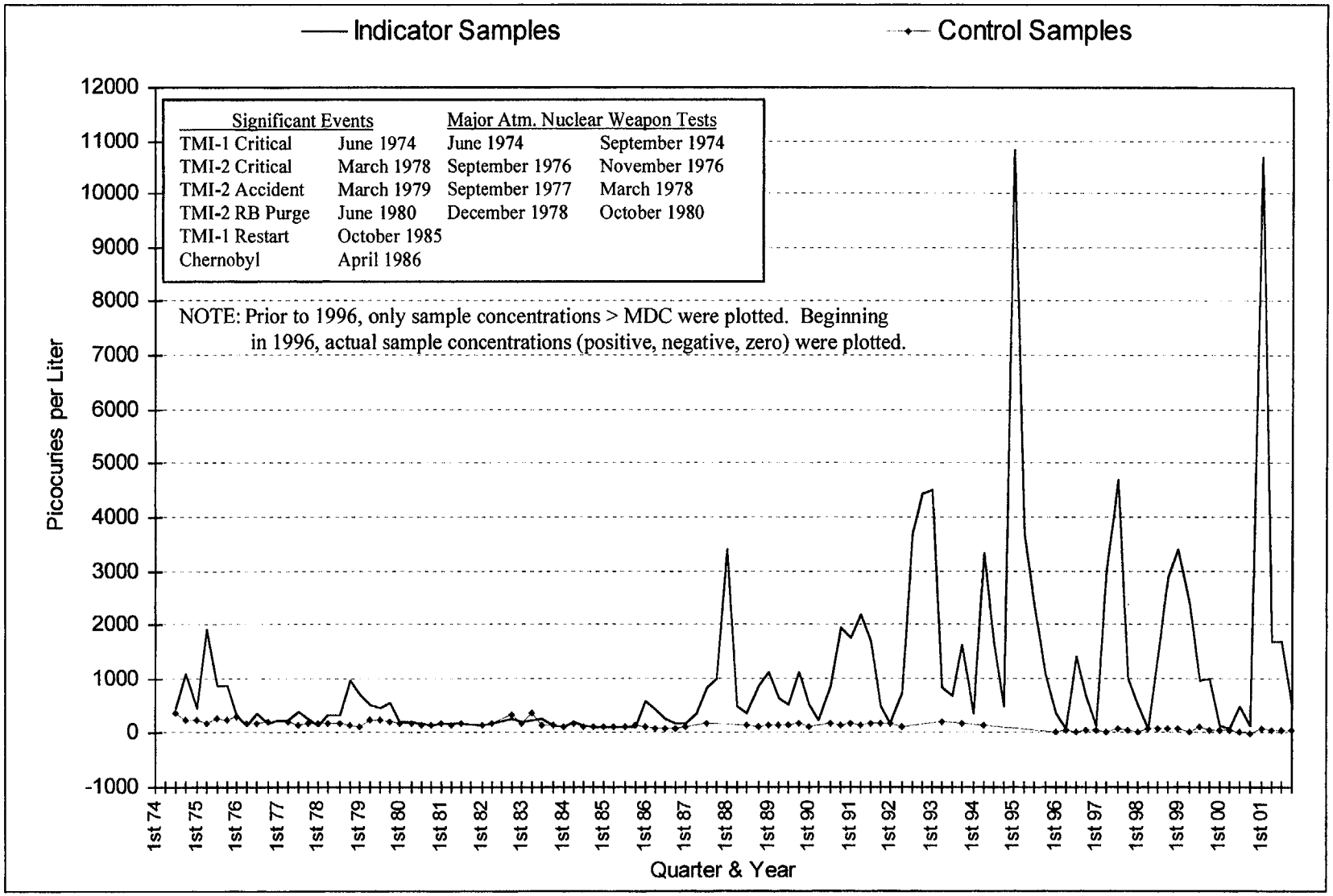
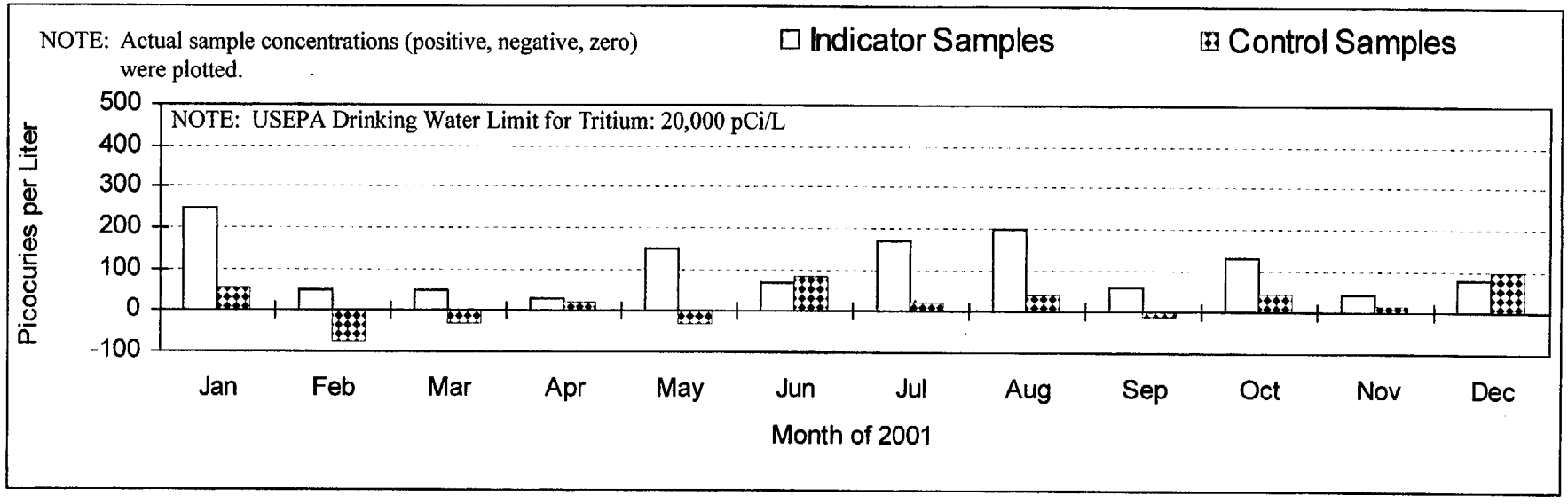


Figure 8

2001 Tritium Concentrations in Drinking Water

Picocuries per Liter by Month



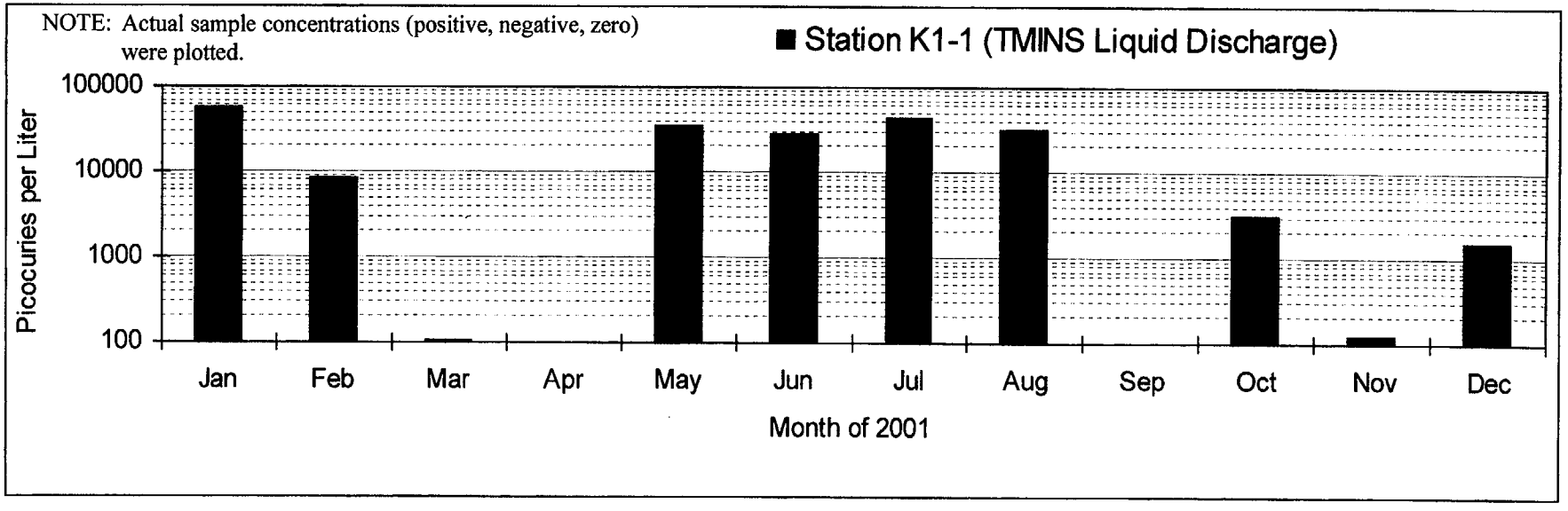


Figure 9

2001 Gross Beta Concentrations in Drinking Water

Picocuries per Liter by Month

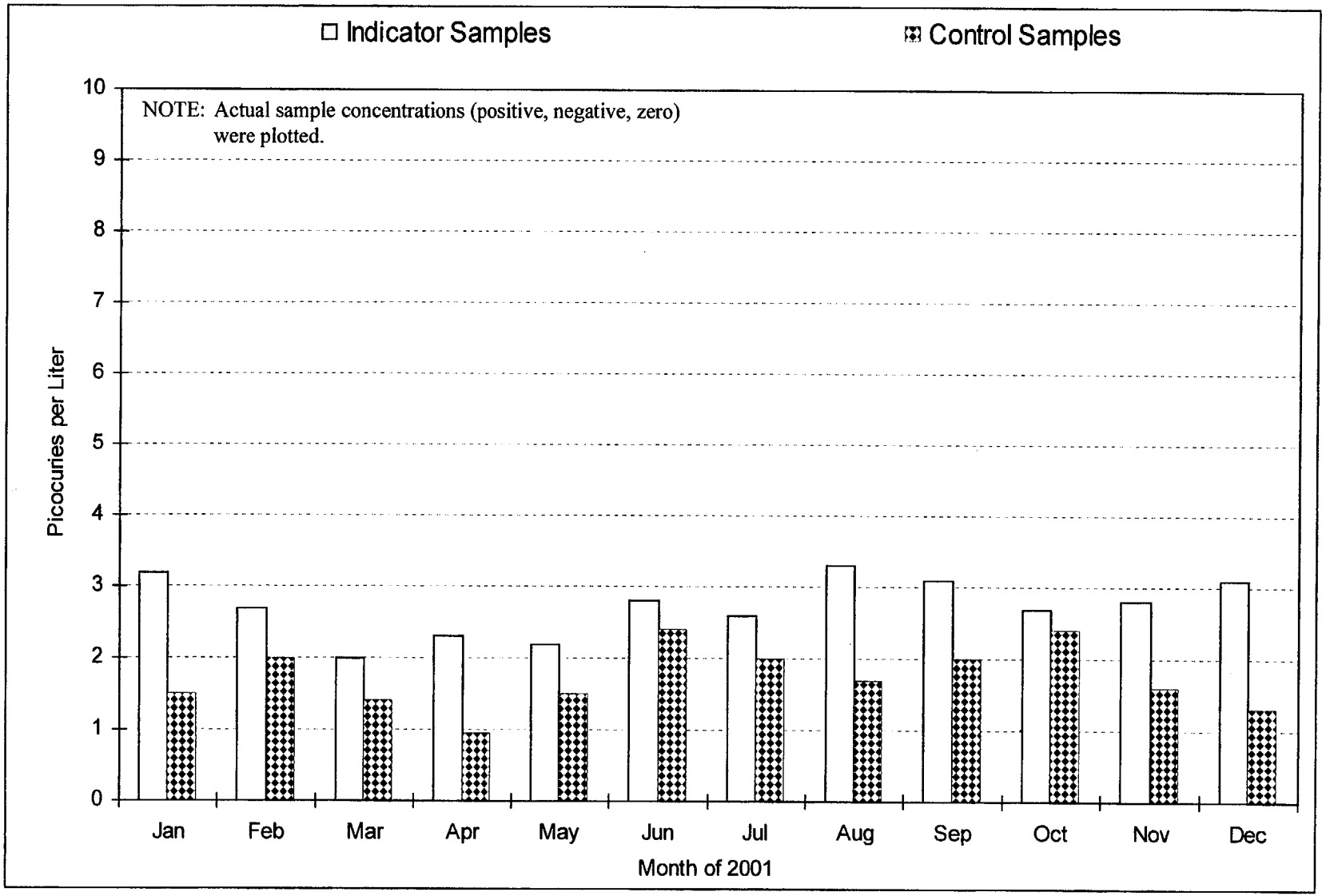


Figure 10

Historical Cesium-137 Concentrations in Aquatic Sediments

Picocuries per Gram (dry)

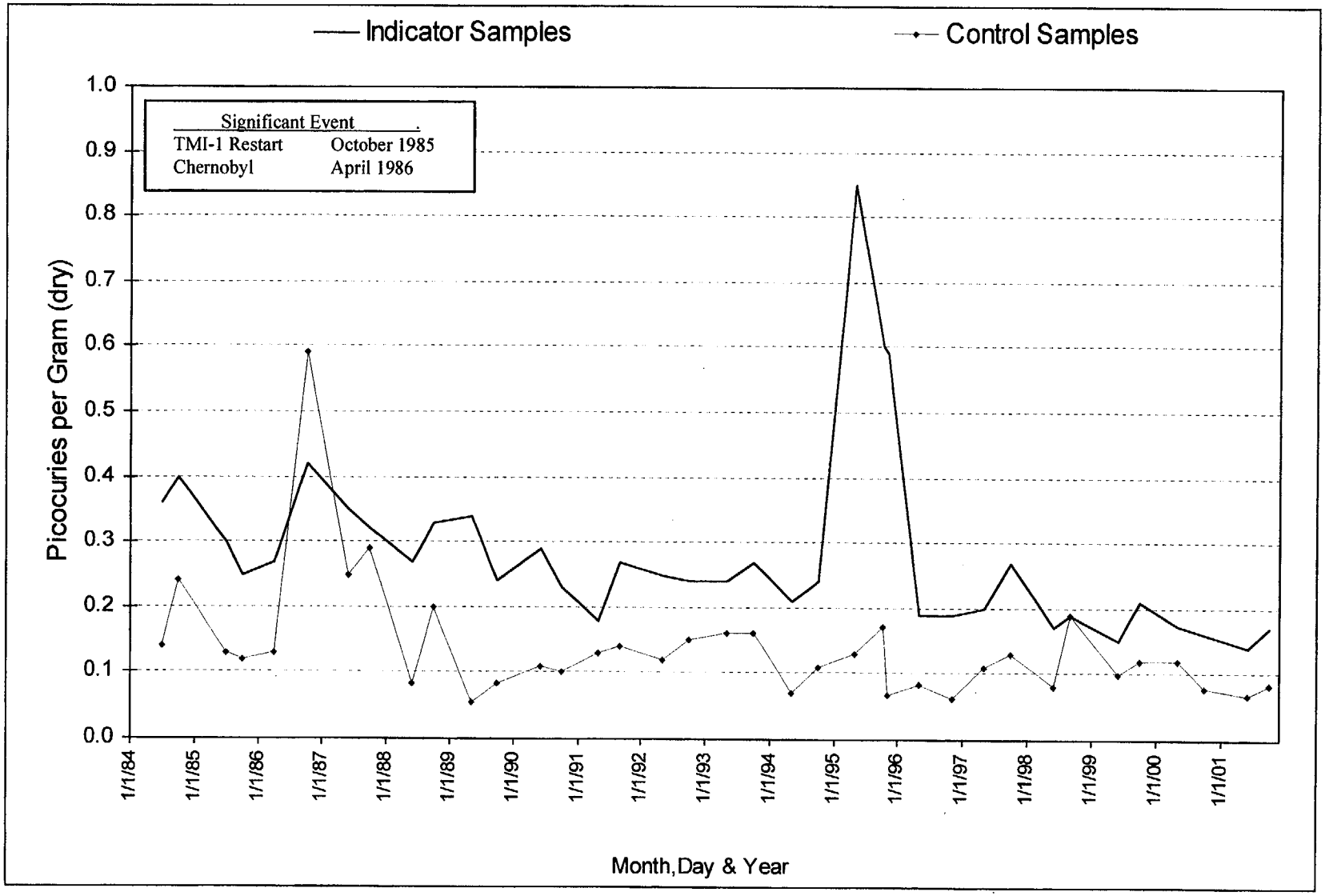


Figure 11

TERRESTRIAL MONITORING

Radionuclides released to the atmosphere may deposit on soil and vegetation. They may eventually be incorporated into milk, meat, fruits, vegetables, or other food products. To assess the impact of TMINS operations to humans from the ingestion pathway, primary food product samples such as green leafy vegetables, root vegetables, fruits, grains and milk were collected and analyzed during 2001. The ingestion pathway also is normally assessed by collecting and analyzing deer meat samples. However, none were available in 2001.

In addition to edible products, rodent carcasses are normally analyzed as part of the TMI-2 Post-Defueling Monitored Storage (PDMS) Rodent Collection and Analysis Program. The purpose of this program is to determine if radioactive materials have been transported by the movement of animals from radiologically-controlled areas to unrestricted areas. No rodent carcasses were available for analysis in 2001.

The radiological contribution of TMINS operations was determined by comparing the results of samples collected in prevalent downwind locations, primarily to the south and east of the site, with control samples collected from distant or generally upwind directions. Comparisons with results from previous years also were performed, as applicable.

The analytical results of samples collected during 2001 indicated that there was no discernible TMINS contribution to radioactivity levels in locally-produced food products. As expected, Sr-90 was found in milk and broad leaf vegetables. The concentrations observed in samples collected near TMINS (indicators) were similar to levels observed in samples collected from the distant sites (controls) and consistent with data from prior years. The presence of Sr-90 in both indicator and control samples was attributed to fallout from prior atmospheric nuclear weapon tests.

As part of the REMP, a surveillance was performed to identify relevant changes in the use of land (unrestricted areas) around TMI. This land use surveillance consisted of a dairy census and a residence census. Sampling of broad leaf vegetation was performed in lieu of a garden census.

The dairy and residence censuses were performed to determine the location of the nearest milk animal and residence within five miles of TMINS in each of the sixteen meteorological sectors. The results of the 2001 dairy and residence censuses are listed in Tables E-1 and E-2 of Appendix E, respectively.

The results of these censuses provide a basis for modifying the radiological environmental monitoring program (REMP) and the model used for calculating offsite doses. Based on the 2001 land use surveillance, no changes to the REMP or the dose model were required.

Broad leaf vegetation sampling was performed in lieu of conducting a garden census. This sampling was performed in accordance with the requirements of the ODCM and in addition to collecting and analyzing edible terrestrial vegetation - fruits and vegetables.

Specifically, three different kinds of tree leaves were collected near the site boundary in the southeast (SE) and east-southeast (ESE) meteorological sectors and then analyzed for gamma-emitting radionuclides and Sr-90. These locations were sampled because they have the highest potential for impact. A control sample also was collected and analyzed.

None of the samples contained reactor-produced gamma-emitting radionuclides above the minimum detectable concentrations (MDCs). Strontium-90 was detected in the control sample and in all but two indicator samples. Its presence was due to fallout from prior weapon tests because the control sample yielded a similar or higher Sr-90 concentration. The analysis results are listed in Table E-3 of Appendix E.

Sample Collection and Analysis

During 2001, samples of raw cow milk were collected biweekly (January - November) and

monthly (December) from local farmers at one control and three indicator locations.

Indicator samples were collected at locations that have a high potential for impact by TMINS operations. These locations generally were proximate to TMINS and in dominant wind directions. Conversely, the control station was located greater than 10 miles from TMINS in a non-prevalent wind direction. The samples collected at these sites should be unaffected by operations at TMINS.

A gamma isotopic analysis and a low-level I-131 analysis were performed on each milk sample. The biweekly and monthly milk samples were then composited quarterly by station and analyzed for Sr-89 and Sr-90.

Edible terrestrial vegetation - fruits, grains, root vegetables and leafy vegetables - were collected when ripe from one indicator and one control garden. Maintained by environmental support personnel, the indicator garden was located at the TMINS Visitors Center (Station E1-2). The control garden was located at Milton Hershey School (MHS). This garden was maintained by MHS students in cooperation with AmerGen.

Like indicator milk samples, indicator edible terrestrial vegetation samples were collected at a location having a high potential for impact by operations at TMINS. Controls samples were obtained from a distant site where they should be unaffected by TMINS operations.

Tomatoes, cabbages, red beets and sweet corn were collected in 2001. All samples were analyzed for gamma-emitting radionuclides, including I-131. Cabbage samples also were analyzed for Sr-89 and Sr-90.

Deer meat samples are normally obtained and analyzed as part of the routine REMP. However, none were available for analysis in 2001.

When available, a limited number of rodent carcasses are analyzed as part of the non-routine REMP. During 2001, no carcasses were available for analysis.

Milk Results

During 2001, 100 milk samples were collected and analyzed. Iodine-131 was not detected above the minimum detectable concentration (MDC) in any of the samples. Gamma isotopic analyses yielded only naturally-occurring potassium-40 (K-40). Potassium-40 was detected in all 2001 milk samples; the concentrations measured in the indicator samples were similar to those measured in the controls.

Strontium analyses were performed on 16 quarterly composite samples. None of the samples contained Sr-89 above the MDC. As expected, Sr-90 was measured in most of the milk samples. Eleven of twelve indicator samples (92%) and three of four control samples (75%) contained Sr-90 above the MDC.

Strontium-90 concentrations in the indicator samples ranged from 0.54 ± 0.29 pCi/L to 2.0 ± 0.5 pCi/L and averaged 1.1 ± 0.9 pCi/L. Similarly, the concentrations measured in the control samples ranged from 0.76 ± 0.36 pCi/L to 2.2 ± 0.5 pCi/L and averaged 1.3 ±

1.5 pCi/L. The Sr-90 concentrations measured in 2001 milk samples were consistent with those measured in 2000 when indicator and control sample concentrations averaged 1.2 ± 0.4 pCi/L and 1.2 ± 0.2 pCi/L, respectively.

The milk collected from Indicator Station D2-1, the dairy farm located 1.1 miles east-northeast of TMINS, contained the highest annual average Sr-90 concentration. Strontium-90 above the MDC was detected in three of the four quarterly composite samples. The average Sr-90 concentration was 1.6 ± 0.9 pCi/L. Milk samples collected in 2001 from the other farms had similar Sr-90 concentrations. Additionally, the milk samples collected in previous years from this and other dairy farms contained similar Sr-90 concentrations.

The results indicated that the Sr-90 measured in the 2001 milk samples was unrelated to operations at TMINS. Its presence in this medium was primarily due to the transfer of this long-lived fallout product from soil to animal feed (fresh or stored) to cow to milk.

Figure 12 depicts the trends of Sr-90 concentrations in indicator and control cow milk samples since 1979. The data plotted for 1996 through 2001 were based on actual sample concentrations because some of the results were below the MDC. Using actual concentrations eliminates biases in the data and missing data points on graphs.

As shown on Figure 12, the Sr-90 concentrations have trended downward. This decrease is directly related to the cessation of atmospheric nuclear weapon testing and the radioactive decay and depletion of both atmospheric and terrestrial Sr-90 associated with prior weapon testing.

Edible Terrestrial Vegetation Results

A total of eight edible terrestrial vegetation samples - leafy vegetables (cabbages), root vegetables (red beets), fruits (tomatoes) and grains (sweet corn) - were collected and analyzed in 2001. Naturally-occurring K-40 was measured in all edible terrestrial vegetation samples. Indicator concentrations were similar to controls. No gamma-emitting radionuclides (including I-131) attributable to TMINS operations were detected above the MDC.

Strontium may be incorporated into plants by either uptake from soil or direct deposition on foliar surfaces. In 2001, none of the leafy vegetables (cabbages) contained Sr-89 above the MDC. Low-level Sr-90 was detected above the MDC in both the indicator sample and the control sample. The measured concentrations were 0.0024 ± 0.0012 pCi/g (wet) and 0.0015 ± 0.0008 pCi/g (wet), respectively. Similar Sr-90 concentrations were detected in previous years. For example, the 2000 indicator cabbage sample contained Sr-90 at a concentration of 0.0046 ± 0.0019 pCi/g (wet). This radionuclide also was measured in the 2000 control sample at a concentration of 0.0049 ± 0.0019 pCi/g (wet).

As in previous years, the data indicated that the Sr-90 measured in the 2001 cabbage samples was attributed to fallout from prior nuclear weapon tests and, therefore, was

unrelated to operations at TMINS. The detection of Sr-90 was not unexpected because measurable amounts of this long-lived fallout product are still present in the terrestrial environment. Additionally, cabbages have a tendency to absorb Sr-90 residing in the soil.

Deer Meat Results

Deer meat samples are normally obtained via local hunters and/or road-kills and analyzed as part of the routine REMP. During 2001, however, no deer meat samples were available for analysis.

Rodent Results

No rodent carcasses were available for analysis in 2001. Previous data suggest that rodents are not transporting radioactive materials to unrestricted areas.

A pest control program is in place at TMINS. This program minimizes the potential for rodents to transport radioactive materials to unrestricted areas.

Historical Strontium-90 Concentrations in Cow Milk

Picocuries per Liter by Quarter

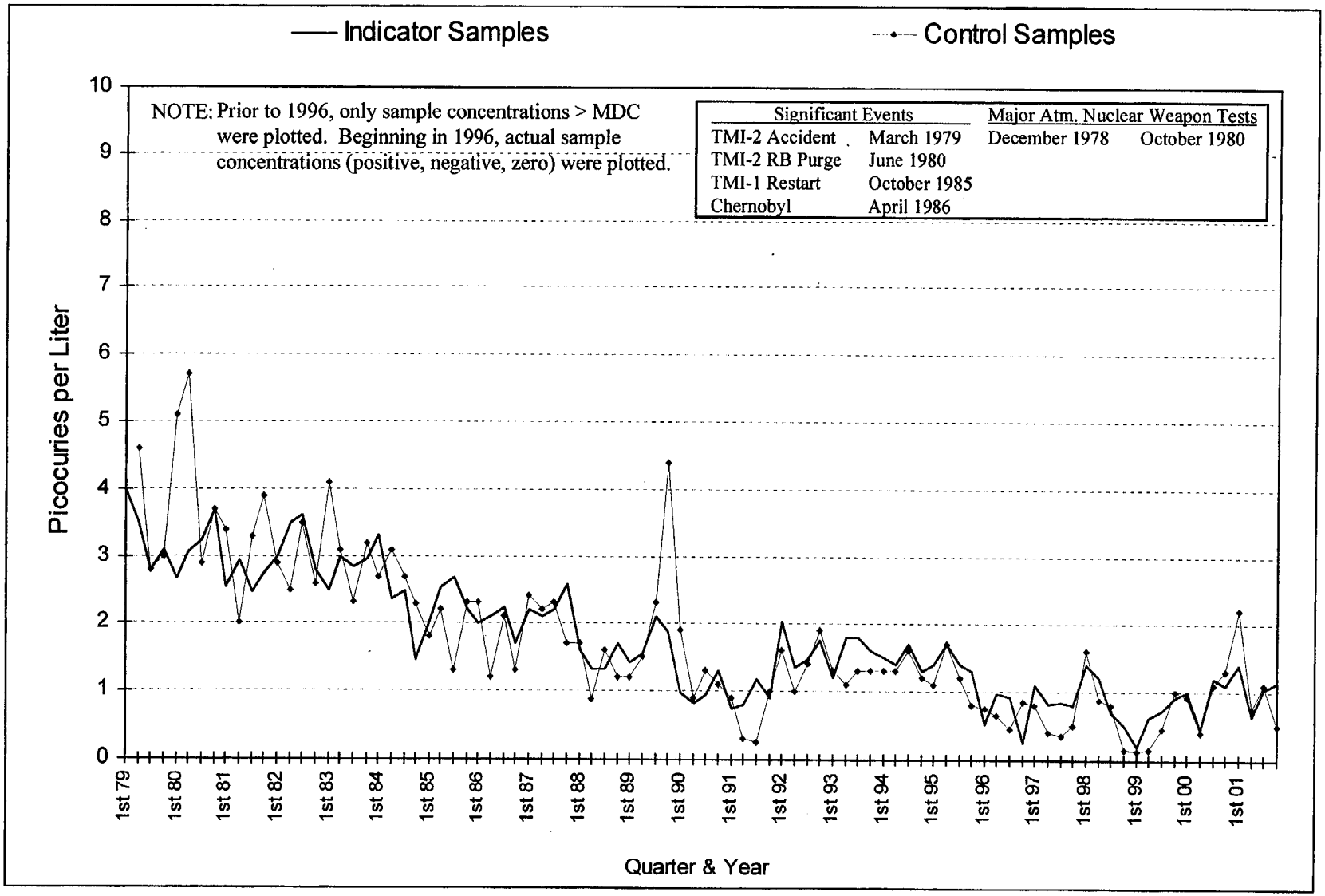


Figure 12

GROUNDWATER MONITORING

Three Mile Island (TMI) is located in the Triassic lowland of Pennsylvania, a region often referred to as the Gettysburg Basin. The Island was formed as a result of fluvial deposition by the Susquehanna River. It is composed of sub-rounded to rounded sand and gravel, containing varying amounts of silt and clay. Soil depths on TMI vary from approximately six feet at the south end to about 30 feet at the center. The site is underlain by Gettysburg shale that lies at an elevation of approximately 277 feet (Refs. 38 and 39).

The Island has two different water-bearing zones. One is composed of the soils overlying the Gettysburg shale (bedrock). The other is the bedrock. Relative to the natural soils, the movement of groundwater is much quicker in the bedrock. Groundwater from TMI migrates to the Susquehanna River, but does not impact onshore groundwater supplies. The migration of TMI groundwater to onshore supplies is prevented by the higher levels and the opposing flows of groundwater that exist beneath the surrounding terrain on the opposite sides of the Susquehanna River. The estimated travel time for groundwater to reach the river from the central portion of TMI is approximately 12 years (Ref. 40).

A groundwater monitoring program (GMP) was initiated in 1980 to detect leakage of water, if any, from the TMI-2 Reactor and Auxiliary Buildings and outside storage tanks. Since 1980, the TMINS GMP has been expanded and now monitors activities associated with both TMI-1 and TMI-2.

During 2001, most of the onsite groundwater samples contained H-3 above the minimum detectable concentration (MDC). The presence of H-3 in these samples was attributed primarily to routine TMI-1 operations and previous TMI-2 operations. Additionally, pipe leaks that were previously identified and repaired contributed to elevated levels of H-3 in certain onsite wells. The pipes continue to be monitored.

Tritium above the MDC was not detected in any of the offsite groundwater samples. However, H-3 was detected in all onsite storm water samples (4 of 4). Its presence was due primarily routine TMI-1 operations and, to a lesser extent, natural production in the atmosphere and fallout from prior nuclear weapon tests.

All H-3 concentrations measured in the groundwater collected from the onsite stations were below the USNRC 10 CFR 20 effluent concentration limit. Additionally, the onsite groundwater used for drinking contained H-3 at concentrations that were well below the USEPA Primary Drinking Water Standard of 20,000 pCi/L.

None of the groundwater samples collected in 2001 contained gamma-emitting radionuclides related to TMINS operations. The same can be said for storm water and sediment collected from Station EDCB. Additionally, Sr-90 was not identified in any of the groundwater samples collected in 2001.

The 2001 TMINS GMP results indicated that the concentrations of radioactive materials measured in onsite and offsite groundwater were too low to have a significant adverse impact on humans or the environment.

As part of the TMINS Groundwater Protection Plan, an aboveground tank monitoring program (ATMP) was established in 1997. The purpose of the program is to detect tank or component leakage at an early stage so that impacts to the local environment, such as soil and groundwater, can be minimized.

In 2001, three aboveground tanks were monitored. Monitoring was performed by collecting and analyzing groundwater samples from wells proximal to the tanks. No discernible tank or component leakage was identified in 2001.

Sample Collection and Analysis

Only one minor change was made to the TMINS GMP in 2001. The change is discussed in Appendix C.

Groundwater from 20 onsite and 2 offsite stations were sampled in 2001. Of the 20 onsite, groundwater stations, 14 were monitoring wells (MS-1, MS-2, MS-4, MS-5, MS-7, MS-8, MS-19, MS-20, MS-21, MS-22, OS-14, OS-18 and RW-1 and RW-2), 2 were drinking water wells (OSF and 48S) and 3 were industrial wells (NW-A, NW-B and NW-C).

The other onsite, groundwater station was the TMINS Pretreatment Building clearwell (NW-CW). Added in 1997, the clearwell is a holding tank for the water pumped from the three industrial wells.

Both offsite stations (E1-2 and N2-1) were drinking water wells. Storm water and sediment were sampled in 2001 from one onsite station (EDCB).

The locations of the onsite groundwater stations sampled in 2001 are shown on Figures G-1 and G-2 (Appendix G). Figure G-2 also shows the location of Station EDCB. The offsite groundwater stations are depicted on Figures 1 and 2 (**Radiological Environmental Monitoring**).

All groundwater samples were collected using standard plumbing, a dedicated, in-well pumping system or a bailing device. The groundwater stations were sampled weekly, monthly, quarterly, semiannually or annually. Storm water and sediment from Station EDCB were collected monthly and annually, respectively.

All groundwater samples collected in 2001 were analyzed for H-3. Some of these samples were analyzed individually for gamma-emitting radionuclides and some were combined into annual composites and analyzed for gamma-emitting radionuclides and/or Sr-90.

The monthly storm water samples collected from Station EDCB were combined into quarterly samples and analyzed for H-3 and gamma-emitting radionuclides. The annual sediment sample collected from this station was analyzed for gamma-emitting radionuclides.

Groundwater Results

During 2001, H-3 was the only radionuclide detected in samples collected from the onsite monitoring wells, the industrial wells and the clearwell. The results are summarized in Table G-1 of Appendix G. For comparison, Table G-1 also includes 2000 station averages. The presence of H-3 in the samples was attributed primarily to routine operations at TMI-1 and past operations at TMI-2. Additionally, pipe leaks previously identified and repaired were the source of H-3 in a few of the onsite groundwater samples. The pipes continue to be monitored and, to date, results indicate that repairs were successful.

Generally, the H-3 concentrations measured in most onsite monitoring well samples remained the same or trended downward in 2001. The highest H-3 concentrations were measured in the onsite groundwater samples collected from Stations OS-18, NW-A, NW-B, NW-C, NW-CW, MS-2, MS-4, MS-19, MS-21 and RW-2.

In August of 1998, Station OS-18 was added to the TMINS GMP to monitor the integrity of two nearby pipes that transport water containing radioactive materials, including H-3. The 1998 and 1999 OS-18 H-3 concentrations were higher than expected and, consequently, a test to determine the integrity of the pipes was initiated. In 1999, one of the pipes was found to be leaking and was repaired. The pipe was returned to service following repairs.

The 2001 OS-18 H-3 concentrations averaged 730 ± 730 pCi/L and ranged from 270 to 1,800 pCi/L. For comparison, the 2000 OS-18 H-3 concentrations averaged 4,000 ± 14,000 pCi/L and ranged from 280 to 31,000 pCi/L. The decrease in H-3 concentrations from 2000 to 2001 indicated that the 1999 pipe repair was successful. Also, the 2001 data indicated that there were no leaks in the two nearby pipes.

Industrial Wells NW-A, NW-B and NW-C were installed in the latter part of 1995. Sampling of these wells was initiated in 1996. Beginning in June of 1997, water from the industrial wells was used to supply water to various TMI-1 systems. Prior to this period, the water used in these systems was obtained from the Susquehanna River.

The 2001 H-3 concentrations in water collected from NW-A averaged 1,000 ± 500 pCi/L and ranged from 850 to 1,200 pCi/L. Slightly higher, the 2000 concentrations averaged 1,300 ± 100 pCi/L and ranged from 1,300 to 1,400 pCi/L.

During 2001, the H-3 concentrations for NW-B were somewhat higher than NW-A, averaging 2,100 ± 2,100 pCi/L and ranging from 1,400 to 2,900 pCi/L. For comparison, the 2000 NW-B concentrations averaged 2,900 ± 1,600 pCi/L and ranged from 2,400 to 3,500 pCi/L.

The 2001 NW-C H-3 concentrations averaged 14,000 ± 4,000 pCi/L and ranged from 12,000 to 15,000 pCi/L. For comparison, the 2000 H-3 concentrations averaged 18,000 ± 4,000 pCi/L and ranged from 17,000 to 20,000 pCi/L.

The presence of H-3 in the water collected from the industrial wells was expected because the wells are located in an area that can be impacted by past TMI-2 operations. A portion of the H-3 detected in the samples also was due to routine TMI-1 operations.

The magnitude of the H-3 concentrations measured in NW-C water, however, was higher than expected. The higher than expected results in NW-C suggested an additional source of H-3. This source is likely the pipe leak that affected OS-18 (discussed above).

The lower H-3 concentrations measured in 2001 industrial well water supported this hypothesis. Furthermore, the lower H-3 concentrations measured in 2001 industrial well water also supported the conclusion that the pipe was successfully repaired.

The H-3 concentrations measured in the samples collected from Stations MS-2, MS-4, MS-19, MS-21, RW-2 ranged from 190 pCi/L to 2400 pCi/L. The presence of H-3 in these samples was most likely due to past pipe leaks, routine airborne releases and/or routine maintenance of the fire service system which is supplied in part by the industrial wells.

All of the H-3 concentrations found in water collected from the onsite monitoring wells, the industrial wells and the clearwell were well below the USNRC 10 CFR 20 (Appendix B, Table 2) effluent concentration of 1,000,000 pCi/L.

Tritium also was measured in the water collected from the two onsite drinking water wells, Stations 48S and OSF. In 1997, the

well at Station 48S was established as the primary source for drinking water on TMINS. To a lesser extent, water from the OSF well was used for drinking and occasionally was used to supply water for various TMI-1 plant systems.

In 2001, 4 of 4 samples collected from Station 48S contained H-3 above the minimum detectable concentration (MDC). The concentrations averaged 200 ± 80 pCi/L and ranged from 160 to 240 pCi/L. The 2001 concentrations were consistent with those measured in 2000 (Table G-1).

The 2001 OSF H-3 concentrations (4 of 4) averaged 490 ± 90 pCi/L and ranged from 420 to 520 pCi/L. As shown on Table G-1, the 2001 OSF concentrations were similar to those reported in 2000.

The H-3 detected in the 2001 onsite drinking water samples was attributed primarily to routine operations at TMI-1 (e.g. routine airborne releases) and possibly past operations at TMI-2 (e.g. prior airborne releases from the TMI-2 Evaporator). A small portion of the H-3 detected in the onsite well water was attributed to natural production in the atmosphere and fallout from prior nuclear weapon tests. All of the H-3 concentrations detected in the onsite drinking water were a small fraction of the USEPA Primary Drinking Water Standard of 20,000 pCi/L.

A conservative dose estimate was performed assuming that a TMINS employee drank OSF water at the 2001 average H-3 concentration for one working year. The maximum hypothetical whole body dose was 0.009 mrem. This calculated dose is equivalent to 0.003% of the whole body dose that an individual living in the TMI area receives each year from natural background radiation (300 mrem).

Offsite groundwater samples were collected annually from two locations. Neither sample contained H-3 above the MDC.

Some of the 2000 groundwater samples (individual or composite) were analyzed for Sr-90 and/or gamma-emitting radionuclides. None were found to contain detectable Sr-90 or gamma-emitting radionuclides related to TMINS operations.

Storm Water and EDCB Sediment Results

Storm water from Station EDCB, an onsite collection basin, was collected monthly. The monthly samples were then combined into quarterly samples and analyzed for H-3 and gamma-emitting radionuclides.

No gamma-emitting radionuclides were detected. All samples contained H-3 above the MDC. The concentrations averaged 280 ± 230 pCi/L and ranged from 200 to 450 pCi/L. Similar H-3 concentrations were measured in 2000 (Table G-1). Since these concentrations were higher than those typically measured in control surface water, a portion of the H-3 detected in the 2000 storm water was attributed to routine operations at TMI-1 (e.g. routine airborne releases). To a lesser extent, a portion of the H-3 was due to natural production in the atmosphere and fallout from prior nuclear weapon tests.

A sediment sample from Station EDCB was collected in the fall and analyzed for gamma-emitting radionuclides. Naturally-occurring K-40, Ra-226 and Ac-228 as well as fallout and/or reactor-produced Cs-137 were identified. No other reactor-produced, gamma-emitting radionuclides were detected above the MDC.

The Cs-137 concentration was 0.25 ± 0.05 pCi/g (dry). Since control sediment samples have contained similar concentrations, the Cs-137 measured in the sample collected from Station EDCB was most likely due to fallout from previous weapon tests and not TMINS operations.

RADIOLOGICAL IMPACT OF TMINS OPERATIONS

An assessment of potential radiological impact indicated that radiation doses to the public from 2001 operations at TMINS were well below all applicable regulatory limits and were significantly less than doses received from natural sources of radiation. The 2001 whole body dose potentially received by an assumed maximum exposed individual from TMI-1 and TMI-2 liquid and airborne effluents was conservatively calculated to be 0.2 mrem. This dose is equivalent to 0.07% of the dose that an individual living in the TMI area receives each year from natural background radiation.

The 2001 whole body dose to the surrounding population from TMI-1 and TMI-2 liquid and airborne effluents was calculated to be 11 person-rem. This is equivalent to 0.002% of the dose that the total population living within 50 miles of TMI receives each year from natural background radiation.

Determination of Radiation Doses to the Public

Dose assessments can be performed by using either effluent data and an environmental transport model or environmental sample data. To the extent possible, doses to the public are based on the direct measurement of dose rates from external sources and the measurement of radionuclide concentrations in environmental media which may contribute to an internal dose of radiation. Thermoluminescent dosimeters (TLDs) positioned in the environment around TMINS provide measurements to determine external radiation doses to humans. Samples of air, water and food products are used to determine internal doses.

The quantity of radioactive materials released during normal operations are typically too small to be measured once distributed in the offsite environment. Therefore, the potential offsite doses are more effectively calculated for TMINS operations using a computerized model that predicts concentrations of radioactive materials in the environment and subsequent radiation doses based on measured effluents. Another reason for using effluent data and a transport model is that environmental sampling data cannot provide enough information to calculate population doses.

Doses are calculated using an advanced "class A" dispersion model. This model incorporates the guidelines and methodology set forth by the USNRC in Regulatory Guide 1.109. Due to the conservative assumptions that are used in the model, the calculated doses are generally higher than the doses based on actual environmental sample concentrations. Therefore, the model predicts doses that are higher than actual doses received by people. The type and amount of radioactivity released from TMINS is calculated using measurements from effluent radiation instruments and effluent sample analyses. Once released, the dispersion of radionuclides in the environment is readily determined by computer modeling.

Airborne releases are diluted and carried away from the site by atmospheric diffusion which continuously acts to disperse radioactivity. Variables that affect atmospheric dispersion include wind speed, temperature at different elevations, terrain, and shift in wind direction. A weather station on the north end of TMI is linked to a computer terminal that permanently records the meteorological data.

Computer models also are used to predict the downstream dilution and travel times for liquid releases into the Susquehanna River. Actual monthly Susquehanna River flows are obtained from FirstEnergy Corp. at the York Haven Hydroelectric Station.

The human exposure pathways also are included in the model and are depicted in Figure 13. The exposure pathways that are considered for the discharge of TMINS liquid effluents are consumption of drinking water and fish, and shoreline exposure. The exposure pathways considered for the discharge of TMINS airborne effluents are plume exposure, inhalation, cow milk consumption, goat milk consumption, fruit and vegetable consumption, meat consumption and land deposition.

Numerous data files are used in the calculations that describe the area around TMI

in terms of population distribution and foodstuffs production. Data files include such information as the distance from the plant stack to the site boundary in each sector, the population groupings, milk cows, milk goats, gardens of more than 500 square feet, meat animals, downstream drinking water users, and crop yields.

When determining the dose to humans, it is necessary to consider all applicable pathways and all exposed tissues, summing the dose from each to provide the total dose for each organ as well as the whole body from a given radionuclide. Dose calculations involve determining the energy absorbed per unit mass in the various tissues. Thus, for radionuclides taken into the body, the metabolism of the radionuclide in the body must be known along with the physical characteristics of the nuclide such as energies, types of radiations emitted and half-life. The dose assessment model also contains dose conversion factors for the radionuclides for each of four age groups (adults, teenagers, children and infants) and eight organs (total body, thyroid, liver, skin, kidney, lung, bone and GI tract).

Doses are calculated for what is termed the "maximum hypothetical individual". This individual is assumed to be affected by the combined maximum environmental concentrations wherever they occur.

For liquid releases, the maximum hypothetical individual would consume 193 gallons of Susquehanna River water per year from the first downstream drinking water supplier, eat 46 pounds of fish each year that reside in the plant discharge area and stand 67 hours per year on the shoreline influenced by the plant discharge.

For airborne releases, the maximum hypothetical individual would live at the location of highest radionuclide concentration for inhalation and direct plume exposure. Additionally, this individual each year would consume 106 gallons of cow milk, 141 pounds of leafy vegetables, 1389 pounds of non-leafy vegetables and fruits and 243 pounds of meat produced at the locations with the highest predicted radionuclide concentrations. Consumption of goat milk is not included, since this exposure pathway does not currently exist.

Doses to the population within 50 miles of TMI for airborne effluents and the entire population using Susquehanna River water downstream of the plant also are calculated.

Results of Dose Calculations

The maximum hypothetical doses due to 2001 TMI-1 and TMI-2 liquid and airborne effluents are summarized in Tables 5 and 6. Table 5 compares the calculated maximum hypothetical individual doses to the USNRC 10 CFR 50 App. I guidelines. This table also compares the calculated doses (to an individual of the public) from effluents and direct radiation to USEPA 40 CFR 190 dose limits.

Table 6 presents the maximum hypothetical whole body doses to an individual and the total population from 2001 TMINS effluents (i.e. TMI-1 and TMI-2 liquid and airborne effluents combined). For airborne releases, population doses are calculated for all people living within

50 miles of TMINS. For liquid releases, population doses are calculated for all people using Susquehanna River water downstream of TMINS. The maximum individual and population whole body doses presented in Table 6 are compared to the doses received from natural background radiation.

As shown in Table 5, the doses calculated for 2001 operations at TMINS were well below the Federal dose limits (USEPA 40 CFR 190) and the guidelines of USNRC 10 CFR 50 App. I. This conclusion was supported by radionuclide concentrations detected in actual environmental samples.

Doses from natural background radiation provide a baseline for assessing the potential public health significance of radioactive effluents. Natural background radiation from cosmic, terrestrial and natural radionuclides in the human body (not including radon), averages about 100 mrem/yr (Ref. 31). Additionally, the average individual living in the United States receives an annual dose of about 2,400 mrem to the lung from natural radon gas. This lung dose is considered to be equivalent to a whole (or total) body dose of 200 mrem (Ref. 31). Therefore, the average person in the United States receives a whole body dose of about 300 mrem/yr from natural background radiation sources.

As shown on Table 6, the maximum hypothetical whole body dose received by an individual from 2001 TMI-1 and TMI-2 liquid and airborne effluents combined was conservatively calculated to be 0.2 mrem. This dose is equivalent to 0.07 percent of the dose that an individual living in the TMI area receives each year from natural background radiation (300 mrem).

The maximum hypothetical whole body dose to the surrounding population from all 2001 TMI-1 and TMI-2 liquid and airborne effluents was calculated to be 11 person-rem. This dose is equivalent to 0.002 percent of the whole body dose that the total population in the TMI area receives each year from natural background radiation.

The low doses calculated for 2001 TMINS operations were the result of efforts to maintain releases "as low as reasonably achievable" (ALARA).

In conclusion, radioactive materials related to TMINS operations were detected in environmental samples, but the measured concentrations were low and consistent with measured effluents. The environmental sample results verified that the doses received by the public from TMINS effluents in 2001 were well below applicable dose limits and only a small fraction of the doses received from natural background radiation. Additionally, the results indicated that there was no permanent buildup of radioactive materials in the environment and no increase in background radiation levels.

Therefore, based on the results of the radiological environmental monitoring program (REMP) and the doses calculated from measured effluents, TMINS operations in 2001 did not have any adverse effects on the health of the public or on the environment.

TABLE 5

Calculated Maximum Hypothetical Doses to an Individual from 2001 TMI-1 and TMI-2 Liquid and Airborne Effluents

	Maximum Hypothetical Doses To An Individual		
	USNRC 10 CFR 50 APP. I Guidelines (mrem/yr)	Calculated Dose (mrem/yr) TMI-1	TMI-2
From Radionuclides In Liquid Releases	3 total body, or	0.2	< 0.01
	10 any organ	0.2	< 0.01
From Radionuclides In Airborne Releases (Noble Gases)	5 total body, or	< 0.01	0*
	15 skin	< 0.01	0*
From Radionuclides In Airborne Releases (Iodines, Tritium and Particulates)	15 any organ	0.01	< 0.01

*No noble gases were released from TMI-2.

	USEPA 40 CFR 190 Limits (mrem/yr)	Calculated Dose (mrem/yr) TMI-1 and TMI-2 Combined**
Total from Site	75 thyroid	0.3
	25 total body or other organs	0.5

* *This sums together TMI-1 and TMI-2 maximum doses regardless of age group for different pathways. The combined doses include those due to radioactive effluents and direct radiation from TMINS. The direct radiation dose is calculated from environmental TLD data. For this calculation, exposure is assumed to be equal to dose.

The direct radiation dose from 2001 TMINS operations was 0.2 mrem. This dose was based on a maximum net fence-line exposure rate of 3 mR/std month and a shoreline/fence-line occupancy factor of 67 hours (Regulatory Guide 1.109). The combination of the maximum organ dose from TMI-1 and TMI-2 effluents (0.3 mrem) and the dose from direct radiation (0.2 mrem) yielded a maximum hypothetical dose of 0.5 mrem.

TABLE 6

Calculated Whole Body Doses to the Maximum Individual and the Population from 2001 TMI-1 and TMI-2 Liquid and Airborne Effluents

	Calculated Maximum Individual Whole Body Dose (mrem/yr) TMI-1	TMI-2
From Radionuclides In Liquid Releases	0.2	< 0.01
From Radionuclides In Airborne Releases (Noble Gases)	< 0.01	0*
From Radionuclides In Airborne Releases (Iodines, Tritium and Particulates)	0.01	< 0.01

*No noble gases were released from TMI-2.

Individual Whole Body Dose Due to TMI-1 and TMI-2 Operations: **0.2 mrem/yr**

Individual Whole Body Dose Due to Natural Background Radiation: **300 mrem/yr**

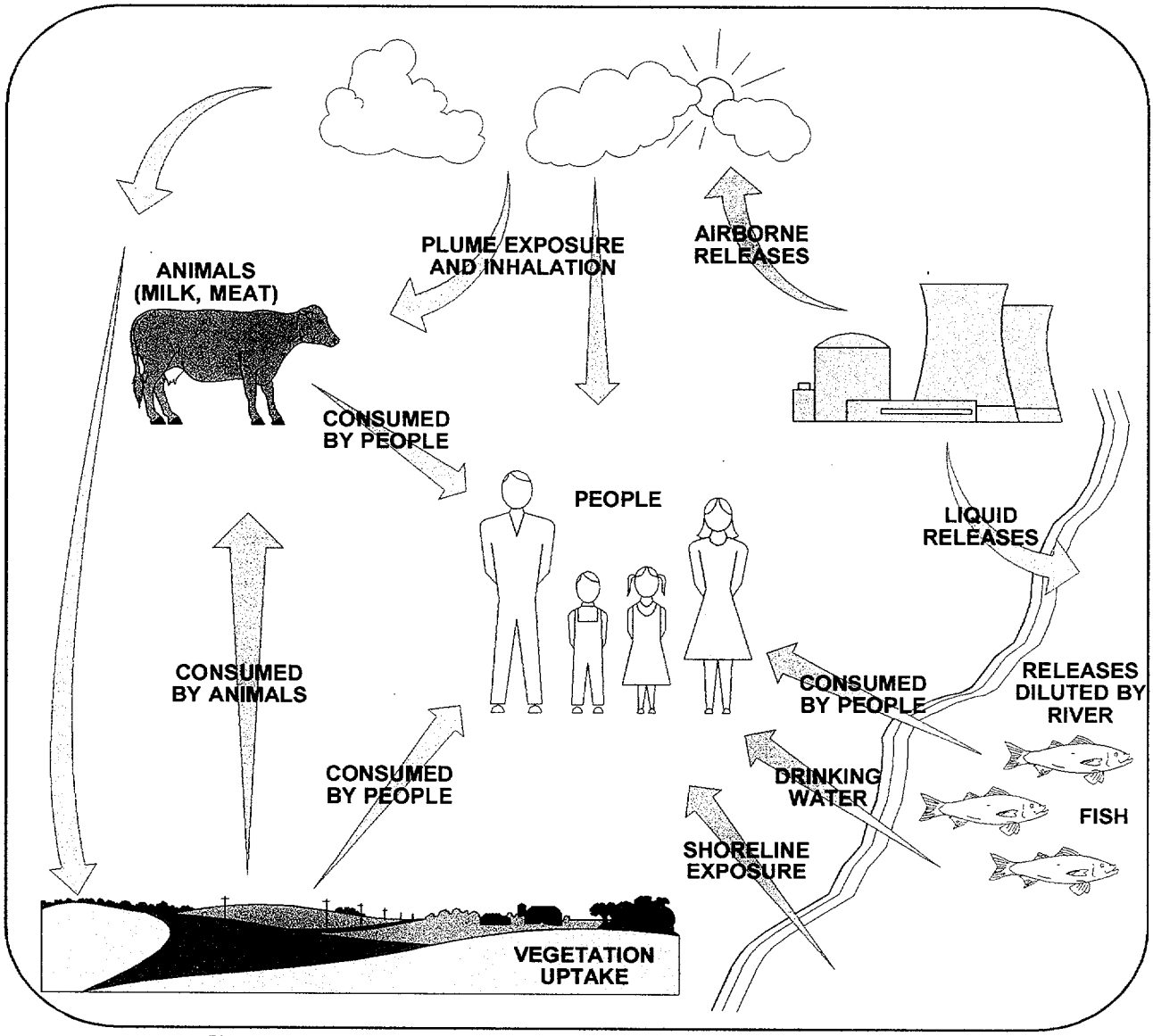
	Calculated Population Whole Body Dose (person-rem/yr) TMI-1	TMI-2
From Radionuclides In Liquid Releases (Downstream Susquehanna River Water Users)	10	< 0.1
From Radionuclides In Airborne Releases (Population within 50 Mile Radius of TMINS)	0.5	< 0.1

Population Whole Body Dose Due to TMI-1 and TMI-2 Operations: **11 person-rem/yr**

Population Whole Body Dose Due to Natural Background Radiation: **660,000 person-rem/yr**

Figure 13

Exposure Pathways For Radionuclides Routinely Released From TMINS



PREDOMINANT RADIONUCLIDES

NOBLE GASES (Xe,Kr)
Plume exposure

RADIOIODINES (I-131, I-133)
Inhalation and consumption of milk, water, fruits, and vegetables

RADIOSTRONTIUMS (Sr-89, Sr-90)
Consumption of milk, meat, fruits, and vegetables

ACTIVATION PRODUCTS (Co-60, Mn-54)
Shoreline exposure

RADIOCESIUMS (Cs-134, Cs-137)
Shoreline exposure and consumption of milk, meat, fish, water, fruits, and vegetables

TRITIUM (H-3)
Inhalation and consumption of water, milk, fruits, and vegetables

REFERENCES

1. Three Mile Island Nuclear Station, Unit 1, Technical Specifications, DPR 50.

2. Three Mile Island Nuclear Station, Unit 2, PDMS Technical Specifications, DPR 73.

3. Radiation Management Corporation. "Three Mile Island Nuclear Station, Preoperational Radiological Environmental Monitoring Program, January 1, 1974 - June 5, 1974." RMC-TR-75-17, January 1975.

4. Radiation Management Corporation. "Radiological Environmental Monitoring Report for the Three Mile Island Nuclear Station, First Operational Period, June 5 through December 31, 1974." RMC-TR-75-02, February 1975.

5. Radiation Management Corporation. "Radiological Environmental Monitoring Report for the Three Mile Island Nuclear Station." RMC-TR-75-13, August 1975.

6. Radiation Management Corporation. "Radiological Environmental Monitoring Report for the Three Mile Island Nuclear Station, 1975 Semi-annual Report II, July 1 through December 31." RMC-TR-76-01, February 1976.

7. Radiation Management Corporation. "Radiological Environmental Monitoring Report for the Three Mile Island Nuclear Station, 1976 Annual Report, January 1 through December 31." RMC-TR-77-01, March 1977.

8. Teledyne Isotopes. "Metropolitan Edison Company, Radiological Environmental Monitoring Report, 1977 Annual Report, January 1 through December 31." IWL-5990-427, 1978.

9. Teledyne Isotopes. "Metropolitan Edison Company, Radiological Environmental Monitoring Report, 1978 Annual Report." IWL-5590-443, 1979.

10. Metropolitan Edison Company. "Three Mile Island Nuclear Station Radiological Environmental Monitoring Program, Annual Report for 1979." April 1980.

11. Metropolitan Edison Company. "Three Mile Island Nuclear Station Radiological Environmental Monitoring Report, 1980 Annual Report." March 1981.

12. GPU Nuclear Corporation. "1981 Radiological Environmental Monitoring Report for Three Mile Island Nuclear Generating Station." May 1982.

13. GPU Nuclear Corporation. "1982 Radiological Environmental Monitoring Report for Three Mile Island Nuclear Generating Station." May 1983.

14. GPU Nuclear Corporation. "1983 Radiological Environmental Monitoring Report for Three Mile Island Nuclear Station." May 1984.

15. GPU Nuclear Corporation. "1984 Radiological Environmental Monitoring Report for Three Mile Island Nuclear Station." May 1985.

16. GPU Nuclear Corporation. "1985 Radiological Environmental Monitoring Report for Three Mile Island Nuclear Station." May 1986.

17. GPU Nuclear Corporation. "1986 Radiological Environmental Monitoring Report for Three Mile Island Nuclear Station." May 1987.

18. GPU Nuclear Corporation. "1987 Radiological Environmental Monitoring Report for Three Mile Island Nuclear Station." May 1988.

19. GPU Nuclear Corporation. "1988 Radiological Environmental Monitoring Report, Three Mile Island Nuclear Station." May 1989.

20. GPU Nuclear Corporation. "1989 Annual Radiological Environmental Monitoring Report for the Three Mile Island Nuclear Station." May 1990.

21. GPU Nuclear Corporation. "1990 Radiological Environmental Monitoring Report, Three Mile Island Nuclear Station." May 1991.

22. GPU Nuclear Corporation. "1991 Radiological Environmental Monitoring Report, Three Mile Island Nuclear Generating Station." May 1992.

23. GPU Nuclear Corporation. "1992 Three Mile Island Nuclear Station, Radiological Environmental Monitoring Report." May 1993.

24. GPU Nuclear Corporation. "1993 Three Mile Island Nuclear Station, Radiological Environmental Monitoring Report." May 1994.

25. GPU Nuclear Corporation. "1994 Three Mile Island Nuclear Generating Station, Radiological Environmental Monitoring Report." May 1995.

26. GPU Nuclear Corporation. "1995 Three Mile Island Nuclear Generating Station, Radiological Environmental Monitoring Report." May 1996.

27. GPU Nuclear Corporation. "1996 Three Mile Island Nuclear Generating Station, Radiological Environmental Monitoring Report." May 1997.

28. GPU Nuclear Corporation. "1997 Three Mile Island Nuclear Generating Station, Radiological Environmental Monitoring Report." May 1998.

29. GPU Nuclear Corporation. "1998 Three Mile Island Nuclear Generating Station, Radiological Environmental Monitoring Report." May 1999.

30. AmerGen Energy Company, LLC. "1999 Three Mile Island Nuclear Generating Station, Radiological Environmental Monitoring Report." May 2000.

31. National Council on Radiation Protection and Measurements. Report No. 93. "Ionizing Radiation Exposure of the Population of the United States." 1987.

32. United States Nuclear Regulatory Commission Branch Technical Position. "An Acceptable Radiological Environmental Monitoring Program." Revision 1, November 1979.

33. GPU Nuclear Corporation. "Three Mile Island Nuclear Generating Station Offsite Dose Calculation Manual (ODCM)." 6610-PLN-4200.01.

34. United States Nuclear Regulatory Commission. Regulatory Guide 4.15. "Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment." Revision 1, February 1979.

35. American National Standards Institute, Inc. "Performance, Testing and Procedural Specifications for Thermoluminescence Dosimetry." ANSI N545-1975.

36. United States Nuclear Regulatory Commission. Regulatory Guide 4.13. "Performance, Testing and Procedural Specifications for Thermoluminescence Dosimetry: Environmental Applications." Revision 1, July 1977.

37. L. F. Toke, B. H. Carson, G. G. Baker, M. H. McBride. "Performance Testing of the Environmental TLD System for the Three Mile Island Nuclear Station." Health Physics Vol. 46, No. 5 (May), pp. 1013 - 1020, 1984.

38. GPU Nuclear Corporation. "Final Safety Analysis Report, Three Mile Island Nuclear Station, Unit 1." 1994.

39. GPU Nuclear Corporation. "Post-Defueling Monitored Storage Safety Analysis Report, Three Mile Island Nuclear Station, Unit 2." 1993.

40. Ground/Water Technology, Inc. "Hydrogeological Investigation, Three Mile Island Nuclear Station, Londonderry Township, Pennsylvania." December 1981.

41. AmerGen Energy Company, LLC. "2000 Three Mile Island Nuclear Generating Station, Radiological Environmental Monitoring Report." May 2000.

APPENDIX A

2001 REMP Sampling Locations and Descriptions, Synopsis of REMP, and Sampling and Analysis Exceptions

TABLE A-1

TMINS Radiological Environmental Monitoring Program Sample Locations - 2001

Sample Medium	Station Code	Map Number	Distance*	Azimuth	Description
AQS	A1-3	16	0.5 mi	0°	N of site off north tip of TMI in Susquehanna River
ID	A1-4	113	0.3	5	N of Reactor Building on W fence adjacent to North Weather Station, TMI
AP,AI,ID	A3-1	39	2.6	358	N of site at Mill Street Substation
SW	A3-2	40	2.5	355	N of site at Swatara Creek, Middletown
ID	A5-1	44	4.3	3	N of site on Vine Street Exit off Route 283
ID	A9-3	127	8.1	3	N of site at Duke Street Pumping Station, Hummelstown
ID	B1-1	2	0.6	25	NNE of site on light pole in middle of North Bridge, TMI
ID	B1-2	114	0.4	26	NNE of Reactor Building on top of dike, TMI
ID	B2-1	132	1.9	16	NNE of site on Sunset Dr. (off Hillsdale Rd.)
ID	B5-1	45	4.8	18	NNE of site at intersection of School House and Miller Roads
ID	B10-1	61	9.4	21	NNE of site at intersection of West Areba Avenue and Mill Street, Hershey
FP	B10-2	1	10.1	28	NNE of site at Milton Hershey School, Hershey
ID	C1-1	17	0.7	35	NE of site along Route 441 N
ID	C1-2	116	0.3	54	NE of Reactor Building on top of dike, TMI
ID	C2-1	43	1.6	48	NE of site at Middletown Junction
ID	C5-1	46	4.5	42	NE of site on Kennedy Lane
ID	C8-1	62	7.2	48	NE of site at Schenk's Church on School House Road
AQF	Control	-	-	-	All locations where finfish are collected upstream of the TMINS liquid discharge outfall (above Dock St. Dam, Harrisburg) are grouped together and referred to as "control"
GAD	Control	-	-	-	All locations greater than 10 miles from TMINS
ID	D1-1	3	0.2	74	ENE of Reactor Building on top of dike, TMI
ID	D1-2	18	0.6	60	ENE of site on Laurel Road
M	D2-1	29	1.1	65	ENE of site at farm on Gingrich Road
ID	D2-2	133	1.7	73	ENE of site along Hillsdale Rd. (S of Zion Rd.)
ID	D6-1	47	5.2	65	ENE of site off Beagle Road
ID	D15-1	80	10.9	63	ENE of site along Route 241, Lawn, PA
AP,AI,ID,GW,FP	E1-2	19	0.4	95	E of site at TMI Visitor's Center
ID	E1-4	117	0.2	98	E of Reactor Building on top of dike, TMI
M	E2-2	109	1.1	93	E of site at farm on Pecks Road
ID	E2-3	134	1.9	96	E of site along Hillsdale Rd. (N of Creek Rd.)
ID	E5-1	48	4.6	81	E of site at intersection of North Market Street (Route 230) and Zeager Road
ID	E7-1	64	6.8	86	E of site along Hummelstown Street, Elizabethtown
ID	F1-1	20	0.5	117	ESE of site near entrance to 500 kV Substation

TABLE A-1 (Continued)

TMINS Radiological Environmental Monitoring Program Sample Locations - 2001

Sample Medium	Station Code	Map Number	Distance*	Azimuth	Description
ID	F1-2	118	0.2 mi	109°	ESE of Reactor Building on top of dike midway within Interim Solid Waste Staging Facility, TMI
AP,AI	F1-3	149	0.6	105	ESE of site in 500 kV Substation
ID	F1-4	154	0.3	115	ESE of Reactor Building on top of dike, TMI
ID	F2-1	135	1.2	120	ESE of site along Engle Road
ID	F5-1	49	4.7	107	ESE of site along Amosite Road
ID	F10-1	66	9.4	112	ESE of site along Donegal Springs Road, Donegal Springs
ID	F25-1	82	21.1	113	ESE of site at intersection of Steel Way and Loop Roads, Lancaster
ID	G1-2	22	0.6	143	SE of site along Route 441 S
ID	G1-3	119	0.3	129	SE of Reactor Building on top of dike, TMI
ID	G1-5	139	0.3	144	SE of Reactor Building on top of dike, TMI
ID	G1-6	140	0.3	141	SE of Reactor Building on top of dike, TMI
AI,AP,M	G2-1	104	1.4	125	SE of site at farm on Becker Road
ID	G2-4	136	1.7	135	SE of site on Becker Road
ID	G5-1	50	4.8	131	SE of site at intersection of Bainbridge and Risser Roads
ID	G10-1	67	9.8	127	SE of site at farm along Engles Tollgate Road, Marietta
ID	G15-1	84	14.4	124	SE of site at Columbia Water Treatment Plant
SW	G15-2	85	13.6	128	SE of site at Wrightsville Water Treatment Plant
SW	G15-3	86	14.8	124	SE of site at Lancaster Water Treatment Plant
ID	H1-1	5	0.5	167	SSE of site, TMI
AP,AI,ID	H3-1	41	2.3	159	SSE of site in Falmouth-Collins Substation
ID	H5-1	52	4.1	157	SSE of site by Guard Shack at Brunner Island Steam Electric Station
ID	H8-1	68	7.4	163	SSE of site along Saginaw Road, Starview
ID	H15-1	87	13.2	157	SSE of site at intersection of Orchard and Stonewood Roads, Wilshire Hills
AQF	Indicator	-	-	-	All locations where finfish are collected downstream of the TMINS liquid discharge outfall are grouped together and referred to as "indicator"
GAD	Indicator	-	-	-	All locations within ten miles of TMINS
ROD	Indicator	-	-	-	All locations where rodents are collected within the owner controlled area, TMI
ID	J1-1	6	0.8	184	S of site, TMI
SW	J1-2	23	0.5	188	S of site downstream of the TMINS liquid discharge outfall in Susquehanna River
ID	J1-3	121	0.3	189	S of Reactor Building on wooden post of Building 221, just S of Unit 2 Admin. Building, TMI
AQS	J2-1	31	1.5	182	S of site in Susquehanna River just upstream of the York Haven Dam
ID	J3-1	141	2.7	178	S of site at York Haven/Cly
ID	J5-1	53	4.9	182	S of site along Canal Road, Conewago Heights

TABLE A-1 (Continued)

TMINS Radiological Environmental Monitoring Program Sample Locations - 2001

Sample Medium	Station Code	Map Number	Distance*	Azimuth	Description
ID	J7-1	69	6.5 mi	177°	S of site off of Maple Street, Manchester
ID	J15-1	88	12.6	180	S of site in Met-Ed York Load Dispatch Station
EW	K1-1	7	0.2	209	On site at RML-7 Main Station Discharge Building
AQS	K1-3	24	0.3	202	SSW of site in Susquehanna River
ID	K1-4	123	0.2	208	SSW of Reactor Building on top of dike behind Warehouse 2, TMI
ID	K2-1	32	1.1	200	SSW of site on S Shelley Island
ID	K3-1	142	2.1	202	SSW of site along Rt. 262, N of Cly
ID	K5-1	54	5.0	200	SSW of site along Conewago Creek Road, Strinestown
ID	K8-1	70	7.4	196	SSW of site at intersection of Coppenhaffer Road and Route 295, Zions View
ID	K15-1	90	12.7	204	SSW of site on the Bird's Nest Child Care Center Building, Weiglestown
M	K15-3	151	14.5	205	SSW of site at farm along S Salem Church Rd, Dover
ID	L1-1	9	0.1	235	SW of site on top of dike W of Mech. Draft Cooling Tower, TMI
ID	L1-2	26	0.5	221	SW of site on Beech Island
ID	L2-1	33	1.9	227	SW of site along Route 262
ID	L5-1	55	4.1	228	SW of site at intersection of Stevens and Wilson Roads
ID	L8-1	71	8.0	225	SW of site along Rohlers Church Rd., Andersontown
ID	L15-1	91	11.7	225	SW of site on W side of Route 74, rear of church, Mt. Royal
ID	M1-1	129	0.1	249	WSW of Reactor Building on SE corner of U-2 Screenhouse fence, TMI
ID	M1-2	143	0.5	241	WSW of site on W side of unnamed island between N tip of Beech Island and Shelley Island
AP,AI,ID	M2-1	34	1.3	253	WSW of site adjacent to Fishing Creek, Goldsboro
ID	M5-1	56	4.3	249	WSW of site at intersection of Lewisberry and Roxberry Roads, Newberrytown
ID	M9-1	72	8.6	242	WSW of site along Alpine Road, Maytown
ID	N1-1	10	0.7	270	W of site on Shelley Island
ID	N1-3	124	0.1	270	W of Reactor Building on fence adjacent to Screenhouse entrance gate, TMI
ID,GW	N2-1	35	1.2	262	W of site at Goldsboro Marina
ID	N5-1	57	4.9	268	W of site off of Old York Road along Robin Hood Drive
ID	N8-1	73	7.8	260	W of site along Route 382, 1/2 mile north of Lewisberry
ID	N15-2	95	10.4	274	W of site at intersection of Lisburn Road and Main Street, Lisburn
ID	P1-1	12	0.4	293	WNW of site on Shelley Island
ID	P1-2	38	0.2	290	WNW of Reactor Building on fence N of Unit 1 Screenhouse, TMI
ID	P2-1	36	1.9	283	WNW of site along Route 262
ID	P5-1	58	4.9	285	WNW of site at intersection of Valley Road (Route 262) and Beinhower Road

TABLE A-1 (Continued)

TMINS Radiological Environmental Monitoring Program Sample Locations - 2001

Sample Medium	Station Code	Map Number	Distance*	Azimuth	Description
ID	P8-1	74	8.0	292	WNW of site along Evergreen Road, Reesers Summit
ID	Q1-1	13	0.5	317	NW of site on Shelley Island
ID	Q1-2	125	0.2	318	NW of Reactor Building on fence W of Warehouse 1, TMI
ID	Q2-1	37	1.8	310	NW of site along access road along river
ID	Q5-1	59	5.0	318	NW of site along Lumber Street, Highspire
SW,ID	Q9-1	76	8.5	308	NW of site at the Steelton Water Company
AP,AI,ID	Q15-1	97	13.5	305	NW of site behind West Fairview Fire Dept. Social Hall
ID	R1-1	14	0.2	335	NNW of Reactor Building along W fence, TMI
ID	R1-2	27	0.7	332	NNW of site on Henry Island
ID	R3-1	107	2.6	338	NNW of site at Crawford Station, Middletown
ID	R5-1	60	4.9	339	NNW of site at interstection of Spring Garden Drive and Route 441
ID	R9-1	77	8.1	340	NNW of site at intersection of Derry and 66th Streets, Rutherford Heights
ID	R15-1	99	11.2	330	NNW of site at intersection of Route 22 and Colonial Road, Colonial Park

IDENTIFICATION KEY

ID = Immersion Dose (TLD)
SW = Surface Water
M = Milk (Cow)
AP = Air Particulate
GW = Ground Water (offsite)
AQS = Aquatic Sediment
EW = Effluent Water
GAD = Meat (Game)
AQF = Finfish
AI = Air Iodine
FP = Food Products (Green Leafy Vegetation, Fruits, Vegetables)
ROD = Rodents

* All distances are measured from a point that is midway between the reactor buildings of TMI-1 and TMI-2.

TABLE A-2

Synopsis of the 2001 TMINS REMP[1]

Sample Type	Number of Sampling Locations	Collection Frequency[2]	Number of Samples Collected	Type of Analysis	Analysis Frequency[2]	Number of Samples Analyzed[3]
Air Iodine	7	Weekly	364	I-131	Weekly	362
Air Particulate	7	Weekly	364	Gr-Beta	Weekly	362
				Gamma	Quarterly	28
Fish	2	Semiannually	8	Gamma	Semiannually	8
				Sr-89	Semiannually	8
				Sr-90	Semiannually	8
Aquatic Sediment	3	Semiannually	6	Gamma	Semiannually	6
	1[6]	Annually	1	Gamma	Annually	1
Discharge Water	1	Weekly	4	Gamma	Monthly	12
		Biweekly	24	Gr-Beta	Monthly	12
				H-3	Monthly	12
				I-131	Monthly	12
				Sr-89	Semiannually	2
				Sr-90	Semiannually	2
Fruits	2	Annually	2	Gamma	Annually	2
Grains	2	Annually	2	Gamma	Annually	2
Broad Leaf Vegetables	2	Annually	2	Gamma	Annually	2
				Sr-89	Annually	2
				Sr-90	Annually	2
Vegetables	2	Annually	2	Gamma	Annually	2
Groundwater	1	Weekly	52	H-3	Weekly	52
	3	Quarterly	12	H-3	Quarterly	12
	11	Semiannually	22	H-3	Semiannually	22
	7	Annually	7	H-3	Annually	7
				Gamma	Quarterly	8
				Gamma	Annually	10
				Sr-90	Annually	6
Dosimeters (TLD)[4]	90	Quarterly	2160	Immersion Dose	Quarterly	2107[5]
Milk	4	Biweekly	96	Gamma	Biweekly	96
		Monthly	4	Gamma	Monthly	4
				I-131	Biweekly	96
				I-131	Monthly	4
				Sr-89	Quarterly	16
				Sr-90	Quarterly	16

TABLE A-2

Synopsis of the 2001 TMINS REMP[1]

Sample Type	Number of Sampling Locations	Collection Frequency[2]	Number of Samples Collected	Type of Analysis	Analysis Frequency[2]	Number of Samples Analyzed[3]
Storm Water	1	Monthly	12	Gamma	Quarterly	4
				H-3	Quarterly	4
Surface/Drinking Water	6	Weekly	24	Gamma	Monthly	60
		Biweekly	144	Gr-Beta	Monthly	36
				H-3	Monthly	60
				I-131	Monthly	48
Deer Meat	2	When Available	0	Gamma	When Available	0
Rodent	1	When Available	0	Radiological Frisk or Gamma	When Available	0

(1) This table presents a synopsis of the primary program only. It does not include the quality control (QC) program.
(2) Weekly means once per week, biweekly means once every two weeks, monthly means once per month, quarterly means once per three months, semiannually means once every six months and annually means once per year.
(3) The total number of analyses does not include duplicate analyses, recounts, or reanalyses.
(4) A thermoluminescent dosimeter (TLD) is considered to be an element.
(5) This is the total number of elements (TLDs) used for data analysis.
(6) This is the sample collected from Station EDCB.

TABLE A-3

Sampling and Analysis Exceptions 2001*

Period of Deviation	Description of Deviation and Corrective Action
12/27/00 - 01/10/01	Hourly aliquots were not collected by the automatic sampler at surface water station J1-2 (West Shore of TMI) due to a frozen sample line. Grab samples were obtained on 12/29/00, 1/3/01, 1/5/01 and 1/10/01 to represent the collection period.
01/10/01 - 01/24/01	For the period of 01/10/01 - 01/17/01, hourly aliquots were not collected by the automatic sampler at surface water station J1-2 (West Shore of TMI) due to a frozen sample line. Grab samples were obtained on 01/12/01 and 01/17/01 and combined with the 01/17/01 - 01/24/01 composite (sample) to represent the collection period.
01/31/01 - 02/14/01	Several hourly aliquots were not collected by the automatic sampler at surface water station J1-2 (West Shore of TMI) due most likely to a frozen sample line. A grab sample was not collected because the sampler collected a sufficient amount of water for analysis.
02/14/01 - 02/28/01	Several hourly aliquots were not collected by the automatic sampler at surface water station J1-2 (West Shore of TMI) due most likely to a frozen sample line. A grab sample was not collected because the sampler collected a sufficient amount of water for analysis.
02/28/01 - 03/14/01	Several hourly aliquots were not collected by the automatic sampler at surface water station J1-2 (West Shore of TMI) due most likely to a frozen sample line. A grab sample was not collected because the sampler collected a sufficient amount of water for analysis.
08/08/01 - 08/22/01	Numerous hourly aliquots were not collected by the automatic sampler at surface water station Q9-1 (Steelton Water Authority) because the sampler was inadvertently turned off. A grab sample was not collected because the sampler collected a sufficient amount of water for analysis.
08/29/01 - 09/12/01	An undetermined number of hourly aliquots were not collected by the automatic sampler at drinking water station Q9-1 (Steelton Water Authority) because the "pump jammed". A grab sample was not collected because the sampler collected a sufficient amount of water for analysis.

TABLE A-3 (Continued)

Sampling and Analysis Exceptions 2001*

Period of Deviation	Description of Deviation and Corrective Action
09/26/01 - 10/10/01	Numerous hourly aliquots were not collected by the automatic sampler at drinking water station Q9-1 (Steelton Water Authority) because the "pump jammed". A grab sample was not collected because the sampler collected a sufficient amount of water for analysis.
10/10/01 - 10/24/01	Numerous hourly aliquots were not collected by the automatic sampler at drinking water station Q9-1 (Steelton Water Authority) because the "pump jammed". A grab sample was not collected because the sampler collected a sufficient amount of water for analysis.
10/24/01 - 10/31/01	Numerous hourly aliquots were not collected by the automatic sampler at surface water station J1-2 (West Shore of TMI) due to strong winds which created waves and exposed the sample line. A grab sample was not collected because the sampler collected a sufficient amount of water for analysis.
10/31/01 - 11/14/01	Numerous hourly aliquots were not collected by the automatic sampler at drinking water station Q9-1 (Steelton Water Authority) because the "pump jammed". A grab sample was not collected because the sampler collected a sufficient amount of water for analysis. The sampler was replaced on 11/19/01.

* The exceptions described in this table are those that are considered to be deviations from the monitoring requirements listed in the Technical Specifications and the ODCM. Other sampling and analysis deviations occurred during the year. They were not included in this table because the minimum number of samples were collected and analyzed. Reports describing all sampling and analysis exceptions are on file.

APPENDIX B

2001 Lower Limit of Detection (LLD) Exceptions

TABLE B

Analytical Results Which Failed to Meet the USNRC Required LLD During 2001*

During 2001, all analysis results achieved the lower limits of detection (LLDs) required by the USNRC. The USNRC-required LLDs are listed in the TMINS ODCM.

* This table only includes USNRC-required results from the primary (base) program.

APPENDIX C

2001 REMP Changes

TABLE C

2001 TMINS REMP Changes

The following changes to the TMINS REMP were effective January 1, 2001:

The collection of air particulate and air iodine samples at Station B1-4 was discontinued. During 2001, air particulate and air iodine samples were collected at seven locations, three more than required by the NRC.

The collection of milk samples at Station P7-1 was discontinued. As required by the NRC, milk samples were collected at four locations in 2001.

As permitted by the NRC, beginning in December and continuing through February 2002, the collection and analysis frequency for milk was reduced from biweekly to monthly. Biweekly collections and analyses will begin again in March 2002.

The collection of unfinished (raw) surface water samples at Station F15-1 was discontinued. During 2001, unfinished (raw) surface water samples were collected at three locations, one more than required by the NRC.

The frequency for analyzing finished and unfinished surface water for low-level I-131 was reduced from biweekly to monthly, the frequency required by the NRC for finished surface water.

The unfinished surface water samples collected from Station Q9-1 were no longer analyzed for low-level I-131. The NRC does not require unfinished surface water samples to be analyzed for low-level I-131.

The unfinished surface water samples collected from Station A3-2 were no longer analyzed for gamma-emitting radionuclides and H-3. As required by the NRC, samples from two unfinished surface water locations (Stations J1-2 and Q9-1) were analyzed for gamma-emitting radionuclides and H-3.

Fish samples were no longer analyzed for H-3. The NRC does not require fish samples to be analyzed for H-3.

The collection of aquatic sediment samples at Station J1-2 was discontinued. During 2001, aquatic sediment samples were collected at three locations, one more than required by the NRC.

The frequency for collecting groundwater at Station NW-CW and analyzing the samples for H-3 was reduced from weekly to semiannually.

APPENDIX D

2001 Cross Check Program Results

TABLE D-1
Environmental, Inc.
2001 DOE EML Cross Check Program Results(A)

Collection Date	Media	Nuclide	Environmental, Inc. Value (B & E)	Environmental, Inc. Uncertainty (C & E)	DOE EML Value (D & E)	DOE EML Min Ratio	DOE EML Max Ratio	Agreement (F)
3/2001	Air Filter	Co-60	20.110	0.160	19.440	0.79	1.30	YES
		Cs-134	2.710	0.150	2.830	0.74	1.21	YES
		Cs-137	9.860	0.230	8.760	0.78	1.35	YES
		Mn-54	7.250	0.220	6.520	0.80	1.36	YES
		Sr-90	7.410	0.150	7.100	0.55	2.05	YES
		Gr Beta	2.300	0.020	2.580	0.76	1.52	YES
3/2001	Soil	Ac-228	45.600	4.000	42.700	0.80	1.50	YES
		Bi-212	53.200	3.100	42.000	0.45	1.23	NO (G)
		Bi-214	42.100	7.700	32.600	0.78	1.50	YES
		Cs-137	1772.600	79.800	1740.000	0.80	1.29	YES
		K-40	583.800	52.600	468.000	0.80	1.37	YES
		Pb-212	46.600	8.500	41.500	0.74	1.36	YES
		Pb-214	45.300	8.600	34.300	0.76	1.53	YES
		Sr-90	55.600	2.200	69.000	0.61	3.91	YES
3/2001	Vegetation	Co-60	28.500	2.100	30.400	0.75	1.51	YES
		Cs-137	795.500	76.400	842.000	0.80	1.37	YES
		K-40	592.600	42.500	603.000	0.78	1.43	YES
		Sr-90	1239.600	130.000	1330.000	0.52	1.23	YES
3/2001	Water	Co-60	97.000	0.800	98.200	0.80	1.20	YES
		Cs-137	70.100	4.000	73.000	0.80	1.24	YES
		H-3	76.500	5.500	79.300	0.74	2.29	YES
		Sr-90	3.850	0.130	4.400	0.64	1.50	YES
		Gr Beta	1246.400	31.100	1297.000	0.56	1.50	YES
9/2001	Soil	Ac-228	68.100	1.400	59.570	0.80	1.50	YES
		Bi-212	65.100	1.600	62.067	0.45	1.23	YES
		Bi-214	47.300	4.700	36.900	0.78	1.50	YES
		Cs-137	659.200	10.800	612.330	0.80	1.29	YES
		K-40	737.700	16.600	623.330	0.80	1.37	YES
		Pb-212	64.700	3.800	58.330	0.74	1.36	YES
		Pb-214	53.700	7.700	39.670	0.76	1.53	YES
		Sr-90	27.400	6.300	30.596	0.61	3.91	YES

TABLE D-1
Environmental, Inc.
2001 DOE EML Cross Check Program Results(A)

Collection Date	Media	Nuclide	Environmental, Inc. Value (B & E)	Environmental, Inc. Uncertainty (C & E)	DOE EML Value (D & E)	DOE EML Min Ratio	DOE EML Max Ratio	Agreement (F)
9/2001	Water	Co-60	206.700	4.700	209.000	0.80	1.20	YES
		Cs-137	46.600	0.800	45.133	0.80	1.24	YES
		H-3	254.100	3.600	207.000	0.74	2.29	YES
		Sr-90	4.100	0.300	3.729	0.64	1.50	YES
		Gr Beta	8461.000	206.000	7970.000	0.56	1.50	YES
9/2001	Air Filter	Co-60	16.900	0.300	17.500	0.79	1.30	YES
		Cs-134	11.800	0.200	12.950	0.74	1.21	YES
		Cs-137	18.300	0.300	17.100	0.78	1.35	YES
		Mn-54	85.400	1.300	81.150	0.80	1.36	YES
		Sr-90	3.110	0.060	3.481	0.55	2.05	YES
		Gr Beta	13.800	0.100	12.770	0.76	1.52	YES
9/2001	Vegetation	Co-60	40.200	0.900	35.300	0.75	1.51	YES
		Cs-137	1184.000	2.800	1030.000	0.80	1.37	YES
		K-40	1023.000	44.100	898.670	0.78	1.43	YES
		Sr-90	1364.000	18.400	1612.800	0.52	1.23	YES

A. Only analyses performed routinely for the REMP are included on this table.
B. The Environmental, Inc. value is the mean of 1 or 3 measurements/determinations.
C. The Environmental, Inc. uncertainty is the 2-sigma counting uncertainty for one determination and one standard deviation for three determinations.
D. The DOE EML value is the mean of replicate determinations for each radionuclide.
E. Reporting units are Bq/L for water, Bq/kg (dry) for soil, Bq/kg (wet) for vegetation and total Bq for air filters.
F. The control limits (min ratio and max ratio) are established by DOE EML. Acceptable agreement is achieved if the ratio of the Environmental, Inc. value divided by the DOE EML value falls within the control limits.
G. This naturally-occurring radionuclide is present in the shield background. No follow-up actions were performed because all of the other gamma scan results were acceptable and the subject result was just outside of the upper control limit.

The control limit concept was established from percentiles of historic data distributions (1982 - 1992). The evaluation of this historic data and the development of the control limits are presented in DOE report EML-564. The control limits listed in this table were developed from percentiles of data distributions for the years 1993 - 1999.

Table D-2
Environmental, Inc.
2001 ERA Statistical Summary
Proficiency Testing Program(A)

Date	Media	Nuclide	Env., Inc. Result (pCi/L) (B)	ERA Known Value (pCi/L) (C)	ERA Exp. Dev. from Known (pCi/L) (D)	ERA Control Limits (pCi/L) (D)	Performance Evaluation (E)
1/2001	Water	Gr Beta	25.3	16.7	5.0	8.0-25.4	A
2/2001	Water	I-131	27.2	28.3	3.0	23.1-33.5	A
3/2001	Water	H-3	17,400	17,800	1780.0	14,700.0-20,900.0	A
4/2001	Water	Co-60	27.9	26.4	5.0	17.7-35.1	A
4/2001	Water	Cs-134	16.0	16.9	5.0	8.2-25.6	A
4/2001	Water	Cs-137	195.4	186.0	9.3	170.0-202.0	A
4/2001	Water	Gr Beta	343.0	340.0	51.0	252.0-428.0	A
4/2001	Water	Sr-89	62.8	64.1	5.0	55.5-72.8	A
4/2001	Water	Sr-90	34.2	33.8	5.0	25.1-42.5	A
6/2001	Water	Ba-133	37.8	36.0	5.0	27.3-44.7	A
6/2001	Water	Co-60	49.9	46.8	5.0	38.1-55.5	A
6/2001	Water	Cs-134	16.0	15.9	5.0	7.2-24.6	A

Table D-2
Environmental, Inc.
2001 ERA Statistical Summary
Proficiency Testing Program(A)

Date	Media	Nuclide	Env., Inc. Result (pCi/L) (B)	ERA Known Value (pCi/L) (C)	ERA Exp. Dev. from Known (pCi/L) (D)	ERA Control Limits (pCi/L) (D)	Performance Evaluation (E)
6/2001	Water	Cs-137	208.0	197.0	9.9	180.0-214.0	A
6/2001	Water	Zn-65	37.8	36.2	5.0	27.5-44.9	A
7/2001	Water	Sr-89	19.8	31.2	5.0	22.5-39.9	NA(F)
7/2001	Water	Sr-90	26.3	25.9	5.0	17.2-34.6	A
7/2001	Water	Gr Beta	48.5	53.0	10.0	35.7-70.3	A
8/2001	Water	H-3	2,680.0	2,730.0	356.0	2,110.0-3,350.0	A
10/2001	Water	I-131	7.7	7.7	2.0	4.2-11.2	A
10/2001	Water	Co-60	82.4	78.4	5.0	69.7-87.1	A
10/2001	Water	Cs-134	52.2	54.1	5.0	45.4-62.8	A
10/2001	Water	Cs-137	39.4	37.9	5.0	26.3-43.7	A
10/2001	Water	Gr Beta	166.0	192.0	28.8	142.0-242.0	A
10/2001	Water	Sr-89	12.8	16.7	5.0	8.0-25.4	A
10/2001	Water	Sr-90	6.8	7.7	5.0	-1.0-16.4	A

Table D-2
Environmental, Inc.
2001 ERA Statistical Summary
Proficiency Testing Program(A)

Date	Media	Nuclide	Env., Inc. Result (pCi/L) (B)	ERA Known Value (pCi/L) (C)	ERA Exp. Dev. from Known (pCi/L) (D)	ERA Control Limits (pCi/L) (D)	Performance Evaluation (E)
10/2001	Water	Gr Beta	26.0	21.5	5.0	12.8-30.2	A
11/2001	Water	Ba-133	66.7	69.3	6.9	57.5-81.1	A
11/2001	Water	Co-60	59.3	59.7	5.0	51.0-68.4	A
11/2001	Water	Cs-134	86.7	93.9	5.0	85.2-103.0	A
11/2001	Water	Cs-137	45.0	42.0	5.0	33.3-50.7	A
11/2001	Water	Zn-65	80.7	77.3	7.7	63.9-90.7	A

A. Only analyses performed routinely for the REMP are included on this table.
B. The Environmental, Inc. result is the mean for three measurements/determinations.
C. The ERA known value is equal to 100% of the parameter present in the standard as determined by gravimetric and/or volumetric measurements made during standard preparation.
D. Established per the guidelines contained in the EPA's National Standards for Water Proficiency Testing Criteria Document, December 1998, as applicable.
E. A= Acceptable - Reported Result falls within the Control Limits.
NA = Not Acceptable - Reported Result falls outside of the Control Limits.
F. A reanalysis was performed; the result was 35.3 ± 4.4 pCi/L which was within the established control limits.

APPENDIX E

2001 Land Use Census

TABLE E-1

2001 ANNUAL DAIRY CENSUS[1]

Distance & Direction	Azimuth & Sector Code	Name[2], Address & Phone Number	Breed	No. Cows	No. Cows Milked	No. Goats	No. Goats Milked	Dairy Used	Grazing Period
3.3km (2.1mi) N	3° A		Cows, goats, sheep and horses are periodically kept for quarantine from a few days to a few weeks. Animals are then shipped interstate or to foreign countries. If milked, milk is used as animal feed.						Animals graze for short periods of time prior to exportation. Animals also receive prepared feed.
6.6km (4.1mi) NE	35° C		Holstein	150 Cows 25 Heifers	150	--	--	Land O Lakes and Own Use	Milk cows receive homegrown feed. Heifers graze from June to October.
1.7km (1.1mi) ENE	65° D	[3]	Holstein	110 Cows 75 Heifers	96	--	--	Mt. Joy Co-op	Animals graze from May 1 to November 1. Animals also fed hay and corn.
1.8km (1.1mi) E	93° E	[3]	Holstein	180 Cows 120 Heifers & Calves	180	--	--	Mt.Joy Co-op	Dry cows graze from April to November and also receive homegrown feed. Milking cows receive homegrown feed; they do not graze on pasture.
5.2km (3.2mi) ESE	104° F		Holstein	115 Cows 10 Heifers	100	--	--	Mt.Joy Co-op	Animals are only on pasture during dry periods. Milk animals fed stored silage and hay.
2.3km (1.4mi) SE	130° G	[3]	Holstein	65 Cows 30 Heifers	50	--	--	National Farmers Organization and Own Use	Animals graze from April to November. During the winter, animals receive silage, hay and high moisture corn, if available.
7.8km (4.9 mi) SSW	200° K		Holstein	70 Cows 30 Heifers	65	--	--	Land O Lakes and Own Use	Animals graze from April 15 to October 15. Otherwise, animals are fed silage and baled hay.
23.3km (14.5mi) SSW	205° K	[3]	Holstein	60 Cows 40 Heifers 24 Calves	50	--	--	Land O Lakes and Own Use	Animals do not graze; they are put in an exercise pen. Animals receive stored feed.
6.0km (3.7mi) WNW	295° P		Holstein	80 Cows	50	12 Nannies	0	Land O Lakes	Animals graze from May to October. Otherwise, animals receive homegrown feed.

[1]This table includes the closest dairy farm in each of the 16 meteorological sectors within a distance of five miles of TMINS (if one exists) plus the regularly sampled milk farms.

[2]Names and addresses are on file.

[3]These are the regularly sampled milk farms.

TABLE E-2

2001 Annual Residence Census[1]

Distance and Direction	Azimuth and Sector Code	Name[2], Address & Telephone No.	Distance and Direction	Azimuth and Sector Code	Name[2], Address & Telephone No.
6,000 ft. (1,839m) N	5° A		12,000 ft. (3,658 m) S	186° J	
3,800 ft. (1,158m) NNE	28° B		3,400 ft. (1,036 m) SSW	213.7° K	
2,800 ft. (853 m) NE	48° C		2,850 ft. (869 m) SW	226° L	
2,450 ft. (747 m) ENE	67.5° D		2,500 ft. (777 m) WSW	250° M	
2,300 ft. (700 m) E	80° E		1,850 ft. (564 m) W	272° N	
5,800 ft. (1,770 m) ESE	123° F		1,900 ft. (579 m) WNW	293° P	
3,750 ft. (1,143 m) SE	145° G		2,150 ft. (655 m) NW	306° Q	
3,750 ft. (1,143 m) SSE	152° H		3,500 ft. (1,067m) NNW	337.5° R	

[1]Census identifies nearest residence in each of the sixteen meteorological sectors.
[2]Names and addresses are on file.

TABLE E-3

2001 Broad Leaf Vegetation Sampling Results[1]

Collection Date	Sample Location	Vegetation Type	Gamma Result (pCi/g, wet)	Sr-90 Result (pCi/g, wet)
09/19/01	TM-FPL-ESE1	Grape Leaves	Be-7: 0.62 ± 0.14 K-40: 1.3 ± 0.2	0.016 ± 0.004 0.014 ± 0.002[3]
09/19/01	TM-FPL-ESE2	Sumac Leaves	Be-7: 0.62 ± 0.13 K-40: 5.5 ± 0.3	0.026 ± 0.005 0.025 ± 0.002[3]
09/19/01	TM-FPL-ESE3	Johnny Smoker Leaves	Be-7: 0.48 ± 0.13 K-40: 1.6 ± 0.2	0.018 ± 0.005 0.013 ± 0.003[3]
09/19/01	TM-FPL-SE1	Sycamore Leaves	Be-7: 1.1 ± 0.2 K-40: 1.5 ± 0.3	< 0.005 < 0.005[3]
09/19/01	TM-FPL-SE2	Beech Sp. Leaves	Be-7: 0.69 ± 0.21 K-40: 3.4 ± 0.4	0.0059 ± 0.0030 0.0091 ± 0.0017[3]
09/19/01	TM-FPL-SE3	Grape Leaves	Be-7: 0.41 ± 0.12 K-40: 1.8 ± 0.2	< 0.010 < 0.004[3]
09/20/01	TM-FPL-B10-2[2]	Sycamore, Maple and Oak Leaves	Be-7: 0.98 ± 0.15 K-40: 3.5 ± 0.3	0.032 ± 0.006 0.033 ± 0.003[3]

[1]Collection and analysis of broad leaf vegetation was performed in lieu of a garden census.
[2]Control Sample
[3]Reanalysis Result

APPENDIX F

2001 Data Reporting and Analysis

Environmental samples frequently contain very little, if any, radioactivity. Even when very sensitive, state-of-the-art counting equipment is used, many of the sample count rates can not be differentiated from the background count rate or the count rate of the blank sample. When this occurs, the sample is said to have a radioactivity level or concentration at or below the sensitivity of the analysis method. In this case, the analysis result is reported as less than a numerical value that corresponds to the sensitivity of the analysis method. Sensitivities are influenced by parameters such as sample volume, background or blank sample count rate and efficiency of the counting device.

The terms used to describe the sensitivity are the lower limit of detection (LLD) and minimum detectable concentration (MDC). For this report, these two terms are considered to be synonymous. They are defined as:

$$\text{LLD (MDC)} = \frac{4.66\ Sb}{E * V * 2.22 * Y * \exp(-\lambda\ \Delta t)}$$

where:

Sb	=	the standard deviation of the background counting rate or the counting rate of a blank sample, as counts per minute,
E	=	the counting efficiency of the equipment, as counts per disintegration,
V	=	the volume or mass of the sample, such as L, g or m^3,
2.22	=	the number of disintegrations per minute per picocurie,
Y	=	the chemical yield, if applicable,
λ	=	the radioactive decay constant for the particular radionuclide and
Δt	=	the elapsed time between sample collection (or end of sample collection period) and counting.

The applicable LLD or MDC for each radionuclide and analysis is listed in Table 1. A large percentage of the 2001 sample results were reported as less than the LLD or MDC. Unless noted otherwise, the results that were reported as less than the LLD or MDC were not included in the calculations of averages, standard deviations and ranges (by station or group) in the text and tables of this report.

The data from samples that contained concentrations above the LLD or MDC were used in the calculations (averages, standard deviations and ranges) contained in this report. The individual sample results were generally reported to two significant figures. Each result also included a two-sigma counting uncertainty (95% confidence interval) to the same decimal place. The counting uncertainties were not used in any statistical calculations in this report.

The data used in a few tables and all annual graphs were actual sample concentrations. For historical graphs, actual sample concentrations were used for 1996 - 2001 data points only. The actual concentration is calculated by subtracting the background count rate or the count rate of a blank sample from the count rate of the sample. The net count rate is then converted to a net sample concentration which is either positive, negative or zero.

There are several advantages of using actual sample concentrations. Biases in the data (averages, ranges, etc.), such as those caused by averaging only sample concentrations above the MDC, are eliminated. Missing data points on graphs also are eliminated. It should be noted that negative sample concentrations are important to the overall averages and trends in the data, but they have no physical significance. A negative sample concentration simply means that the background or blank sample count rate is greater than the sample.

The data were grouped by station, time period and by control and indicator status. Minimum, maximum and average values were calculated for each of these groups as well as standard deviations (2σ, 95% confidence interval).

Quality control results (inter-laboratory and intra-laboratory) were not statistically analyzed with other data. Including quality control data would introduce a bias at selected stations while providing little additional interpretive information.

APPENDIX G

2001 Groundwater Monitoring Results

TABLE G-1
2001 Tritium Concentrations in Onsite Groundwater and Storm water (pCi/L)

Station (Well Type)	2000 Average ± 2 std dev*	2001 Average ± 2 std dev*	2001 Range*
MS-1 (Monitoring)	160	250	**
MS-2 (Monitoring)	260 ± 50	600 ± 1,100	190 - 960
MS-4 (Monitoring)	1,900	1,300	**
MS-5 (Monitoring)	190 ± 160	290 ± 30	280 - 300
MS-7 (Monitoring)	180	< 180	**
MS-8 (Monitoring)	360 ± 280	260 ± 90	230 - 290
MS-19 (Monitoring)	540	910	**
MS-20 (Monitoring)	360 ± 400	350 ± 150	300 - 410
MS-21 (Monitoring)	190	1000	**
MS-22 (Monitoring)	640 ± 530	480 ± 150	390 - 560
OS-14 (Monitoring)	170	230	**
OS-18 (Monitoring)	4,000 ± 14,000	730 ± 730	270 - 1,800
RW-1 (Monitoring)	2,700 ± 2,800	350 ± 410	200 - 490
RW-2 (Monitoring)	500	1,400 ± 2,900	340 - 2,400
NW-A (Service Water)	1,300 ± 100	1,000 ± 500	850 - 1,200
NW-B (Service Water)	2,900 ± 1,600	2,100 ± 2,100	1,400 - 2,900
NW-C (Service Water)	18,000 ± 4,000	14,000 ± 4,000	12,000 - 15,000
NW-CW (Clearwell)	5,800 ± 3,100	1,700 ± 1,200	1,300 - 2,100
OSF (Drinking Water)	430 ± 390	490 ± 90	420 - 520
48S (Drinking Water)	220 ± 40	200 ± 80	160 - 240
EDCB (Storm water)	340 ± 210	280 ± 230	200 - 450

* = Averages, standard deviations and ranges were based on concentrations > the minimum detectable concentration (MDC).
** = Only one concentration in 2001 was > MDC or only one sample was collected in 2001.
< MDC = Measured concentration(s) was equal to or below the MDC.
NS = Station was not sampled and, therefore, no data were available.
(Refer to Figures G-1 and G-2 for locations of onsite groundwater and storm water stations).

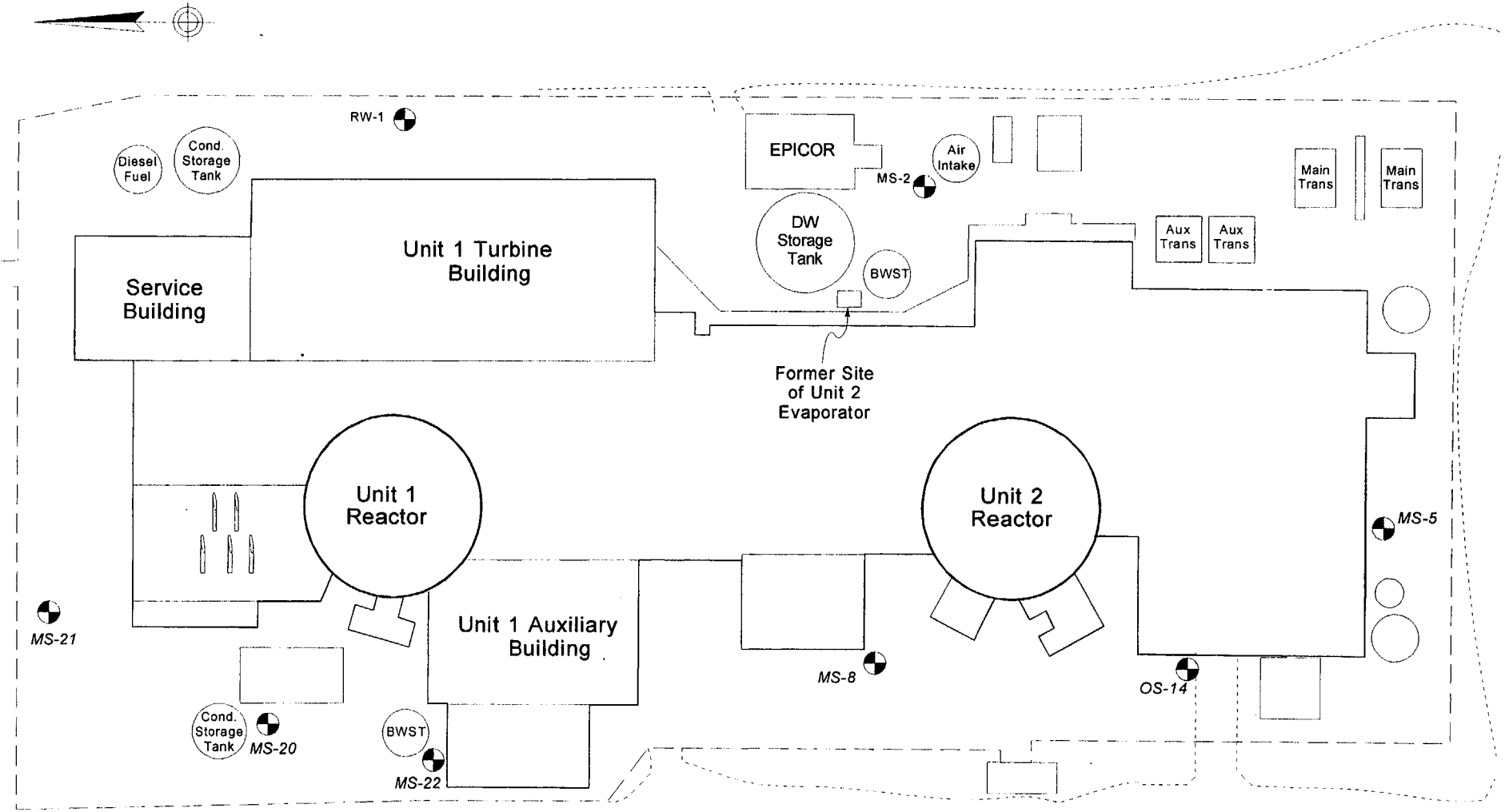
TABLE G-2
2001 Tritium Concentrations in Offsite Groundwater
(pCi/L)

Station (Location)	2000 Concentration	2001 Concentration
E1-2 (TMINS Visitors Center)	< MDC	< MDC
N2-1 (Goldsboro Marina)	< MDC	< MDC

< MDC = Measured concentration was ≤ the minimum detectable concentration (MDC).

(Refer to Table A-1 and Figures 1 and 2 for locations of the offsite stations).

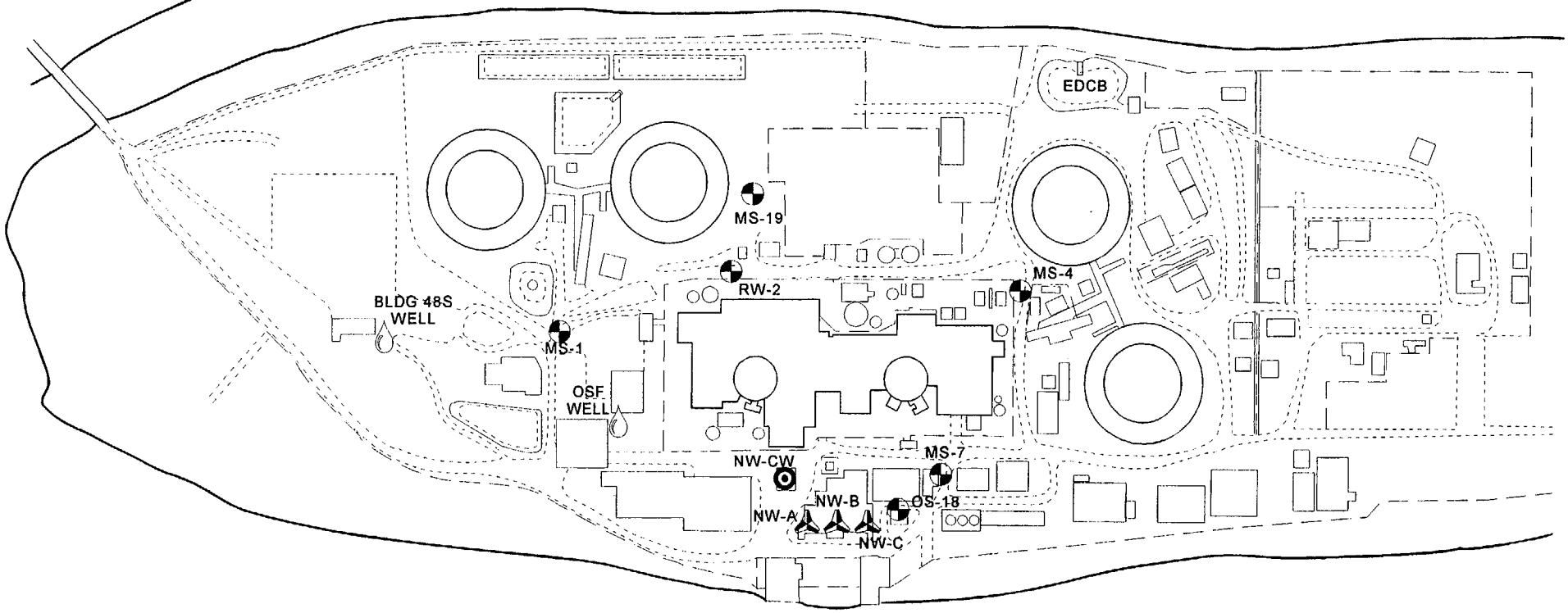
Figure G-1
TMINS REMP Groundwater Stations
Inside the Protected Area



NO SCALE

(3/2001)

Figure G-2
TMINS REMP Groundwater Stations
Outside the Protected Area*



LEGEND

- Monitoring Well
- Drinking Water Well
- Clearwell
- Industrial Well

NO SCALE
(3/2001)

*The offsite groundwater wells are located at the TMI Visitors Center (E1-2) and the Goldsboro Marina (N2-1). The locations of these wells are shown on Figures 1 and 2.

APPENDIX H

2001 TLD Quarterly Data

TABLE H-1
2001 TLD Quarterly Data
(mR/std month)

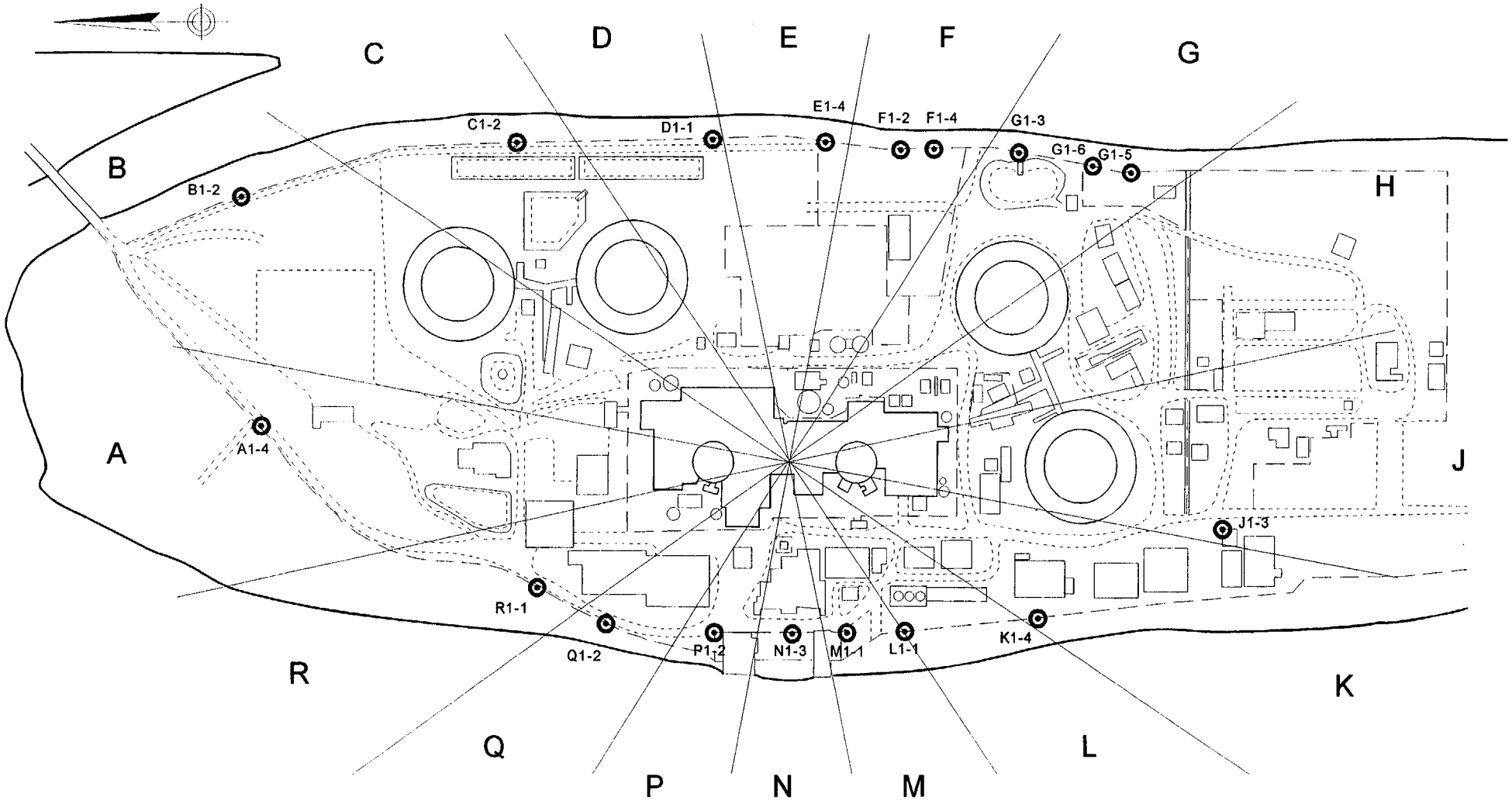
Station	Historical	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Yearly Avg	2 std dev
A1-4	4.3	3.7	4.0	4.8	4.6	4.3	1.0
A3-1	4.3	3.8	3.6	4.6	4.6	4.2	1.1
A5-1	5.5	5.2	4.8	5.9	5.5	5.4	0.9
A9-3		4.1	4.1	4.9	4.9	4.5	0.9
B1-1	4.4	3.9	4.0	4.9	4.6	4.4	1.0
B1-2	4.3	4.1	4.0	4.9	4.9	4.5	1.0
B2-1		4.2	4.1	5.1	4.7	4.5	0.9
B5-1	5.3	4.9	5.0	5.7	5.5	5.3	0.8
B10-1	5.1	4.6	4.4	5.5	5.1	4.9	1.0
C1-1	5.2	4.5	5.1	5.7	5.5	5.2	1.1
C1-2	4.3	4.2	4.0	4.8	4.8	4.5	0.8
C2-1		4.4	4.5	5.4	5.1	4.9	1.0
C5-1	5.1	4.8	4.8	5.9	5.5	5.3	1.1
C8-1	5.9	5.2	5.1	5.9	5.6	5.5	0.7
D1-1	4.6	4.2	4.1	5.0	4.8	4.5	0.9
D1-2	5.4	4.6	4.7	5.6	5.1	5.0	0.9
D2-2		5.4	5.5	6.4	6.3	5.9	1.0
D6-1	6.4	5.4	5.3	6.4	6.5	5.9	1.3
D15-1	5.7	4.8	4.7	5.9	5.6	5.3	1.2
E1-2	4.9	4.4	4.5	5.3	4.9	4.8	0.8
E1-4	5.7	4.0	4.0	4.6	4.7	4.3	0.8
E2-3		4.9	5.4	6.0	6.0	5.6	1.1
E5-1	5.3	4.7	5.1	5.9	5.8	5.4	1.1
E7-1	5.2	4.8	4.8	5.8	5.3	5.2	1.0
F1-1	5.0	4.4	4.8	5.6		4.9	1.2
F1-2		4.4	4.5	5.2	5.1	4.8	0.8
F1-4		4.1	4.1	5.2	5.1	4.6	1.2
F2-1		5.2	5.1	6.0	6.3	5.7	1.2
F5-1	6.0	5.3	5.2	6.1	6.1	5.7	1.0
F10-1	6.3	5.5	5.9	6.6	6.6	6.2	1.1
F25-1	5.6	4.9	4.8	6.1	5.6	5.4	1.2
G1-2	4.9	4.7	4.6	5.7	5.8	5.2	1.3
G1-3	6.9	3.8	4.0	4.6	4.9	4.3	1.0
G1-5		4.0	4.2	4.8	5.3	4.6	1.2
G1-6		4.2	4.1	5.1	5.4	4.7	1.3
G2-4		5.8	5.4	6.6	6.5	6.1	1.1
G5-1	5.1	4.4	4.4	5.4	4.9	4.8	1.0
G10-1	7.6	6.7	6.6	7.5	8.0	7.2	1.3
G15-1	6.4	5.0	5.0	5.7	5.8	5.4	0.9
H1-1	5.3	4.6	4.5	5.5	5.2	5.0	1.0
H3-1	4.1	3.7	3.6	4.9	4.1	4.1	1.2
H5-1	4.1	3.7	3.7	4.7	4.2	4.1	1.0
H8-1	7.9	6.7	7.2	8.0	8.1	7.5	1.3
H15-1	5.8	5.2	5.2	6.2	6.3	5.7	1.2
J1-1	5.3	3.9	4.1	5.0	4.6	4.4	1.0
J1-3	3.7	3.5	3.8	4.3	4.5	4.0	0.9
J3-1		4.2	4.4	5.6	5.3	4.9	1.4

TABLE H-1
2001 TLD Quarterly Data
(mR/std month)

Station	Historical	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Yearly Avg	2 std dev
J5-1	5.7	5.1	5.1	6.1	6.1	5.6	1.2
J7-1	4.7	5.3	5.2	6.1	6.3	5.7	1.1
J15-1	6.1	5.3	5.2	6.1	6.1	5.7	1.0
K1-4	4.7	3.9	4.0	5.0	4.7	4.4	1.1
K2-1	5.8		5.2	6.1	5.8	5.7	0.9
K3-1		3.9	4.1	5.2	4.5	4.4	1.1
K5-1	6.9	5.3	5.2	6.1	6.1	5.7	1.0
K8-1	5.4	5.0	5.2	5.7	5.7	5.4	0.7
K15-1	4.8	4.7	4.4	5.6	5.3	5.0	1.1
L1-1	5.1	4.2	4.4	5.1	5.2	4.7	1.0
L1-2	4.3		4.1	5.2	4.6	4.6	1.1
L2-1	5.5	4.8	4.5	5.6	5.1	5.0	0.9
L5-1	4.5	4.1	4.1	5.1	4.8	4.5	1.0
L8-1	5.0	4.7	4.7	5.6	5.3	5.1	0.9
L15-1	5.2	4.9	4.6	5.7	5.4	5.2	1.0
M1-1		4.1	3.8	4.6	4.8	4.3	0.9
M1-2			4.3	4.9	5.0	4.7	0.8
M2-1	4.3	3.8	3.7	4.7	4.7	4.2	1.1
M5-1	5.2	4.3	4.3	5.3	5.1	4.8	1.1
M9-1	6.5	5.4	5.7	6.6	6.2	6.0	1.1
N1-1	4.8		4.1	5.2	5.0	4.8	1.2
N1-3	4.6	3.7	3.8	5.1	4.9	4.4	1.5
N2-1	5.3	3.8	4.0	4.9	4.5	4.3	1.0
N5-1	5.3	3.8	3.9	4.6	4.2	4.1	0.7
N8-1	5.4	4.9	4.9	5.8	5.4	5.3	0.9
N15-2	5.9	5.2	5.3	6.1	5.7	5.6	0.8
P1-1	4.7		4.2	5.3	5.0	4.8	1.1
P1-2		3.7	4.0	5.0	6.1	4.7	2.2
P2-1	5.4	5.1	5.4	6.2	5.9	5.7	1.0
P5-1	4.8	4.6	4.6	5.3	5.1	4.9	0.7
P8-1	4.7	3.9	4.1	4.4	4.3	4.2	0.4
Q1-1	4.6		4.6	5.3	5.0	5.0	0.7
Q1-2	4.4	3.7	3.6	4.5	4.6	4.1	1.0
Q2-1	5.4	4.2	4.3	5.3	4.8	4.7	1.0
Q5-1	4.9	4.2	4.0	4.9	4.7	4.5	0.8
Q9-1	5.3	4.4	4.4	5.3	5.1	4.8	0.9
Q15-1	5.9	4.8	5.1	6.0	5.9	5.5	1.2
R1-1	4.8	4.1	4.0	4.8	4.9	4.5	0.9
R1-2	4.2		3.9	4.9	4.3	4.4	1.0
R3-1		6.3	5.3	6.1	6.0	5.9	0.9
R5-1	5.1	5.9	4.8	5.6	5.4	5.4	0.9
R9-1	5.2	5.9	4.8	5.7	5.4	5.5	1.0
R15-1	4.4	5.3	4.2	5.3	4.8	4.9	1.0

NOTES: 1) Missing data indicates no data
2) Some newer stations have no historical data

Figure H-1
Onsite TLD Station Locations at TMINS



Stations H1-1 and J1-1 are located off the map to the south.

NO SCALE