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 26, 2001

5928-01-20114

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

Dear Sir or Madam:

SUBJECT: 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
2000 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 2000 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 01011

IE25
1/1

Radiological Environmental Monitoring Report 2000

Prepared by
Three Mile Island
Rad, Health & Safety

AmerGen SM
An Exelon/British Energy Company

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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

ACRONYMS

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 2000 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 2000 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). 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 2000, 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 2000, 1239 samples were collected from the aquatic, atmospheric and terrestrial environments around TMINS. There were 1681 analyses performed on these samples. Also, 2106 radiation exposure measurements were taken using thermoluminescent dosimeters (TLDs). Finally, 264 groundwater samples were collected and 288 analyses were performed on these samples. The monitoring performed in 2000 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 of the measured concentrations were well below the United States Environmental Protection Agency's

(USEPA) Primary Drinking Water Standard of 20,000 picocuries per liter (pCi/L).

- 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. Like surface water, the H-3 concentrations measured in drinking water were well below the standard established by the USEPA.

- Very low concentrations of H-3 were detected in indicator fish samples as a result of routine TMINS operations. This was expected because H-3 was released in liquid effluents and the indicator fish samples were collected in a zone where mixing of effluents and river water was incomplete. The hypothetical whole body dose from consuming fish flesh at the measured concentrations was insignificant and a small fraction of the dose received from natural background radiation.

- 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 2000, 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, the industrial wells and the clearwell 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 (< 4 percent) of the USEPA Primary Drinking Water Standard.

- Gamma radiation exposure rates recorded at the offsite indicator TLD stations averaged 56 milliroentgens per year (mR/yr). Offsite controls were similar, averaging 61 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 2000, small amounts of radioactive materials were released in TMI-1 and TMI-2 liquid and gaseous effluents. Excluding H-3, the amount of radioactive material released from TMI-1 was one of the lowest in plant operating history. This achievement was attributed to good fuel integrity, minimal leakage in the steam generators and improved efficiency of the waste processing systems. Tritium,

because of its chemical and physical properties, can not be removed practically from water or air.

- The calculated doses to the public from TMINS operations in 2000 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 2000 TMI-1 and TMI-2 liquid and airborne effluents combined was conservatively calculated to be 0.04 mrem. This dose is equivalent to 0.01 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 2000 liquid and airborne effluents was calculated to be 2.5 person-rem. This dose is equivalent to 0.0004 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 2000 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 2000 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 in along the Susquehanna River in Londonderry Township, Dauphin County, Pennsylvania. Three Mile Island Nuclear Station (TMINS) is situated on the northern one-half of TMI. The TMINS reactors - TMI-1, owned and operated by AmerGen and TMI-2, owned by GPU - are pressurized water reactors (PWR). 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).

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 alpha and 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 reporting level is reached.

Table 1 provides a summary of radionuclide concentrations detected in the environmental samples analyzed by the primary (main) laboratories. 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 immediate 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.

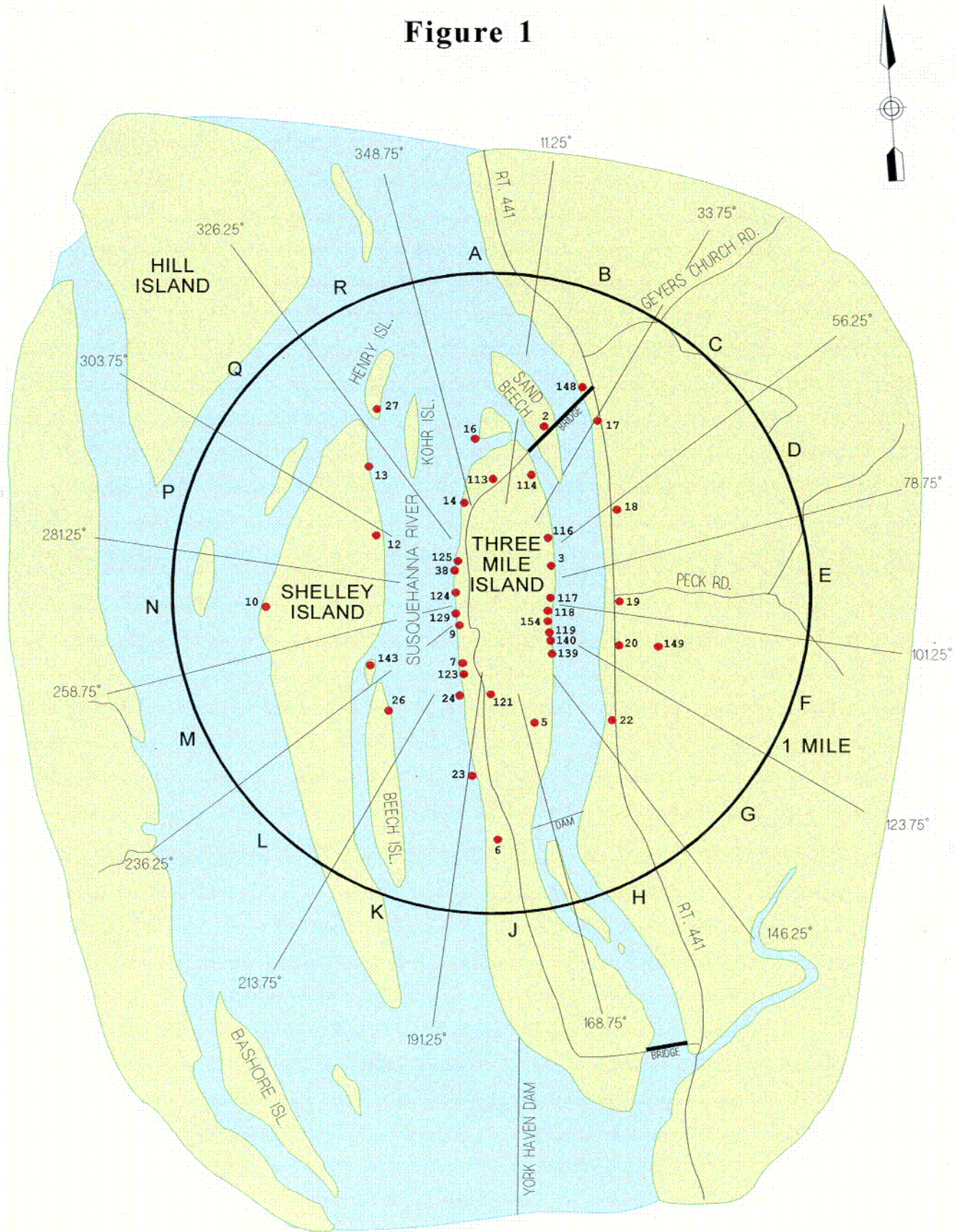
The TLD readers are calibrated on a routine basis against recognized standards. Also, each group of TLDs processed by a reader contains control TLDs. The accuracy and variability of the control TLD results are examined to assure the reader is functioning properly. In addition, each element (TLD) has 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 (PaBRP) 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.

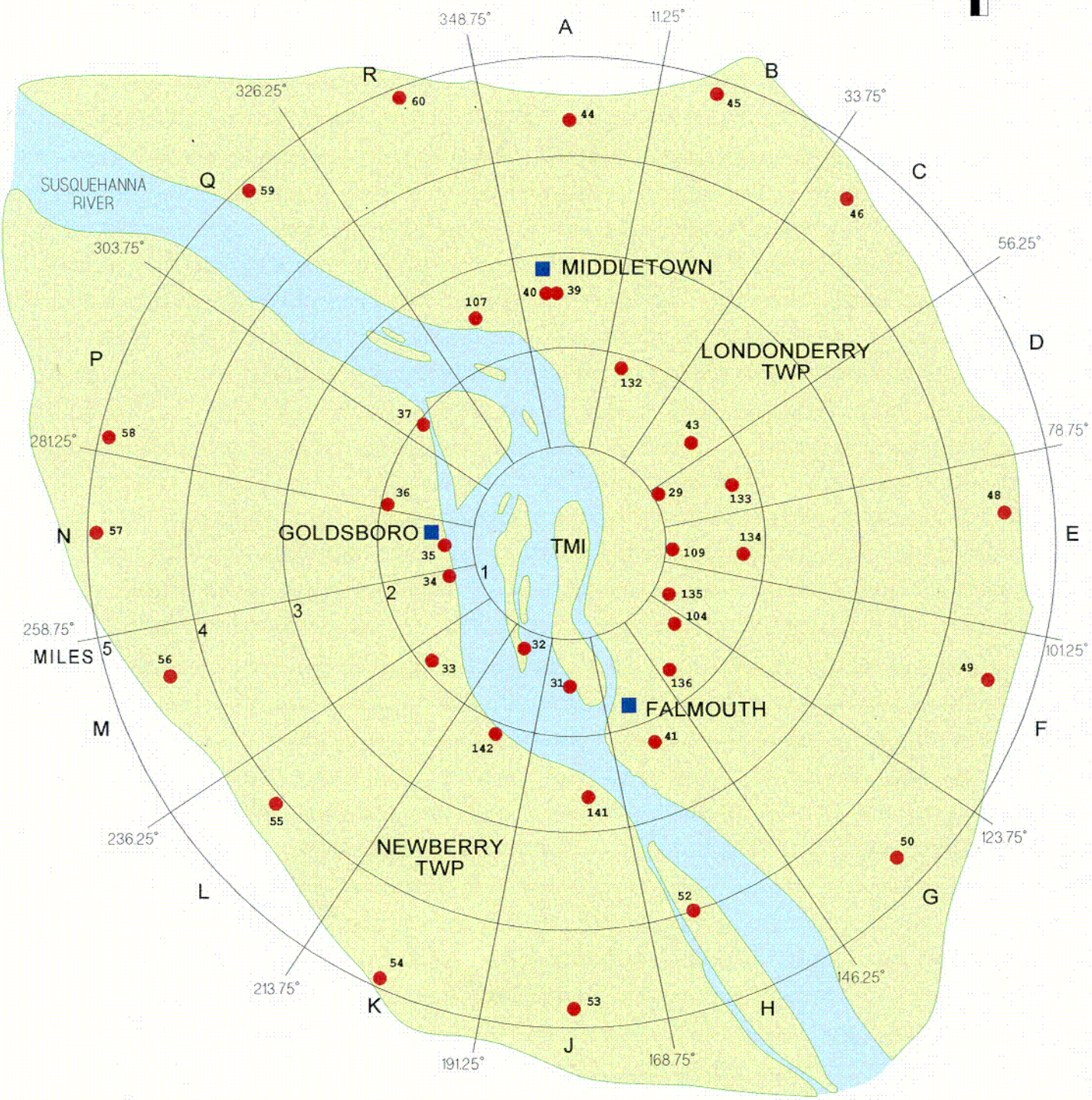
Samples of the TMINS liquid discharge are collected and analyzed as a QC check for the inplant effluent monitoring program. For 2000, the results obtained by the REMP were consistent with those reported for the inplant effluent monitoring program.

Figure 1



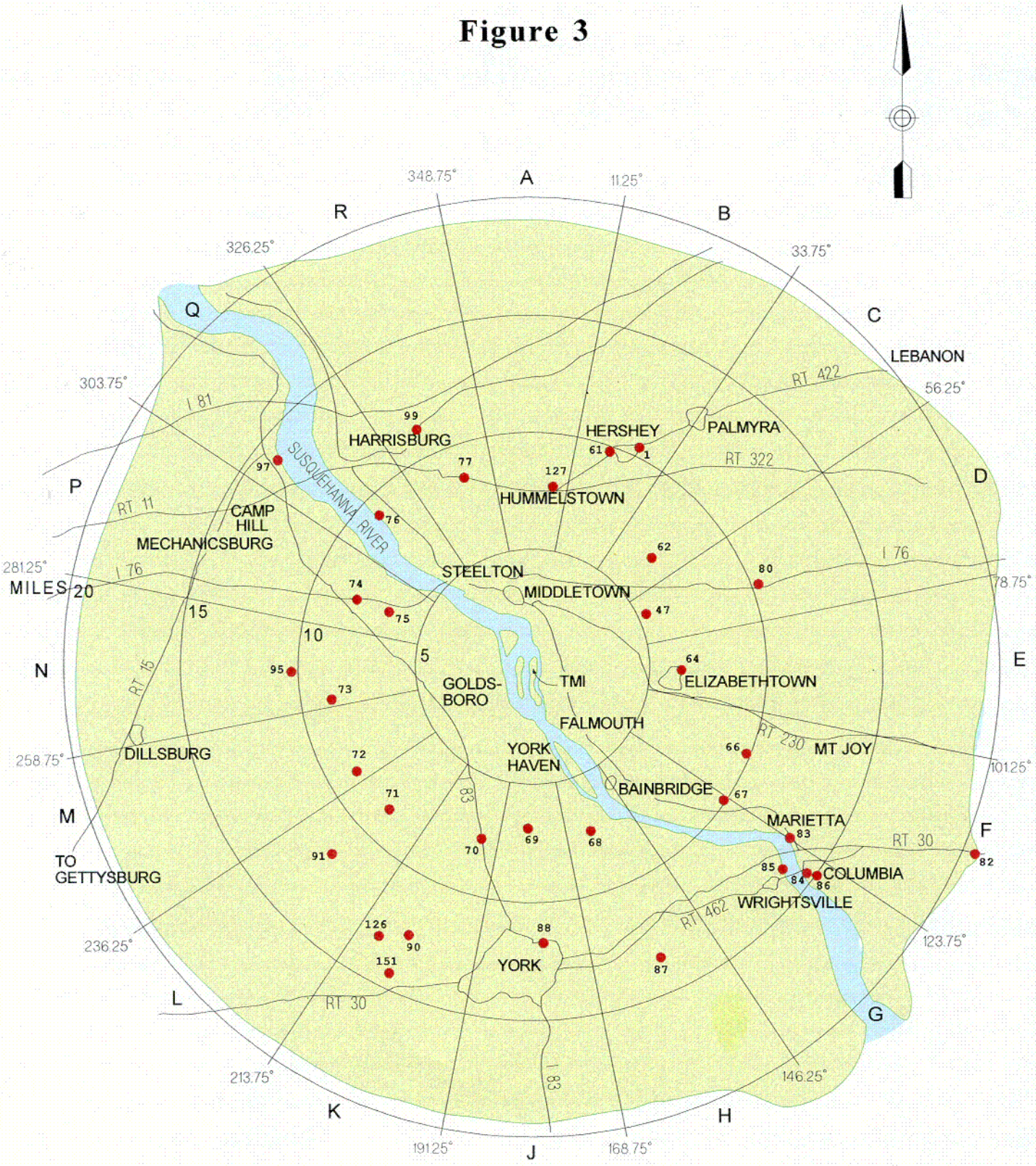
Locations of REMP Stations Within 1 Mile of TMINS

Figure 2



Locations of REMP Stations
1 to 5 Miles from TMINS

Figure 3



Locations of REMP Stations
Greater Than 5 Miles From TMINS

C03

TABLE 1

Summary of Radionuclide Concentrations in 2000 Environmental Samples from 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)	I-131	424	0.07	ND(8)	---	---	ND	0
Air Particulates (pCi/m3)	Gr-Beta	424	0.01	1.7E-02 (371/371) (5.2E-03 - 4.1E-02)	M2-1, 1.3 mi WSW Goldsboro Air Station	1.7E-02 (53/53) (6.3E-03 - 4.0E-02)	1.7E-02 (53/53) (6.8E-03 - 3.8E-02)	0
	Gamma Spec.	32						
	Be-7		0.05	5.4E-02 (28/28) (4.3E-02 - 7.2E-02)	M2-1, 1.3 mi WSW Goldsboro Air Station	5.9E-02 (4/4) (4.8E-02 - 7.2E-02)	5.4E-02 (4/4) (4.2E-02 - 6.2E-02)	0
	Cs-134		0.05	ND	---	---	ND	0
	Cs-137		0.06	ND	---	---	ND	0
	K-40		0.02	1.6E-02 (6/28) (9.9E-03 - 2.0E-02)	G2-1, 1.4 mi SE Dairy Farm	2.0E-02 (1/4)	ND	0
Fish (pCi/g, wet)	H-3	8	0.2	1.1E-01 (4/4) (8.4E-02 - 1.7E-01)	INDP, Indicator Predator Below Discharge	1.3E-01 (2/2) (8.4E-02 - 1.7E-01)	ND	0
	Sr-89	8	0.025	ND	---	---	ND	0
	Sr-90	8	0.01	ND	---	---	ND	0
	Gamma Spec.	8						
	Co-58		0.13	ND	---	---	ND	0
	Co-60		0.13	ND	---	---	ND	0
Fish	Cs-134		0.13	ND	---	---	ND	0

Note: See footnotes at end of table.

TABLE 1

Summary of Radionuclide Concentrations in 2000 Environmental Samples from 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)
(pCi/g, wet)								
	Cs-137		0.15	ND	---	---	ND	0
	Fe-59		0.26	ND	---	---	ND	0
	K-40		0.50	3.1E+00 (4/4) (2.6E+00 - 3.4E+00)	BKGP, Control Predator Above Discharge	3.5E+00 (2/2) (3.2E+00 - 3.8E+00)	3.2E+00 (4/4) (2.8E+00 - 3.8E+00)	0
	Mn-54		0.13	ND	---	---	ND	0
	Zn-65		0.26	ND	---	---	ND	0
Aquatic Sediment (pCi/g, dry)	Gamma Spec.	8						
	Be-7		0.2	2.4E+00 (6/6) (3.4E-01 - 6.7E+00)	J2-1, 1.5 mi S Above York Haven Dam	4.2E+00 (2/2) (1.7E+00 - 6.7E+00)	2.1E+00 (2/2) (5.9E-01 - 3.7E+00)	0
	Cs-134		0.15	ND	---	---	ND	0
	Cs-137		0.18	1.7E-01 (6/6) (1.1E-01 - 2.2E-01)	K1-3, 0.3 mi SSW West Shore of TMI	2.0E-01 (2/2) (1.7E-01 - 2.2E-01)	9.9E-02 (2/2) (7.7E-02 - 1.2E-01)	0
	I-131		0.1	2.4E-01 (1/6)	J2-1, 1.5 mi S Above York Haven Dam	2.4E-01 (1/2)	9.9E-02 (1/2)	0
	K-40		0.2	1.5E+01 (6/6) (9.5E+00 - 2.3E+01)	J2-1, 1.5 mi S Above York Haven Dam	2.1E+01 (2/2) (1.9E+01 - 2.3E+01)	1.4E+01 (2/2) (1.2E+01 - 1.5E+01)	0
Aquatic Sediment (pCi/g, dry)	Ra-226		0.2	2.4E+00 (6/6) (1.7E+00 - 3.1E+00)	J2-1, 1.5 mi S Above York Haven Dam	3.1E+00 (2/2) (3.0E+00 - 3.1E+00)	2.3E+00 (2/2) (2.2E+00 - 2.4E+00)	0

Note: See footnotes at end of table.

TABLE 1

Summary of Radionuclide Concentrations in 2000 Environmental Samples from 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)
	Th-232		0.2	1.3E+00 (6/6) (8.4E-01 - 1.7E+00)	J2-1, 1.5 mi S Above York Haven Dam	1.6E+00 (2/2) (1.5E+00 - 1.7E+00)	1.2E+00 (2/2) (1.0E+00 - 1.4E+00)	0
Drinking Water (pCi/L)	Gr-Beta	36	4	2.2E+00 (20/24) (1.2E+00 - 3.0E+00)	G15-2, 13.6 mi SE Wrightsville Water Supply	2.4E+00 (10/12) (1.2E+00 - 3.0E+00)	2.1E+00 (9/12) (9.7E-01 - 2.6E+00)	0
	H-3	36	2000	1.8E+02 (4/24) (9.1E+01 - 2.9E+02)	G15-2, 13.6 mi SE Wrightsville Water Supply	2.3E+02 (1/12)	ND	0
	I-131	84	1	7.0E-01 (5/56) (4.1E-01 - 1.0E+00)	G15-3, 14.8 mi SE Lancaster Water Authority	7.0E-01 (5/28) (4.1E-01 - 1.0E+00)	4.1E-01 (1/28)	0
	Gamma Spec.	36						
	Ba-140		60	ND	---	---	ND	0
	Co-58		15	ND	---	---	ND	0
	Co-60		15	ND	---	---	ND	0
	Cs-134		15	ND	---	---	ND	0
	Cs-137		18	ND	---	---	ND	0
Drinking Water (pCi/L)	Fe-59		30	ND	---	---	ND	0
	K-40		50	7.6E+01 (1/20)	Q9-1, 8.5 mi NW Steelton Water Authority	9.2E+01 (1/10)	9.2E+01 (1/10)	0

Note: See footnotes at end of table.

TABLE 1

Summary of Radionuclide Concentrations in 2000 Environmental Samples from 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)
	La-140		15	ND	---	---	ND	0
	Mn-54		15	ND	---	---	ND	0
	Nb-95		15	ND	---	---	ND	0
	Zn-65		30	ND	---	---	ND	0
	Zr-95		30	ND	---	---	ND	0
Fruits (pCi/g, wet)	Gamma Spec.	2						
	Cs-134		0.06	ND	---	---	ND	0
	Cs-137		0.08	ND	---	---	ND	0
	I-131		0.06	ND	---	---	ND	0
	K-40		0.4	2.5E+00 (1/1)	E1-2, 0.4 mi E TMI Visitors Center	2.5E+00 (1/1)	2.1E+00 (1/1)	0
Grains (pCi/g, wet)	Gamma Spec.	2						
	Cs-134		0.06	ND	---	---	ND	0
Grains (pCi/g, wet)	Cs-137		0.08	ND	---	---	ND	0
	I-131		0.06	ND	---	---	ND	0
	K-40		0.4	2.4E+00 (1/1)	B10-2, 10.1 mi NNE Milton Hershey School, Hershey	2.6E+00 (1/1)	2.6E+00 (1/1)	0

Note: See footnotes at end of table.

TABLE 1

Summary of Radionuclide Concentrations in 2000 Environmental Samples from 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)	Sr-89	2	0.025	ND	---	---	ND	0
	Sr-90	2	0.01	4.6E-03 (1/1)	B10-2, 10.1 mi NNE Milton Hershey School, Hershey	4.9E-03 (1/1)	4.9E-03 (1/1)	0
	Gamma Spec.	2						
	Cs-134		0.02	ND	---	---	ND	0
	Cs-137		0.02	ND	---	---	ND	0
	I-131		0.025	ND	---	---	ND	0
	K-40		0.4	2.3E+00 (1/1)	E1-2, 0.4 mi E TMI Visitors Center	2.3E+00 (1/1)	1.9E+00 (1/1)	0
Vegetables (pCi/g, wet)	Gamma Spec.	2						
	Cs-134		0.06	ND	---	---	ND	0
	Cs-137		0.08	ND	---	---	ND	0
Vegetables (pCi/g, wet)	I-131		0.06	ND	---	---	ND	0
	K-40		0.4	5.8E+00 (1/1)	E1-2, 0.4 mi E TMI Visitors Center	5.8E+00 (1/1)	3.9E+00 (1/1)	0
Milk (cow) (pCi/L)	I-131	130	1	ND	---	---	ND	0
	Sr-89	20	5	ND	---	---	ND	0

Note: See footnotes at end of table.

TABLE 1

Summary of Radionuclide Concentrations in 2000 Environmental Samples from 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)
	Sr-90	20	2	1.2E+00 (11/16) (8.2E-01 - 1.5E+00)	E2-2, 1.1 mi E Dairy Farm	1.3E+00 (3/4) (1.2E+00 - 1.4E+00)	1.2E+00 (2/4) (1.1E+00 - 1.3E+00)	0
	Gamma Spec.	130						
	Ba-140		60	ND	---	---	ND	0
	Cs-134		15	ND	---	---	ND	0
	Cs-137		18	ND	---	---	ND	0
	K-40		80	1.5E+03 (104/104) (1.3E+03 - 1.7E+03)	P7-1, 6.7 mi WNW Dairy Farm	1.5E+03 (26/26) (1.3E+03 - 1.7E+03)	1.5E+03 (26/26) (1.3E+03 - 1.6E+03)	0
	La-140		15	ND	---	---	ND	0
	Ra-226		50	9.2E+01 (1/80)	K15-2, 12.8 mi SSW Dairy Farm	1.0E+02 (1/20)	1.0E+02 (1/20)	0
Surface Water (10) (pCi/L)	H-3	48	2000	4.4E+02 (5/12) (8.3E+01 - 1.4E+03)	J1-2, 0.5 mi S West Shore of TMI	4.4E+02 (5/12) (8.3E+01 - 1.4E+03)	9.9E+01 (2/36) (8.7E+01 - 1.1E+02)	0
Surface Water (pCi/L)	I-131	84	1	(11)	F15-1, 12.6 mi ESE Chickies Creek, Marietta	2.1E+00 (5/28) (6.2E-01 - 3.9E+00)	1.5E+00 (15/84) (3.3E-01 - 3.9E+00)	0
	Gamma Spec.	48						
	Ba-140		60	ND	---	---	ND	0
	Co-58		15	ND	---	---	ND	0
	Co-60		15	ND	---	---	ND	0

Note: See footnotes at end of table.

TABLE 1

Summary of Radionuclide Concentrations in 2000 Environmental Samples from 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)
	Cs-134		15	ND	---	---	ND	0
	Cs-137		18	ND	---	---	ND	0
	Fe-59		30	ND	---	---	ND	0
	K-40		50	5.4E+01 (2/10) (2.7E+01 - 8.1E+01)	A3-2, 2.5 mi N Swatara Creek Middletown	1.1E+02 (1/10)	7.6E+01 (3/30) (2.9E+01 - 1.1E+02)	0
	La-140		15	ND	---	---	ND	0
	Mn-54		15	ND	---	---	ND	0
	Nb-95		15	ND	---	---	ND	0
	Ra-226		50	ND	Q9-1, 8.5 mi NW Steelton Water Authority	5.1E+01 (1/9)	5.1E+01 (1/9)	0
Surface Water (pCi/L)	Zn-65		30	ND	---	---	ND	0
	Zr-95		30	ND	---	---	ND	0
Direct Radiation (mR/std month)	Gamma	2101(5)		4.6E+00 (1842/1842) (3.2E+00 - 8.5E+00)	F1-2, 0.2 mi ESE TMI	7.6E+00 (24/24) (6.2E+00 - 8.5E+00)	5.1E+00 (259/259) (4.1E+00 - 7.1E+00)	0

Notes:

Note: See footnotes at end of table.

TABLE 1

Summary of Radionuclide Concentrations in 2000 Environmental Samples from 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 (base) program results > minimum detectable concentration (MDC). It does not include results from the Quality Control (QC) program, the Rodent Monitoring Program or the Groundwater Monitoring Program. The results listed are expressed in exponential form (i.e., 1.2E-2 = .012). Results from recounts supersede original results; reanalysis results supersede 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 samples or elements (TLDs) 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) 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 figures.
(10) Sample results from TMINS liquid discharge point (Station K1-1) were used as a check for the inplant effluent sampling program and, therefore, were not included in this table.
(11) Analysis not performed.

Note: See footnotes at end of table.

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 2000 were within normal ranges and were consistent with previous results.

No relationship between TMINS operations and offsite exposure rates was detected at any station. The 2000 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 composed of 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 2000, the average annual exposure rate for offsite indicator stations, which excludes stations located on the TMINS site boundary fence, was 4.7 ± 1.4 mR/std month. Quarterly exposure rates at offsite indicator stations ranged from 3.3 to 7.6 mR/std month. The average annual exposure rate for all control stations, those stations approximately 10 miles or more from TMINS, was 5.1 ± 1.4 mR/std month. Quarterly exposure rates at control stations ranged from 4.1 to 7.1 mR/std month. Similar exposure rates were measured in 1999 when offsite indicators and controls averaged 4.8 ± 1.5 mR/std month and 5.3 ± 1.4 mR/std month, respectively.

Control stations typically have been slightly higher than average exposures 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 due to the cessation of atmospheric nuclear weapon testing and the decay of fallout products. This trend is depicted in Figure 4.

Some indicator stations located on the site boundary fence can show elevated exposure rates, especially in Sectors E, F, and G. Stations in these sectors are located close enough to radioactive material transit and storage areas to be affected to some degree. In 2000, the average annual exposure rate for all indicator stations, including those stations located on the TMINS site boundary fence, was 4.6 ± 1.7 mR/std month. Quarterly average exposure rates ranged from 3.2 to 8.5 mR/std month. Similar exposure rates were measured in 1999 when all indicator stations averaged 4.7 ± 1.6 mR/std month and ranged from 3.2 to 9.6 mR/std month.

Some onsite stations in Sections E, F, and G did show slightly elevated exposure rates for some of 2000, but average onsite exposure rates still were lower than is typical 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 2000, the highest annual average exposure rate for an offsite location was 7.4 ± 0.5 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 2000, average quarterly exposure rates for offsite indicators and controls were relatively constant. The average exposure rates observed at offsite indicator stations for the first, second, third and fourth quarters of 2000

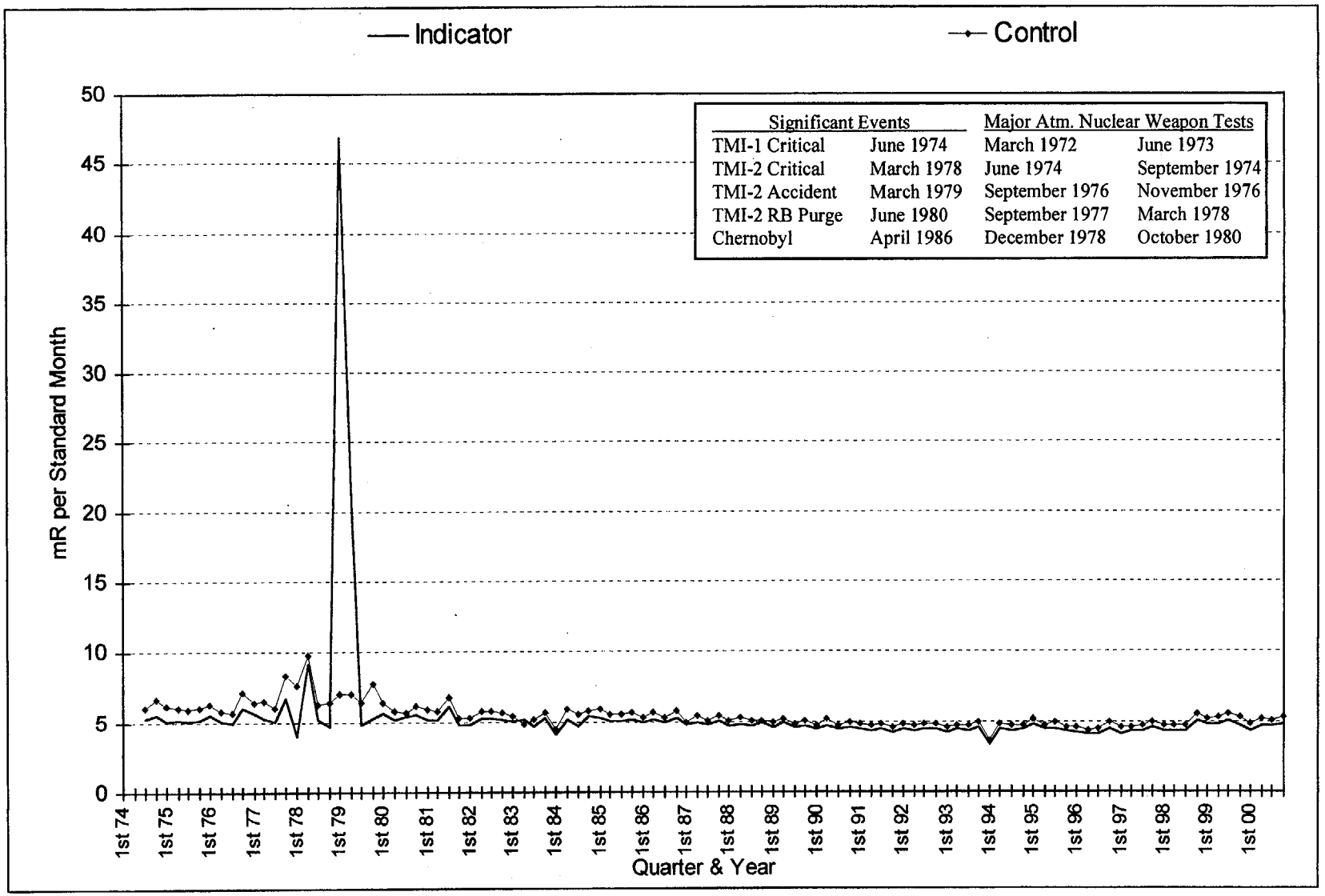
were 4.4, 4.7, 4.7 and 4.9 mR/std month. With slightly higher quarterly exposure rates, the controls trended similarly. Average exposure rates at control stations for the first, second, third and fourth quarters of 1999 were 4.8, 5.2, 5.1 and 5.3 mR/std month. The fact that both indicators and controls 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 2000. 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 2000. The annual average gamma radiation exposure rate recorded at all offsite indicator TLD monitoring stations was 4.7 mR/std month. This equates to an annual exposure rate of 56 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
Chernobyl	April 1986	December 1978	October 1980

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 2000.

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). There also was an indicator air sampling site to the north-northeast (TMINS North Gate, Station B1-4).

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.

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.

Air Particulate Results

During 2000, more than 400 air particulate samples (filters) were collected weekly from eight 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 0.0052 ± 0.0016 pCi/m^3 to 0.041 ± 0.003 pCi/m^3 and averaged 0.017 ± 0.014 pCi/m^3. The air particulate samples collected from the control location had gross beta concentrations that ranged from 0.0068 ± 0.0019 pCi/m^3 to 0.038 ± 0.003 pCi/m^3 and averaged 0.017 ± 0.014 pCi/m^3. The 2000 annual average gross beta concentrations were consistent with the 1999 averages of 0.016 ± 0.009 pCi/m^3 and 0.016 ± 0.010 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 indicator Station M2-1 (Goldsboro). The average gross beta concentration for airborne particulates collected at this station was 0.017 ± 0.014 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 2000 data indicated that gross beta radioactivity levels did not change 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 2000 are depicted in Figure 6. Generally, the gross beta concentrations have decreased with time. The 2000 average gross beta concentration of 0.017 pCi/m^3, for indicators and controls combined, is approximately 10% 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 2000. 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 several samples.

Air Iodine Results

During 2000, more than 400 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

2000 Average Gross Beta Concentrations in Airborne Particulates (pCi/m^3)

Station	Description	Average +/- 2 std dev*
A3-1(I)	Middletown	0.017 ± 0.014
B1-4(I)	TMINS North Gate	0.017 ± 0.014
E1-2(I)	TMINS Visitors Center	0.017 ± 0.014
F1-3 (I)	500 kV Substation	0.016 ± 0.013
G2-1(I)	Dairy Farm (Near Falmouth)	0.017 ± 0.014
H3-1(I)	Falmouth	0.016 ± 0.014
M2-1(I)	Goldsboro	0.017 ± 0.014
Q15-1(C)	West Fairview	0.017 ± 0.014

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

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

2000 Gross Beta Concentrations in Air Particulates

Picocuries per Cubic Meter by Week

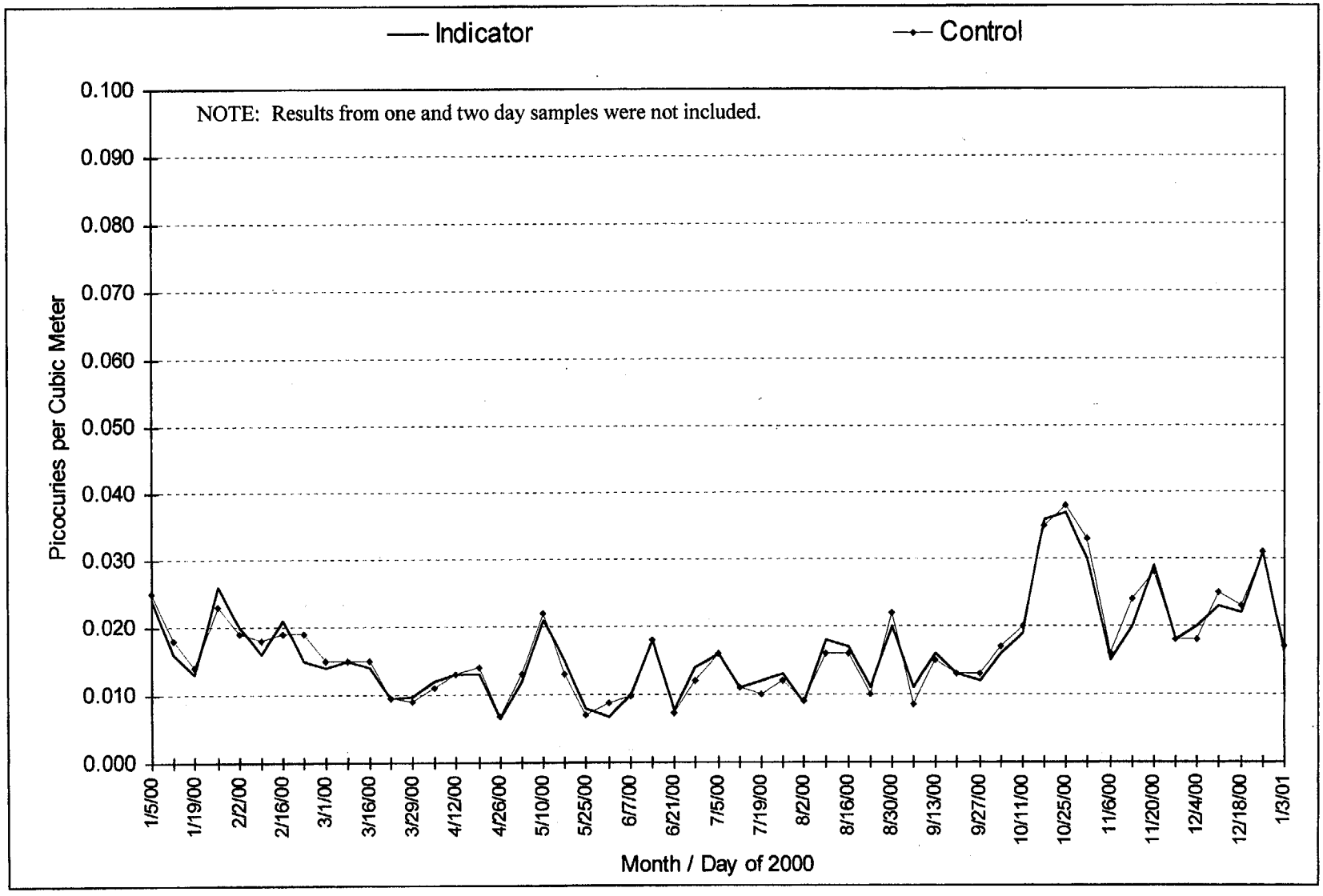


Figure 5

Historical Gross Beta Concentrations in Air Particulates

Picocuries per Cubic Meter by Quarter

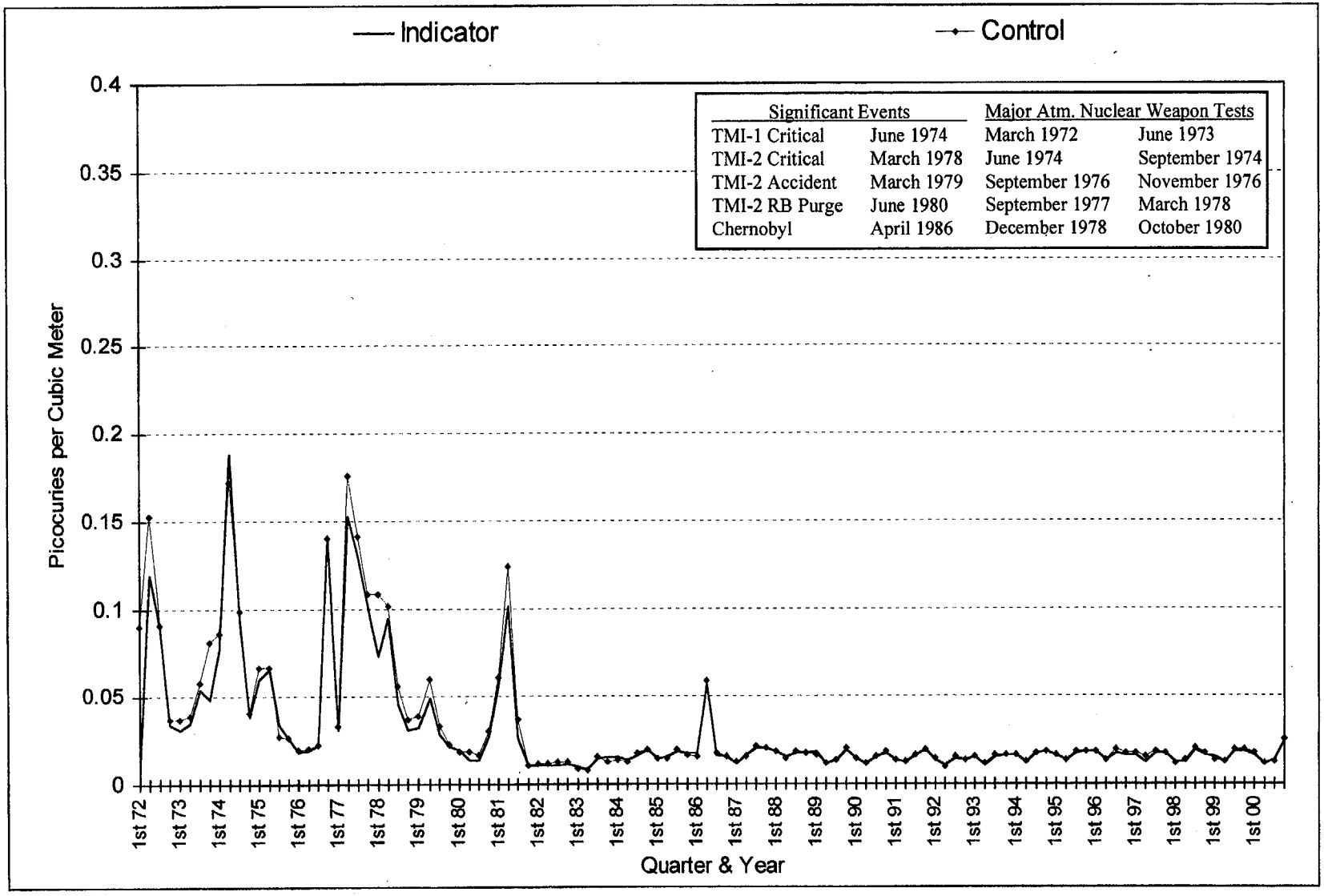


Figure 6

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 2000, 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, drinking water and possibly fish. 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 (finished) water samples were collected at seven stations (three indicators and four controls) and analyzed during 2000. 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 three locations -- Station A3-2 (Swatara Creek, Middletown, PA), Station F15-1 (Chickies Creek, Marietta, 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.

Except for those collected at Station F15-1 (Chickies Creek), all water samples were normally obtained by an automatic water compositor. Samples from Chickies Creek (Station F15-1) were collected as grabs twice per week. Grab samples also were collected when the automatic compositors were not operating (e.g. AC power loss, sampler malfunction or frozen sampling line) and/or when sufficient sample volumes were not available. The water 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 composite samples normally were retrieved biweekly (every two weeks). To verify that the samplers were operating properly, a surveillance was performed weekly. Occasionally, composite samples were retrieved weekly to close out a calendar month or quarter. The grab samples collected from Chickies Creek (Station F15-1) were composited into weekly or biweekly samples.

The weekly and biweekly composite samples from indicator Stations G15-3 and G15-2 along with those collected from control

Stations Q9-1 (surface and drinking water), F15-1 and 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.

All water samples retrieved weekly and biweekly were combined by station into monthly composites and 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 composite samples were prepared only from monthly samples collected at Station K1-1 and then analyzed for Sr-89 and Sr-90.

Electro-shocking equipment and hook and line were used to collect fish samples in the spring (May) and fall (October) of 2000. 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, H-3 and gamma-emitting radionuclides.

As part of the routine REMP, river sediments from four locations (three indicators and one control) were collected in the spring (May) and fall (October) of 2000. Indicator sediment samples were collected at a site just downstream of the TMINS liquid discharge outfall (Station K1-3), at the York Haven Dam, YHD, (Station J2-1) and at a site on the west shore of TMI, between the TMINS liquid discharge outfall and the YHD (Station J1-2). 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 2000, low-level I-131 using the chemical separation/concentration technique was detected above the minimum detectable concentration (MDC) in 15 of 84 control surface water samples, 5 of 56 indicator drinking water samples and 1 of 28 control drinking water samples. Iodine-131 above the MDC also was identified in 12 of 28 samples collected from Station K1-1, the TMINS liquid discharge. 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 0.33 ±

0.17 pCi/L to 3.9 ± 0.3 pCi/L and averaged 1.5 ± 2.5 pCi/L. For comparison, the average I-131 concentration for 1999 control surface water samples was 0.9 ± 1.2 pCi/L.

The I-131 concentrations measured in indicator drinking water samples ranged from 0.41 ± 0.30 pCi/L to 1.0 ± 0.2 pCi/L and averaged 0.70 ± 0.46. The lone concentration measured in control drinking water was 0.41 ± 0.30 pCi/L.

When I-131 was identified in an indicator sample, it also was identified in at least one control sample during the same or previous collection period. This coupled with the fact that I-131 was not detected above the MDC in any of the effluent monitoring program samples indicated that the medical industry was responsible for the presence of I-131 in the indicator drinking water samples as well as the control drinking and surface water samples.

Twelve of twenty-eight TMINS liquid discharge samples collected in 2000 contained I-131 above the MDC. The I-131 concentrations ranged from 0.31 ± 0.26 pCi/L to 2.1 ± 0.2 pCi/L and averaged 1.0 ± 1.2 pCi/L. The 1999 results were similar, ranging from 0.40 ± 0.29 pCi/L to 2.1 ± 0.4 pCi/L and averaging 1.0 ± 0.9 pCi/L.

Generally, each time I-131 was detected in a liquid discharge sample, a similar concentration of this material was measured in a control sample(s). Sometimes, however, I-131 was not detected concurrently in a control sample or the concentration detected in the discharge sample was slightly higher than the concentration measured in the control sample(s). 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 the liquid discharge samples. The absence of I-131 in 2000 liquid effluent samples supported this conclusion.

In 2000, H-3 above the MDC was measured in 2 of 36 monthly control surface water samples and 5 of 12 monthly indicator surface water samples. 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.

The H-3 measured in the control surface water samples ranged from 87 ± 55 pCi/L to 110 ± 60 pCi/L and averaged 99 ± 33 pCi/L. These concentrations were consistent with

those measured previously in control surface and drinking water samples. The presence of H-3 in the control samples was attributed to fallout from prior nuclear weapon tests and natural production of this material in the atmosphere.

As expected, H-3, a major component of 2000 TMINS liquid effluents, was detected above the MDC in 42% 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 400 ± 1100 pCi/L. The results ranged from 83 ± 50 pCi/L to 1400 ± 100 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 10 of 12 1999 monthly samples collected at Station J1-2. The concentrations ranged from 100 ± 60 pCi/L to 10000 ± 1000 pCi/L and averaged 2300 ± 6300 pCi/L. Like some of the 2000 H-3 concentrations, some of the 1999 concentrations were biased when the sampler was inoperable.

A lower average concentration was expected in 2000 because a smaller amount of H-3 was released in 2000 liquid effluents. Approximately 280 Ci of H-3 were released in liquid effluents in 2000, whereas, about 550 Ci were released in 1999.

Figure 7 depicts the 2000 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. Except for the biased results, 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 of the H-3 concentrations measured in surface water during 2000 were, however, below the USEPA Primary Drinking Water Standard of 20,000 pCi/L.

In 2000, 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 180 ± 180 pCi/L and ranged from 91 ± 55 pCi/L to 290 ± 100 pCi/L.

The H-3 concentrations measured in the 2000 indicator drinking water samples were similar to those measured in 1999, when 14 samples contained H-3 above the MDC. The measured concentrations averaged 210 ± 220 pCi/L and ranged from 98 ± 57 pCi/L to 490 ± 70 pCi/L. The 2000 results also were consistent with those measured in other years.

Figure 9 (upper) displays the average monthly H-3 concentrations measured in the 2000 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 or natural production.

To put the 2000 H-3 results into perspective, the highest monthly indicator concentration of 290 ± 100 pCi/L represented less 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 0.03 mrem. This calculated dose is equivalent to 0.01% 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 2000 contained gross beta radioactivity concentrations above the MDC. Indicator results ranged from 1.2 ± 0.7 pCi/L to 3.0 ± 0.8 pCi/L and averaged 2.2 ± 1.2 pCi/L. Similarly, the controls ranged from 0.97 ± 0.59 pCi/L to 2.6 ± 0.9 pCi/L and averaged 2.1 ± 1.1 pCi/L. The 2000 averages were consistent with the 1999 averages of 2.9 ± 2.3 pCi/L and 2.5 ± 1.5 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 2000 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 2000, 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 1.8 ± 1.1 pCi/L to 6.2 ± 1.2 pCi/L and averaged 4.2 ± 3.2 pCi/L. The 2000 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 2000 contained detectable levels of reactor-produced, gamma-emitting radionuclides. Naturally-occurring K-40 was detected in 7 samples; naturally-occurring Ra-226 was detected in one sample.

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 2000 semiannual composites contained Sr-89 or Sr-90 above the MDC.

Fish Results

During 2000, fish samples were collected at one indicator and one control location in the spring (May) and fall (October). They included recreationally important predators (Smallmouth bass) and bottom feeders (Carp, Yellow bullhead and Channel catfish). All samples were analyzed for gamma-emitting radionuclides, Sr-89, Sr-90, and H-3. None of the fish samples collected in 2000 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 2000 fish samples.
Tritium above the MDC was detected in 4 of 4 indicator fish samples. None of the controls contained H-3 above the MDC. Indicator H-3 concentrations ranged from 0.084 ± 0.040

pCi/g (wet) to 0.17 ± 0.04 pCi/g (wet) and averaged 0.11 ± 0.08 pCi/g (wet).

Like previous years, 2000 indicator fish samples contained somewhat higher H-3 concentrations than controls. This was expected for a number of reasons. First, H-3 was released routinely in 2000 TMINS liquid effluents. Second, indicator fish samples were collected in the York Haven Pond (YHP) between the TMINS liquid discharge outfall and the York Haven Dam (YHD). In this region of the YHP, mixing of TMINS liquid effluents and river water is incomplete. More complete mixing is not achieved until liquid effluents pass over the YHD.

Since H-3 was measured at slightly higher concentrations in the indicator samples, it is possible that a portion of the H-3 measured in these samples was due to routine TMINS operations. Since H-3 was detected in previous control fish samples, a portion of this material also was due to fallout and natural production in the atmosphere.

A conservative dose estimate was performed assuming that an individual consumed fish flesh with the highest H-3 concentration for one year. The maximum hypothetical whole body dose would be 0.0004 mrem. This calculated dose is equivalent to 0.0001% of the whole body dose that an individual living in the TMI area receives each year from natural background radiation (300 mrem).

Sediment Results

In May and October of 2000, routine REMP sediment samples were collected from four sites in the Susquehanna River. Control samples were collected from a location upstream of the TMINS liquid discharge outfall. Indicators were collected from three 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 Be-7, K-40, Ra-226 and thorium-232 (Th-232) as well as fallout and/or reactor-produced Cs-137 were identified in all indicator and control samples. Additionally, one indicator and the control collected in May contained I-131 related to the medical industry. No other reactor-produced, gamma-emitting radionuclides were detected above the MDC.

Indicator Cs-137 concentrations ranged from 0.11 ± 0.03 pCi/g (dry) to 0.22 ± 0.03 pCi/g (dry) and averaged 0.17 ± 0.08 pCi/g (dry). Control sample concentrations were slightly lower, ranging from 0.077 ± 0.020 pCi/g (dry) to 0.12 ± 0.02 pCi/g (dry) and averaging 0.099 ± 0.061 pCi/g (dry). For comparison, 1999 average Cs-137 concentrations were 0.18 ± 0.11 pCi/g (dry) and 0.11 ± 0.03 pCi/g (dry), for indicators and controls, respectively.

The sediment samples collected from Indicator Station K1-3, a location just downstream of the TMINS liquid discharge outfall, had the highest annual average Cs-137 concentration. The concentrations ranged from 0.17 ± 0.02 pCi/g (dry) to 0.22 ± 0.03 pCi/g (dry) and averaged 0.20 ± 0.07 pCi/g (dry). This was expected because Cs-137 is typically released in TMINS liquid effluents and less mixing of effluents and river water occurs at this location. Also, radioactive materials such as Cs-137 are readily adsorbed by suspended particles in the water and bottom sediments.

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 2000 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 2000. 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 (Ref. 38).

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 K1-3, 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 (0.00008%) of the whole body dose received by an individual from natural background radiation (300 mrem/yr).

In previous years, sediment samples were collected at Safe Harbor Dam (SHD), the first major sediment trap downstream of TMINS. The purpose of this sampling was to determine if radionuclides released in TMINS liquid effluents were present and accumulating at SHD.

The results indicated that a portion of the Cs-137 detected in the SHD sediments may be due to TMINS operations since the concentrations were higher than those collected at control locations. However, the absence of other reactor-related radionuclides, such as Cs-134, indicated that recent TMINS discharges were not present at significant levels and most of the Cs-137 was attributable to fallout from prior nuclear weapon tests and/or the Chernobyl Accident of 1986. The results also indicated that a buildup of TMINS-related materials was not occurring at SHD.

TABLE 3

2000 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			
A3-2 (C)	Swatara Creek (Middletown, PA)	---	---	11 ± 50	(-48) - 46
F15-1 (C)	Chickies Creek (Marietta, PA)	87	---	12 ± 94	(-81) - 87
Q9-1 (C)	Steelton Water Authority (Steelton, PA)	110	---	40 ± 110	(-97) - 110
J1-2 (I)	West Shore of TMI	400 ± 1100	83 - 1400	210 ± 780	7.4 - 1400
		Drinking Water			
Q9-1 (C)	Steelton Water Authority (Steelton, PA)	---	---	66 ± 60	28 - 140
G15-2 (I)	Wrightsville Water Supply (Wrightsville, PA)	230	---	50 ± 130	(-26) - 230
G15-3 (I)	Lancaster Water Authority (Columbia, PA)	170 ± 210	91 - 290	80 ± 150	(-1.0) - 290

(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

2000 Average Gross Beta Concentrations in Drinking Water (pCi/L)

Station	Description	Sample Concentrations > MDC [1] Average +/- 2 std dev	Sample Concentrations > MDC [1] Range	Actual Sample Concentrations [2] Average +/- 2 std dev	Actual Sample Concentrations [2] Range
Q9-1 (C)	Steelton Water Authority (Steelton, PA)	2.1 ± 1.1	0.97 - 2.6	1.8 ± 1.5	0.32 - 2.6
G15-2 (I)	Wrightsville Water Supply (Wrightsville, PA)	2.4 ± 1.2	1.2 - 3.0	2.1 ± 1.7	0.39 - 3.0
G15-3 (I)	Lancaster Water Authority (Columbia, PA)	2.0 ± 1.2	1.2 - 3.0	1.8 ± 1.3	0.75 - 3.0

(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

2000 Tritium Concentrations in Surface Water

Picocuries per Liter by Month

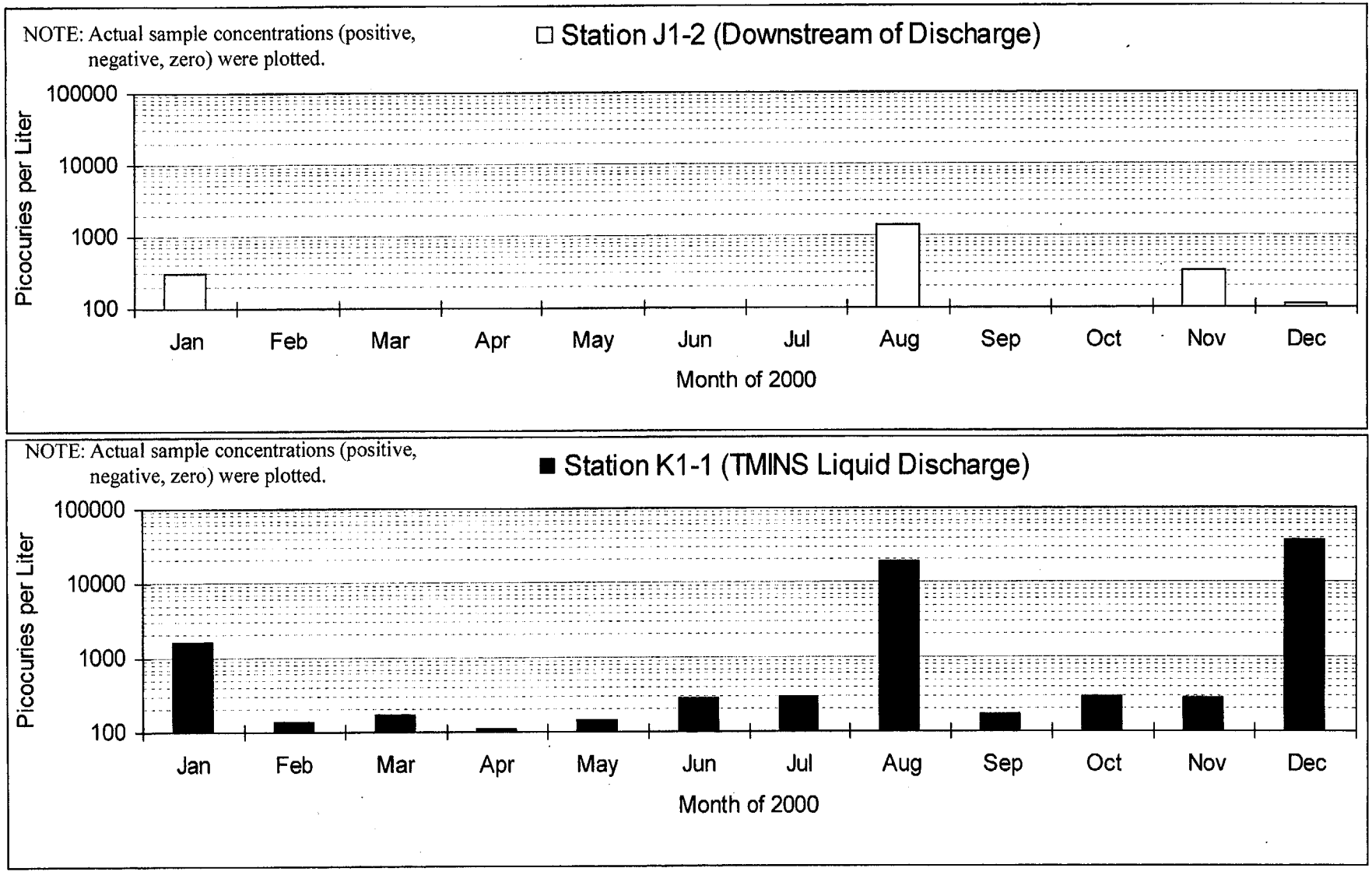


Figure 7

Historical Tritium Concentrations in Surface Water

Picocuries per Liter by Quarter

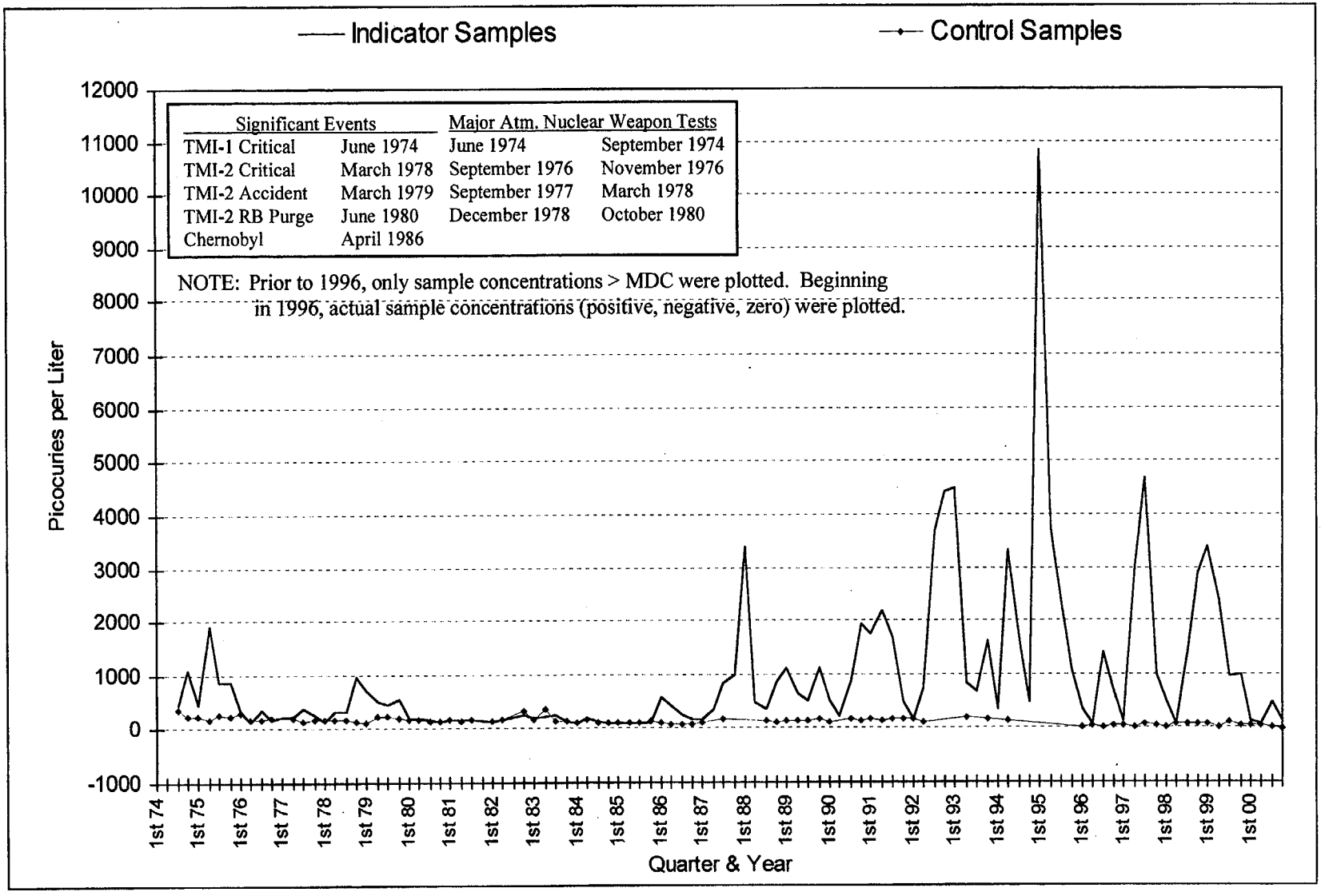
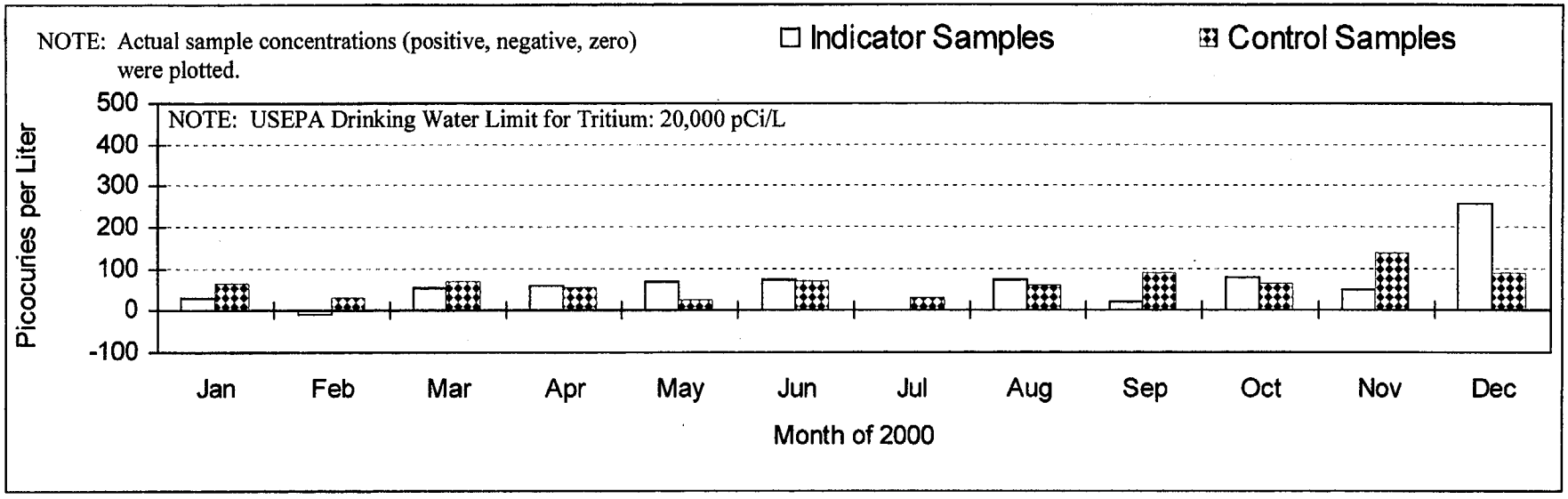


Figure 8

2000 Tritium Concentrations in Drinking Water

Picocuries per Liter by Month



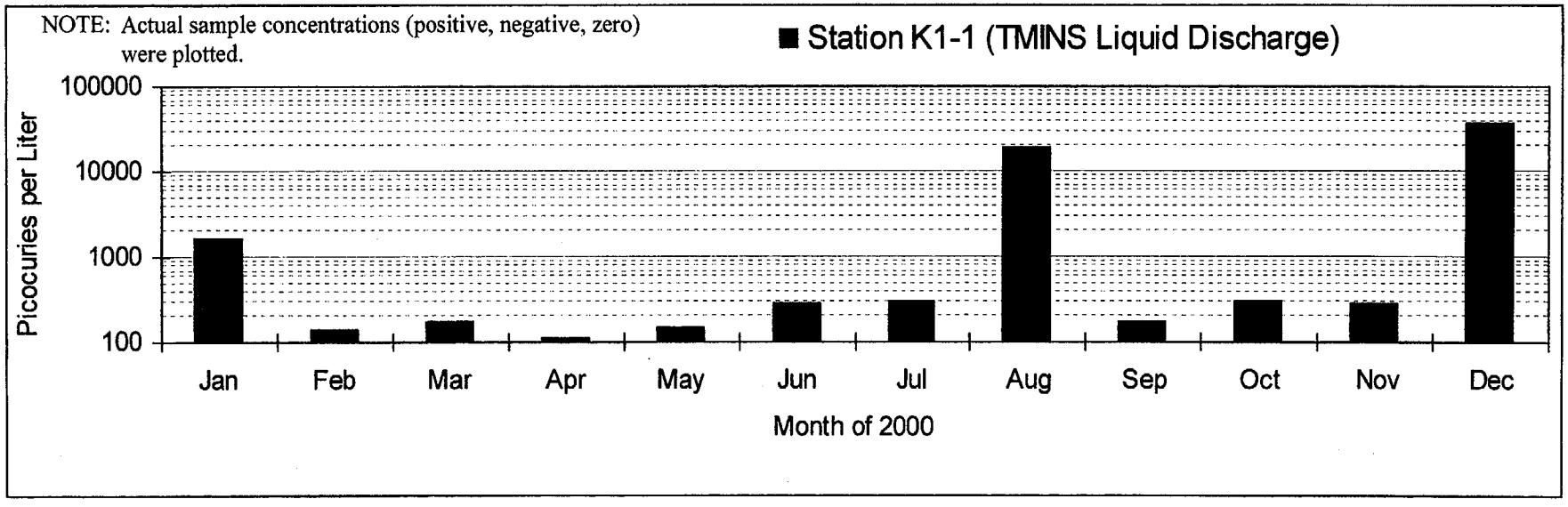


Figure 9

2000 Gross Beta Concentrations in Drinking Water

Picocuries per Liter by Month

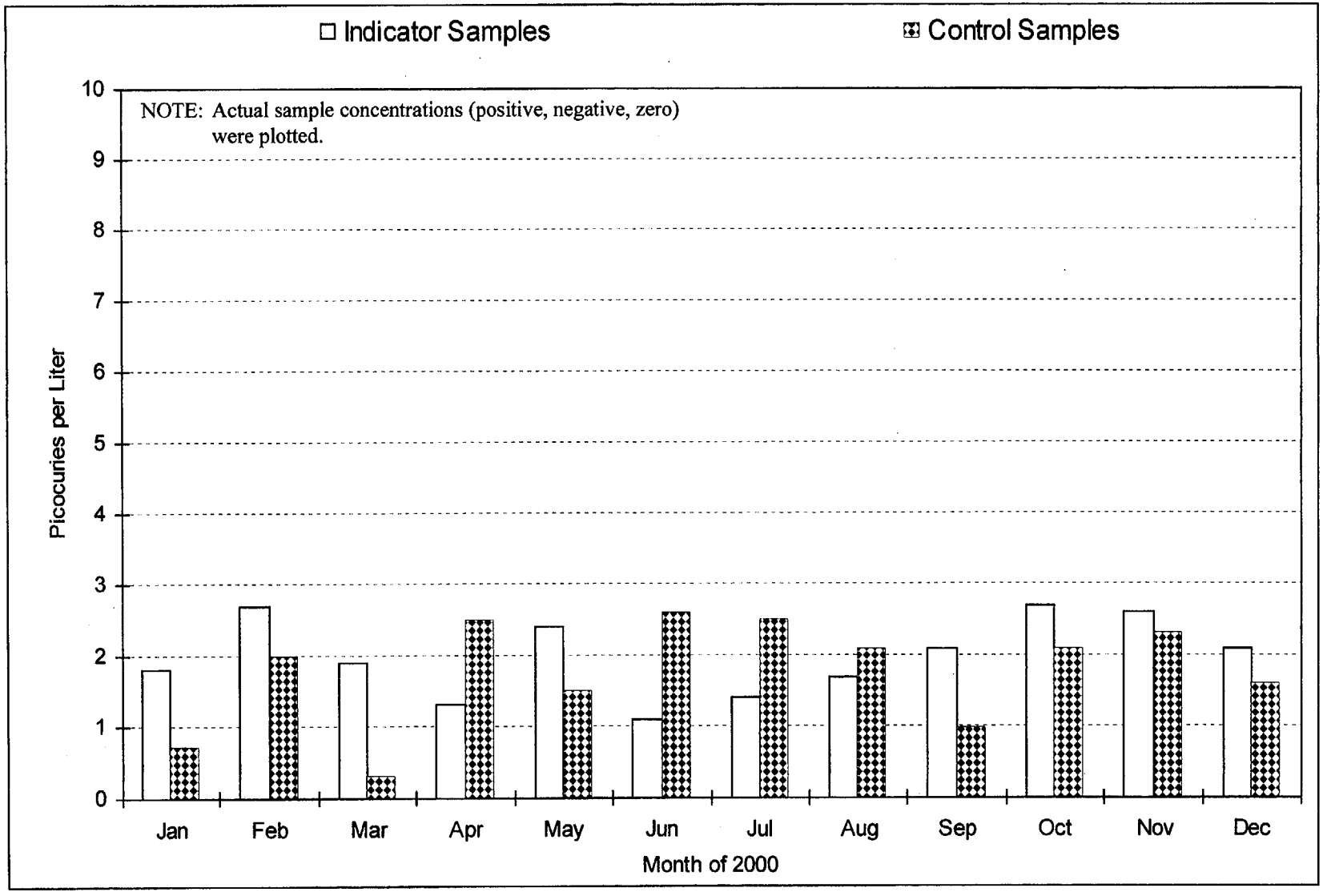


Figure 10

Historical Cesium-137 Concentrations in Aquatic Sediments

Picocuries per Gram (dry)

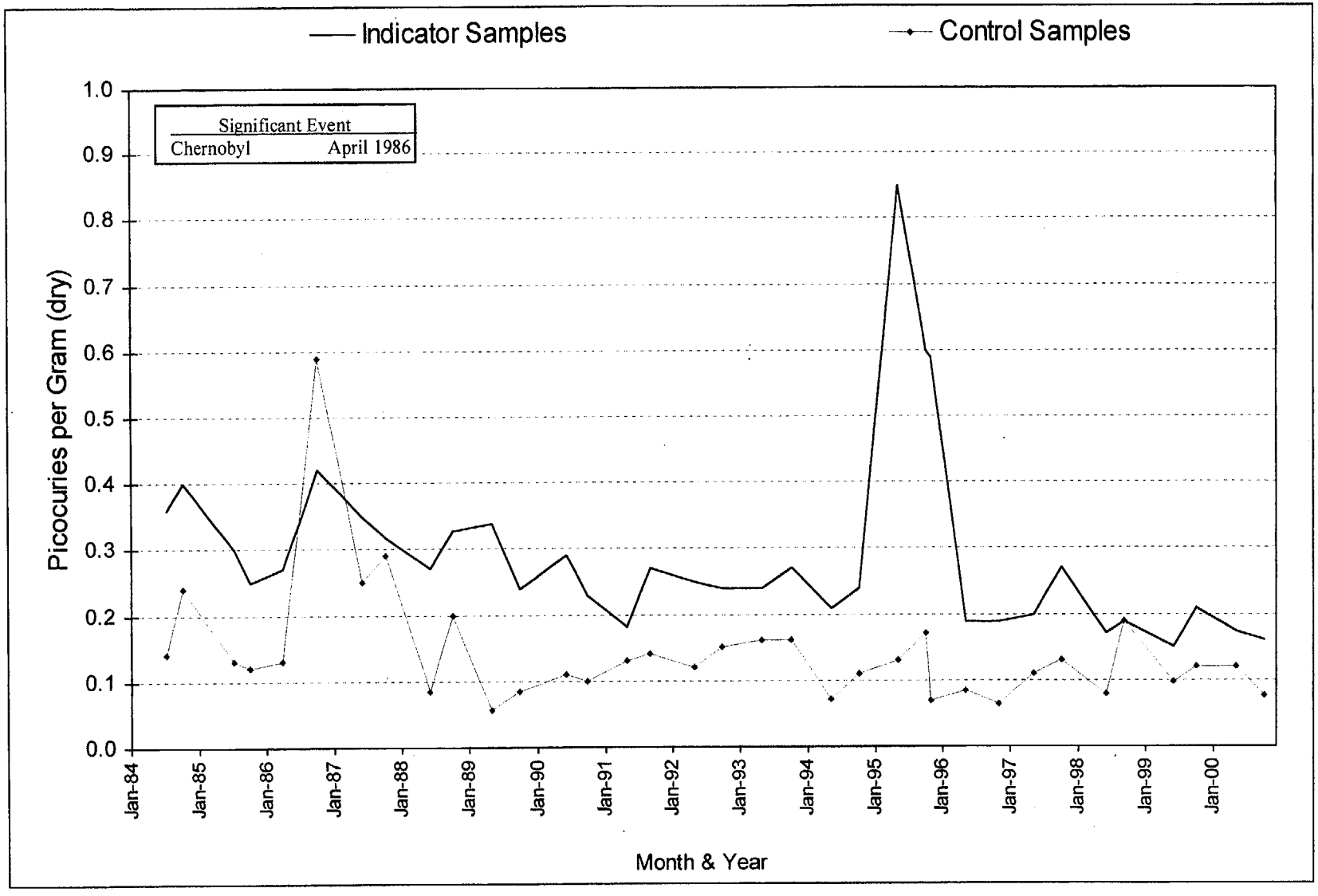


Figure 11

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 2000. The ingestion pathway also is normally assessed by collecting and analyzing deer meat samples. No deer meat samples were analyzed in 2000 because indicator samples were not available.

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 2000.

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 2000 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 2000 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 2000 land use surveillance, no changes to the REMP or the dose model were required.

Unlike previous years, 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 all samples. Its presence was most likely due to fallout from prior weapon tests because the control sample yielded a similar Sr-90 concentration. The analysis results are listed in Table E-3 of Appendix E.

Sample Collection and Analysis

During 2000, samples of raw cow milk were collected biweekly from local farmers at two control and four indicator locations. Two control sites were sampled in 2000 because

the farmer at station K15-2 ceased operations at the end of September.

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 stations were 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 biweekly milk sample. The biweekly 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 2000. 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. Deer meat samples were not analyzed in 2000 because indicator samples were not available.

When available, a limited number of rodent carcasses are analyzed as part of the non-routine REMP. During 2000, no carcasses were available for analysis.

Milk Results

During 2000, 130 biweekly milk samples were collected and analyzed. Iodine-131 was not detected above the minimum detectable concentration (MDC) in any of the milk samples. Gamma isotopic analyses yielded only naturally-occurring potassium-40 (K-40) and radium-226 (Ra-226). Potassium-40 was detected in all 2000 milk samples. The K-40 concentrations measured in the indicator samples were similar to those measured in the controls. Radium-226, a naturally-occurring radionuclide commonly measured in soil, was detected in one indicator and one control milk sample. Its presence in the milk was probably due to ingestion of soil by the cows.

Strontium analyses were performed on 20 quarterly composite samples. None of the samples contained Sr-89 above the MDC. As expected, Sr-90 was measured in a number of milk samples. Eleven of sixteen indicator samples (69%) and two of four control samples (50%) contained Sr-90 above the MDC.

Strontium-90 concentrations in the indicator samples ranged from 0.82 ± 0.54 pCi/L to 1.5 ± 0.6 pCi/L and averaged 1.2 ± 0.4 pCi/L. Similarly, the concentrations measured in the control samples ranged from 1.1 ± 0.6 pCi/L to 1.3 ± 0.4 pCi/L and averaged 1.2 ± 0.2 pCi/L. The Sr-90 concentrations measured in 2000 milk samples were consistent with those measured in 1999 when indicator sample concentrations averaged 0.96 ± 0.48 pCi/L and a control sample contained 1.0 ± 0.6 pCi/L, respectively.

The milk collected from Indicator Station E2-2, the dairy farm located 1.1 miles east 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 1.3 ± 0.2 pCi/L. Milk samples collected in 2000 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 2000 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 2000 were based on actual sample concentrations because many 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 2000. 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 2000, 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 and the control sample. The measured concentrations were 0.0046 ± 0.0019 pCi/g (wet) and 0.0049 ± 0.0019 pCi/g (wet), respectively. Similar Sr-90 concentrations were detected in previous years. For example, the 1999 indicator cabbage sample contained Sr-90 at a concentration of 0.0036 ± 0.0017 pCi/g (wet). This radionuclide also was measured in the 1999 control sample at a concentration of 0.0025 ± 0.0015 pCi/g (wet).

As in previous years, the data indicated that the Sr-90 measured in the 2000 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 2000, however, no deer meat samples were analyzed because indicator samples were not available.

Rodent Results

No rodent carcasses were available for analysis in 2000. 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

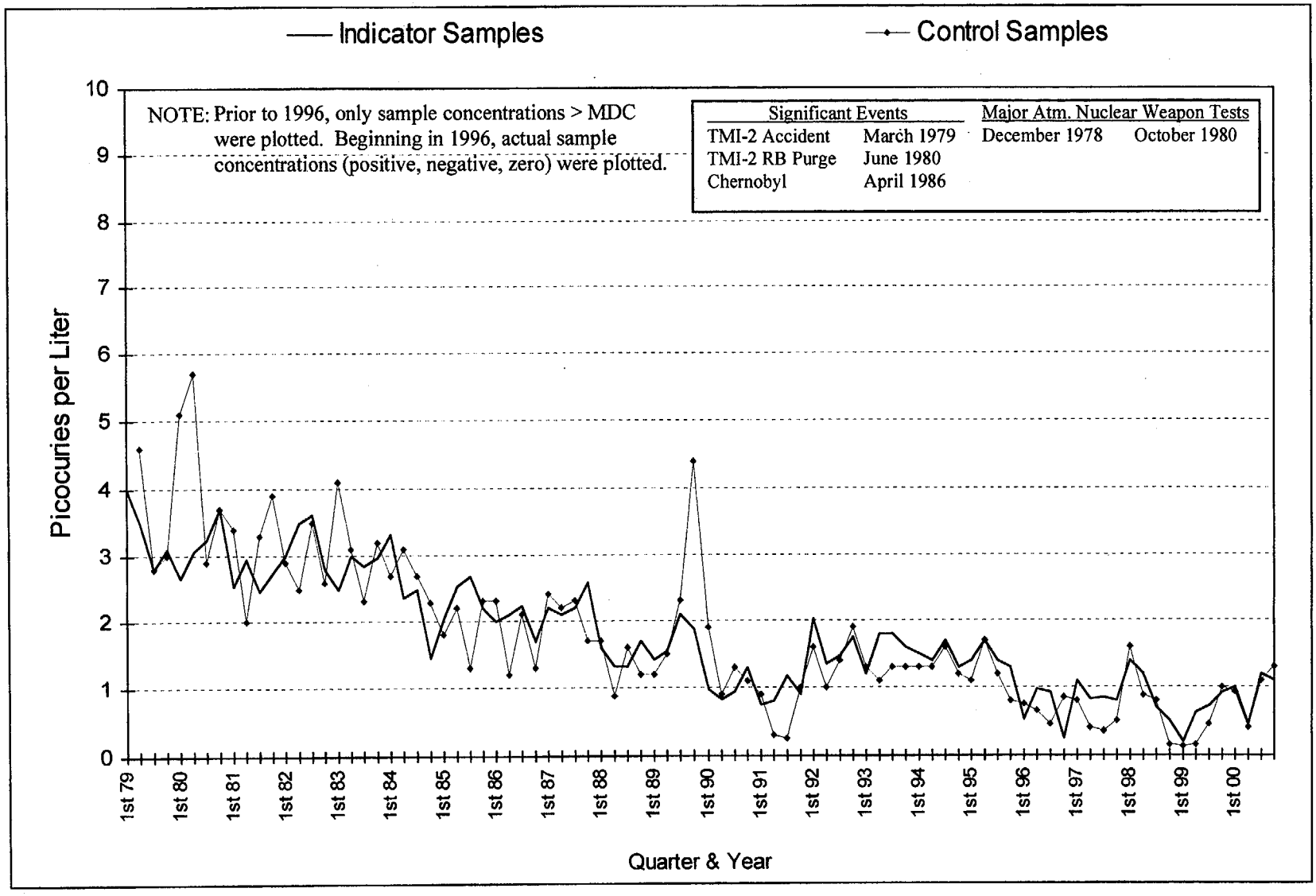


Figure 12

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. 39 and 40).

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. 41).

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 2000, 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, two pipe leaks that were identified and fixed in 1999 contributed to elevated levels of H-3 in certain onsite wells. Both pipes continue to be monitored.

Tritium above the MDC was not detected in any of the offsite groundwater samples. This material was detected in all onsite storm water samples (4 of 4). Its presence was due to a combination of routine TMI-1 operations, 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 2000 contained Sr-90 or gamma-emitting radionuclides related to TMINS operations. The same can be said for storm water and sediment collected from Station EDCB.

The 2000 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 2000, three aboveground tanks were monitored. Monitoring was performed by collecting and analyzing groundwater samples from wells proximal to the tanks. Periodic inspections also were performed at one of the tanks. No discernible tank or component leakage was identified in 2000.

Sample Collection and Analysis

Several minor changes were made to the TMINS GMP in 2000. The changes are discussed in Appendix C.

Groundwater from 20 onsite and 2 offsite stations were sampled in 2000. 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), 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 industrial wells.

Both offsite stations (E1-2 and N2-1) were drinking water wells. Storm water and sediment were sampled in 2000 from one onsite station (EDCB).

The locations of the onsite groundwater stations sampled in 2000 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. Most groundwater stations were sampled either weekly, monthly, quarterly, semiannually or annually. A few were sampled on an as needed basis. Storm water and sediment from Station EDCB were collected monthly and annually, respectively.

All groundwater samples collected in 2000 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 2000, H-3 was the only radionuclide consistently 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 1999 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, two pipe leaks identified in 1999 were the source of H-3 in a few of the onsite groundwater samples. Projects to repair or replace the pipes were completed in 1999. Both 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 2000. Additionally, the annual average concentrations generally were similar to or below those calculated for the period just prior to the operations of the TMI-2 Evaporator (January 1991 through August 1993). The highest H-3 concentrations were measured in the onsite groundwater samples collected from Stations MS-4, RW-1, MS-22, OS-18, NW-A, NW-B, NW-C and NW-CW.

The RW-1 well was originally drilled to recover oil from a past pipe leak. After the oil recovery process was completed, the well was included in the TMINS GMP to provide additional monitoring coverage for TMI-1 activities and systems (e.g. tanks, components and pipes).

The 2000 RW-1 H-3 concentrations averaged 2,700 ± 2,800 pCi/L and ranged from 500 to 4,100 pCi/L. For comparison, the 1999 RW-1 H-3 concentrations averaged 7,200 ± 5,300 pCi/L and ranged from 1,800 to 11,000 pCi/L.

In the past, the groundwater collected from RW-1 was impacted by leakage of system components that migrated to the ground near the well. A decrease was noted for the last six months of 1997 through most of 1998. This was a direct result of repairing the components at the end of 1996.

At the end of 1998, the H-3 concentrations in RW-1 began to increase. An investigation was initiated and a leak in a nearby pipe was discovered. Repairs were affected in 1999. Groundwater at three other stations - MS-4, MS-19 and RW-2 - also were affected by this leak. Since the pipe was repaired, the H-3 concentrations in the groundwater at all four stations have trended downward. Although most of the H-3 detected in these samples was due to the pipe leak, some also was due to normal atmospheric releases of this material from TMI-1.

Station MS-22 was installed in November of 1996 to monitor the TMI-1 Borated Water Storage Tank (BWST). The station is located near the TMI-1 Station Vent, a release point where the largest amount of airborne H-3 is vented to the environment.

The 2000 MS-22 H-3 concentrations averaged 640 ± 530 pCi/L and ranged from 400 to 890 pCi/L. For comparison, the 1999 MS-22 H-3 concentrations averaged 960 ± 640 pCi/L and ranged from 520 to 1,700 pCi/L.

The concentrations measured in the 2000 MS-22 samples were within the expected range based on the location of this station. The presence of H-3 in these samples was attributed to routine airborne releases of H-3 from the TMI-1 Station Vent. Additionally, the periodic inspections of this tank indicated no leakage and, therefore, no contribution from the TMI-1 BWST or its components.

In August of 1998, Station OS-18 was added to the TMINS GMP. The well was originally installed to investigate alleged past spills of photographic waste. It was not sampled for several years and was never sampled for radioactive materials. The well was added to the TMINS GMP because of its proximity to pipes that transport water containing radioactive materials, including H-3. These pipes were the last significant potential sources of H-3 to the groundwater.

The 2000 OS-18 H-3 concentrations averaged 4,000 ± 14,000 pCi/L and ranged from 280 to 31,000 pCi/L. For comparison, the 1999 OS-18 H-3 concentrations averaged 26,000 ± 54,000 pCi/L and ranged from 320 to 130,000 pCi/L.

The highest concentrations occurred shortly after water was transported in one of the pipes. This indicated that there may be a leak in at least one of the lines. A test to determine the integrity of the lines began in March of 1999. One of the pipes was found to be leaking and was repaired.

The pipe has been used since the repairs were affected. To date, the groundwater data

indicate that the pipe was successfully repaired and that there are no other unidentified leaks in this pipe or a different pipe.

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 2000 H-3 concentrations in water collected from NW-A averaged 1,300 ± 100 pCi/L and ranged from 1,300 to 1,400 pCi/L. Similar, the 1999 concentrations averaged 1,800 ± 500 pCi/L and ranged from 740 to 2,400 pCi/L.

During 2000, the H-3 concentrations for NW-B were somewhat higher than NW-A, averaging 2,900 ± 1,600 pCi/L and ranging from 2,400 to 3,500 pCi/L. For comparison, the 1999 NW-B concentrations averaged 3,800 ± 4,400 pCi/L and ranged from 2,100 to 9,800 pCi/L.

The 2000 NW-C H-3 concentrations averaged 18,000 ± 4,000 pCi/L and ranged from 17,000 to 20,000 pCi/L. For comparison, the 1999 H-3 concentrations averaged 50,000 ± 52,000 pCi/L and ranged from 23,000 to 160,000 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 that another source of H-3 may exist. It is likely that the pipe leak that affected OS-18 (discussed above) may have affected the H-3 concentrations found in the industrial well water.

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 also was used for drinking. Occasionally, water from this well also was used to supply water for various TMI-1 systems.

In 2000, 4 of 4 samples collected from Station 48S contained H-3 above the minimum detectable concentration (MDC). The concentrations averaged 220 ± 40 pCi/L and ranged from 200 to 240 pCi/L. The 2000 concentrations were consistent with those measured in 1999 (Table G-1).

The 2000 OSF H-3 concentrations (4 of 4) averaged 430 ± 390 pCi/L and ranged from 170 to 630 pCi/L. As shown on Table G-1,

the 2000 OSF concentrations were similar to those reported in 1999.

The H-3 detected in the 2000 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 portion of the H-3 detected in the onsite well water also 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 2000 average H-3 concentration for one working year. The maximum hypothetical whole body dose was 0.008 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. Only naturally-occurring potassium-40 (K-40) and radium-226 (Ra-226) were detected.

Storm Water and EDCB Sediment Results

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

For gamma-emitting radionuclides, only naturally-occurring K-40 was detected. All samples contained H-3 above the MDC. The concentrations averaged 340 ± 210 pCi/L and ranged from 190 to 430 pCi/L. Similar H-3 concentrations were measured in 1999 (Table G-1).

Since these concentrations were higher than those typically measured in control surface water, a portion of H-3 detected in the 2000 storm water was attributed to routine operations at TMI-1 (e.g. routine airborne releases). A portion of the H-3 also 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 Be-7, K-40, Ra-226 and thorium-232 (Th-232) 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 ± 0.03 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 2000 operations at TMINS were well below all applicable regulatory limits and were significantly less than doses received from natural sources of radiation. The 2000 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 0.04 mrem. This dose is equivalent to 0.01% of the dose that an individual living in the TMI area receives each year from natural background radiation.

The 2000 whole body dose to the surrounding population from TMI-1 and TMI-2 liquid and airborne effluents was calculated to be 2.5 person-rem. This is equivalent to 0.0004% 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 GPU Generation, Inc. 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 2000 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 2000 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 2000 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 2000 TMI-1 and TMI-2 liquid and airborne effluents combined was conservatively calculated to be 0.04 mrem. This dose is equivalent to 0.01 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 2000 TMI-1 and TMI-2 liquid and airborne effluents was calculated to be 2.5 person-rem. This dose is equivalent to 0.0004 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 2000 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 2000 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 2000 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 2000 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	0.04	< 0.01
	10 any organ	0.05	< 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	0.02	< 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	0.51
	25 total body or other organs	0.55

* *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 2000 TMINS operations was 0.49 mrem. This dose was based on a maximum net fence-line exposure rate of 5.3 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 (0.06 mrem) and the dose from direct radiation (0.49 mrem) yielded a maximum hypothetical dose of 0.55 mrem.

TABLE 6

Calculated Whole Body Doses to the Maximum Individual and the Population from 2000 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	0.04	< 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: **0.04 mrem/yr**

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

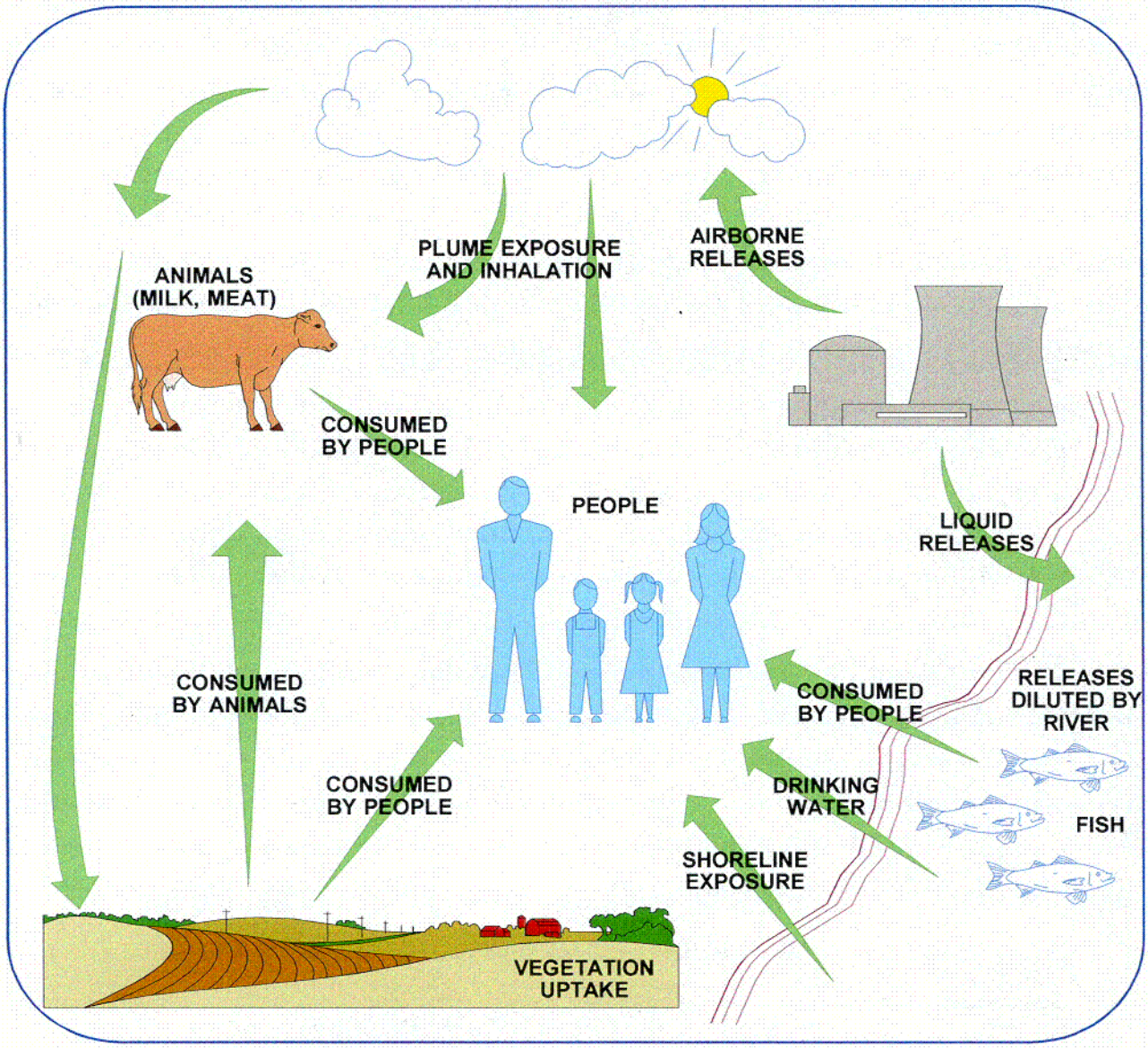
	Calculated Population Whole Body Dose (person-rem/yr) TMI-1	TMI-2
From Radionuclides In Liquid Releases (Downstream Susquehanna River Water Users)	2.3	< 0.1
From Radionuclides In Airborne Releases (Population within 50 Mile Radius of TMINS)	0.2	< 0.1

Population Whole Body Dose Due to TMI-1 and TMI-2 Operations: **2.5 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

C04

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APPENDIX A

2000 REMP Sampling Locations and Descriptions, Synopsis of REMP, and Sampling and Analysis Exceptions

TABLE A-1

TMINS Radiological Environmental Monitoring Program Sample Locations - 2000

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
AP,AI	B1-4	148	0.8	28	NNE of site at North Gate, 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 - 2000

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
SW	F15-1	83	12.6	122	ESE of site at Chickies Creek, Marietta
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, AQS	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 - 2000

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	K15-2	126	12.8	208	SSW of site at farm along Route 74 N
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 - 2000

Sample Medium	Station Code	Map Number	Distance*	Azimuth	Description
M	P7-1	75	6.7 mi	293°	WNW of site at farm along Old York Road, New Cumberland
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 2000 TMINS REMP[1]

Sample Type	Number of Sampling Locations	Collection Frequency[6]	Number of Samples Collected	Type of Analysis	Analysis Frequency	Number of Samples Analyzed[2]
Air Iodine	8	Weekly	424	I-131	Weekly	424
Air Particulate	8	Weekly	424	Gr-Beta	Weekly	424
				Gamma	Quarterly	32
Fish	2	Semiannually	8	Gamma	Semiannually	8
				H-3	Semiannually	8
				Sr-89	Semiannually	8
				Sr-90	Semiannually	8
Aquatic Sediment	4	Semiannually	8	Gamma	Semiannually	8
	1[7]	Annually	1	Gamma	Annually	1
Discharge Water	1	Weekly	4	I-131	Weekly	4
		Biweekly	24	I-131	Biweekly	24
				Gamma	Monthly	12
				Gr-Beta	Monthly	12
				H-3	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	9	Weekly	212	H-3	Weekly	212
	2	Monthly	15	H-3	Monthly	15
	3	Quarterly	12	H-3	Quarterly	12
	11	Semiannually	18	H-3	Semiannually	18
	7	Annually	7	H-3	Annually	7
				Gamma	Quarterly	8
				Gamma	Annually	10
				Sr-90	Annually	6
Dosimeters (TLD)[3]	90	Quarterly	2106	Immersion Dose	Quarterly	2101[4]

NOTE: See Notes at end of table.

TABLE A-2

Synopsis of the 2000 TMINS REMP[1]

Sample Type	Number of Sampling Locations	Collection Frequency[6]	Number of Samples Collected	Type of Analysis	Analysis Frequency	Number of Samples Analyzed[2]
Milk	6	Biweekly	130	Gamma	Biweekly	130
				I-131	Biweekly	130
				Sr-89	Quarterly	20
				Sr-90	Quarterly	20
Storm Water	1	Monthly	12	Gamma	Quarterly	4
				H-3	Quarterly	4
Surface/Drinking Water	7	Weekly	28	I-131	Weekly	24[5]
		Biweekly	168	I-131	Biweekly	144[5]
				Gamma	Monthly	84
				Gr-Beta	Monthly	36
				H-3	Monthly	84
Deer Meat	2	When Available	0	Gamma	When Available	0
Rodent	1	When Available	0	Radiological Frisk or Gamma	When Available	0

NOTES:

(1) This table is a synopsis of the primary (base) program only. It does not include the quality control (QC) program.
(2) The total number of analyses does not include duplicate analyses, recounts, or reanalyses.
(3) A dosimeter is considered to be a phosphor (element).
(4) This is the total number of samples or elements (TLDs) used for data analysis.
(5) Water samples collected from Station J1-2 were not analyzed for low level I-131.
(6) 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.
(7) This reflects the sample collected from Station EDCB.

TABLE A-3

Sampling and Analysis Exceptions 2000*

Period of Deviation	Description of Deviation and Corrective Action
December 27, 1999 to January 11, 2000	During the subject period, numerous hourly aliquots were not collected by the automatic water at indicator surface water station J1-2 (West Shore of TMI) due to a blocked sample line (i.e. source water froze in the sample line) and a disconnected sample line. A grab sample was combined with a composite sample to represent the sample collection period.
January 11, 2000 to January 25, 2000	During the subject period, numerous hourly aliquots were not collected by the automatic water at indicator surface water station J1-2 (West Shore of TMI) due to a blocked sample line (i.e. source water froze in the sample line). A grab sample was combined with a composite sample to represent the sample collection period.
January 11, 2000 to January 25, 2000	During the subject period, numerous hourly aliquots were not collected by the automatic water at control drinking water station Q9-1 (Steelton Water Authority) due to a sampler malfunction. Since the sampler collected a sufficient amount of water for analysis, a grab sample was not collected.
January 25, 2000 to February 8, 2000	During the subject period, no hourly aliquots were not collected by the automatic water at indicator surface water station J1-2 (West Shore of TMI) due to a blocked sample line (i.e. source water froze in the sample line). Four grab samples were collected and combined to represent the sample collection period.
February 8, 2000 to February 22, 2000	During the subject period, numerous hourly aliquots were not collected by the automatic water at indicator surface water station J1-2 (West Shore of TMI) due to a blocked sample line (i.e. source water froze in the sample line). Since the sampler collected a sufficient amount of water for analysis, a grab sample was not collected.
February 22, 2000 to February 29, 2000	During the subject period, numerous hourly aliquots were not collected by the automatic water at indicator surface water station J1-2 (West Shore of TMI) due to a blocked sample line (i.e. source water froze in the sample line). Since the sampler collected a sufficient amount of water for analysis, a grab sample was not collected.

TABLE A-3 (Continued)

Sampling and Analysis Exceptions 2000*

Period of Deviation	Description of Deviation and Corrective Action
July 25, 2000 to August 8, 2000	During the subject period, numerous hourly aliquots were not collected by the automatic water at control drinking water station Q9-1 (Steelton Water Authority) due to a sampler malfunction. Since the sampler collected a sufficient amount of water for analysis, a grab sample was not collected.
November 13, 2000 to November 27, 2000	During the subject period, numerous hourly aliquots were not collected by the automatic water at indicator surface water station J1-2 (West Shore of TMI) due to a blocked sample line (i.e. source water froze in the sample line). Since the sampler collected a sufficient amount of water for analysis, a grab sample was not collected.
November 27, 2000 to December 11, 2000	During the subject period, numerous hourly aliquots were not collected by the automatic water at indicator surface water station J1-2 (West Shore of TMI) due to a blocked sample line (i.e. source water froze in the sample line). Since the sampler collected a sufficient amount of water for analysis, a grab sample was not collected.
December 11, 2000 to December 27, 2000	During the subject period, numerous hourly aliquots were not collected by the automatic water at indicator surface water station J1-2 (West Shore of TMI) due to a blocked sample line (i.e. source water froze in the sample line). Since the sampler collected a sufficient amount of water for analysis, a grab sample was not collected.

* 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

2000 Lower Limit of Detection (LLD) Exceptions

TABLE B

Analytical Results Which Failed to Meet the USNRC Required LLD During 2000*

During 2000, 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

2000 REMP Changes

TABLE C

2000 TMINS REMP Changes

January, 2000	The collection of air particulate and air iodine samples at Station Q4-1 was discontinued.
	Weekly gross alpha and semiannual strontium analyses on air particulate samples were discontinued.
	The collection of offsite groundwater at Stations A2-2, D1-4, J3-3, K1-6, L1-3 and L1-4 was discontinued.
	The frequency for collecting groundwater at Station OS-18 and analyzing the samples for H-3 was reduced from twice per week to weekly.
	The frequency for collecting groundwater at Station MS-22 and analyzing the samples for H-3 was reduced from monthly to quarterly. Additionally, the frequency for analyzing the samples for gamma-emitting radionuclides was reduced from quarterly to annually (as a composite) and the annual Sr-90 analysis was eliminated.
	The frequency for collecting groundwater at Stations MS-2, MS-5, MS-20, OS-14 and RW-2 and analyzing the samples for H-3 was reduced from quarterly to semiannually. Additionally, the frequency for analyzing the samples for gamma-emitting radionuclides was reduced from quarterly to annually (as a composite).
	The frequency for analyzing the groundwater from Station RW-1 for gamma-emitting radionuclides was reduced from quarterly to annually (as a composite). Additionally, the annual strontium analysis was eliminated.
	Monitoring of groundwater at Station MS-8 was initiated. Samples were collected semiannually and analyzed for H-3. The semiannual samples were combined annually and analyzed for gamma-emitting radionuclides and Sr-90.
	The frequency for collecting groundwater at Stations NW-A, NW-B and NW-C and analyzing the samples for H-3 was reduced from weekly to semiannually.

TABLE C

2000 TMINS REMP Changes

March, 2000	The frequency for collecting groundwater at Station RW-1 and analyzing the samples for H-3 was reduced from weekly to monthly.
June, 2000	The frequency for collecting groundwater at Station RW-1 and analyzing the samples for H-3 was reduced from monthly to semiannually.

APPENDIX D

2000 Cross Check Program Results

TABLE D-1
ERL 2000 DOE EML Cross Check Program Results(A)

Collection Date	Media	Nuclide	ERL Value (B & F)	ERL Uncertainty (C & F)	DOE EML Value (D & F)	DOE EML Uncertainty (E & F)	Ratio	Min. Ratio	Max. Ratio	Agreement
3/1/2000	Air Filter	Co-57	5.9	0.6	5.31	0.22	1.111	0.65	1.39	YES
		Co-60	6.4	0.6	5.32	0.26	1.203	0.75	1.32	YES
		Cs-137	7.1	0.7	6.10	0.30	1.164	0.73	1.37	YES
		Mn-54	31	3	27.2	0.8	1.140	0.80	1.36	YES
		Ru-106	3.3	1.7	2.01	1.94	1.642	0.59	1.30	NO (G)
		Gr Beta	2.8	0.3	2.42	0.20	1.157	0.72	1.67	YES
3/1/2000	Soil	Cs-137	393	40	339	9.3	1.159	0.83	1.32	YES
		K-40	943	97	811	29	1.163	0.78	1.53	YES
		Sr-90	18	5	20.2	0.2	0.891	0.60	3.66	YES
3/1/2000	Vegetation	Co-60	55	6	52.8	1.0	1.042	0.69	1.46	YES
		Cs-137	1400	100	1380	20	1.014	0.80	1.40	YES
		K-40	550	60	521	20	1.056	0.79	1.42	YES
		Sr-90	2200	200	1780	17.8	1.236	0.50	1.33	YES
3/1/2000	Water	Co-60	53	5	48.9	1.8	1.084	0.80	1.20	YES
		Cs-137	110	10	103	4	1.068	0.80	1.26	YES
		H-3	81	7	79.4	2.5	1.020	0.71	1.79	YES
		Sr-90	3.1	0.8	3.39	0.12	0.914	0.75	1.50	YES
		Gr Beta	940	100	690	70	1.362	0.55	1.54	YES

A. Only analyses performed routinely for the REMP are included in this table.
B. The ERL value is the mean of 1 to 4 determinations.
C. The ERL uncertainty is the mean of the 2-sigma counting uncertainties.
D. The DOE EML value is the mean of replicate determinations for each radionuclide.
E. The DOE EML uncertainty is the standard error of the mean.
F. Units are Bq/L for water, Bq/kg (dry) for soil, Bq/kg (wet) for vegetation and total Bq for air filter.
G. This sample was analyzed three times for Ru-106 and the average (3.3 +/- 1.7 Bq/un) was reported. The individual results were 3.5 ± 2.0 Bq, 3.0 ± 1.4 Bq and 3.4 ± 1.7 Bq. The EML value was 2.01 +/- 1.94. The ERL/EML ratio was 1.642 and was not acceptable. The acceptance range was between 0.59 and 1.3. No follow-up actions were requested because the concentrations were not statistically different (i.e. the results with their counting uncertainties overlapped.).

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
ERL 2000 ANALYTICS Environmental Cross Check Program Results

Collection Date	Media	Nuclide	ERL Value (B)	ANALYTICS Value (A)	ANALYTICS Uncertainty (3 Sigma)	ANALYTICS Uncertainty (1 Sigma)	Resolution	Ratio	Min. Ratio	Max. Ratio	Agreement
6/22/2000	Milk	I-131 (Resin)	92	84	4	1.3	63.0	1.10	0.80	1.25	YES
	Milk	I-131	89	84	4	1.3	63.0	1.06	0.80	1.25	YES
6/22/2000	Cartridge	I-131	66	72	4	1.3	54.0	0.92	0.80	1.25	YES

A. The Analytics value is the known concentration. Units are pCi/L for milk, pCi/g (dry) for soil and total pCi for filter and cartridge.
B. The ERL value is an average of three or more determinations. Units are pCi/L for milk, pCi/g (dry) for soil and total pCi for filter and cartridge.

To determine agreement or possible agreement:

1. Divide each Analytics value by its associated one sigma uncertainty to obtain the resolution.
2. Divide each ERL value by the corresponding Analytics value to obtain the ratio.
3. The ERL measurement is in agreement if the value of the ratio falls within the limits shown in the following table for the corresponding resolution.

Resolution	Agreement
< 4	0.4 - 2.5
≥ 4 - < 8	0.5 - 2.0
≥ 8 - < 16	0.6 - 1.66
≥ 16 - < 51	0.75 - 1.33
≥ 51 - < 200	0.80 - 1.25
≥ 200	0.85 - 1.18

Criteria are similar to those listed in USNRC Inspection Procedure 84750 "Radioactive Waste Treatment, and Effluent and Environmental Monitoring" with minor adjustments to account for activity concentrations with large uncertainties.

TABLE D-3
Environmental, Inc.
2000 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)
3/2000	Air Filter	Co-57	5.90	0.10	5.31	0.65	1.39	YES
		Co-60	5.90	0.10	5.32	0.75	1.32	YES
		Cs-137	7.50	0.10	6.10	0.73	1.37	YES
		Mn-54	31.80	0.30	27.20	0.80	1.36	YES
		Ru-106	3.50	1.00	2.01	0.59	1.30	NO (G)
		Sr-90	0.31	0.16	0.24	0.61	1.93	YES
		Gr Beta	2.70	0.10	2.42	0.72	1.67	YES
3/2000	Soil	Ac-228	98.30	7.10	97.60	0.79	1.75	YES
		Bi-212	98.50	15.10	106.00	0.42	1.22	YES
		Bi-214	88.00	3.80	86.70	0.75	1.42	YES
		Cs-137	324.00	5.00	339.00	0.83	1.32	YES
		K-40	872.00	34.00	811.00	0.78	1.53	YES
		Pb-212	93.70	2.70	97.30	0.74	1.33	YES
		Pb-214	100.10	3.70	86.50	0.65	1.45	YES
		Sr-90	13.60	3.10	20.20	0.60	3.66	YES
3/2000	Vegetation	Co-60	46.50	2.10	52.80	0.69	1.46	YES
		Cs-137	1872.00	46.00	1380.00	0.80	1.40	YES
		K-40	506.40	28.00	521.00	0.79	1.42	YES
		Sr-90	1198.00	85.00	1780.00	0.50	1.33	YES
3/2000	Water	Co-60	51.00	1.20	48.90	0.80	1.20	YES
		Cs-137	108.60	1.80	103.00	0.80	1.26	YES
		H-3	147.00	26.00	79.40	0.71	1.79	YES (H)
		Sr-90	4.46	0.99	3.39	0.75	1.50	YES
		Gr Beta	792.00	25.00	690.00	0.55	1.54	YES
9/2000	Soil	Ac-228	78.00	1.50	80.20	0.80	1.50	YES
		Bi-212	73.00	3.30	80.50	0.45	1.23	YES
		Bi-214	91.00	4.00	83.30	0.78	1.50	YES
		Cs-137	925.70	14.20	1020.00	0.80	1.29	YES
		K-40	713.60	7.10	713.00	0.80	1.37	YES
		Pb-212	66.10	4.30	79.30	0.74	1.36	YES
		Pb-214	100.10	3.70	86.30	0.76	1.53	YES
		Sr-90	39.90	5.30	50.40	0.61	3.91	YES

TABLE D-3
Environmental, Inc.
2000 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)
9/2000	Water	Co-60	71.90	7.20	73.70	0.80	1.20	YES
		Cs-137	62.70	6.30	67.00	0.80	1.24	YES
		H-3	92.30	8.90	91.30	0.74	2.29	YES
		Sr-90	4.60	0.40	4.53	0.64	1.50	YES
		Gr Beta	1129.40	16.70	950.00	0.56	1.50	YES
9/2000	Air Filter	Co-57	16.50	0.60	14.55	0.69	1.37	YES
		Co-60	9.20	0.40	8.43	0.79	1.30	YES
		Cs-137	8.80	0.50	7.41	0.78	1.35	YES
		Mn-54	50.20	2.30	43.20	0.80	1.36	YES
		Sr-90	3.30	0.10	1.64	0.55	2.05	YES
		Gr Beta	2.08	0.02	1.52	0.76	1.52	YES
9/2000	Vegetation	Co-60	29.40	0.40	32.80	0.75	1.51	YES
		Cs-137	739.30	23.00	867.00	0.80	1.37	YES
		K-40	597.50	49.30	639.00	0.78	1.43	YES
		Sr-90	4.60	0.40	4.53	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. 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.
H. The sample was reanalyzed. The reanalysis result (mean of three determinations) of 97.5 Bq/L was acceptable (i.e. within the established control limits). No further actions were performed.

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-4
Environmental, Inc.
2000 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)
1/2000	Water	Gr Beta	40.7	42.1	4.2	33.4-50.8	A
1/2000	Water	Sr-89	17.1	22.5	5.0	13.8-31.2	A
1/2000	Water	Sr-90	8.1	9.6	5.0	0.9-18.3	A
3/2000	Water	H-3	23,500	23,800	2,380	19,800-27,800	A
3/2000	Water	Gr Beta	15.4	16.8	1.7	8.1-25.5	A
3/2000	Water	I-131	18.7	19.9	2.0	14.7-25.1	A
4/2000	Water	Co-60	19.2	16.9	5.0	8.2-25.6	A
4/2000	Water	Cs-134	81.0	86.4	5.0	77.7-95.1	A
4/2000	Water	Cs-137	119.0	123.0	6.2	112.0-134.0	A
4/2000	Water	Gr Beta	276.0	289.0	43.4	214.0-364.0	A
4/2000	Water	Sr-89	32.3	50.7	5.0	42.0-59.4	NA(F)
4/2000	Water	Sr-90	11.3	32.8	5.0	24.1-41.5	NA(F)

TABLE D-4
Environmental, Inc.
2000 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)
6/2000	Water	Ba-133	22.4	25.5	5.0	16.8-34.2	A
6/2000	Water	Co-60	69.9	65.6	5.0	56.9-74.3	A
6/2000	Water	Cs-134	13.5	13.8	5.0	5.1-22.5	A
6/2000	Water	Cs-137	232.0	238.0	11.9	217.0-259.0	A
6/2000	Water	Zn-65	50.9	54.6	5.5	45.3-63.9	A
7/2000	Water	Gr Beta	88.8	87.5	10.0	70.2-105.0	A
8/2000	Water	H-3	8,740	8,320	832	6,910-9,730	A
10/2000	Water	I-131	16.9	15.9	1.6	10.7-21.1	A
10/2000	Water	I-131 (Gamma)	17.1	15.9	1.6	10.7-21.1	A
10/2000	Water	Co-60	93.4	91.1	5.0	82.4-99.8	A
10/2000	Water	Cs-134	54.8	59.8	5.0	51.1-68.5	A
10/2000	Water	Cs-137	45.5	45.0	5.0	36.3-53.7	A
10/2000	Water	Gr Beta	209.0	256.0	38.4	189.0-323.0	A

Table D-4
Environmental, Inc.
2000 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)
10/2000	Water	Sr-89	32.8	41.3	5.0	32.6-50.0	A
10/2000	Water	Sr-90	16.0	18.0	5.0	9.3-26.7	A
11/2000	Water	Gr Beta	28.6	25.5	5.0	16.8-34.2	A
11/2000	Water	Ba-133	78.0	82.2	8.2	68.0-96.4	A
11/2000	Water	Co-60	30.8	27.8	5.0	19.1-36.5	A
11/2000	Water	Cs-134	67.2	76.0	5.0	67.3-84.7	NA(G)
11/2000	Water	Cs-137	109.0	106.0	5.3	96.8-115.0	A
11/2000	Water	Zn-65	81.5	79.0	7.9	65.3-92.7	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 Warning Limits.
NA = Not Acceptable - Reported Result falls outside of the Control Limits.

F. An error was found in the calculation for activity concentration. The corrected results were 55.5 ± 7.2 pCi/L for Sr-89 and 30.7 ± 3.0 for Sr-90 pCi/L. Reanalyses also were performed. The reanalysis results were 47.4 ± 14.5 pCi/L for Sr-89 and 33.0 ± 1.4 for Sr-90 pCi/L. Both results (corrected and reanalysis) for Sr-89 and Sr-90 were within the established control limits.

G. Since the Environmental, Inc. result was consistent with the mean of all participating laboratories (70.7 pCi/L), all other gamma emitters were within the established control limits and library values were reviewed and found to be correct, no additional follow-up actions were performed.

APPENDIX E

2000 Land Use Census

TABLE E-1
2000 ANNUAL DAIRY CENSUS*

Distance & Direction	Azimuth & Sector Code	**Name, 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 here 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 prior to exportation. They also receive prepared feed.
6.6km (4.1mi) NE	35° C		Holstein	120 Cows 100 Heifers	120	--	--	Land O Lakes & Own Use	Milk cows are on home grown feed. Heifers graze June to October.
1.7km (1.1mi) ENE	65° D	***	Holstein	110 Cows 75 Heifers	96	--	--	Mt. Joy Co-op	May 1 to November 1 plus hay & corn
1.8km (1.1mi) E	93° E	***	Holstein	150 Cows 100 Heifers & Calves	150	--	--	Mt.Joy Co-op	April to November plus home-grown feed for dry cows. Milking cows don't graze & are on home-grown feed.
5.2km (3.2mi) ESE	104° F		Holstein	115 Cows	100	--	--	Mt.Joy Co-op	Only on pasture during dry periods. Milk animals fed stored silage & hay.
2.3km (1.4mi) SE	130° G	***	Holstein Ayrshire	65 Cows 30 Heifers	50	--	--	National Farmers Organization & Own Use	April to November (during winter on silage, hay & high moisture corn if available).
7.8km (4.9 mi) SSW	200° K		Holstein	70 Cows 30 Heifers	65	--	--	Land O Lakes & Own Use	April 15 to October 15 (otherwise on silage & baled hay)
23.3km (14.5mi) SSW	205° K	***	Holstein	60 Cows 40 Heifers 20 Calves	50	--	--	Land O Lakes & Own Use	No grazing (animals put in exercise pen)
6.0km (3.7mi) WNW	295° P		Holstein	90 Cows	50	12 Nannies	0	Land O Lakes	May to October (otherwise on home-grown feed
10.8km (6.7mi) WNW	293° P	***	Holstein	45 Cows 41 Calves & Heifers	40	--	--	Rutters Dairy & Own Use	May to October plus stored feed (hay & silage)

* 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.
** Names and addresses are on file at Three Mile Island Environmental Affairs.
*** Regularly sampled milk farms.

TABLE E-2

2000 Annual Residence Census*

Distance and Direction	Azimuth and Sector Code	Name, Address** & Telephone No.	Distance and Direction	Azimuth and Sector Code	Name, 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	

* Census identifies nearest residence in each of the sixteen meteorological sectors.

** Names and addresses are on file at Three Mile Island Environmental Affairs.

TABLE E-3

2000 Broad Leaf Vegetation Sampling Results*

Collection Date	Sample Location	Vegetation Type	Gamma Result (pCi/g, wet)	Sr-90 Result (pCi/g, wet)
10/4/00	TM-FPL-ESE1	Johnny Smoker Leaves	Be-7: 1.9 ± 0.2 K-40: 2.3 ± 0.3	0.047 ± 0.005
10/4/00	TM-FPL-ESE2	Maple Sp. Leaves	Be-7: 2.4 ± 0.2 K-40: 2.1 ± 0.2	0.021 ± 0.003
10/4/00	TM-FPL-ESE3	Sycamore Leaves	Be-7: 3.5 ± 0.4 K-40: 1.9 ± 0.3	0.020 ± 0.003
10/4/00	TM-FPL-SE1	Sycamore Leaves	Be-7: 2.4 ± 0.2 K-40: 8.3 ± 0.8	0.014 ± 0.002
10/4/00	TM-FPL-SE2	Beech Sp. Leaves	Be-7: 1.89 ± 0.2 K-40: 2.8 ± 0.3	0.0097 ± 0.0022
10/4/00	TM-FPL-SE3	Sumac Leaves	Be-7: 1.5 ± 0.1 K-40: 5.0 ± 0.5	0.033 ± 0.004
10/5/00	TM-FPL-B10-2*	Sycamore, Maple and Oak Leaves	Be-7: 0.95 ± 0.14 K-40: 4.7 ± 0.5	0.050 ± 0.005

*Collection and analysis of broad leaf vegetation was performed in lieu of a garden census.
**Control Sample

APPENDIX F

2000 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 3. A large percentage of the 2000 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 - 2000 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

2000 Groundwater Monitoring Results

TABLE G-1
2000 Tritium Concentrations in Onsite Groundwater and Storm water (pCi/L)

Station (Well Type)	1999 Average ± 2 std dev*	2000 Average ± 2 std dev*	2000 Range*
MS-1 (Monitoring)	350	160	**
MS-2 (Monitoring)	460 ± 110	260 ± 50	250 - 280
MS-4 (Monitoring)	1,600 ± 1,800	1,900	**
MS-5 (Monitoring)	360 ± 200	190 ± 160	130 - 240
MS-7 (Monitoring)	270 ± 70	180	**
RW-2 (Monitoring)	7,500 ± 3,300	500	**
OS-14 (Monitoring)	270 ± 170	170	**
OS-18 (Monitoring)	26,000 ± 54,000	4,000 ± 14,000	280 - 31,000
MS-19 (Monitoring)	5,500 ± 6,100	540	**
MS-20 (Monitoring)	700 ± 530	360 ± 400	220 - 500
MS-21 (Monitoring)	200	190	**
MS-22 (Monitoring)	930 ± 640	640 ± 530	400 - 890
RW-1 (Monitoring)	7,200 ± 5,300	2,700 ± 2,800	500 - 4,100
NW-A (Service Water)	1,800 ± 500	1,300 ± 100	1,300 - 1,400
NW-B (Service Water)	3,800 ± 4,400	2,900 ± 1,600	2,400 - 3,500
NW-C (Service Water)	50,000 ± 52,000	18,000 ± 4,000	17,000 - 20,000
NW-CW (Clearwell)	9,200 ± 4,200	5,800 ± 3,100	2,000 - 7,800
OSF (Drinking Water)	490 ± 140	430 ± 390	170 - 630
48S (Drinking Water)	250 ± 50	220 ± 40	200 - 240
MS-8 (Monitoring)	NS	360 ± 280	260 - 460
EDCB (Storm water)	300 ± 50	340 ± 210	190 - 430

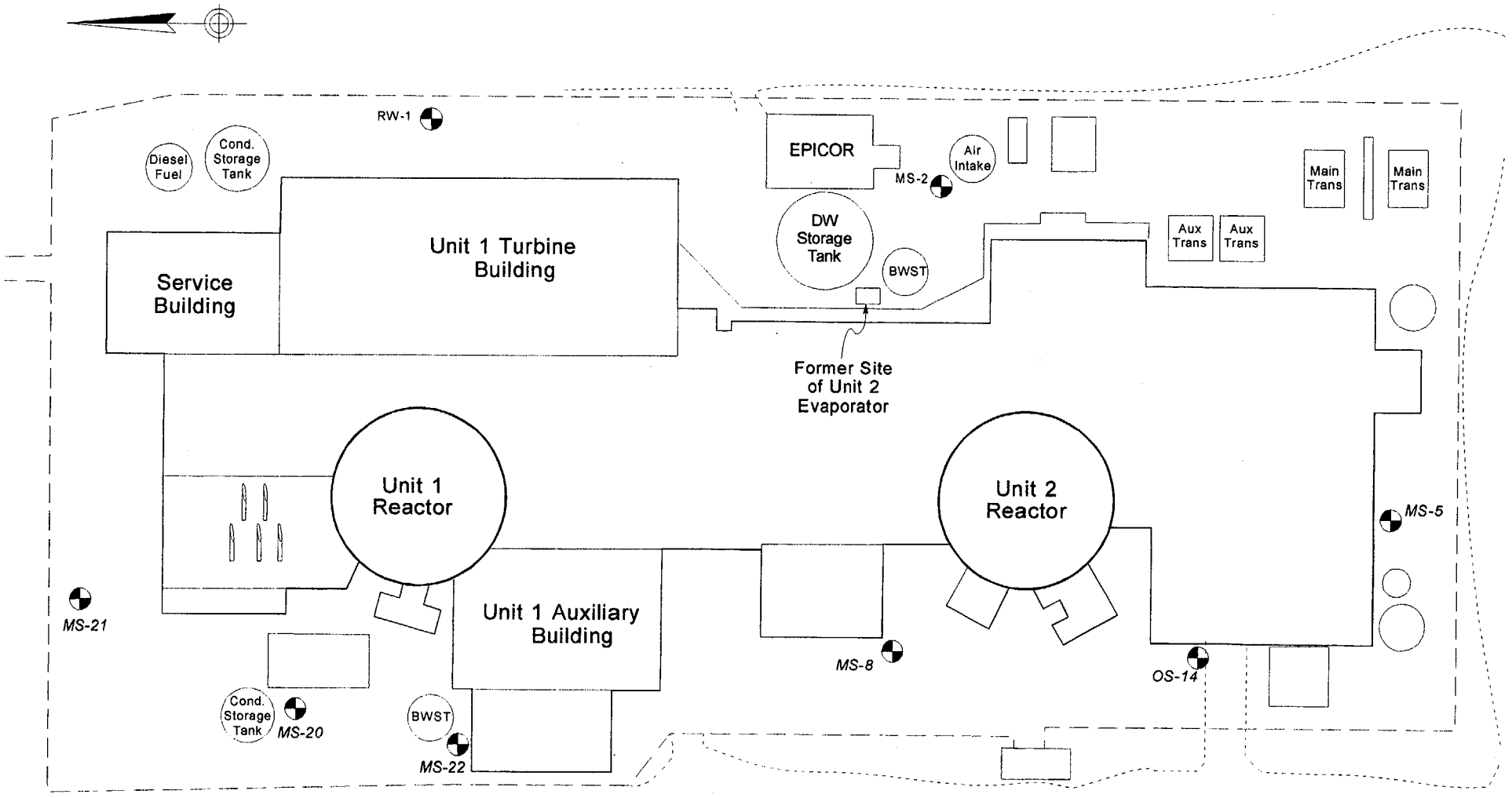
* = Averages, standard deviations and ranges were based on concentrations > the minimum detectable concentration (MDC).
** = Only one concentration in 2000 was > MDC or only one sample was collected in 2000.
< MDC = Measured concentration(s) was equal to or below the MDC.
NS = Station was not sampled 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
2000 Tritium Concentrations in Offsite Groundwater
(pCi/L)

Station (Location)	1999 Concentration	2000 Concentration
E1-2 (TMINS Visitors Center)	130 ± 70	< MDC
N2-1 (Goldsboro Marina)	120 ± 70	< 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).

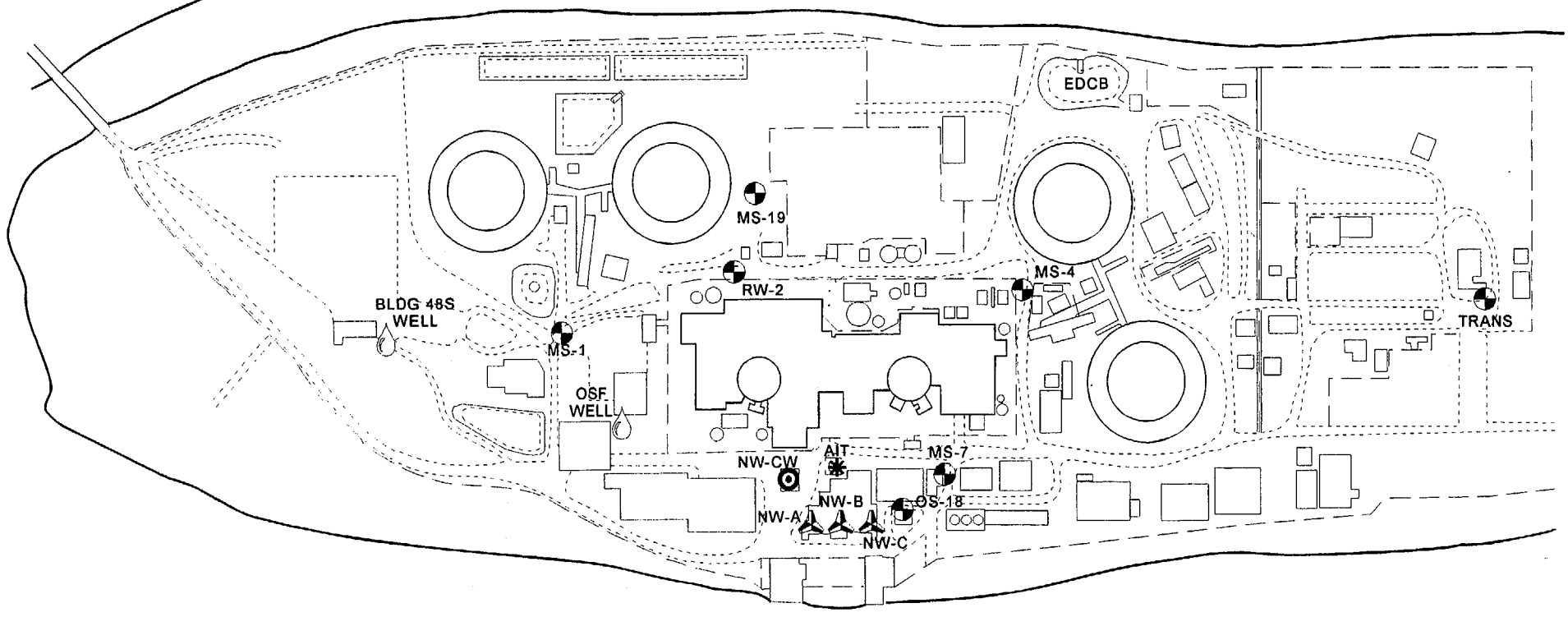
Figure G-1
2000 TMINS REMP Groundwater Stations
Inside the Protected Area



NO SCALE

(3/2001)

Figure G-2
2000 TMINS REMP Groundwater Stations
Outside the Protected Area*



LEGEND

- Monitoring Well
- Drinking Water Well
- Clearwell
- Industrial Well
- Air Intake Tunnel - Groundwater Infiltration

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

2000 TLD Quarterly Data

TABLE H-1
2000 TLD Quarterly Data
(mR/std month)

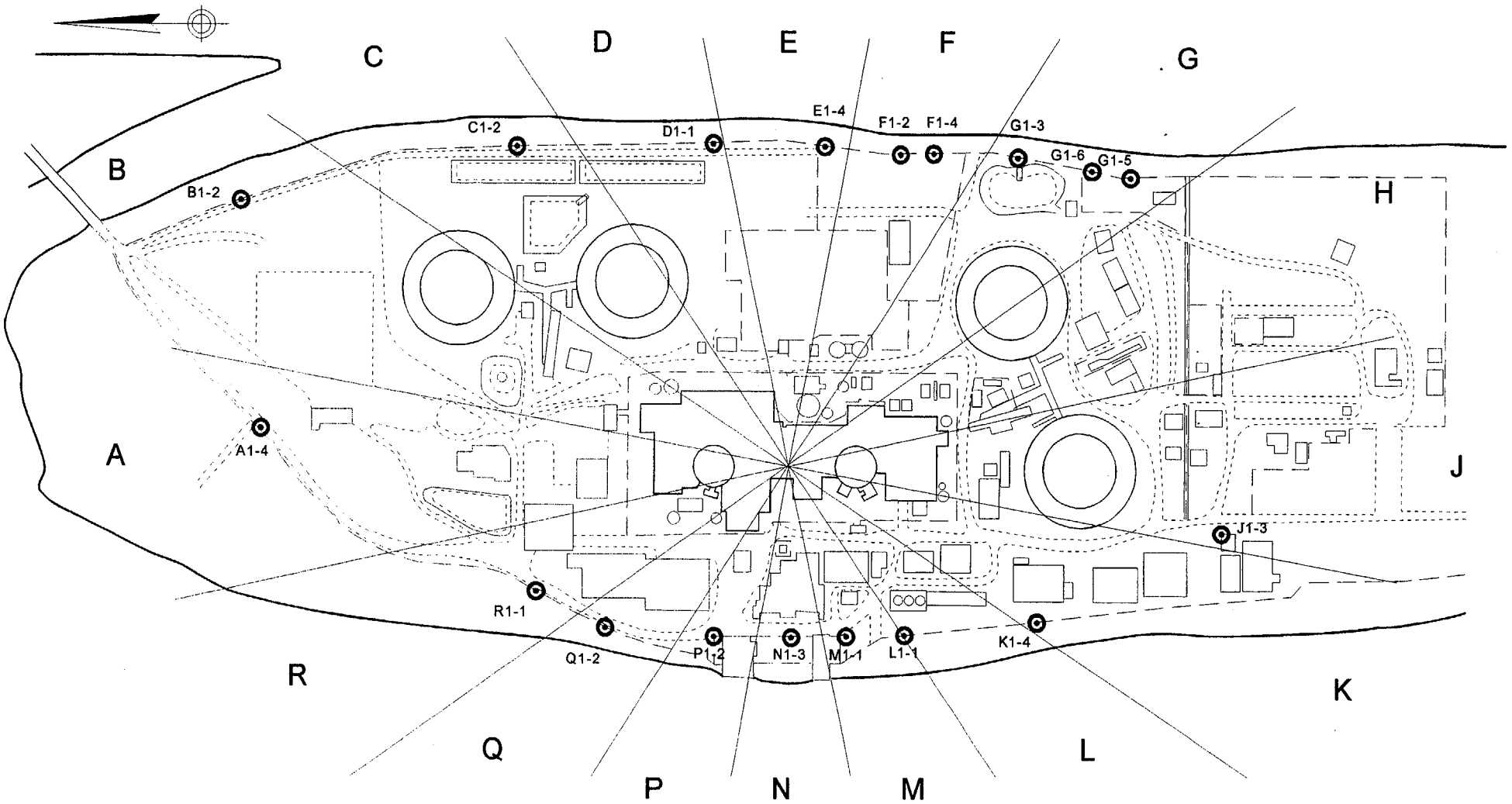
Station	Historical	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Yearly Avg	2 std dev
A1-4	4.3	3.7	3.9	3.8	4.0	3.8	0.2
A3-1	4.3	3.6	3.7	3.6	3.8	3.7	0.2
A5-1	5.5	4.6	5.3	4.7	5.1	4.9	0.7
A9-3		3.8	4.2	3.8	4.2	4.0	0.5
B1-1	4.4	3.7	4.0	4.1	4.2	4.0	0.4
B1-2	4.3	3.7	4.2	3.9	4.2	4.0	0.5
B2-1		3.8	4.2	3.8	4.1	4.0	0.4
B5-1	5.3	4.8	5.0	5.0	5.1	5.0	0.2
B10-1	5.1	4.3	4.7	4.5	4.6	4.5	0.3
C1-1	5.2	4.4	4.8	4.5	4.7	4.6	0.4
C1-2	4.3	3.7	4.1	3.9	4.1	4.0	0.4
C2-1		4.1	4.6	4.5	4.6	4.4	0.5
C5-1	5.1	4.5	5.0	4.9	5.0	4.9	0.5
C8-1	5.9	4.6	5.1	4.9	5.3	5.0	0.6
D1-1	4.6	3.9	4.1	3.9	4.4	4.1	0.5
D1-2	5.4	4.5	4.6	4.5	4.8	4.6	0.3
D2-2		5.0	5.6	5.6	5.8	5.5	0.7
D6-1	6.4	5.2	5.6	5.9	5.7	5.6	0.6
D15-1	5.7	4.4	4.9	4.6	4.9	4.7	0.5
E1-2	4.9	4.0	4.4	4.2	4.5	4.3	0.4
E1-4	5.7	4.1	4.2	4.0	4.3	4.2	0.3
E2-3		5.0	5.2	5.1	5.3	5.1	0.2
E5-1	5.3	4.6	4.9	4.7	4.8	4.8	0.3
E7-1	5.2	4.6	4.9	4.9	5.0	4.8	0.3
F1-1	5.0	4.3	4.5	4.6	4.7	4.5	0.3
F1-2		8.5	8.1	7.4	6.2	7.6	2.0
F1-4		7.7	7.2	6.6	5.8	6.8	1.6
F2-1		5.3	5.4	5.6	5.4	5.4	0.3
F5-1	6.0	5.2	5.5	5.4	5.4	5.4	0.3
F10-1	6.3	5.4	6.2	6.0	5.9	5.9	0.7
F25-1	5.6	4.6	5.1	5.1	5.1	5.0	0.5
G1-2	4.9	4.3	4.9	5.3	5.0	4.9	0.8
G1-3	6.9	4.0	4.3	4.1	4.4	4.2	0.4
G1-5		3.8	4.0	3.8	4.4	4.0	0.6
G1-6		3.9	4.4	4.1	4.6	4.2	0.6
G2-4		5.3	5.9	5.7	5.8	5.7	0.5
G5-1	5.1	4.1	4.4	4.3	4.6	4.3	0.4
G10-1	7.6	6.3	7.0	6.6	7.1	6.8	0.7
G15-1	6.4	4.5	5.0	5.0	5.1	4.9	0.5
H1-1	5.3	4.1	4.5	4.6	4.7	4.5	0.5
H3-1	4.1	3.3	3.6	3.5	3.7	3.5	0.4
H5-1	4.1	3.5	3.7	3.5	4.3	3.8	0.8
H8-1	7.9	7.0	7.4	7.6	7.5	7.4	0.5
H15-1	5.8	5.1	5.6	5.4	5.8	5.5	0.6
J1-1	5.3	3.8	3.9	4.3	4.3	4.1	0.6
J1-3	3.7	3.2	3.4	3.2	3.6	3.4	0.4
J3-1		4.2	4.3	4.7	4.6	4.5	0.5

TABLE H-1
2000 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	5.2	5.2	5.0	5.7	5.3	0.6
J7-1	4.7	5.2	5.5	5.5	5.4	5.4	0.3
J15-1	6.1	5.1	5.5	5.5	5.5	5.4	0.4
K1-4	4.7	3.8	3.9	4.1	4.2	4.0	0.4
K2-1	5.8	4.7	5.1	5.3		5.0	0.6
K3-1		3.8	4.0	3.9	4.5	4.1	0.6
K5-1	6.9	5.1	5.4	5.1	5.6	5.3	0.5
K8-1	5.4	4.9	5.2	5.0	5.3	5.1	0.3
K15-1	4.8	4.4	4.7	4.7	4.7	4.6	0.3
L1-1	5.1	4.1	4.2	4.2	4.2	4.2	0.1
L1-2	4.3	3.8	4.1	3.8		3.9	0.3
L2-1	5.5	4.4	4.8	4.7	4.9	4.7	0.4
L5-1	4.5	4.1	4.3	4.0	4.3	4.2	0.3
L8-1	5.0	4.3	4.6	4.6	4.8	4.6	0.4
L15-1	5.2	4.4	4.7	4.2	4.9	4.6	0.7
M1-1		4.0	3.8	3.9	4.0	3.9	0.2
M1-2		3.8	4.1	4.1		4.0	0.3
M2-1	4.3	3.6	3.7	3.8	4.1	3.8	0.5
M5-1	5.2	4.3	4.3	4.5	4.6	4.4	0.3
M9-1	6.5	5.3	5.9	5.9	5.9	5.8	0.6
N1-1	4.8	3.9	4.2	4.6		4.2	0.7
N1-3	4.6	3.7	3.8	3.7	4.0	3.8	0.3
N2-1	5.3	3.8	4.0	4.0	4.1	4.0	0.2
N5-1	5.3	3.5	3.8	3.9	4.3	3.9	0.6
N8-1	5.4	4.5	4.9	5.3	5.1	4.9	0.7
N15-2	5.9	5.3	5.2	5.5	5.4	5.3	0.3
P1-1	4.7	4.2	4.3	4.5		4.3	0.3
P1-2		3.8	3.9	3.9	3.9	3.9	0.1
P2-1	5.4	5.2	5.3	5.5	5.4	5.4	0.3
P5-1	4.8	4.3	4.5	4.3	4.6	4.4	0.3
P8-1	4.7		3.9	3.7	4.3	4.0	0.6
Q1-1	4.6	4.0	4.4	4.3		4.2	0.4
Q1-2	4.4	3.4	3.6	3.6	4.1	3.7	0.6
Q2-1	5.4	3.9	4.2	4.3	4.6	4.2	0.6
Q5-1	4.9	4.2	4.3	4.0	4.7	4.3	0.6
Q9-1	5.3	4.5	4.4	4.3	4.8	4.5	0.5
Q15-1	5.9	4.8	5.2	4.8	4.9	4.9	0.4
R1-1	4.8	3.8	4.1	3.9	4.2	4.0	0.4
R1-2	4.2	3.6	3.9	4.0		3.8	0.4
R3-1		4.7	5.6	5.1	5.3	5.2	0.8
R5-1	5.1	4.8	5.2	4.9	5.0	5.0	0.3
R9-1	5.2	4.9	5.1	5.1	5.0	5.0	0.2
R15-1	4.4	4.1	4.3	4.3	4.4	4.3	0.3

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