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MAY 12 2003

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
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Washington, D. C. 20555

**SUSQUEHANNA STEAM ELECTRIC STATION
ANNUAL RADIOLOGICAL ENVIRONMENTAL
OPERATING REPORT
PLA-5623**

**Docket Nos. 50-387
and 50-388**

The Susquehanna SES Annual Radiological Environmental Operating Report is hereby submitted for the calendar year 2002 in accordance with Technical Specification Section 5.6.2.

If you have any questions, please contact Mr. Eric J. Miller at (570) 542-3321.

Sincerely,

A handwritten signature in black ink, appearing to read "Bryce L. Shriver". The signature is fluid and cursive, with a large initial "B" and "S".

B. L. Shriver

Attachments

copy: NRC Region I
Mr. R. V. Guzman, NRC Project Manager
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Mr. R. Janati, DEP/BRP

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	B. E. Rhoads	NUCSA1	"
	C. A. Smith	NUCSA4	"
	R. E. Smith	NUCSB2	"
	T. G. Wales	GENA63	"
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	R. L. Anderson	NUCSB3	w/o attach.
	T. G. Bannon	GENA62	"
	F. J. Hickey	NUCSA3	"
	D. J. Morgan	NUCSA3	"
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	A. J. Wrape	GENA92	"
	NRA Files	GENA61	w/attach.
	DCS	GENA62	w/attach.

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OUTGOING NRC CORRESPONDENCE REVIEW

MAY 12 2003

PLA - 5623

RELEASE DUE DATE: 05/15/03

ORIGINATOR: Eric Miller

SUBJECT: Annual Radiological Environmental Operating Report

AFFIDAVIT: YES NO

VERIFICATION:

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COMMENTS PROVIDED BY: R. R. Sgarro 5/5/2003

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Eric J. Miller 5-13-03
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<i>W E Morrissey</i>	5/5/03	<i>Eric J Miller</i>	5-13-03
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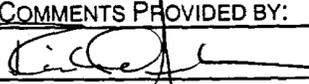
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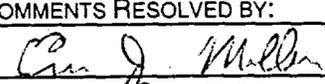
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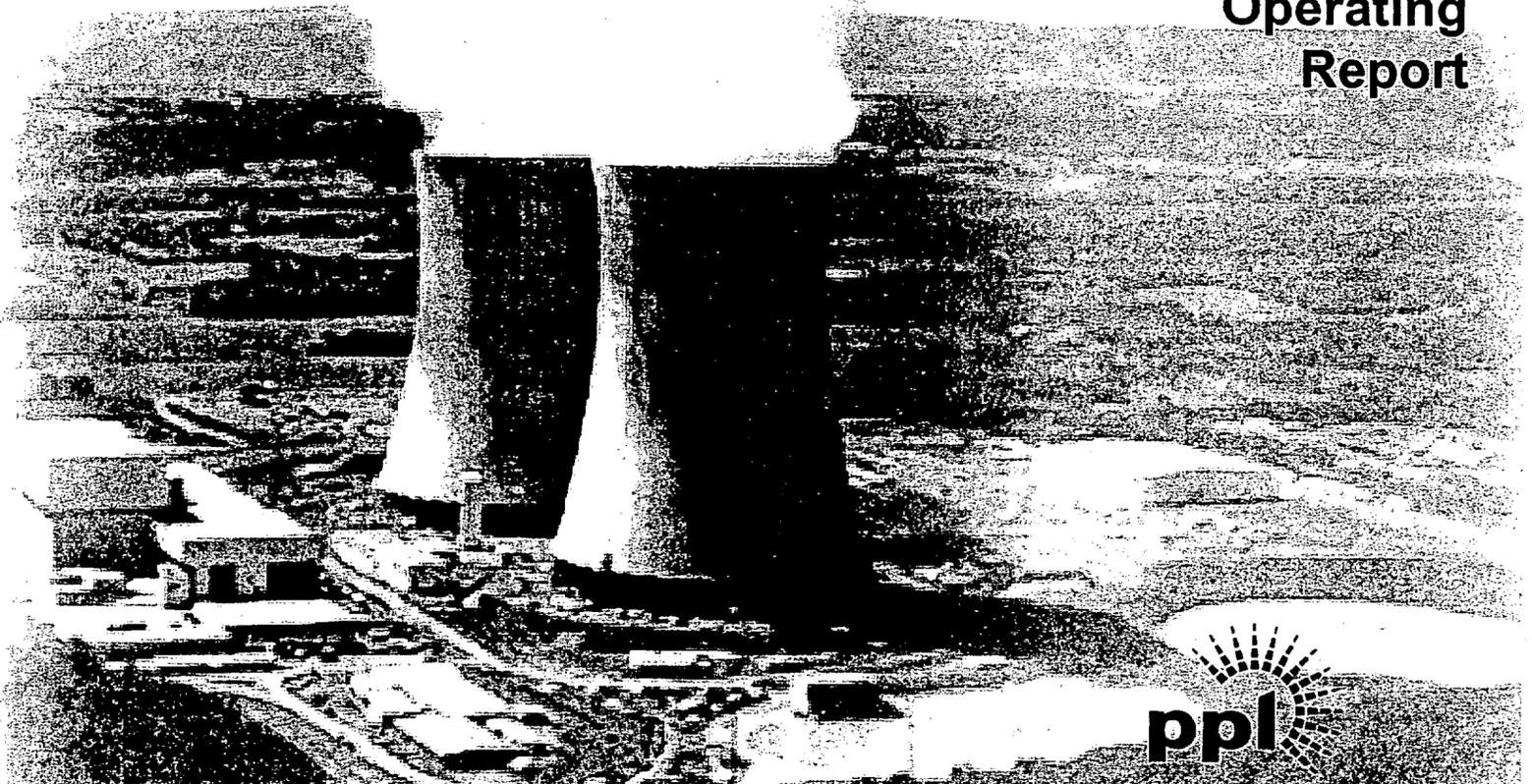
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Susquehanna Steam Electric Station

Units 1 & 2

2002 ANNUAL REPORT

Annual
Radiological
Environmental
Operating
Report

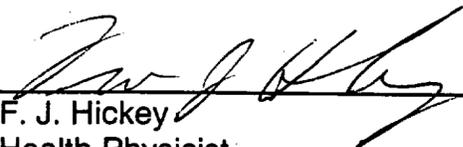


PPL Susquehanna, LLC
Berwick, PA
April 2003

SUSQUEHANNA STEAM ELECTRIC STATION
ANNUAL RADIOLOGICAL ENVIRONMENTAL
OPERATING REPORT

REPORT PERIOD: 12/26/01 – 1/31/03

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Reviewed by:



R. E. Doebler
Chemistry Support Supervisor – SSES

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SUMMARY AND CONCLUSIONS

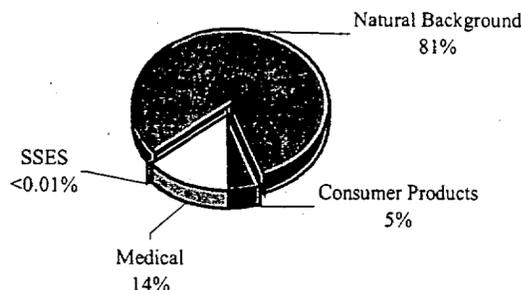
Radiological Dose Impact

The extent of the 2002 Radiological Environmental Monitoring Program (REMP) sampling met or exceeded the requirements of the Susquehanna Steam Electric Station (SSES) Technical Requirements. The types of analyses that were performed on these samples for the identification and quantification of radioactivity also met or exceeded the SSES Technical Requirements. The result of this effort was the verification of the SSES Effluent Monitoring Program data that indicate that the SSES operation has no deleterious effect on the health and safety of the public or the environment.

The amounts of the radionuclides detected in environmental samples during 2002 were very small, as in past years. Based on the radionuclide levels measured by the REMP, the maximum whole body dose or maximum organ dose to a member of the public from SSES operation is estimated to be less than one-tenth of one percent of the per unit dose guidelines established by the Nuclear Regulatory Commission (NRC) as stated in 10 CFR 50, Appendix I. The maximum hypothetical off-site whole body and organ doses from radionuclides detected by the REMP and attributable to the SSES operations were calculated to be approximately 0.0014 mrem/year.

By contrast, potassium-40, a very long-

COMPARISON OF PERCENT OF AVERAGE ANNUAL PUBLIC EFFECTIVE DOSE-EQUIVALENT FROM OTHER SOURCES WITH THAT FROM THE SSES



Sources for the values provided, with the exception of Susquehanna, are the following from NCRP Report #93 (1987): Tables 2.4 (Natural Background), 5.1 (Consumer Products), and 7.4 (Medical).

Summary and Conclusions

lived, naturally occurring radionuclide found in the human body, is estimated to deliver an average annual dose to the blood forming organs of individuals in the United States of about 27 millirem. While a small portion of the background dose from natural radiation sources, the potassium-40 dose is still more than 19,300 times the estimated maximum whole body and organ doses to a hypothetical member of the public from ingestion of radionuclides attributable to the SSES.

The maximum direct radiation dose from SSES operation to a member of the public was determined to be approximately 0.030 millirem/year. The total whole body dose from both ingested radionuclides and direct radiation is negligible compared to the public's exposure from natural background radiation, medical irradiation, and radiation from consumer products of more than 300 millirem/year effective dose-equivalent.

Identified Radionuclides and Their Dose Contributions

Naturally Occurring Radionuclides

In 2002, the SSES REMP reported the naturally occurring radionuclides beryllium-7, potassium-40, radium-226, and thorium-228 in the environment at levels exceeding the minimum detectable concentrations (MDCs) for their respective gamma spectroscopic analyses. Beryllium-7 was identified in air and sediment. Potassium-40 was observed in fish, sediment, surface water, ground water, milk, soil, and fruit

and vegetables. Thorium-228 and radium-226 were reported in surface water, sediment, and soil. These radionuclides are not related to the operation of the SSES. Doses from the presence of these radionuclides were not included in the estimate of the dose from SSES attributable radionuclides.

Man-made Radionuclides

Although not all due to SSES operation, the following man-made radionuclides were reported at levels in the environment in excess of the MDCs for their respective analyses: tritium, iodine-131, cesium-137, and Mn-54. These radionuclides, with the exception of cesium-137 and Mn-54, were identified in surface and drinking water. Tritium was measured above minimum detectable concentrations in some surface water, drinking water, and ground water analyzed. Iodine-131 was identified in surface water and drinking water. Cesium-137 was observed in sediment and soil. Mn-54 was identified in a fourth quarter air particulate composite

Tritium and Mn-54 were the only man-made radionuclides attributed to SSES operation. Tritium in media other than Susquehanna River water downstream of the SSES was attributed to both natural production by the interaction of cosmic radiation with the upper atmosphere and previous atmospheric testing of nuclear weapons. The presence of cesium-137 was attributed to non-SSES sources. Cesium-137 was considered to be present only as residual fallout from atmospheric weapons testing. Iodine-131 was found in the aquatic pathway. Evidence indicates that it is there only as the result of the

discharge of medical waste to the Susquehanna or Lackawanna Rivers through sewage treatment plants upstream of the SSES.

All of the man-made radionuclides mentioned above were not analyzed for in all media. For example, no analyses were performed in an effort to determine iodine-131 levels in ground water. When selecting the types of analyses that would be performed, consideration was given to the potential importance of different radionuclides in the pathways to man and the regulatory analysis requirements for various environmental media.

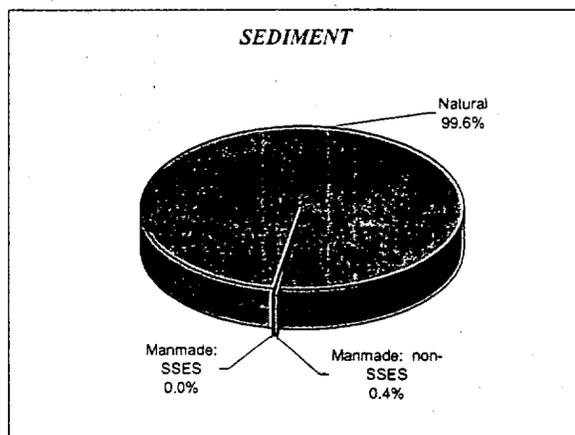
Relative Radionuclide Activity Levels in Selected Media

Some media monitored in the environment are significant for the numbers of gamma-emitting radionuclides routinely measured at levels exceeding analysis MDCs. Sediment in the aquatic pathway and soil in the terrestrial pathway are two such media.

The following pie graphs show the relative activity contributions for the types of gamma-emitting radionuclides reported at levels above the analysis MDCs in sediment and soil at indicator locations during 2002.

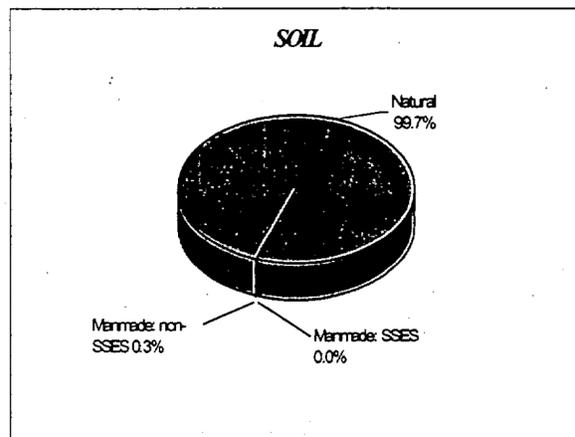
AQUATIC PATHWAY

PERCENT TOTAL GAMMA ACTIVITY



TERRESTRIAL PATHWAY

PERCENT TOTAL GAMMA ACTIVITY



Naturally occurring radionuclides account for 99.6% and 99.7% of the gamma-emitting activity in sediment and in soil, respectively, in 2002. Man-made radionuclides of non-SSES origin

Summary and Conclusions

account for most of the rest of the gamma-emitting activity in sediment and all of the rest in soil during 2002. Generally, the activity for naturally occurring radionuclides reported in sediment and soil dwarfs the activity of the man-made radionuclides also reported, especially those originating from the SSES.

Radionuclides Contributing to Dose from SSES Operation

Of the four man-made radionuclides reported in the environment by the SSES REMP, tritium and Mn-54 are the only radionuclides attributable to SSES operation.

The dose to members of the public attributable to the identified Tritium was 0.0014 mrem.

The dose to members of the public attributable to the identified Mn-54 was 9.10E-5 mrem.

Mn-54 was included in the dose calculation because it was identified in a fourth quarter air particulate composite sample.

The presumed exposure pathway to the public from this radionuclide is inhalation. The calculated inhalation pathway is based on 100% occupancy at the air sample location.

Tritium was included in the dose calculation because it was identified in the REMP samples of water being discharged to the river. The concentration of tritium in the water and the volume of water discharged were used to determine the amount of tritium released. The presumed exposure

pathways to the public from this radionuclide were drinking water taken from the Susquehanna River at Danville, PA, and eating fish caught near the SSES discharge to the river. This assumption is based on the fact that tritium does not emit gamma radiation and the beta radiation emitted by tritium is not sufficiently penetrating to reach an individual on the shore.

INTRODUCTION

Radiological Environmental Monitoring

The enclosed information is consistent with the objectives outlined in the SSES ODCM and in 10CFR50 Appendix I, Section IV.B.2, IV.B.3 and IV.C.

In addition to the steps taken to control and to monitor radioactive effluents from the SSES, the SSES Technical Specifications also require a program for the radiological monitoring of the environment in the vicinity of the SSES. The objectives of the SSES REMP are as follows:

- Fulfillment of SSES Technical Requirements' radiological environmental surveillance obligations,
- Verification of no detrimental effects on public health and safety and the environment from SSES operations,
- Assessment of dose impacts to the public, if any,
- Verification of adequate SSES radiological effluent controls, and
- Identification, measurement, trending, and evaluation of radionuclides and their concentrations in critical environmental pathways near the SSES.

PPL has maintained a Radiological Environmental Monitoring Program (REMP) in the vicinity of the existing Susquehanna Steam Electric Station

Units 1 and 2 since April, 1972, prior to construction of both units and ten years prior to the initial operation of Unit 1 in September, 1982. The SSES is located on an approximately 1500 acre tract along the Susquehanna River, five miles northeast of Berwick in Salem Township, Luzerne County, Pennsylvania. The area around the site is primarily rural, consisting predominately of forest and agricultural lands. (More specific information on the demography, hydrology, meteorology, and land use characteristics of the area in the vicinity of the SSES can be found in the Environmental Report (14), the Final Safety Analysis Report (15), and the Final Environmental Statement (16) for the SSES.) The purpose of the preoperational REMP (April, 1972 to September, 1982) was to establish a baseline for radioactivity in the local environment that could be compared with the radioactivity levels observed in various environmental media throughout the operational lifetime of the SSES. This comparison facilitates assessments of the radiological impact of the SSES operation.

The SSES REMP was designed on the basis of the NRC's Radiological Assessment Branch Technical Position on radiological environmental monitoring, as described in Revision 1, November 1979.(17) However, the

Introduction

REMP conducted by PPL for the SSES exceeds the monitoring suggested by the NRC's branch technical position, as well as the SSES Technical Requirements in terms of the number of monitoring locations, the frequency of certain monitoring, the types of analyses required for the samples, and the achievable analysis sensitivities.

Potential Exposure Pathways

The three pathways through which radioactive material may reach the public from nuclear power plants are the atmospheric, terrestrial, and aquatic pathways. (Figure 1 depicts these pathways for the intake of radioactive materials.) Comprehensive radiological environmental monitoring must sample media from all of these pathways.

Mechanisms by which people may be exposed to radioactivity and radiation in the environment vary with the pathway. Three mechanisms by which a member of the public has the potential to be exposed to radioactivity or radiation from nuclear power plants such as the SSES are as follows:

- inhalation (breathing)
- ingestion (eating and drinking), and
- whole body irradiation directly from a plant or from immersion in the radioactive effluents.

REMP Scope

During the operational period of the SSES, it has been important to establish two different categories of monitoring locations, called control and indicator locations, to further assist in assessing the impact of the station operation.

Control locations have been situated at sites where it is considered unlikely that radiation or radioactive material from normal station operation would be detected. Indicator locations are sited where it is expected that radiation and radioactive material that might originate from the station would be most readily detectable.

Control locations for the atmospheric and terrestrial pathways are more than 10 miles from the station. Preferably, the controls also are in directions from the station less likely to be exposed to wind blowing from the station than are the indicator locations. Control locations for the aquatic pathway, the Susquehanna River, are upstream of the station's discharge to the river.

Indicator locations are selected primarily on the basis of proximity to the station, although factors such as meteorology, topography, and sampling practicality also are considered. Indicator locations for the atmospheric and terrestrial pathways are typically less than 10 miles from the station. Most often, they are within 5 miles of the station. Indicator locations in the Susquehanna River are downstream of the station's discharge. Monitoring results from indicator locations are compared with results from control locations. These comparisons are made to discern any differences in the levels and/or types of radioactive material and/or radiation that might exist between indicators and controls and that could be attributable to the station.

In 2002, the SSES REMP collected more than 730 samples at more than 40 locations and performed more than

1,400 analyses. In addition, the REMP monitors ambient radiation levels using thermoluminescent dosimeters (TLDs) at 84 indicator and control locations, making as many as 336 radiation level measurements each year. The media monitored and analyses performed are summarized in the table below. Figures 2 through 7 display the REMP TLDs and sampling locations in the vicinity of the SSES. Appendix C provides directions, distances, and a brief description of each of the locations in Figures 2 through 7.

Regulatory agencies also participate in monitoring the SSES environment and also oversee PPL's monitoring efforts. The State of Pennsylvania's Department of Environmental Protection (PADEP) monitors air for radioactive particulates and radioactive iodine. It also monitors milk, fruits and vegetables, surface and drinking water, fish, river sediments, and ambient radiation levels. PADEP makes this data available to the NRC. Inspectors from the NRC regularly visit both PPL's Corporate Office and the

effluent and environmental monitoring for the SSES.

REMP Monitoring Sensitivity

The sensitivity of the SSES REMP was demonstrated in 1986, following the problem with the Chernobyl reactor in the former Soviet Union. When the Chernobyl incident occurred, the SSES REMP was able to detect a relatively small increase in the level of gross beta activity in air samples at both control and indicator locations, as well as the presence of some specific radioactive materials that are not normally observed.

Detection of radiation and radioactive material from the SSES in the environment is complicated by the presence of naturally occurring radiation and radioactive materials from both terrestrial and cosmic sources. Man-made radiation and radioactive material from non-SSES sources, such as nuclear fallout from previous nuclear weapons tests and medical wastes, also can make identification of SSES radiation and

SSES REMP	
Type of Monitoring	Media Monitored
Gross Alpha Activity	Drinking Water
Gross Beta Activity	All Waters, except Ground Water, and Air Particulates
Gamma-Emitting Radionuclide Activities	All Media
Tritium Activity	All Waters
Iodine-131 Activity	Surface Water, Drinking Water, Air & Milk
Exposure Rates (by TLD)	Ambient Radiation Levels

SSES to review procedures and records, conduct personnel interviews, observe activities first-hand, and generally examine the programs supporting the

radioactive material difficult. Together, this radiation and radioactive material present background levels from which an attempt is made to distinguish

Introduction

relatively small contributions from the SSES. This effort is further complicated by the natural variations that typically occur from both monitoring location to location and with time at the same locations.

The naturally occurring radionuclides potassium-40, beryllium-7, radium-226, and thorium-228 are routinely observed in certain environmental media. Potassium-40 has been observed in all monitored media and is routinely seen at readily detectable levels in such media as milk, meat, fish, and fruits and vegetables. Seasonal variations in beryllium-7 in air samples are regularly observed. Man-made radionuclides, such as cesium-137 and strontium-90 left over from nuclear weapons testing are often observed as well. In addition, the radionuclide tritium, produced by both cosmic radiation interactions in the upper atmosphere as well as man-made (nuclear weapons), is another radionuclide typically observed.

Radioactivity levels in environmental media are usually so low that their measurements, even with state-of-the-art measurement methods, typically have significant degrees of uncertainty associated with them.(18) As a result, expressions are often used when referring to these measurements that convey information about the levels being measured relative to the measurement sensitivities. Terms such as "minimum detectable concentration" (MDC) are used for this purpose. The formulas used to calculate MDCs may be found in Appendix E.

The methods of measurement for sample radioactivity levels used by

PPL's contracted REMP radioanalytical laboratories are capable of meeting the analysis sensitivity requirements found in the SSES Technical Requirements. Summary descriptions of the analytical procedures and the accompanying calculational methods used by the laboratories can be found in Appendix E.

Additional terrestrial and aquatic environmental monitoring is performed independent of the SSES REMP by the Academy of Natural Sciences of Philadelphia, Pennsylvania. The monitoring program is titled "Safety Net" and an annual report is provided to PPL Susquehanna, LLC. Although the Safety Net program is not part of the SSES REMP, the data has provided additional information relative to the environmental impact of the operation of the SSES.

Exposure Pathways to Humans

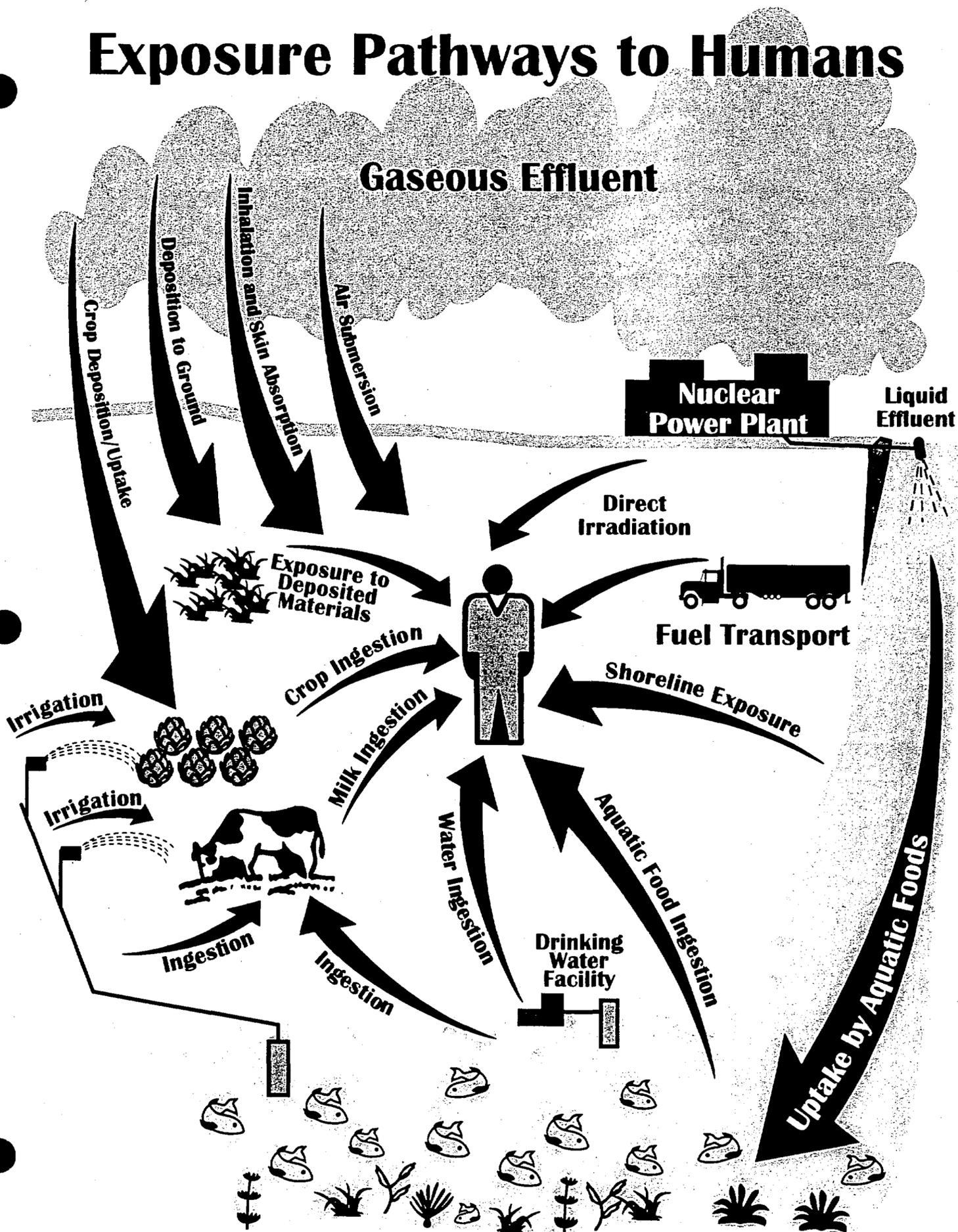


Figure 1

FIGURE 3
2002 TLD MONITORING LOCATIONS
FROM ONE TO FIVE MILES FROM THE SSES

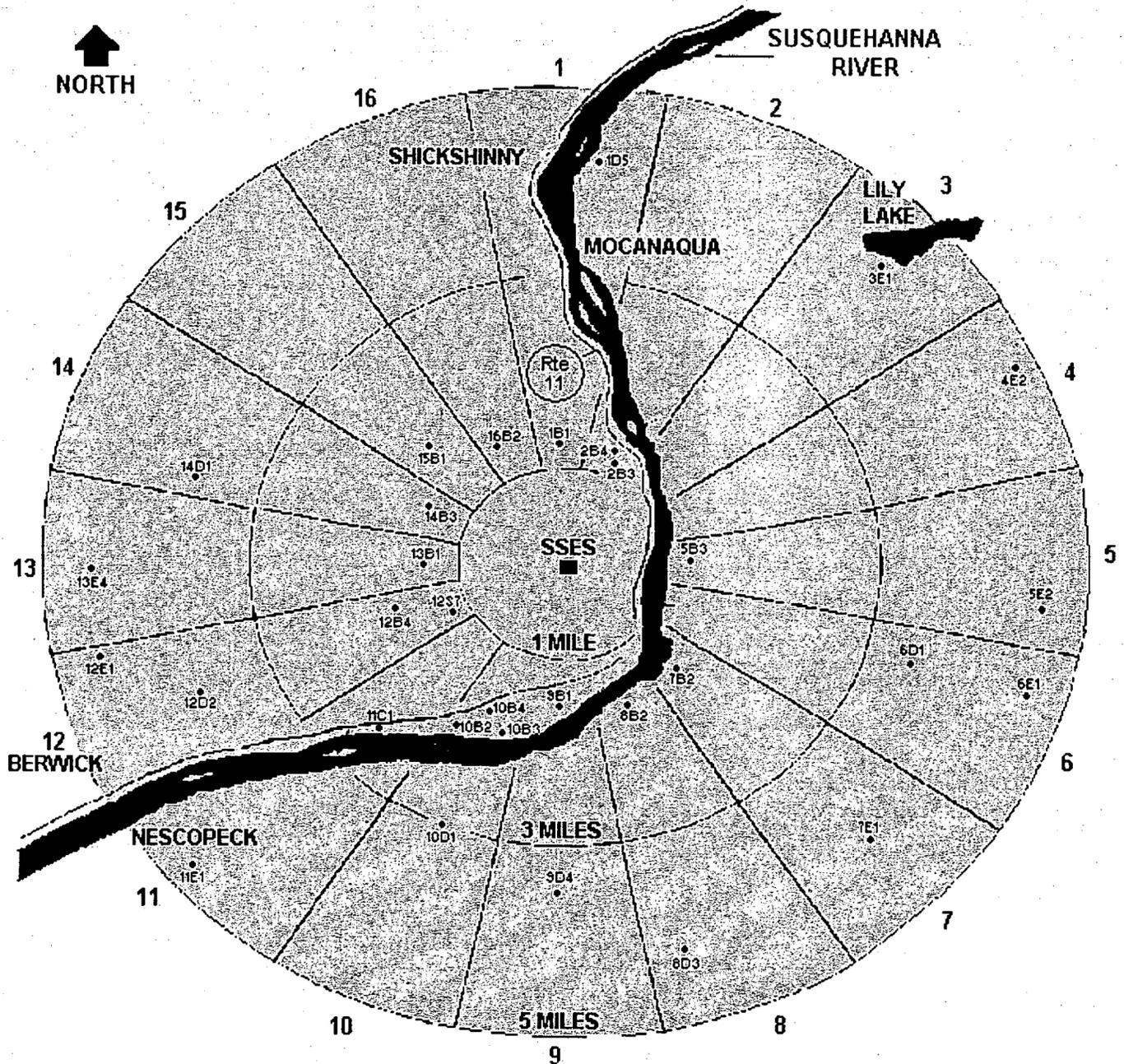


FIGURE 4
2002 TLD MONITORING LOCATIONS
GREATER THAN FIVE MILES FROM THE SSES

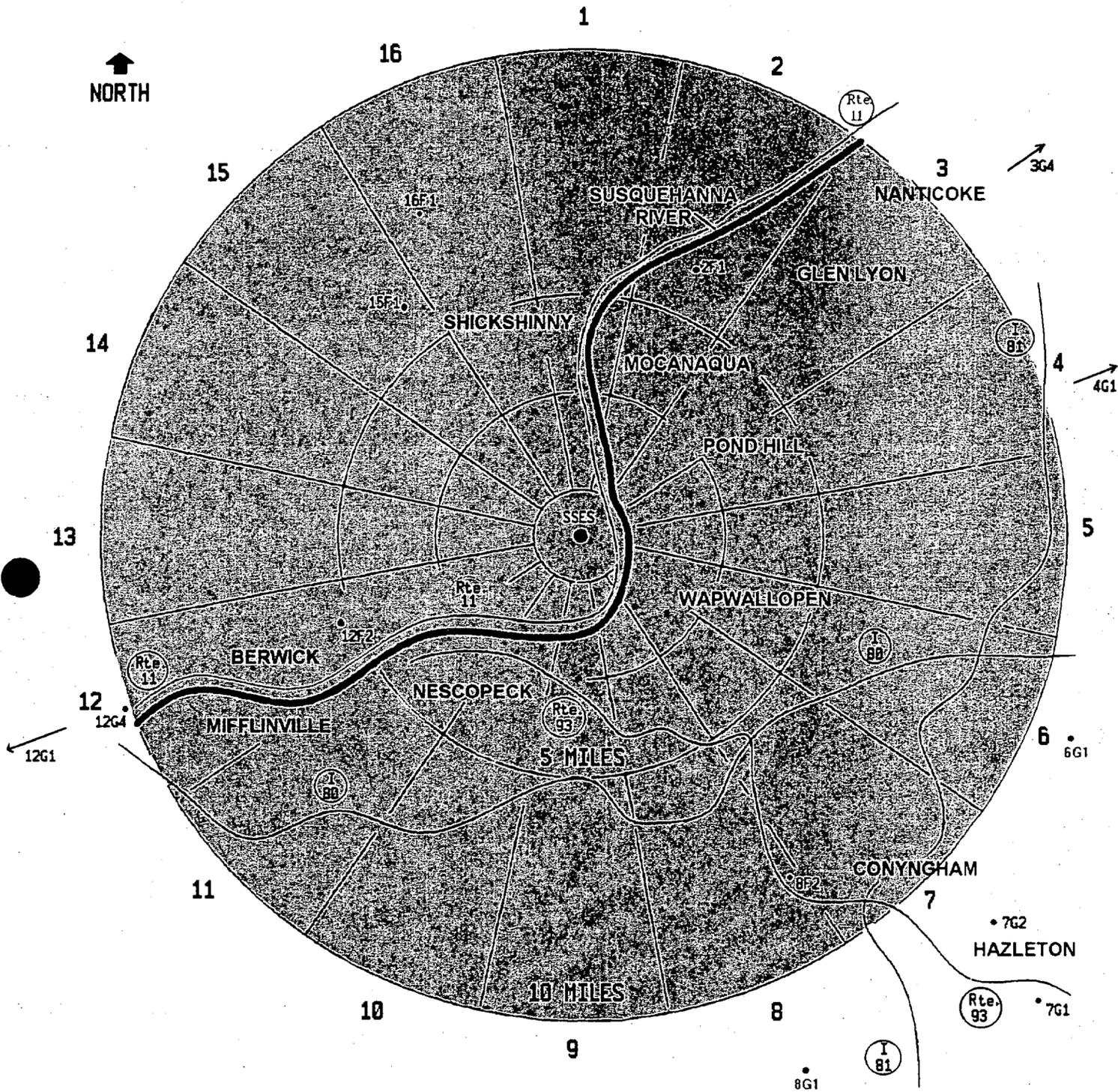
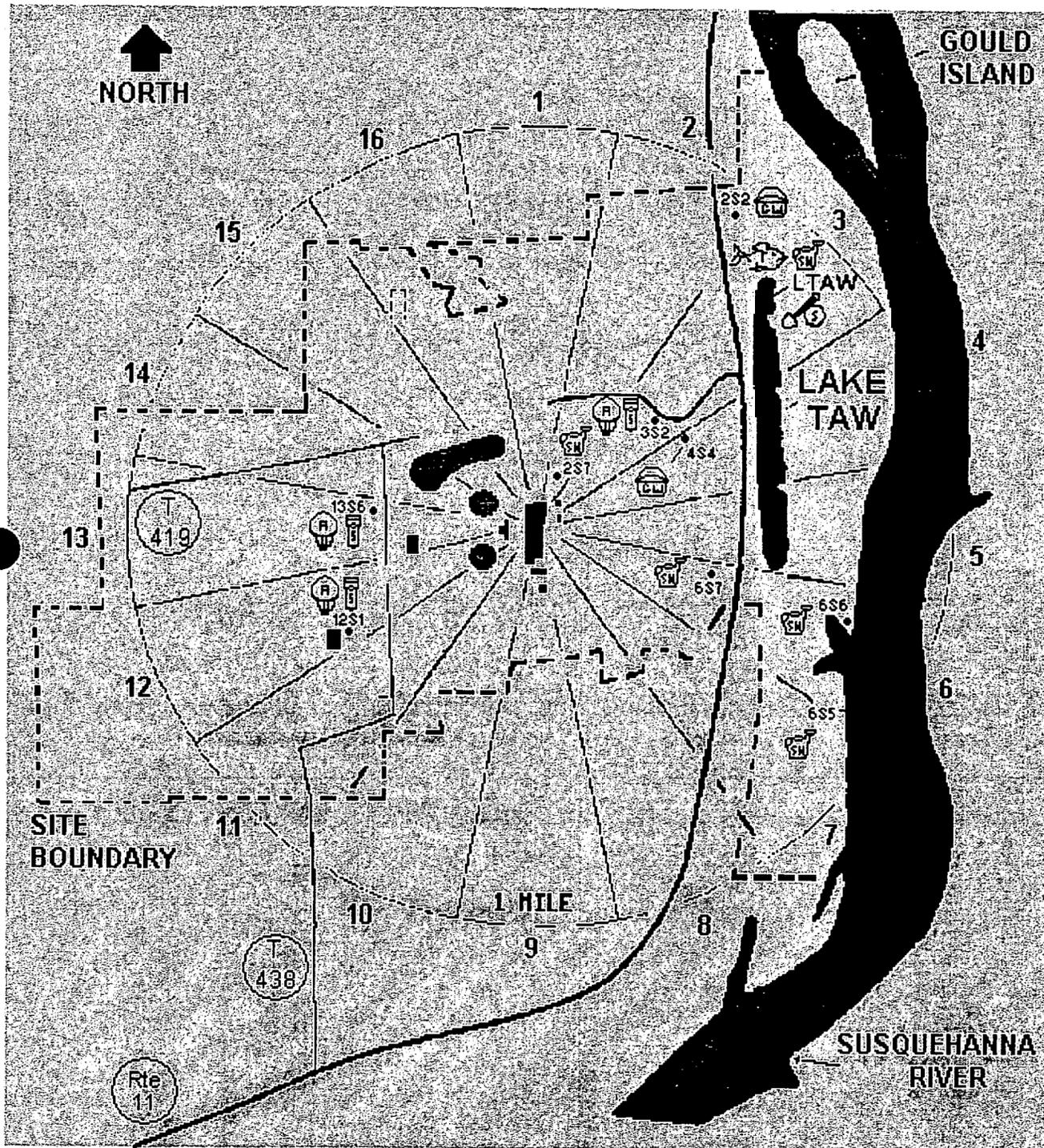


FIGURE 5 2002 ENVIRONMENTAL SAMPLING LOCATIONS WITHIN ONE MILE OF THE SSES



- | | |
|---------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|
|  SURFACE WATER |  AIR |
|  SEDIMENT |  MILK |
|  FISH |  FRUITS / VEGETABLES |
|  GROUND WATER |  SOIL |

FIGURE 6

2002 ENVIRONMENTAL SAMPLING LOCATIONS FROM ONE TO FIVE MILES FROM THE SSES

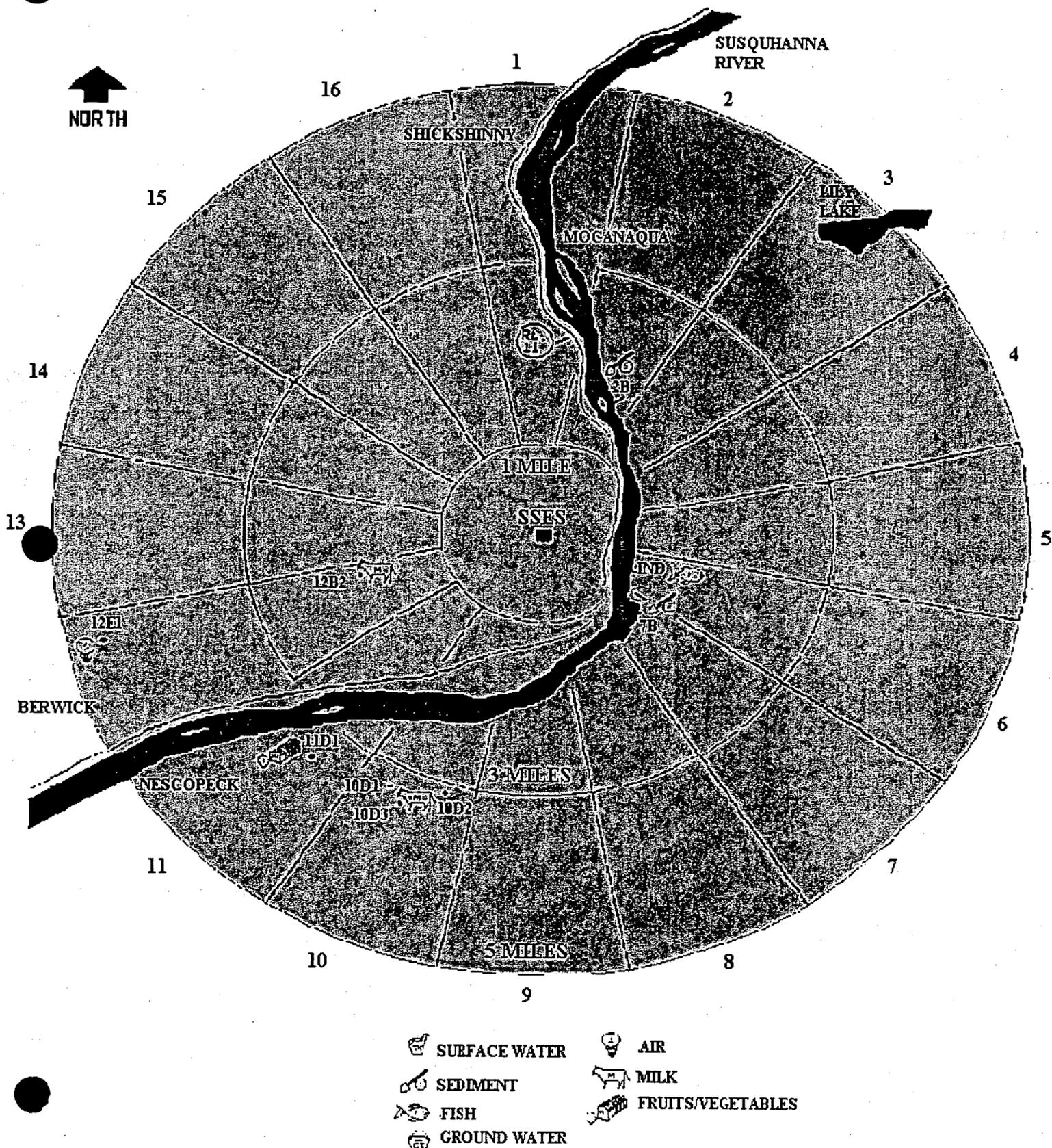
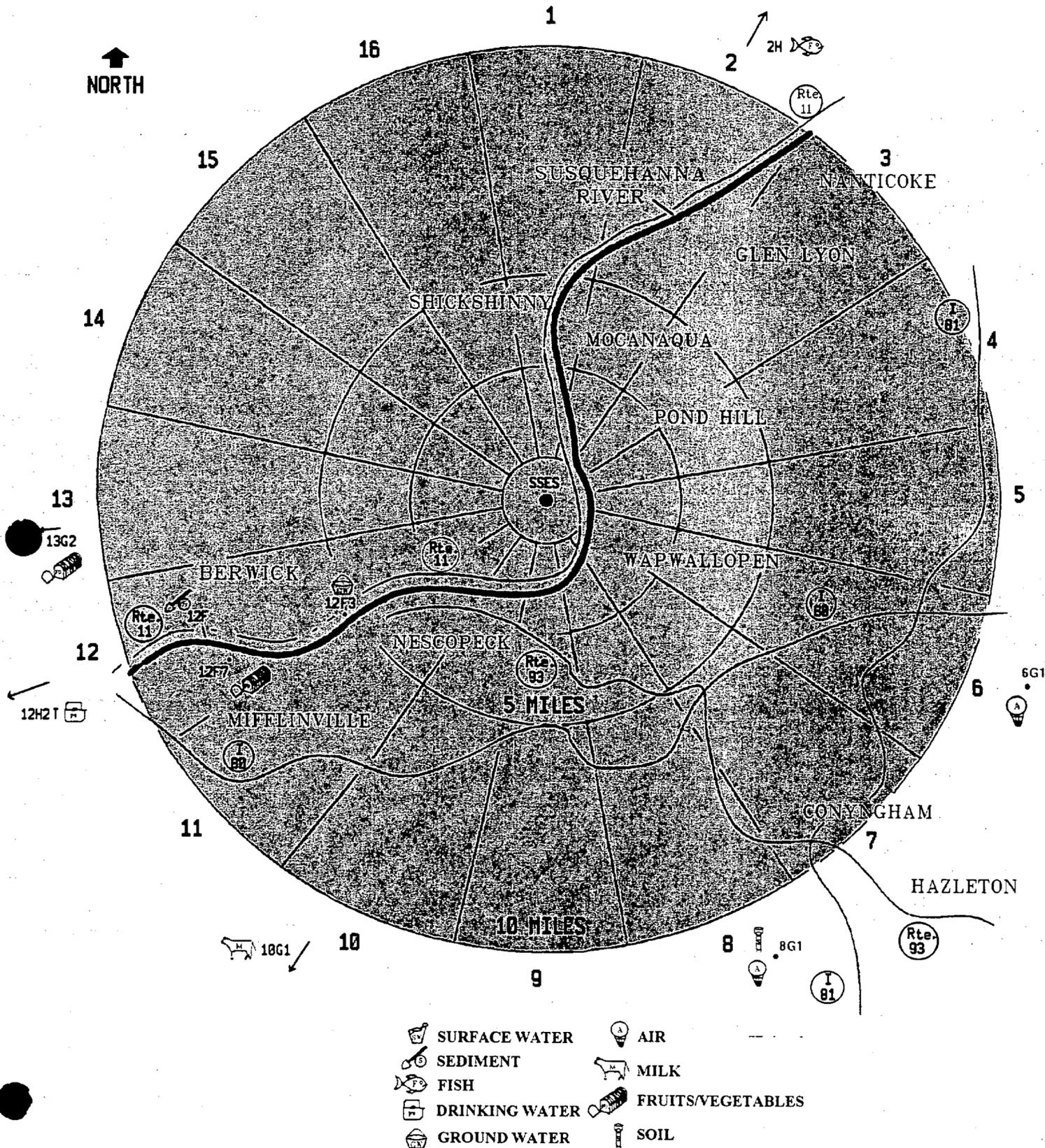


FIGURE 7
2002 ENVIRONMENTAL SAMPLING LOCATIONS
GREATER THAN FIVE MILES FROM THE SSES



AMBIENT RADIATION MONITORING

INTRODUCTION

The principal or primary method for the SSES REMP's measurement of ambient radiation levels is the use of thermoluminescent dosimeters (TLDs). The TLDs are crystals (calcium sulfate) capable of detecting and measuring low levels of radiation by absorbing a portion of the radiation's energy that is incident upon them and storing the captured energy until the TLDs are processed (read). Processing involves heating the TLDs to release their stored energy in the form of light and measuring the intensity of the light that they emit. The intensity of the emitted light is proportional to the amount of radiation to which they were exposed. Calibration of the TLD processors permits a reliable relationship to be established between the light emitted and the amount of radiation dose received by the TLDs; the result permits accurate measurements of the ambient radiation in the environment.

Environmental TLDs are continually exposed to natural radiation from the ground (terrestrial radiation) and from the sky (cosmic) radiation. In addition, they also may be exposed to man-made radiation. Most of the environmental TLD's natural radiation exposure comes from sources in the ground. These terrestrial sources vary naturally with time due to changes in soil moisture, snow cover, etc. The natural-radiation picture is complicated because these factors affecting radiation reaching the TLDs from the ground vary differently with time from one location to another

due to locational differences in such factors as soil characteristics (amounts of organic matter, particle size, etc.), drainage opportunities, and exposure to sunlight. Environmental TLDs can also be affected by direct radiation (shine) from the SSES turbine buildings during operation, radwaste transfer and storage, and radioactive gaseous effluents from the SSES.

Unfortunately, TLDs do not have any inherent ability to indicate the source of the radiation to which they are exposed. The placement of numerous TLDs in the environment can facilitate decision-making about the possible radiation sources to which TLDs are exposed. However, a method for evaluating TLD data is still required. The SSES REMP relies on a statistically based approach to simultaneously compare indicator TLD data with control TLD data and operational TLD data with preoperational TLD data. This approach permits the flagging of environmental TLD doses that might have been produced by both man-made sources of radiation, as well as natural radiation sources. It also provides a means for attributing a portion of the total TLD dose to SSES operation if appropriate. Appendix E, pages E-6 through E-10, provides a description of the process for evaluating the results of TLD measurements.

Ambient Radiation Monitoring

Scope

TLDs

The area around the SSES was divided for monitoring purposes into sixteen sectors radiating outwards from the plant site, each encompassing an area described by an arc of 22.5 degrees. TLDs were placed in all 16 sectors at varying distances from the plant. Monitoring locations were chosen according to the criteria presented in the NRC Branch Technical Position on Radiological Monitoring (Revision 1, November, 1979).(17) The locations for the TLDs were selected by considering factors such as local meteorological, topographical, and population distribution characteristics.

During 2002, the SSES REMP had 76 indicator TLD locations and eight control TLD locations. This level of monitoring exceeds that which is required by the Nuclear Regulatory Commission. The indicator TLDs nearest the SSES are positioned at the security or perimeter fences surrounding the site. This is the closest that a member of the public would be able to approach the station. The control TLDs are the most distant from the SSES, ranging from 10 to 20 miles from the site.

Monitoring Results

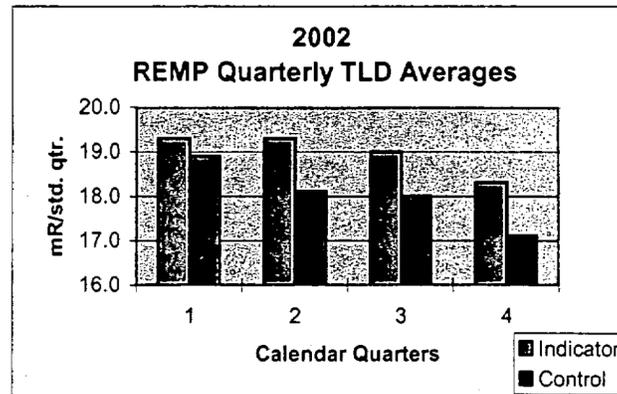
TLDs

TLDs were retrieved and processed quarterly in 2002. Average ambient radiation levels measured by environmental TLDs generally decreased each successive quarter throughout 2002, as shown in the bar

graph on the following page. Refer to Figure 8 which trends both indicator and control data quarterly from 1973 through 2002.

The 2002 annual average exposures for indicator and control locations were 19.0 mR/std. qtr. and 18.1 mR/std. qtr., respectively. These are 1.0 mR/std. qtr. and 1.1 mR/std. qtr., respectively, below the corresponding 2001 annual averages. The 2002 exposures are within the ranges of annual averages for the prior operational periods at each type of monitoring location. Refer to Figure 8 at the end of this section which trends quarterly TLD results for both preoperational and operational periods at the SSES. Refer to Appendix H, Table H 1, page H 3 for a comparison of the 2002 mean indicator and control TLD results with the means for the preoperational and prior operational periods at the SSES.

Indicator environmental TLD results for 2002 were examined quarterly on an individual location basis and compared with both current control location results and preoperational data. Very small SSES exposure contributions were suggested during 2002 at the following onsite locations: 1S2, 6S4, 6S9, 7S6, 8S2, 9S2, 10S2, 11S3, 12S4, 13S2, 13S4, 13S5, 16S1 and 16S2. Thus, there were 14 monitored locations in 2002 where a SSES dose contribution is considered to have been discernible. Refer to Appendix E, page E-6, for a discussion of "TLD Data Interpretation." TLD results for all locations for each quarter of 2002 may be found in Appendix I, Table I-1, beginning at page I-2.



The estimated quarterly exposure contributions were summed by location for the entire year. The largest dose suggested was approximately 0.0299 mrem at an onsite monitoring location, 9S2, 0.2 mile south of the SSES. This dose was used for determining compliance with SSES Technical Requirement Limit 3.11.3 for annual effluent reporting purposes. This dose amounts to only 0.12% of the 25 mrem whole-body dose limit of SSES Technical Requirement 3.11.3.

FIGURE 8 - AMBIENT RADIATION LEVELS BASED ON TLD DATA

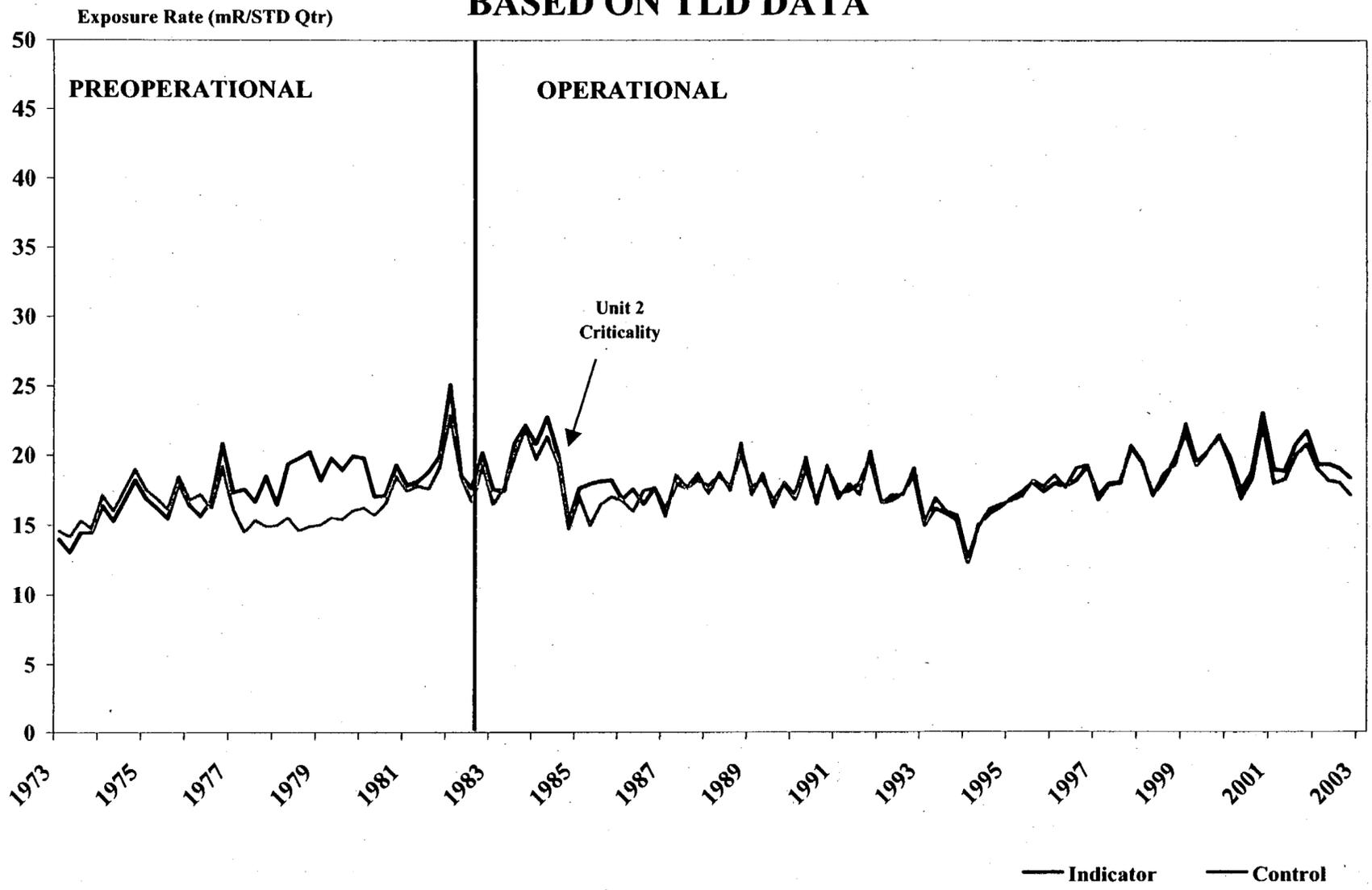


FIG. 8 - H\REMPFIG02.xls

AQUATIC PATHWAY MONITORING

INTRODUCTION

The following media were monitored in 2002 by the SSES REMP in the aquatic pathway: surface water, drinking water, fish, and sediment. Some of the media (e.g., drinking water and fish) provide information that can be especially useful to the estimation of possible dose to the public from potentially ingested radioactivity, if detected. Other media, such as sediment, can be useful for trending radioactivity levels in the aquatic pathway, primarily because of their tendency to assimilate certain materials that might enter the surface water to which they are exposed. The results from monitoring all of these media provide a picture of the aquatic pathway that is more clear than that which could be obtained if one or more were not included in the REMP.

Fruits or vegetables that are grown in fields irrigated with surface water would also be in the aquatic pathway. The land use census (Reference 73) conducted in 2002 looked at farms within 10 miles downstream of the SSES. Two farms were found to have been irrigated during the 2002 growing season.

The aquatic pathway in the vicinity of the SSES is the Susquehanna River. Monitoring of all of the aquatic media, except drinking water, is conducted both downstream and upstream of the location from which occasional SSES low-level radioactive discharges enter the river. The upstream monitoring locations serve as controls to provide

data for comparison with downstream monitoring results. The potential exists for radioactive material that might be present in SSES airborne releases to enter the Susquehanna River upstream of the plant through either direct deposition (e.g., settling or washout) or by way of runoff from deposition on land adjacent to the river. However, direct deposition and runoff are considered to be potentially insignificant as means of entry for SSES radioactivity into the Susquehanna River when compared to liquid discharges under normal conditions.

Lake Took-a-While (LTAW), which is located in PPL's Riverlands Recreation Area adjacent to the Susquehanna River, is also considered to be part of the aquatic pathway for monitoring purposes. Although it is not in a position to receive water discharged to the river from the SSES, it can receive storm runoff from the SSES. Storm runoff from the SSES site should not normally contain any measurable radioactivity from the plant. However, the SSES REMP, consistent with other aspects of aquatic monitoring and the REMP, in general, goes beyond its requirements by monitoring LTAW.

Scope

Surface Water

Surface water was routinely sampled from the Susquehanna River at one indicator location (6S5) and one control location (6S6) at the SSES River Water Intake during 2002. Sampling also took

Aquatic Pathway Monitoring

place at the following additional indicator locations: the SSES discharge line to the river (2S7/6S7) and Lake Took-A-While (LTAW).

Drinking Water

Drinking water samples were collected at location 12H2, the Danville Municipal Water Authority's treatment facility on the Susquehanna River, in 2002. Treated water is collected from the end of the processing flowpath, representing finished water that is suitable for drinking. This is the nearest point downstream of the SSES discharge to the River at which drinking water is obtained. No drinking water control location is sampled. For all intents and purposes, control surface water sampling locations would be suitable for comparison.

Fish

Fish were sampled from the Susquehanna River in the spring and fall of 2002 at one indicator location, IND, downstream of the SSES liquid discharge to the River and one control location, 2H, sufficiently upstream to essentially preclude the likelihood that the fish caught there would spend any time below the SSES discharge. In addition, fish were also sampled from PPL's Lake Took-a-While, location LTAW. This location is not downstream of the SSES discharge. It is sampled because of its potential for receiving runoff from the SSES. LTAW is considered an indicator location.

Sediment

Sediment sampling was performed in the spring and fall at indicator locations 7B and 12F and control location 2B on

the Susquehanna River. In addition, sediment was also obtained from location LTAW.

Sampling

Surface Water

Weekly grab sampling was performed at the indicator location 6S5. Weekly grab samples were composited both monthly and biweekly at this location. Location 6S5 was considered a backup for locations 2S7 and 6S7 in the event that water could not be obtained from the automatic samplers at these locations. Nevertheless, 6S5 was sampled routinely throughout 2002, since it is the closest downstream sampling point to the SSES discharge.

Indicator locations 2S7 and 6S7, the SSES Cooling Tower Blowdown Discharge (CTBD) line, and control location 6S6, the SSES River Water Intake structure, were sampled time proportionally using automatic continuous samplers. The samplers were typically set to obtain 30-60 ml aliquots every 20-25 minutes. Weekly, the water obtained by these samplers was retrieved for either biweekly or monthly compositing.

The other surface water monitoring location, LTAW, was grab sampled once each month.

Drinking Water

Treated water was sampled time proportionally by an automatic sampler. The sampler was typically set to obtain three 12-ml aliquots every twenty minutes. Weekly, the water obtained by this sampler was retrieved for either biweekly or monthly compositing.

Fish

Fish were obtained by electrofishing. Electrofishing stuns the fish and allows them to float to the surface so that those of the desired species and sufficient size can be sampled. Sampled fish include recreationally important species, such as smallmouth bass, and also channel catfish and shorthead redhorse. The fish are filleted and the edible portions are kept for analysis.

Sediment

Shoreline sediment was collected to depths of four feet of water.

Sample Preservation and Analysis

Surface and Drinking Water

Surface and drinking water samples were analyzed monthly for beta activities, the activities of gamma-emitting radionuclides, and tritium activities. Iodine-131 was analyzed biweekly for composite samples and monthly for the grab samples. In addition, drinking water samples were analyzed for gross alpha activity.

To optimize the accuracy of these sample analyses, preservatives were added to the samples as soon after collection as practical. Nitric acid was added to sample aliquots destined for gross alpha and beta activity analysis and the analysis of gamma-emitting radionuclide activity analysis.

Sufficient acid was added to reduce the pH of these sample aliquots to nearly two in order to reduce the potential for radionuclides leaving the water and

depositing on the sides of the sample containers.

Sodium bisulfite was added to sample aliquots destined for iodine-131 analysis in amounts equivalent to one gram per each gallon of water. This amount was recommended by the radioanalytical laboratory (Teledyne Brown Engineering) analyzing the samples. The purpose for sodium bisulfite addition is to reduce the potential for volatilization and loss of iodine from samples by maintaining it in a chemically reduced form.

Sediment and Fish

Fish are frozen until shipment. All samples are analyzed by gamma spectroscopy for the activities of any gamma emitting radionuclides that may be present.

Monitoring Results

Surface Water

Results from specific sample analyses of surface water may be found in Tables I-2 and I-3 of Appendix I. A summary of the 2002 surface water data may be located in Table G of Appendix G. Comparisons of 2002 monitoring results with those of past years may be found in Tables H 2 through H 4 of Appendix H.

The Nuclear Regulatory Commission (NRC) requires that averages of the activity levels for indicator environmental monitoring locations and for control environmental monitoring locations of surface water, as well as other monitored media, be reported to the NRC annually. Data from the following three surface water

Aquatic Pathway Monitoring

monitoring locations were averaged together as indicators for reporting purposes: one location (6S5) on the Susquehanna River downstream of the SSES, Lake-Took-a-While (LTAW) adjacent to the river, and the SSES cooling tower blowdown discharge (CTBD) line to the river (2S7).

Technically, the CTBD line is not part of the environment. The CTBD line is a below ground pipe to which the public has no access, contrary to the other environmental monitoring locations on the Susquehanna River to which the public does have access. However, it currently is required that the water that is discharged to the Susquehanna River through the CTBD line from the SSES be included as an indicator monitoring location in the radiological environmental monitoring program.

Most of the water entering the Susquehanna River through the SSES CTBD line is simply water that was taken from the river upstream of the SSES, used for cooling purposes without being radioactively contaminated by SSES operation, and returned to the river. Nevertheless, batch discharges of relatively small volumes of slightly radioactively contaminated water are made to the river through the SSES CTBD at times throughout each year. The water is released from tanks of radioactively contaminated water on site to the CTBD and mixes with the noncontaminated water already present in the CTBD. Flow rates from the tanks containing radioactively contaminated water being discharged to the CTBD are limited to a maximum of 200 gpm. In addition, the minimum flow rate for the returning

water in the CTBD is maintained at a flow rate of 5,000 gpm or higher. These requirements are in place to ensure adequate dilution of radioactively contaminated water by the returning noncontaminated water in the CTBD prior to entering the river.

At the point that CTBD water enters the river, additional, rapid dilution of the discharged water by the river is promoted by releasing it through a diffuser. The diffuser is a large pipe with numerous holes in it that is positioned near the bottom of the river. CTBD discharges exit the diffuser through the many holes, enhancing the mixing of the discharge and river waters. The concentrations of contaminants are reduced significantly as the discharged water mixes with the much larger flow of river water. The mean flow rate of the Susquehanna River in 2002 was approximately 6,400,000 gpm. This is more than 1,300 times the required minimum flow rate through the CTBD for discharges to be permitted.

The amounts of radioactively contaminated water being discharged are small. Nevertheless, sensitive analyses of the water samples can often detect the low levels of certain types of radioactivity in the CTBD water following dilution. Though the levels of radioactivity measured in the CTBD water are generally quite low, they tend to be higher than those in the river downstream of the SSES. Most radionuclides discharged from the SSES CTBD are at such low levels in the downstream river water that, even with the sensitive analyses performed, they cannot be detected.

When the radioactivity levels from the CTBD samples throughout the year are averaged with those obtained from actual downstream monitoring locations, the result is an overall indicator location average that is too high to be representative of the actual average radioactivity levels of the downstream river water. As the following discussions are reviewed, consideration should be given to this inflation of average radioactivity levels from the inclusion of CTBD (location 2S7/6S7) results in the indicator data that is averaged.

The 2002 data for **gross beta activity** analyses of surface water are lower than those of 2001. The 2002 mean gross beta activity of 5.4 pCi/liter for indicator locations is less than the 2001 indicator mean gross beta activity of 6.5 pCi/liter. The 2002 indicator mean activity is within the range of the annual means for the previous operational period of the SSES. The 2002 mean gross beta activity of 2.9 pCi/liter for control locations is less than the 3.5 pCi/liter for the 2001 control mean gross beta activity. The 2002 control mean activity is within the range of the annual means for both the previous operational and preoperational periods. Refer to Figure 9 which trends gross beta activities separately for surface water indicator and control locations quarterly from 1975 through 2002.

Comparison of the 2002 indicator mean (5.4 pCi/l) to the 2002 control mean (2.9 pCi/l) suggests a contribution of beta activity from the SSES. The 2002 data is similar in this regard to the averages of annual means for indicator

and control locations for the prior operational period. During the prior operational period, the average of annual indicator means exceeds the average of annual control means for gross beta activity.

The 2002 means for **iodine-131 activity** at indicator and control surface water monitoring locations were 0.61 pCi/liter and 0.43 pCi/liter, respectively. The 2002 indicator mean is greater than the 2001 indicator mean. The 2002 control mean is less than the 2001 control mean. Both the 2002 indicator and control mean activities are also greater than the averages of the annual means for both indicator and control locations for the prior operational and preoperational periods of the SSES.

Throughout the course of a year, iodine-131 is typically measured at levels in excess of analysis MDCs in some samples obtained from control surface water monitoring locations on the Susquehanna River upstream of the SSES as well as indicator locations downstream of the SSES. As determined by measurements of samples obtained by the SSES REMP, the mean iodine-131 activity level from the CTBD for all of 2002 was approximately 1.04 pCi/liter. This may be compared to the activity level of 0.43 pCi/liter for control surface water monitoring locations in 2002.

Iodine-131 from the discharge of medical wastes into the Susquehanna River upstream of the SSES is drawn into the SSES cooling tower basins through the SSES River Water Intake Structure. It is reasonable to assume that concentration of the already existing iodine-131 in the cooling tower

Aquatic Pathway Monitoring

basins occurs as it does for other substances found in the river. For example, the SSES routinely assumes concentration factors in the basin for calcium of four to five times the concentrations in the river water entering the basins, based on past measurements. This concentrating effect occurs because of the evaporation of the water in the basins, leaving behind most dissolved and suspended materials in the unevaporated water remaining in the basins. If a concentration factor of four for iodine-131 were to be applied to the 2002 mean iodine-131 activity level for the control samples from the Susquehanna River, a mean concentration of 1.72 pCi/liter for iodine-131 in the basin water and the water being discharged from the basins would be expected. The actual 2002 mean of 1.04 pCi/liter for the CTBD iodine-131 activity level was less than this.

Because iodine-131 is radioactive, unlike the calcium that has been measured, iodine-131 is removed from the water while it is in the basins through the radioactive decay process. Thus, it might be expected that the net concentration factor for iodine-131 would be somewhat less than that for calcium, considering this additional removal process. The extent to which the iodine-131 concentration factor is less than that for calcium would depend on the mean residence time for the water in the basins compared to iodine-131's radioactive half-life - the greater the ratio of the mean residence time to the half-life, the smaller the concentration factor. A mean residence time for water in the basins is expected to be about two days. This is only about

one-fourth of the approximately eight-day half-life of iodine-131. Thus, radioactive decay would not be expected to reduce the concentration factor for iodine-131 by a large amount. Therefore, the difference between the 2002 mean iodine-131 activity of about 1.04 pCi/liter in the CTBD and the 2002 mean iodine-131 activity for the control location of 0.43 pCi/liter should be the result of concentration in the basins. Iodine-131 was not reported to have been discharged with water released from the SSES to the Susquehanna River during 2002.

The 2002 mean tritium activity for indicator locations is more than the corresponding 2001 mean. The 2002 means for tritium activity at indicator and control locations were 1,363 pCi/liter and 36.1 pCi/liter, respectively. The 2002 indicator mean is greater than the annual average mean for prior operational and preoperational periods of the SSES. The control mean is within the range of the corresponding annual mean reported for the prior operational period of the SSES. Refer to Figure 10 which trends tritium activity levels separately for surface water indicator and control locations from 1972 through 2002.

The 2002 indicator mean tritium level for all surface water locations can be misleading for those interested in the mean tritium level in the Susquehanna River downstream of the SSES for 2002. The much higher levels of tritium observed in the CTBD line (location 2S7/6S7), when averaged with the low levels from the downstream location 6S5 sample analysis results distort the real environmental picture. The mean

tritium activity level from indicator location 6S5 for 2002 was 49.6 pCi/liter, which is much closer to the mean tritium activity, 36.1 pCi/liter, for the control location, both of which represent actual river water levels.

In spite of the fact that the tritium activity levels reported for 2S7/6S7 are from the discharge line prior to dilution in the river, the highest quarterly average tritium activity reported at 2S7/6S7 during 2002 was approximately 6,955 pCi/liter for the second quarter, well below the NRC non-routine reporting levels for quarterly average activity levels of 20,000 pCi/liter when a drinking water pathway exists or 30,000 pCi/liter when no drinking water pathway exists.

The tritium activity reported in the CTBD line from location 2S7/6S7 is attributable to the SSES. Refer to the "Dose from the Aquatic Pathway" discussion at the end of this section for additional information on the projected dose to the population from tritium and other radionuclides in the aquatic pathway attributable to the SSES.

With the following exceptions, no gamma-emitting radionuclides were measured in surface water primary samples at an activity level exceeding an analysis MDC in 2002: potassium-40, iodine-131, radium-226, and thorium-228.

Drinking Water

Drinking water was monitored during 2002 at the Danville Water Company's facility 26 miles WSW of the SSES on the Susquehanna River. From 1977 (when drinking water samples were first

collected) through 1984, drinking water samples were also obtained from the Berwick Water Company at location 12F3, 5.2 miles WSW of the SSES. The drinking water supply for the Berwick Water Company is not, however, water from the Susquehanna River; it is actually well water.

There are no known drinking water supplies in Pennsylvania on the Susquehanna River upstream of the SSES and therefore no drinking water control monitoring locations. Danville drinking water analysis results may be compared to the results for surface water control monitoring locations.

Results from specific sample analyses of drinking water may be found in Table I-4 of Appendix I. A summary of the 2002 drinking water data may be located in Table G of Appendix G. Comparisons of 2002 monitoring results with those of past years may be found in Tables H 5 through H 7 of Appendix H.

Gross alpha activity has been monitored in drinking water since 1980. Gross alpha activity has been observed at levels above the analysis MDCs in a small minority of the samples during most years since 1980. The 2002 mean gross alpha activity level for drinking water was 0.24 pCi/liter. The 2002 mean alpha activity level is within the range of the corresponding annual means for the prior operational years. No gross alpha activity in drinking water during 2002 is attributed to liquid discharges from the SSES to the Susquehanna River.

Gross beta activity has been monitored in drinking water since 1977. Gross

Aquatic Pathway Monitoring

beta activity is typically measured at levels exceeding the MDCs in drinking water samples. The 2002 mean gross beta activity level for drinking water was 2.75 pCi/liter. The 2002 mean is above the 2001 mean gross beta activity level for drinking water but within the range of the corresponding annual means for both the prior operational and preoperational periods of the SSES. Refer to Figure 11 which trends gross beta activity levels separately for drinking water indicator and control locations from 1977 through 2002. No gross beta activity in drinking water during 2002 is attributed to liquid discharges from the SSES to the Susquehanna River.

Iodine-131 was measured in excess of analysis MDCs in 6 out of 26 drinking water samples in 2002. This compares with results from 17 samples for which analysis MDCs were exceeded in 2001. The 2002 mean iodine-131 activity level in drinking water samples was 0.22 pCi/liter. This is less than the 2001 mean drinking water activity level of 0.35 pCi/liter. Also, it is less than the 2002 mean of 0.43 pCi/liter for the surface water control location. No iodine-131 activity in drinking water during 2002 is attributed to liquid discharges from the SSES to the Susquehanna River.

Tritium was measured in excess of analysis MDCs twice in 2002 in drinking water. The 2002 mean tritium activity level for drinking water was 55.7 pCi/liter. The 2002 mean is below the averages of the corresponding annual means for both the prior operational and preoperational periods of the SSES. The low 2002 mean

tritium activity level for drinking water is higher than the 2002 mean tritium activity level for the surface water control location. Tritium activity in drinking water can be attributed to liquid discharges from the SSES to the Susquehanna River.

With the exception of I-131, no gamma-emitting radionuclides were measured above the analysis MDCs for gamma spectroscopic analyses of drinking water samples during 2002.

Fish

Results from specific sample analyses of fish may be found in Table I 5 of Appendix I. A summary of the 2002 fish data may be located in Table G of Appendix G. A comparison of 2002 monitoring results with those of past years may be found in Table H 8 of Appendix H.

Three species of fish were sampled at each of one indicator location and one control location on the Susquehanna River in April 2002 and again in October 2002. The species included the following: smallmouth bass, channel catfish, and shorthead redhorse. In addition, one largemouth bass was sampled from PPL's LTAW. A total of 15 fish were collected and analyzed.

The only gamma-emitting radionuclide reported in excess of analysis MDCs in fish during 2002 was naturally occurring potassium-40. The 2002 indicator and control means for the activity levels of potassium-40 in fish were 3.61 pCi/gram and 3.78 pCi/gram, respectively. The 2002 indicator and control means were slightly greater than the 2001 means. Both the 2002

indicator and control means are within the ranges of their corresponding annual means for prior operational and preoperational years. Naturally occurring potassium-40 in fish is not attributable to the liquid discharges from the SSES to the Susquehanna River.

Sediment

Shoreline sediment was sampled in April 2002 and again in October 2002. Results from specific sample analyses of sediment may be found in Table I-6 of Appendix I. A summary of the 2002 sediment data is located in Table G of Appendix G. Comparisons of 2002 monitoring results with those of past years may be found in Tables H 9 through H 12 of Appendix H.

Naturally occurring potassium-40, radium-226, and thorium-228 were measured at activity levels above analysis MDCs in all shoreline sediment samples in 2002 with two exceptions. Thorium-228 did not exceed the MDC in a sample from April and October.

The 2002 indicator and control means for potassium-40 activity levels in shoreline sediment were 12.8 pCi/gram and 10.4 pCi/gram, respectively. The 2002 indicator and control means for potassium-40 activity are less than their corresponding 2001 means. The 2002 indicator and control means were within the ranges of corresponding annual means for all prior operational and preoperational years.

The 2002 indicator and control means for radium-226 activity levels in shoreline sediment were 2.02 pCi/gram and 2.4 pCi/gram, respectively. The

2002 indicator and control mean radium-226 activities are higher than the corresponding 2001 means. These 2002 radium-226 means were above the ranges of the corresponding annual means for all prior operational years.

The 2002 indicator and control means for thorium-228 activity levels in shoreline sediment were 1.7 and 2.11 pCi/gram, respectively. The 2002 indicator mean is the same as the 2001 indicator mean. The 2002 control mean is greater than the corresponding 2001 control mean. The 2002 control mean is greater than the range of corresponding means for prior operational years. The 2002 indicator mean is within the range of corresponding means for prior operational years. The naturally occurring radionuclides in sediment discussed above are not attributable to the liquid discharges from the SSES to the Susquehanna River.

Cesium-137 was measured at activity levels in shoreline sediment exceeding analysis MDCs in 4 of 6 analyses during 2002. The 2002 indicator and control means for cesium-137 activity levels in sediment were 0.055 pCi/gram and 0.13 pCi/gram, respectively. The 2002 indicator mean is less than the corresponding 2001 mean. The 2002 control mean is greater than the corresponding 2001 mean. The 2002 indicator mean is less than the average of corresponding annual means for both prior operational as well as preoperational years. The 2002 control mean is greater than the averages of corresponding annual means for both prior operational as well as preoperational years. This cesium-137 in the sediment is attributed to residual

Aquatic Pathway Monitoring

fallout from past atmospheric nuclear weapons tests.

Dose from the Aquatic Pathway

Tritium was the only radionuclide identified in 2002 by the SSES REMP in the aquatic pathway that was attributable to SSES operation and also included in the pathway to man.

The total tritium activity released from the SSES for the year was estimated based on REMP monitoring results for use in projecting maximum doses to the public. This estimate assumed that the tritium was present continuously in the CTBD line throughout 2002 at a level equivalent to the annual mean activity level of tritium. It was also assumed that the annual average activity level of tritium being contributed to the Susquehanna River water could be represented by the difference between the annual mean activity levels of tritium in the CTBD line (without correction for cooling tower basin reconcentration) and in the river upstream of the SSES.

The annual mean activity level of tritium in the CTBD line (monitoring location 2S7\6S7) for 2002 was 3,885 pCi/l. The annual mean activity level for the river upstream of the SSES (monitoring location 6S6) was approximately 36 pCi/l. Thus, the difference in the mean activity levels for these two locations was about 3,849 pCi/l. The annual mean flow rate for the CTBD line was 7,839 gpm. Using the proper unit conversions and multiplying 7,839 gpm times 3,849 pCi/l yields a value of 58.4 curies

for the estimate of tritium released during 2002 based on the results of radiological environmental monitoring. This estimate is 7 curies less than the amount of tritium determined by effluent monitoring to have been released to the river by the SSES in 2002. This agreement between the estimate based on environmental monitoring and the amount reported by effluent monitoring is consistent with previous years comparisons.

Given the total tritium activity released, the maximum whole-body and organ doses to hypothetical exposed individuals in four age groups (adult, teenager, child, and infant) were determined according to the methodology of the Offsite Dose Calculation manual using the RETDAS computer program. This is in accordance with SSES Technical Requirement 3.11.4.1.3.

The maximum dose obtained from the ingestion of tritium was estimated at the nearest downriver municipal water supplier via the drinking water pathway and near the outfall of the SSES discharge to the Susquehanna River via the fish pathway. The maximum whole body and organ doses were each estimated to be approximately 0.0014 mrem.

FIGURE 9 - GROSS BETA ACTIVITY IN SURFACE WATER

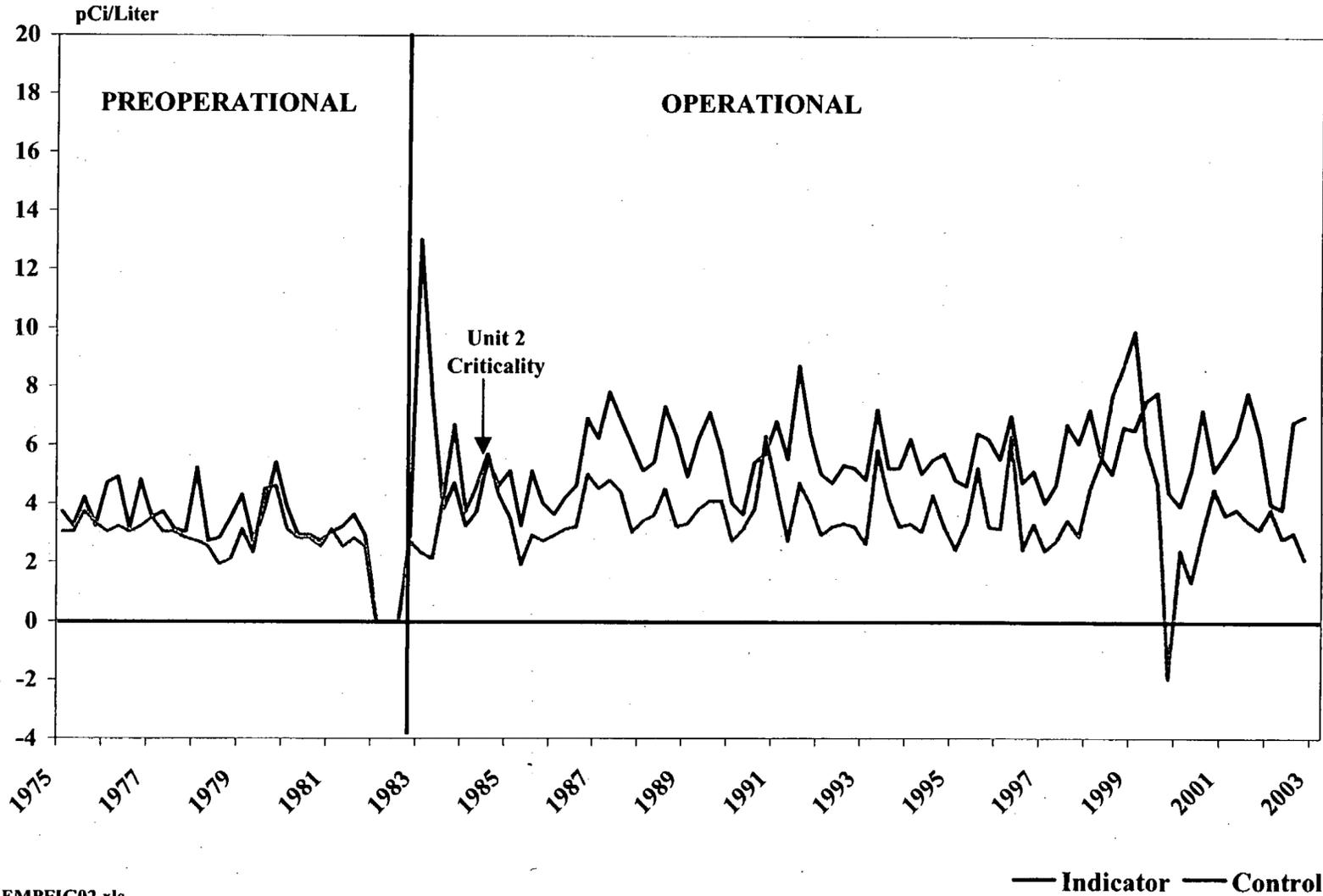


FIG. 9 - H\REMPFIG02.xls

— Indicator — Control

FIGURE 10 - TRITIUM ACTIVITY IN SURFACE WATER

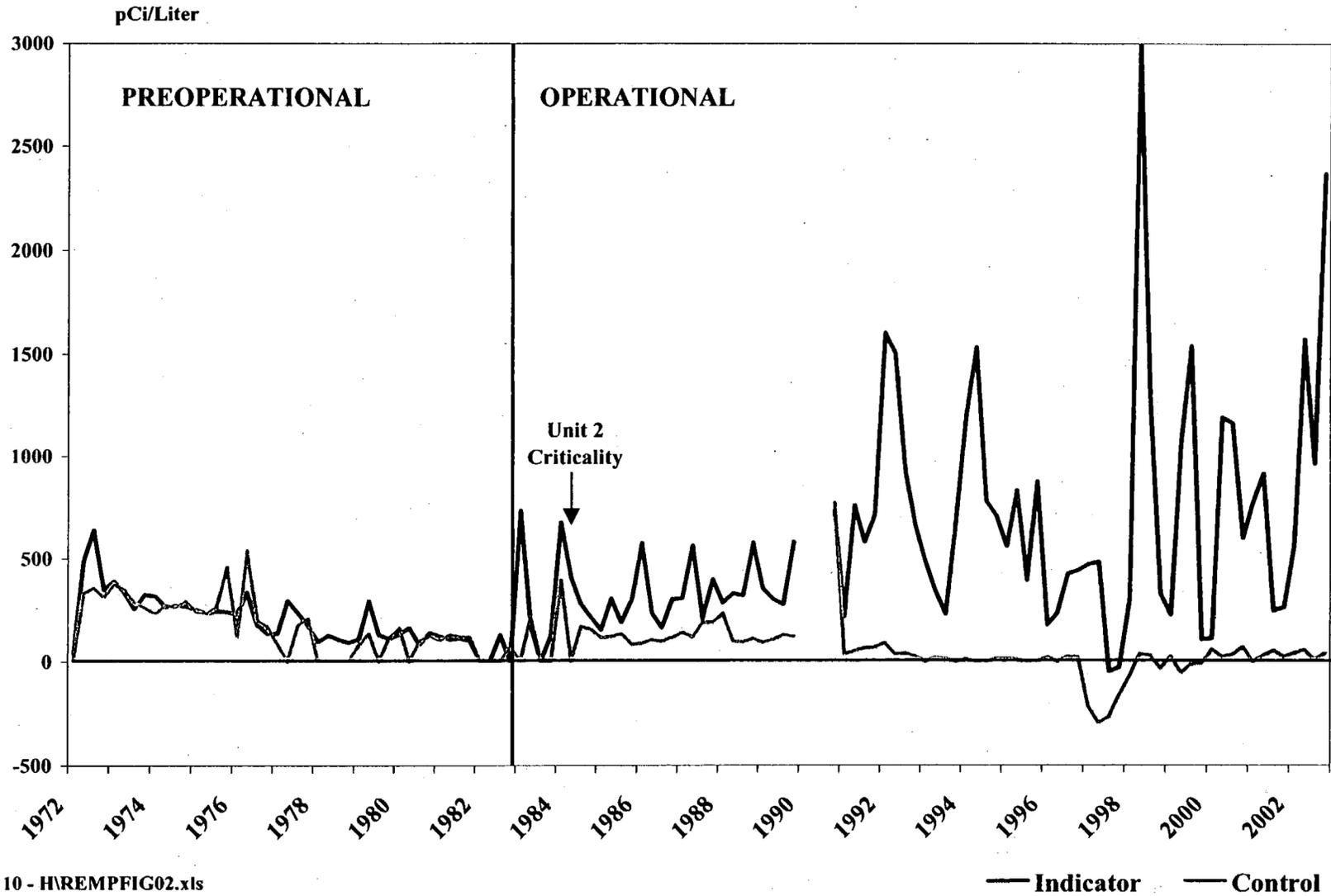


FIG. 10 - HIREMPFIG02.xls

— Indicator — Control

FIGURE 11 - GROSS BETA ACTIVITY IN DRINKING WATER

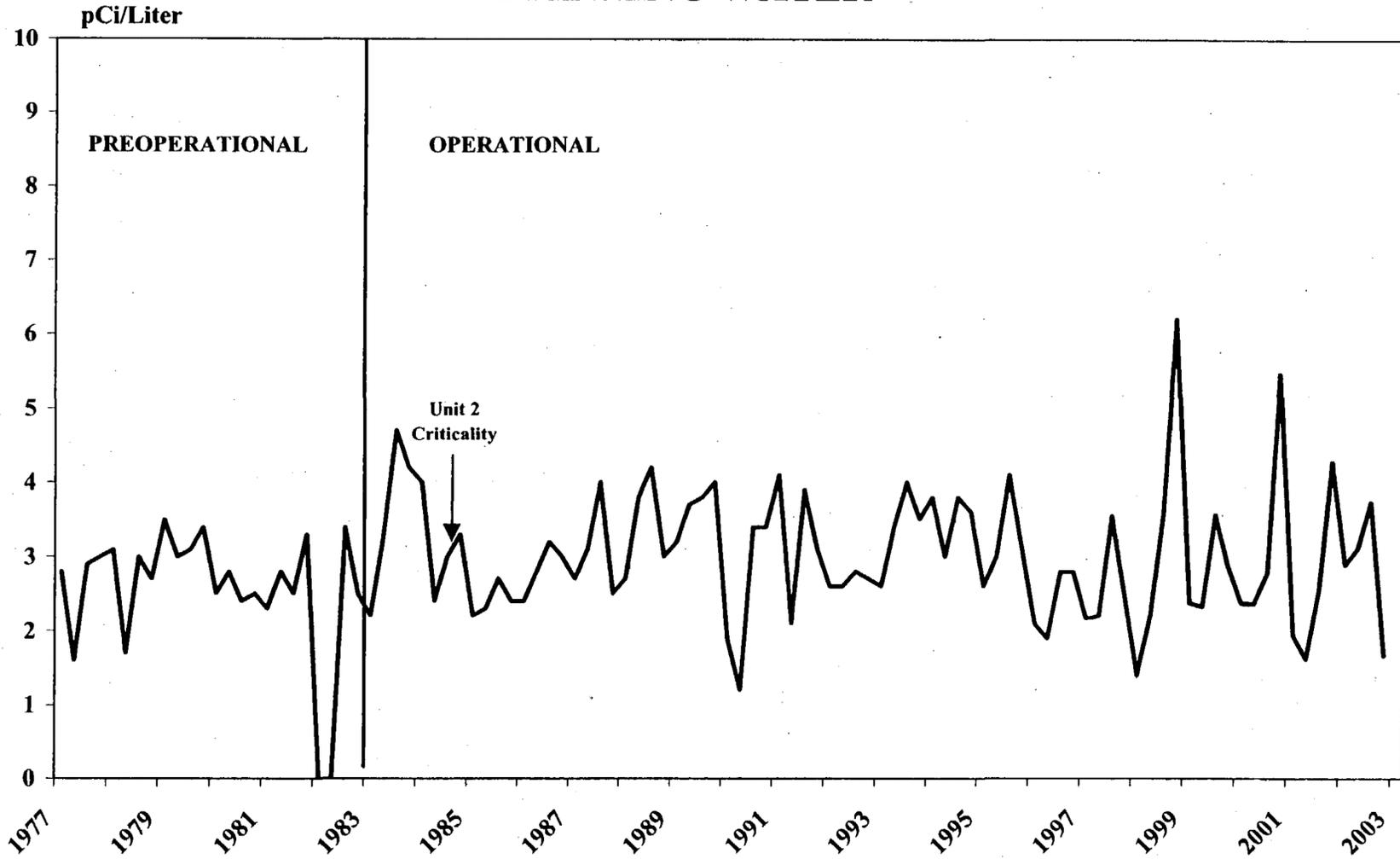


FIG. 11 - HREMFIG02.XLS

ATMOSPHERIC PATHWAY MONITORING

INTRODUCTION

Atmospheric monitoring by the SSES REMP involves the sampling and analysis of air. Because the air is the first medium that SSES vent releases enter in the pathway to man, it is fundamental that it be monitored. Mechanisms do exist for the transport of airborne contaminants to other media and their concentration in them. For example, airborne contaminants may move to the terrestrial environment and concentrate in milk. Concentrations of radionuclides can make the sampling and analysis of media like milk more sensitive approaches for the detection of radionuclides, such as iodine-131, in the pathway to man than the monitoring of air directly. (PPL also samples milk; refer to the Terrestrial Pathway Monitoring section of this report.) Nevertheless, the sensitivity of air monitoring can be optimized by the proper selection of sampling techniques and the choice of the proper types of analyses for the collected samples.

Scope

Air samples were collected on particulate filters and charcoal cartridges at indicator locations 3S2, 12S1, 13S6 and 12E1, and control locations 6G1 and 8G1.

Sampling and Analysis

Air

The SSES REMP monitored the air at four indicator locations and two control locations during 2002. The SSES Technical Requirements require monitoring at only a total of five sites. Monitoring is required at three locations at the SSES site boundary in different sectors with the greatest predicted sensitivities for the detection of SSES releases. Monitoring must be performed at the community in the vicinity of the SSES with the greatest predicted sensitivity. A control location that is expected to be unaffected by any routine SSES releases must be monitored.

Airborne particulates were collected on glass fiber filters using low volume (typically 2.0 to 2.5 cfm sampling rates) air samplers that run continuously. Air iodine samples were collected on charcoal cartridges, placed downstream of the particulate filters.

Particulate filters and charcoal cartridges were exchanged weekly at the air monitoring sites. Sampling times were recorded on elapsed-time meters. Air sample volumes for particulate filters and charcoal cartridges were measured with dry-gas meters.

Air filters were analyzed weekly for gross beta activity, then composited quarterly and analyzed for the activities of gamma-emitting radionuclides. The charcoal cartridges were analyzed weekly for iodine-131.

Atmospheric Pathway Monitoring

Monitoring Results

Air Particulates

Gross beta activity is always measured at levels in excess of the analysis MDCs on the fiber filters. The highest gross beta activity levels that have been measured during the operational period of the SSES were obtained in 1986 following the Chernobyl accident in the former Soviet Union. Figure 12 trends the quarterly mean gross beta activities for the indicator and control locations separately from 1974 through 2002. Note that prior to SSES operation, before 1982, the unusually high gross beta activities were generally attributable to fallout from atmospheric nuclear weapons tests. Typical gross beta activities measured on air particulate filters are the result of naturally occurring radionuclides associated with dust particles suspended in the sampled air. They are thus terrestrial in origin.

Particulate gross beta activity levels for each monitoring location and monitoring period in 2002 are presented in Table I-8 of Appendix I. Comparisons of 2002 gross beta analysis results with those of previous years may be found in Table H 13 of Appendix H. For 2002, the annual means for the beta activities of the indicator and control locations are $16.0\text{E-}3$ pCi/m³ and $14.0\text{E-}3$ pCi/m³, respectively. These are near the low end of the corresponding ranges of previous operational yearly averages. They are significantly below the corresponding lower ends of their preoperational yearly averages. A contribution of radioactivity from the SSES may be suggested from the 2002 airborne gross beta data based

on the higher mean activity reported for indicator location.

Quarterly gamma spectroscopic measurements of composited filters often show the naturally occurring radionuclide beryllium-7. Occasionally, other naturally occurring radionuclides, potassium-40 and radium-226, are also observed. Beryllium-7 is cosmogenic in origin, being produced by the interaction of cosmic radiation with the earth's atmosphere. The other two gamma-emitting radionuclides originate from soil and rock.

Beryllium-7 was measured above analysis MDCs for all quarterly composite samples in 2002. The 2002 indicator and control means for beryllium-7 activity were $137\text{E-}3$ pCi/m³, and $94\text{E-}3$ pCi/m³, respectively. The 2002 means are higher than the corresponding 2001 means. The 2002 indicator and control means were higher than the averages of the corresponding annual means for the prior operational and preoperational periods. Beryllium-7 activity levels for each 2002 calendar quarter at each monitoring location are presented in Table I-9 of Appendix I. Comparisons of 2002 beryllium-7 analysis results with previous years may be found in Table H 14 of Appendix H.

Mn-54 was identified in the fourth quarter composite sample from monitoring location 12S1.

No other gamma-emitting radionuclides were reported for air in 2002. Beryllium-7 and potassium-40 are not attributable to SSES operation. Mn-54 was identified on SSES effluent air

samples and thus can be attributable to SSES operations.

Air Iodine

Iodine-131 has been detected infrequently from 1976, when it was first monitored, through 2002. Since operation of the SSES began in 1982, iodine-131 has only been positively detected in air samples in 1986 due to the Chernobyl accident. No iodine-131 was reported for the 2002 air monitoring results.

FIGURE 12 - GROSS BETA ACTIVITY IN AIR PARTICULATES

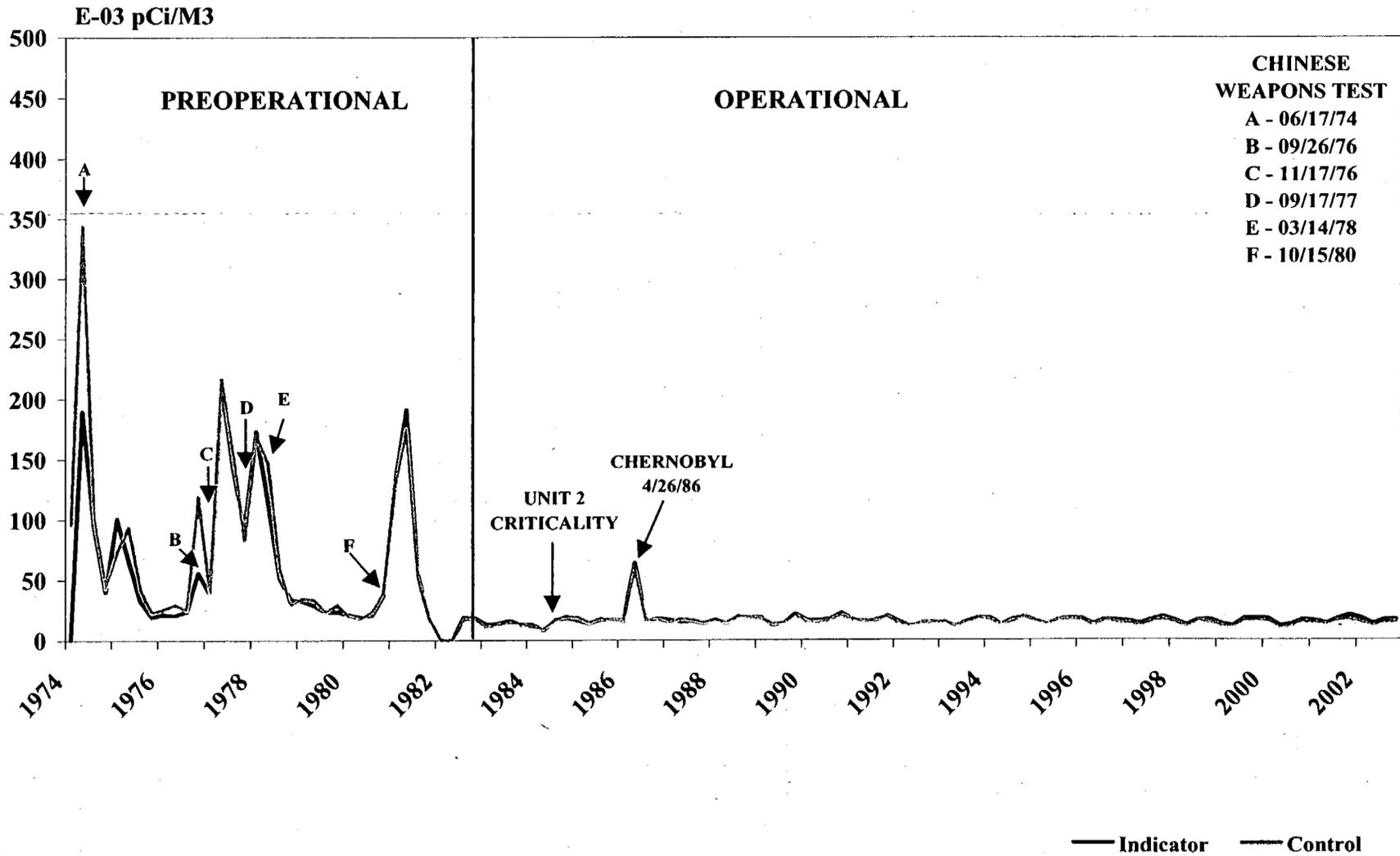


FIG. 12 - H\REMPFIG02.xls

TERRESTRIAL PATHWAY MONITORING

INTRODUCTION

The following media were monitored in the Terrestrial Pathway in 2002: soil, milk, fruits and vegetables.

Soil can be a great accumulator of man-made radionuclides that enter it. The extent of the accumulation in the soil depends of course on the amount of the radionuclides reaching it, but it also depends on the chemical nature of those radionuclides and the particular characteristics of the soil. For example, the element cesium, and, therefore, cesium-137 can be bound very tightly to clay in soils. The amount of clay in soil can vary greatly from one location to another. In highly clay soils, cesium-137 may move very slowly and also may be taken up very slowly in plants as they absorb soil moisture.

Any medium, such as soil, that tends to accumulate radioactive materials can also provide more sensitivity for radionuclide detection in the environment than those media that don't. Such a medium facilitates the early identification of radionuclides in the environment, as well as awareness of changes that subsequently may occur in the environmental levels of the identified radionuclides.

The SSES REMP samples soil near four of the six REMP air sampling stations. The purpose for soil sampling near the air sampling sites is to make it easier to correlate air sampling results with soil sampling results if any SSES related

radioactive material were found in either medium. Sampling is performed at different depths near the surface to help provide information on how recently certain radioactive materials may have entered the soil. Sampling at more than one depth also may help ensure the detection of materials that move relatively quickly through the soil. Such quick-moving materials may have already passed through the topmost layer of soil at the time of sampling.

Milk was sampled at four locations and fruit and vegetable samples were obtained at 3 locations in 2002. SSES Technical Requirements require that the SSES REMP sample milk at the three most sensitive monitoring locations near the SSES and one control location distant from the SSES. Additional milk sampling was performed from April through June in conjunction with a new dairy farm replacing an existing dairy farm. SSES Technical Requirements only require that fruit and vegetables be sampled at locations irrigated by Susquehanna River from points downstream of the SSES discharge to the River. There are only three locations within 10 miles downstream of the SSES that have been known to irrigate with water from the Susquehanna River during unusually dry periods. These locations do not irrigate every year. Irrigation was performed at the Zehner Brothers Farm (11D1) and the Lupini Farm (12F7) during 2002 as identified by the 2002 Land Use Census (Reference 73).

No requirement exists for the SSES REMP to monitor soil. All monitoring of the terrestrial pathway that is conducted by the SSES REMP in addition to milk and certain fruit and vegetables is voluntary and reflects PPL's willingness to exceed regulatory requirements to ensure that the public and the environment are protected.

Scope

Soil

Soil was sampled in September 2002 in accordance with its scheduled annual sampling frequency, at the following four REMP air sampling locations, 3S2, 12S1, 13S6, and 8G1. Location 8G1 was a control sampling location; the remaining sampling sites were indicator locations.

Twelve soil plugs were taken at selected spots at each monitoring location. The plugs were separated into "top" (0-2 inches) and "bottom" (2-6 inches) segments. Each set of top and bottom segments was composited to yield 2 soil samples from each location for analysis. Since there are four monitoring locations, a total of 8 soil samples were analyzed in 2002.

Milk

Milk was sampled at least monthly at the following four locations through June of 2002: 10D1, 10D2, 10D3, and 10G1. Location 12B2 was added in April 2002.

Milk was sampled semi-monthly from April through October when cows were more likely to be on pasture. As of

July 1, 2002 12B2 replaced 10D3 due to location 12B2 believed to be a more sensitive indicator site than 10D3. Locations 10D1, 10D2, 10D3, and 12B2 are believed to be the most sensitive indicator sites available for the detection of radionuclides released from the SSES. Location 10G1 is the control location. A total of 76 milk samples from both indicator and control locations were analyzed in 2002.

Fruits and Vegetables

Pumpkins, green beans, and potatoes were sampled during the harvest season at 3 locations surrounding the SSES. A total of 5 samples were collected from locations 11D1, 12F7, and 13G2. Location 13G2 was the control location.

Both locations were identified as having irrigated with Susquehanna River water from downstream of the SSES during 2002. There are often years with adequate rainfall when no irrigation is performed.

Sample Preservation and Analysis

The only sample medium monitored in the terrestrial pathway in which preservatives were used is milk. Sodium bisulfite was added to milk samples at the rate of 40 grams per gallon. This both helps maintain iodine in a reduced form and reduces the spoilage rate.

All media in the terrestrial pathway are analyzed for the activities of gamma-emitting radionuclides using gamma spectroscopy. The other analysis that is routinely performed is the

Terrestrial Pathway Monitoring

radiochemical analysis for iodine-131 in milk.

Monitoring Results

The only man-made radionuclides normally expected at levels in excess of analysis MDCs in the terrestrial pathway are strontium-90 and cesium-137. Both of these radionuclides are present in the environment as a residual from previous atmospheric nuclear weapons testing.

Strontium-90 analyses are not now routinely performed for any media samples in the terrestrial pathway. Strontium-90 activity would be expected to be found in milk. SSES Technical Requirements do not require that milk be analyzed for strontium-90. Strontium-90 analyses may be performed at any time if the results of other milk analyses would show detectable levels of fission product activity which might suggest the SSES as the source.

Cesium-137 normally has been measured in excess of analysis MDCs in most soil samples. Although game is not currently being monitored, cesium-137 has also been seen often at levels above the MDCs in game in the past.

Certain naturally occurring radionuclides are also routinely found above analysis MDCs in terrestrial pathway media. Potassium-40, a primordial and very long-lived radionuclide, which is terrestrial in origin, is observed in all terrestrial pathway media. Other naturally occurring radionuclides often observed

are thorium-228 and radium-226 in soil, and beryllium-7 in fruits and vegetables.

The results of the 2002 terrestrial pathway monitoring resemble those of the past. Results for specific sample analyses of terrestrial pathway media may be found in Tables I-10 through I-12 of Appendix I. A summary of the 2002 terrestrial monitoring data may be located in Appendix G. Comparisons of 2002 monitoring results with those of past years may be found in Tables H 15 through H 20 of Appendix H.

Soil

The following gamma-emitting radionuclides are routinely measured in soil at levels exceeding analysis MDCs: naturally occurring potassium-40, radium-226, and thorium-228 and man-made cesium-137. The 2002 analysis results were similar to those for previous years. No other gamma-emitting radionuclides were reported at levels above analysis MDCs.

The 2002 means for indicator and control location sample potassium-40 activity were 13.3 pCi/gram and 8.32 pCi/gram, respectively. The indicator and control means are within the range of corresponding means for both prior operational and preoperational years. This is not the result of SSES operation because the potassium-40 is naturally occurring. The 2002 indicator mean for potassium-40 was below its corresponding 2001 mean.

All soil samples in 2002 were not analyzed for radium-226. The vendor lab performing the soil sample analysis normally does not analyze for

radium - 226 in soil. Radium-226 to be added to the soil sample analysis spectrum for 2003 soil samples.. Radium-226 is not the result of SSES operation because it is naturally occurring.

The 2002 means for indicator and control location sample thorium-228 activity were 0.8 pCi/gram and 0.7 pCi/gram, respectively. The 2002 indicator and control means for thorium-228 are lower than the corresponding 2001 means. The indicator and control means are within the ranges of the corresponding means for both the previous operational and preoperational periods, as applicable, of the SSES. Thorium-228 in soil is not the result of SSES operation because it is naturally occurring.

The 2002 means for indicator and control location sample cesium-137 activity were 0.02 pCi/g and 0.09 pCi/g, respectively. The 2002 indicator mean is below the range of the corresponding annual mean for prior operational years and preoperational years. The 2002 control mean is below the ranges of the corresponding annual means for both prior operational and preoperational years. Cesium-137 levels in soil samples typically vary widely from sample to sample. Levels of cesium-137 activity in 2002 samples varied by nearly a factor of ten over the entire range. Cesium-137 in soil, although man-made, is not from the operation of the SSES. It is residual fallout from previous atmospheric nuclear weapons testing.

Milk

Iodine-131 has been chemically separated in milk samples and counted routinely since 1977. Refer to Figure 13 which trends iodine-131 activity in milk for indicator and control locations separately from 1977 through 2002. Typically, iodine-131 is not reported at levels exceeding the MDCs for the analyses in any milk samples during a monitored year. The 2002 monitoring year was no exception; no iodine-131 above the analysis MDCs was observed in either indicator or control samples.

The preoperational years 1976, 1978, and 1980 were exceptional years in the sense that iodine-131 activity was observed in excess of MDCs due to fallout from atmospheric nuclear weapons testing. Iodine-131 activity was also measured at levels exceeding MDCs in milk samples in 1986 in the vicinity of the SSES as a result of the Chernobyl incident.

With the exception of the naturally occurring potassium-40, no gamma-emitting radionuclides were measured in excess of analysis MDCs in 2002. The 2002 means for indicator and control location sample potassium-40 activity were 1403 pCi/liter and 1338 pCi/liter, respectively. The 2002 indicator and control means are higher than the 2001 means. The 2002 indicator and control means for potassium-40 activity are within the corresponding ranges of annual means for previous operational and preoperational years. The potassium-40 activity in milk is not attributable to the SSES operation because it is naturally occurring.

Terrestrial Pathway Monitoring

Fruits and Vegetables

Naturally occurring potassium-40 was the only gamma-emitting radionuclide measured in fruits and vegetables at an activity level in excess of analysis MDC during 2002.

The 2002 means for indicator and control location sample potassium-40 activity were 2.5 pCi/gram and 3.0 pCi/gram, respectively. The 2002 indicator mean is the same as its corresponding 2001 mean. The 2002 control mean is slightly below its corresponding 2001 mean. The 2002 indicator and control means are within the range of the corresponding annual means for pre-operational and prior operational years. Potassium-40 in fruits and vegetables is not attributable to SSES operation because it is a naturally occurring radionuclide.

FIGURE 13 - IODINE-131 ACTIVITY IN MILK

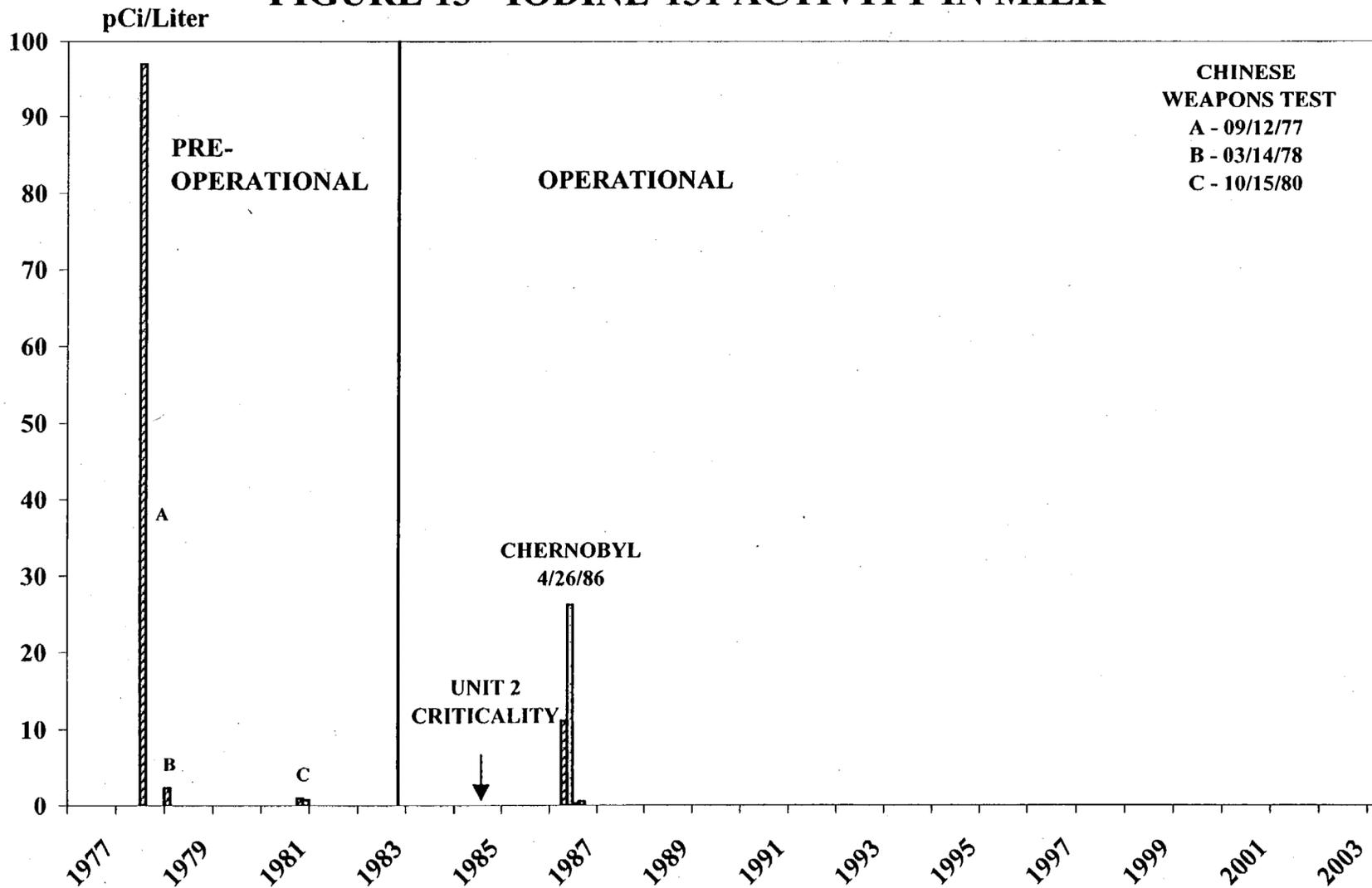


FIG. 13 - HAREMPFIG02.XLS

▨ Indicator ▣ Control

GROUND WATER MONITORING

INTRODUCTION

Normal operation of the SSES does not involve the release of radioactive material to ground water directly or indirectly through the ground. As a result, there are no effluent monitoring data to compare with REMP ground water monitoring results. Ground water could conceivably become contaminated by leakage or spills from the plant or by the washout or deposition of radioactive material that might be airborne. If deposited on the ground, precipitation/soil moisture could aid in the movement of radioactive materials through the ground to water that could conceivably be pumped for drinking purposes. No use of ground water for irrigation near the SSES has been identified.

Because routine SSES operation releases primarily tritium and, to a lesser extent, isotopes of xenon and krypton to the air, no radionuclides attributable to SSES operation are expected to be observed in ground water. Iodine and particulate releases to the air are negligible. Gaseous xenon and krypton tend to remain airborne; deposition or washout of these would be expected to be very minimal. Tritium would be the most likely radionuclide to reach the ground with precipitation and, if not lost to streams (surface water) by runoff, move readily through the soil to the ground water.

Scope

Ground water in the SSES vicinity was sampled monthly at 2 indicator locations (2S2 and 4S4) and one control location (12F3) during 2002.

With the exception of location 4S4, untreated ground water was sampled. Untreated means that the water has not undergone any processing such as filtration, chlorination, or softening. At location 4S4, the SSES Training Center, well water actually is obtained from on-site and piped to the Training Center after treatment. This sampling is performed as a check to ensure that water has not been radioactively contaminated. Sampling is performed at the Training Center to facilitate the sample collection process.

Sample Preservation & Analysis

All samples (except the aliquots assigned for tritium analyses) were preserved with nitric acid, as described in Aquatic Pathway Monitoring.

Ground water samples were analyzed for the activities of gamma-emitting radionuclides and tritium activity. Gamma spectrometric analyses of ground water were begun in 1979 and tritium analyses in 1972, both prior to SSES operation.

Ground Water Monitoring

Monitoring Results

Tritium activity levels in ground water have typically been observed to be lower than in surface water. A noticeable decline occurred between 1992 and 1993. Fewer measurements were above the analysis sensitivities in 1993 than in 1992.

Gamma-emitting radionuclides in excess of MDCs have been found in only a few samples in all the years that these analyses have been performed. The naturally occurring radionuclides potassium-40 and thorium-228 have been measured above their MDCs occasionally in ground water. Potassium-40 was reported in 1979, 1981, 1985, 1991, 1992, 1993, and 1997. Thorium-228 was found in 1985 and 1986. The man-made radionuclide cesium-137 has been detected only occasionally since 1979. Its presence has always been attributed to residual fallout from previous atmospheric nuclear weapons tests.

The results of the 2002 REMP ground water surveillance resemble those of the past. Results for specific ground water sample analyses may be found in Table I-7 of Appendix I. A summary of the 2002 ground water monitoring data may be located in Appendix G. Comparisons of 2002 monitoring results for tritium with those of past years may be found in Table H 21 of Appendix H.

During 2002, tritium was measured in excess of analysis MDCs on 1 occasion. The 2002 mean tritium activity levels for indicator and control monitoring locations were 78 pCi/liter and 63 pCi/liter, respectively. The indicator

and control means are higher than those for 2001. Both the 2002 indicator and control mean tritium activity levels are within the range of corresponding averages of annual means for prior operational and preoperational years.

Naturally occurring potassium-40 was measured in excess of analysis MDCs for some ground water samples during 2002. No man-made gamma-emitting radionuclides were determined to be at levels in excess of analysis MDCs. No radioactivity contributions to ground water from the SSES were identifiable in 2002.

REFERENCES

1. Radiation Management Corporation, "Susquehanna Steam Electric Station, Radiological Environmental Monitoring Program, Report #1 (April-December 1972)" RMC-TR-73-14, July 1973.
2. Radiation Management Corporation, "Susquehanna Steam Electric Station, Pre-operational Radiological Environmental Monitoring Program 1973," RMC-TR-74-07, May 1974.
3. Radiation Management Corporation, "Susquehanna Steam Electric Station, Preoperational Radiological Environmental Monitoring Program, 1974 Annual Report," RMC-TR-75-07, April 1975.
4. Radiation Management Corporation, "Susquehanna Steam Electric Station, Radiological Environmental Monitoring Program, 1975 Annual Report," RMC-TR-76-05, May 1976.
5. Radiation Management Corporation, "Susquehanna Steam Electric Station, Radiological Environmental Monitoring Program, 1976 Annual Report," RMC-TR-77-04, March 1977.
6. Radiation Management Corporation, "Susquehanna Steam Electric Station, Radiological Environmental Monitoring Program, 1977 Annual Report," RMC-TR-78-01, May 1978.
7. Radiation Management Corporation, "Susquehanna Steam Electric Station, Radiological Environmental Monitoring Program, 1978 Annual Report," RMC-TR-79-01, April 1979.
8. Radiation Management Corporation, "Susquehanna Steam Electric Station, Radiological Environmental Monitoring Program, 1979 Annual Report," RMC-TR-80-01, March 1980.
9. Radiation Management Corporation, "Susquehanna Steam Electric Station, Radiological Environmental Monitoring Program, 1980 Annual Report," RMC-TR-81-02, July 1981.
10. Radiation Management Corporation, "Susquehanna Steam Electric Station, Radiological Environmental Monitoring Program, 1981 Annual Report," RMC-TR-82-03, July 1982.
11. Radiation Management Corporation, "Susquehanna Steam Electric Station, Radiological Environmental Monitoring Program, 1982 Preoperational Report," RMC-TR-83-01, April 1983.

References

12. Radiation Management Corporation, "Susquehanna Steam Electric Station, Radiological Environmental Monitoring Program, 1982 Operational Report." RMC-TR-83-02, April 1983.
13. NUS Corporation, "Susquehanna Steam Electric Station, Radiological Environmental Monitoring Program, 1983 Annual Report," NUS-4516 March 1984.
14. Pennsylvania Power and Light Company, "Susquehanna Steam Electric Station, Environmental Report, Operating License Stage," May 1978.
15. Pennsylvania Power and Light Company, "Susquehanna Steam Electric Station, Final Safety Analysis Report".
16. United States Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, "Final Environmental Statement Related to the Operation of Susquehanna Steam Electric Station, Units 1 and 2," Docket Nos. 50-387 and 50-388, June 1981.
17. United States Nuclear Regulatory Commission, "An Acceptable Radiological Environmental Monitoring Program," Radiological Assessment Branch Technical Position, November 1979, Revision 1.
18. National Council on Radiation Protection and Measurements, "Environmental Radiation Measurement," NCRP Report No. 50, Washington, D.C., December 27, 1976.
19. Oakley, D.C., "Natural Radiation Exposure in the United States," ORP/SID 72-1 Office of Radiation Programs, U.S. Environmental Protection Agency, Washington, D.C., June 1972.
20. Denham, D.H., Roberts, M.C., Novitsky, W.M., Testa, E.D., "Investigation of Elevated Cesium-137 Concentrations in Small Game in Luzerne County, Pennsylvania." Proceedings of Papers presented at Health Physics Society Tenth Midyear Topical Symposium, October 11-13, 1976, pgs. 271-279.
21. Teledyne Isotopes, "Susquehanna Steam Electric Station, Radiological Environmental Monitoring Program, 1984 Annual Report," April 1985.
22. Currie L.A., "Lower Limit of Detection: Definition and Elaboration of a Proposed Position for Radiological Effluent and Environmental Measurements," NUREG/CR-4007, September 1984.
23. Pennsylvania Power and Light Company, "Susquehanna Steam Electric Station, Semi-annual Effluent Waste Disposal Report, Data Period: January-June 1986", August 1986.

24. Pennsylvania Power and Light Company, "Susquehanna Steam Electric Station, Semi-annual Effluent Waste Disposal Report, Data Period: July-December 1986," February 1987.
25. Pennsylvania Power and Light Company Technical Specifications Susquehanna Steam Electric Station, Units No. 1 and 2; Docket No. 50-387 and 50-388 Appendix A to License No. NPF-14 and NPF-22.
26. Teledyne Isotopes, "Susquehanna Steam Electric Station, Radiological Environmental Monitoring Program, 1985 Annual Report", April 1986.
27. Teledyne Isotopes, "Susquehanna Steam Electric Station, Radiological Environmental Monitoring Program, 1986 Annual Report," April 1987.
28. Pennsylvania Power and Light Company, "Susquehanna Steam Electric Station, Semi-annual Effluent Waste Disposal Report, Data Period: January-June 1987, August 1987.
29. Pennsylvania Power and Light Company, "Susquehanna Steam Electric Station, Semi-annual Effluent Waste Disposal Report, Data Period: July-December 1987, February 1988.
30. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Radiological Environmental Monitoring Program, 1987 Annual Report," April 1988.
31. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Semi-annual Effluent Waste Disposal Report, Data Period: January-June 1988," August 1988.
32. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Semi-annual Effluent Waste Disposal Report, Data Period: July-December 1988," February 1989.
33. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Radiological Environmental Monitoring Program, 1988 Annual Report," April 1989.
34. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Semi-annual Effluent Waste Disposal Report, Data Period: January-June 1989," August 1989.
35. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Semi-annual Effluent Waste Disposal Report, Data Period: July-December 1989," February 1990.

References

36. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Radiological Environmental Monitoring Program, 1989 Annual Report," April 1990.
37. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Semi-annual Effluent Waste Disposal Report, Data Period: January-June 1990," August 1990.
38. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Semi-annual Effluent Waste Disposal Report, Data Period: July-December, 1990," February 1991.
39. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Radiological Environmental Monitoring Program, 1990 Annual Report," April 1991.
40. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Semi-Annual Effluent Waste Disposal Report, Data Period: January-June 1991," August 1991.
41. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Semi-Annual Effluent Waste Disposal Report, Data Period: July 1-December, 1991," February 1992.
42. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Radiological Environmental Monitoring Program, 1991 Annual Report," April 1992.
43. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Semi-Annual Effluent Waste Disposal Report, Data Period: January-June 1992," August 1992.
44. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Semi-Annual Effluent Waste Disposal Report, Data Period: July 1-December 1992," February 1993.
45. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Radiological Environmental Monitoring Program, 1992 Annual Report," April 1993.
46. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Annual Effluent & Waste Disposal Report, Data Period: January-December 1993, March 1994.
47. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Radiological Environmental Monitoring Program, 1993 Annual Report," April 1994.

48. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Annual Effluent & Waste Disposal Report," Data Period: January-December 1994, March 1995.
49. Ecology III, Inc., "Susquehanna Steam Electric Station, 1994 Land Use Census," November 1994.
50. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Radiological Environmental Monitoring Program, 1994 Annual Report," April 1995.
51. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Annual Effluent & Waste Disposal Report," Data Period: January-December 1995, March 1996.
52. Ecology III, Inc., "Susquehanna Steam Electric Station, 1995 Land Use Census," October 1995.
53. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Radiological Environmental Monitoring Program, 1995 Annual Report," April 1996.
54. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Annual Effluents & Waste Disposal Report," Data Period: January-December 1996, March 1997.
55. Ecology III, Inc., "Susquehanna Steam Electric Station, 1996 Land Use Census," November 1996.
56. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Radiological Environmental Monitoring Program 1996 Annual Report," April 1997.
57. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Annual Effluents & Waste Disposal Report," Data Period: January-December 1997, March 1998.
58. Ecology III, Inc., "Susquehanna Steam Electric Station, 1997 Land Use Census," November 1997.
59. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, 1997 Annual Radiological Environmental Operating Report," April 1998.
60. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Annual Effluents & Waste Disposal Report," Data Period: January-

References

- December 1998, April 1999.
61. Ecology III, Inc., "Susquehanna Steam Electric Station, 1998 Land Use Census," October 1998.
 62. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, 1998 Annual Radiological Environmental Operating Report," May 1999.
 63. Pennsylvania Power & Light Company, "Susquehanna Steam Electric Station, Annual Effluents & Waste Disposal Report," Data Period: January–December 1999, April 2000.
 64. Ecology III, Inc., "Susquehanna Steam Electric Station, 1999 Land Use Census," October 1999.
 65. PPL, "Susquehanna Steam Electric Station, 1999 Annual Radiological Environmental Operating Report," May 2000.
 66. PPL, "Susquehanna Steam Electric Station, Annual Effluents & Waste Disposal Report," Data Period: January-December 2000, April 2001.
 67. Ecology III, "Susquehanna Steam Electric Station, 2000 Land Use Census," November 2000.
 68. PPL, "Susquehanna Steam Electric Station, 2000 Annual Radiological Environmental Operating Report," May 2001.
 69. PPL, "Susquehanna Steam Electric Station, Annual Effluents & Waste Disposal Report," Data Period: January – December 2001, April 2002.
 70. Ecology III, "Susquehanna Steam Electric Station, 2001 Land Use Census," November 2001.
 71. PPL, "Susquehanna Steam Electric Station, 2001 Annual Radiological Environmental Operating Report," May 2002.
 72. PPL, "Susquehanna Steam Electric Station, Annual Effluents & Waste Disposal Report," Data Period: January – December 2002, April 2003.
 73. Ecology III, "Susquehanna Steam Electric Station, 2002 Land Use Census," November 2002.

APPENDIX A

2002 REMP CHANGES

REMP Sample Analyses

All primary analyses (beta & I-131 weekly and gamma quarterly) of air samples during the periods of January through September 2002 were conducted by PPL Susquehanna LLC's Corporate Environmental Radioactivity Measurements Laboratory (CERML). In addition, CERML was the primary laboratory during the periods of January through September 2002 for the following analyses: alpha, beta, and tritium analyses of drinking water; beta and tritium analyses of surface water; gamma analyses of fish and sediment samples in the spring; and gamma analyses of fruits and vegetables. Teledyne Brown Engineering laboratory replaced CERML as the primary analyses laboratory for all analysis and media as outlined above for the period of October through December 2002. The following table summarizes the REMP sample analyses for which different laboratories were responsible during 2002. Note that TBE represents Teledyne Brown Engineering and E-LAB represents Framatome ANP. Framatome ANP purchased Duke Engineering & Services Environmental Laboratory on May 1, 2002.

SOURCE OF REMP DATA FOR MONITORING YEAR 2002				
Sample Medium	Analysis Type	Sample/Analysis Frequency	Data Period	Lab
Air	Gross Beta	Weekly	1 st , 2 nd , 3 rd Quarter	CERML
Air	Gross Beta	Weekly	4 th Quarter	TBE
Air	I-131	Weekly	1 st , 2 nd , 3 rd Quarter	CERML
Air	I-131	Weekly	4 th Quarter	TBE
Air	Gamma	Quarterly	1 st , 2 nd , 3 rd Quarter	CERML
Air	Gamma	Quarterly	4 th Quarter	TBE
Surface Water	Gross Beta	Monthly	1 st , 2 nd , 3 rd Quarter	CERML
Surface Water	Gross Beta	Monthly	4 th Quarter	TBE
Drinking Water	Gross Beta & Gross Alpha	Monthly	1 st , 2 nd , 3 rd Quarter	CERML
Drinking Water	Gross Beta & Gross Alpha	Monthly	4 th Quarter	TBE

Appendix A

SOURCE OF REMP DATA FOR MONITORING YEAR 2002				
(continued)				
Sample Medium	Analysis Type	Sample/Analysis Frequency	Data Period	Lab
All Water	Tritium	Monthly	1 st , 2 nd , 3 rd Quarter	CERML
All Water	Tritium	Monthly	4 th Quarter	TBE
Surface & Drinking Water	Gamma	Monthly	All Year	E-LAB
Surface Water (LTAW)	I-131	Monthly	All Year	E-LAB
Ground Water	Gamma	Monthly	All Year	E-LAB
Surface & Drinking Water	I-131	Bi/weekly	All Year	E-LAB
Milk	Gamma	Monthly/ Semi-Monthly	All Year	E-LAB
Milk	I-131	Monthly/ Semi-Monthly	All Year	E-LAB
Fish	Gamma	Semi-Annually	Spring	CERML
Fish	Gamma	Semi-Annually	Fall	TBE
Sediment	Gamma	Semi-Annually	Spring	CERML
Sediment	Gamma	Semi-Annually	Fall	TBE
Fruits & Vegetables	Gamma	In Season	All Year	CERML /TBE*
Soil	Gamma	Annually	All Year	E-LAB

*TBE data for pumpkin sample irrigated with Susquehanna River water collected from 13G2 and 11D1 on 10/16/02.

Direct Radiation Monitoring

The only change to direct radiation monitoring was the change in the name of TLD location 12B4 from the "Shultz Farm" to the "Berger Farm" and the change in the name of TLD location 2B3 from "Durabond Corporation" to "Leggett and Platt".

Air Monitoring

There were no changes to the air monitoring program during 2002.

Milk Monitoring

Milk monitoring at the Drasher Farm (REMP location 10D3) was discontinued in July 2002 and replaced by the Berger Farm (REMP location 12B2). During the period of April through June 2002, duplicate milk monitoring occurred at the Drasher and Berger Farms. The Berger Farm is closer to the SSES (1.7 miles) than the Drasher Farm (3.5 miles).

Ground Water Monitoring

There were no changes to the ground water monitoring program during 2002.

Fruits & Vegetables

There were no changes to the fruit and vegetable monitoring program during 2002. Because of the milk monitoring that is performed, there is no requirement to sample from gardens that have a potential for the deposition of activity by way of the airborne pathway. Fruits and vegetables are sampled from locations that irrigate with water taken from the Susquehanna River downstream from the SSES diffuser.

APPENDIX B

2002 REMP MONITORING SCHEDULE (SAMPLING AND ANALYSIS)

TABLE 1
(Page 1 of 2)

**Annual Analytical Schedule for the
PP&L Susquehanna Steam Electric Station
Radiological Environmental Monitoring Program - 2002**

Media & Code	No. of Locations	Sample Freq.(a)	Analyses Required	Analysis Freq. (b)
Airborne Particulates	6	W	Gross Beta (c) Gamma Spectrometry	W QC
Airborne Iodine	6	W	I-131	W
Sediment	4	SA	Gamma Spectrometry	SA
Fish	2	SA	Gamma Spectrometry	SA
	1	A	(on edible portion)	
Surface Water (d)	5	MC, M, or BWC	Gross Beta I-131 Gamma Spectroscopy Tritium	M BW M M
Well (ground) Water	3	M	Gamma Spectroscopy Tritium	M M
Drinking Water (e)	1	MC, BWC	Gross Alpha Gross Beta I-131 Gamma Spectrometry Tritium	M M BW M M
Cow Milk	4 ^(f) 5 ^(f)	M, SM ^(f)	I-131 Gamma Spectrometry	SM, M SM, M
Food Products (Various Fruits and Vegetables)	3	A	Gamma Spectrometry	A
Soil	4	A	Gamma Spectrometry	A
Direct Radiation	84	Q	TLD	Q

Note: See footnotes at end of table.

Appendix B

- (a) W = weekly, BW = biweekly, BWC = biweekly composite, M = monthly, SM = semi-monthly, Q = quarterly, QC = quarterly composite, SA = semi-annually, A = annually, MC = monthly composite.
- (b) Codes are the same as for sample frequency.
- (c) If the gross beta activity were greater than 10 times the yearly mean of the control sample, gamma analysis would be performed on the individual filter. Gross beta analysis was performed 24 hours or more following filter change to allow for radon and thoron daughter decay.
- (d) Locations 6S6, 6S7, and 2S7 were checked at least weekly to ensure that the automatic composite samplers were operational. Time proportional sampling was performed at locations 6S6, 6S7 and 2S7 the entire year. Station 6S5 was grab sampled weekly. Individual composites of the weekly samples were made both monthly (MC) and biweekly (BWC) for analysis.
- (e) Water from location 12H2 was retrieved weekly. Composite samples of the weekly collections at this location were made both monthly (MC) and biweekly (BWC) for analysis. Sampling at 12H2 was performed using an automatic continuous sampler (ACS) that was operated in the time proportional mode.
- (f) Locations 10D1, 10D2, 10G1, and 12B2 were sampled semi-monthly from April through October. Location 10D3 was sampled semi-monthly from April through June then discontinued.

APPENDIX C

2002 REMP MONITORING LOCATION DESCRIPTIONS

TABLE C 1**(Page 1 of 5)**

**TLD Locations for the SSES
Radiological Environmental Monitoring Program – 2002**

Less Than One Mile from the SSES^(a) - See Figure 2

Location Code(b)	Distance (miles)	Direction	Description
1S2	0.2	N	Perimeter Fence
2S2	0.9	NNE	Energy Information Center
2S3	0.2	NNE	Perimeter Fence
3S2	0.5	NE	SSES Backup Met Tower
3S3	0.9	NE	ANSP Riverlands Garden
3S4	0.3	NE	Perimeter Fence
4S3	0.2	ENE	Post, West of SSES APF
4S6	0.7	ENE	Riverlands
5S4	0.8	E	West of Environmental Laboratory
5S7	0.3	E	Perimeter Fence
6S4	0.2	ESE	Perimeter Fence (north)
6S9	0.2	ESE	Perimeter Fence (south)
7S6	0.2	SE	Perimeter Fence
7S7	0.4	SE	End of Kline's Road
8S2	0.2	SSE	Perimeter Fence
9S2	0.2	S	Security Fence
10S1	0.4	SSW	Post - south of switching station
10S2	0.2	SSW	Security Fence
10S3	0.6	SSW	Confer's Lane – east of Confer's Lane, south of Towers Club
11S3	0.3	SW	Security Fence
11S7	0.4	SW	SSES Access Road Gate #50
12S1	0.4	WSW	SSES West Building

Appendix C

TABLE C 1
(Page 2 of 5)

**TLD Locations for the SSES
Radiological Environmental Monitoring Program – 2002**

Less Than One Mile from the SSES^(a) - See Figure 2

Location Code (b)	Distance (miles)	Direction	Description
12S3	0.4	WSW	Perimeter Fence
12S4	0.4	WSW	Perimeter Fence
12S5	0.4	WSW	Perimeter Fence
12S6	0.4	WSW	Perimeter Fence
13S2	0.4	W	Perimeter Fence
13S4	0.4	W	Perimeter Fence
13S5	0.4	W	Perimeter Fence
13S6	0.4	W	Former Laydown Area - west of Confer's Lane
14S5	0.5	WNW	Beach Grove Road/Confer's Lane
14S6	0.7	WNW	Beach Grove Road (pole)
15S5	0.4	NW	Perimeter Fence
16S1	0.3	NNW	Perimeter Fence (east)
16S2	0.3	NNW	Perimeter Fence (west)
6A4	0.6	ESE	Restaurant (U.S. Route 11)
8A3	0.9	SSE	PPL Wetlands Sign (U. S. Route 11)
15A3	0.9	NW	Hosler Residence
16A2	0.8	NNW	Benkinney Residence

From One to Five Miles from the SSES^(a) - See Figure 3

12S7	1.1	WSW	Kisner Residence
1B1	1.4	N	Mingle Inn Road
2B3	1.3	NNE	Leggett & Platt
2B4	1.4	NNE	U.S. Route 11/Mingle Inn Road Intersection
5B3	1.6	E	PPL Switchyard
7B2	1.5	SE	Heller's Orchard Store
8B2	1.4	SSE	Lawall Residence

TABLE C 1
(Page 3 of 5)

TLD Locations for the SSES
Radiological Environmental Monitoring Program – 2002

From One to Five Miles from the SSES^(a) - See Figure 3

Location Code (b)	Distance (miles)	Direction	Description
9B1	1.3	S	Transmission Line - east of Route 11
10B2	2.0	SSW	Algatt Residence
10B3	1.7	SSW	Castek Inc.
10B4	1.4	SSW	U. S. Route 11/River Road Intersection
12B4	1.7	WSW	Berger Farm
13B1	1.3	W	Walker Run Creek (Tele. Pole #36)
14B3	1.3	WNW	Moskaluk Residence
15B1	1.7	NW	Country Estates Trailer Park
16B2	1.7	NNW	Walton Power Line
11C1	2.0	SW	Salem Township Fire Company
1D5	4.0	N	Shickshinny/Mocanaqua Sewage Treatment Plt.
6D1	3.5	ESE	St. Peters Church – Hobbie
8D3	4.0	SSE	Mowry Residence
9D4	3.6	S	Country Folk Store
10D1	3.0	SSW	R. & C. Ryman Farm
12D2	3.7	WSW	Dagostin Residence
14D1	3.6	WNW	Moore's Hill/Mingle Inn Roads Intersection
3E1	4.7	NE	Webb Residence - Lilly Lake
4E2	4.7	ENE	Ruckles Hill/Pond Hill Roads Intersection
5E2	4.5	E	Bloss Farm
6E1	4.7	ESE	St. James Church

Appendix C

TABLE C 1
(Page 4 of 5)

**TLD Locations for the SSES
Radiological Environmental Monitoring Program – 2002**

From One to Five Miles from the SSES^(a) - See Figure 3

Location Code (b)	Distance (miles)	Direction	Description
7E1	4.2	SE	Harwood Transmission Line Pole #2
11E1	4.7	SW	Thomas Residence
12E1	4.7	WSW	Berwick Hospital
13E4	4.1	W	Kessler Farm

Greater than Five Miles from the SSES^(a) - See Figure 4

2F1	5.9	NNE	St. Adalberts Cemetery
8F2	8.5	SSE	Huff Residence
12F2	5.2	WSW	Berwick Substation
15F1	5.4	NW	Zawatski Farm
16F1	7.8	NNW	Hidlay Residence
3G4	17	NE	Wilkes Barre Service Center
4G1	14	ENE	Mountaintop - Crestwood Industrial Park
6G1	13.5	ESE	Freeland Substation
7G1	14	SE	Hazleton PP&L Complex
7G2	12	SE	Hazleton Cemetery - 14th Street
8G1	12	SSE	PPL SFC - Humbolt Industrial Park
12G1	15	WSW	PPL Service Center, Bloomsburg
12G4	10	WSW	Naus Residence

TABLE C 1
(Page 5 of 5)**TLD Locations for the SSES**
Radiological Environmental Monitoring Program – 2002

- a) All distances from the SSES to monitoring locations are measured from the standby gas treatment vent at 44200/N34117 (Pa. Grid System). The location codes are based on both distance and direction from the SSES. The letters in the location codes indicate if the monitoring locations are on site (within the site boundary) or, if they are not on site, the approximate distances of the locations from the SSES as described below:

S - on site	E - 4-5 miles
A - <1 mile	F - 5-10 miles
B - 1-2 miles	G - 10-20 miles
C - 2-3 miles	H - >20 miles
D - 3-4 miles	

The numbers preceding the letters in the location codes provide the directions of the monitoring locations from the SSES by indicating the sectors in which they are located. A total of 16 sectors (numbered 1 through 16) equally divide an imaginary circle on a map of the SSES and its vicinity, with the SSES at the center of the circle. The middle of sector 1 is directed due north (N). Moving clockwise from sector 1, the sector immediately adjacent to sector 1 is sector 2, the middle of which is directed due north, northeast (NNE). Continuing to move clockwise, the sector numbers increase to 16, which is the north, northwest sector.

The numbers following the letters in the location codes are used to differentiate sampling locations found in the same sectors at approximately the same distances from the SSES.

Appendix C

TABLE C 2
(Page 1 of 4)

Sampling Locations for the SSES
Radiological Environmental Monitoring Program – 2002

Less Than One Mile from the SSES^(a) - See Figure 5

Location Code	Distance (miles)	Direction	Description
SURFACE WATER			
2S7	0.1	NNE	Cooling Tower Blowdown Line
6S5	0.9	ESE	Outfall Area
6S6	0.8	ESE	River Water Intake Line
6S7	0.4	ESE	Cooling Tower Blowdown Line (alternate for 2S7)
LTAW		NE - ESE	Lake Took-A-While (on site)
FISH			
LTAW		NE - ESE	Lake Took-A-While (on site)
SEDIMENT(c)			
LTAW		NE - ESE	Lake Took-A-While (on site)
AIR			
3S2	0.5	NE	SSES Backup Meteorological Tower
12S1	0.4	WSW	SSES West Building
13S6	0.4	W	Former Laydown Area, West of Confers Lane
SOIL			
3S2	0.5	NE	SSES Backup Meteorological Tower
12S1	0.4	WSW	SSES West Building
13S6	0.4	W	Former Laydown Area, West of Confers Lane

TABLE C 2
(Page 2 of 4)

**Sampling Locations for the SSES
Radiological Environmental Monitoring Program – 2002**

Less Than One Mile from the SSES^(a) - See Figure 5

Location Code	Distance (miles)	Direction	Description
GROUND WATER			
2S2	0.9	NNE	Energy Information Center
4S4	0.5	ENE	Training Center
From One to Five Miles From the SSES - See Figure 6			
FISH^(b)			
IND	0.9 - 1.4	ESE	At or Below the SSES Discharge Diffuser
SEDIMENT^(c)			
2B	1.6	NNE	Gould Island
7B	1.2	SE	Bell Bend
AIR			
12E1	4.7	WSW	Berwick Hospital
MILK			
10D1	3.0	SSW	R. & C. Ryman Farm
10D2	3.1	SSW	Raymond Ryman Farm
10D3	3.5	SSW	C. & K. Drasher Farm
12B2	1.7	WSW	Berger Farm
FRUITS/VEGETABLES			
11D1	3.3	SW	Zehner Farm

TABLE C 2
(Page 3 of 4)

**Sampling Locations for the SSES
Radiological Environmental Monitoring Program - 2002**

Greater than Five Miles from the SSES^(a) - See Figure 7

Location Code	Distance (miles)	Direction	Description
DRINKING WATER			
12H2	26	WSW	Danville Water Co. (treated)
FISH^(b)			
2H	30	NNE	Near Falls, Pa.
SEDIMENT^(c)			
12F	6.9	WSW	Old Berwick Test Track
AIR			
6G1	13.5	ESE	Freeland Substation
8G1	12	SSE	PPL SFC - Humbolt Industrial Park
SOIL			
8G1	12	SSE	PPL SFC - Humbolt Industrial Park
MILK			
10G1	14	SSW	Davis Farm
FRUITS/VEGETABLES			
12F7	8.3	WSW	Lupini Farm
13G2	16	W	Kile Farm
GROUND WATER			
12F3	5.2	WSW	Berwick Water Company

TABLE C 2
(Page 4 of 4)

Sampling Locations for the SSES
Radiological Environmental Monitoring Program – 2002

- a) All distances from the SSES to monitoring locations are measured from the standby gas treatment vent at 44200/N34117 (Pa. Grid System). The location codes are based on both distance and direction from the SSES. The letters in the location codes indicate if the monitoring locations are on site (within the site boundary) or, if they are not on site, the approximate distances of the locations from the SSES as described below:

S - on site	E - 4-5 miles
A - <1 mile	F - 5-10 miles
B - 1-2 miles	G - 10-20 miles
C - 2-3 miles	H - >20 miles
D - 3-4 miles	

The numbers preceding the letters in the location codes provide the directions of the monitoring locations from the SSES by indicating the sectors in which they are located. A total of 16 sectors (numbered 1 through 16) equally divide an imaginary circle on a map of the SSES and its vicinity, with the SSES at the center of the circle. The middle of sector 1 is directed due north (N). Moving clockwise from sector 1, the sector immediately adjacent to sector 1 is sector 2, the middle of which is directed due north, northeast (NNE). Continuing to move clockwise, the sector numbers increase to 16, which is the north, northwest sector.

The numbers following the letters in the location codes are used to differentiate sampling locations found in the same sectors at approximately the same distances from the SSES.

- b) No actual location is indicated since fish are sampled over an area which extends through 3 sectors (5, 6, 7) near the outfall area.
- c) No permanent locations exist; samples are taken based on availability. Consequently, it is not necessary to assign a number following the letter in the location code.

APPENDIX D

2002 LAND USE CENSUS RESULTS

2002 LAND USE CENSUS RESULTS

The SSES Technical Requirements require that a census be conducted annually during the growing season to determine the location of the nearest milk animal, residence and garden greater than 50 m² (approx. 500 ft²) producing broad leaf vegetation within a distance of 8 km (approx. 5 miles) in each of the 16 meteorological sectors surrounding the SSES. To comply with this requirement, a land-use census was conducted for the SSES during 2002.

A comparison of the 2001 and 2002 Land Use Census results for the Susquehanna SES indicates the changes listed in the tables below. Tables 1 and 2 display the changes in the nearest dairy animal and nearest gardens from 2001 to 2002. It should be noted that milk sampling at the Berger farm (Table 1, REMP location 12B2) began in the spring of 2002. Milk monitoring at the Drasher farm (REMP location 10D3) was discontinued in July 2002 and replaced by the Berger farm. During the period of April through June 2002, duplicate milk monitoring occurred at the Drasher and Berger farms. The Berger farm is closer to the SSES (1.7 miles) than the Drasher farm (3.5 miles). The Berger farm is identified by the REMP location designation code 12B2.

Table 3 identifies the changes in the other foods produced at the nearest gardens in certain sectors and the nearest residence in one sector from 2001 to 2002. Table 4 identifies the only change in irrigated foods from 2001 to 2002.

Sector/ Direction	2001		2002	
	Owner's Name	Distance from SSES (mi.)	Owner's Name	Distance from SSES (mi.)
12/WSW	None	N/A	Berger*	1.7

*Note that the meat of cows may be consumed at this location.

Sector/ Direction	2001		2002	
	Owner's Name	Distance from SSES (mi.)	Owner's Name	Distance from SSES (mi.)
4/ENE	Glova	3.6	Dennis	2.4
8/SSE	Roinick	2.6	Dawson	1.5

Appendix D

Sector/ Direction	Census Category	Owner	Distance from SSES (mi.)	2001 Food Items	2002 Food Items
4/ENE	Garden	Dennis	2.4	None	Sheep, Geese, Chickens, Eggs, & Turkeys
5/E	Residence/ Garden	Koslowski & Witts	1.4	None	Steer & Chickens
15/NW	Garden	Goff	1.8	None	Sheep

These changes in gardens had no impact on the intended sampling of fruits and vegetables during 2002. Because of the milk monitoring that is performed, there is no requirement to sample from gardens that have a potential for the deposition of activity by way of the airborne pathway.

Sector/Direction	Owner	Distance from SSES (mi.)	2001	2002
12F7/WSW	Lupini Farm	8.3	Potatoes	Potatoes & Beans

Monitoring of two indicator locations did take place during 2002. Irrigation was identified as having been performed at a field where pumpkins were grown at the Zehner farm (REMP location 11D1) and at a field where potatoes and beans were grown at the Lupini farm (REMP location 12F7).

TABLE 5

Nearest residence, garden, and dairy animal in each of the 16 meteorological sectors within a 5-mile radius of the Susquehanna Steam Electric Station, 2002.

<u>SECTOR</u>	<u>DIRECTION</u>	<u>NEAREST RESIDENCE</u>	<u>NEAREST GARDEN</u>	<u>NEAREST DAIRY ANIMAL</u>
1	N	1.3 mi	3.2 mi	>5.0 mi
2	NNE	1.0 mi	2.3 mi	>5.0 mi
3	NE	0.9 mi	2.7 mi	>5.0 mi
4	ENE	2.1 mi	2.4 mi ^{a,c,d,f,l}	>5.0 mi
5	E	1.4 mi	1.4 mi ^{a,i}	4.5 mi ^{g,i}
6	ESE	0.5 mi	2.5 mi	2.7 mi
7	SE	0.5 mi	0.6 mi	>5.0 mi
8	SSE	0.6 mi	1.5 mi	>5.0 mi
9	S	1.0 mi	1.1 mi	>5.0 mi
10	SSW	0.9 mi	1.2 mi	3.0 mi ^{a,b,c,d,e,g}
11	SW	1.5 mi	1.9 mi	>5.0 mi
12	WSW	1.1 mi	1.1 mi	1.7 mi
13	W	1.2 mi	1.2 mi	5.0 mi ^g
14	WNW	0.8 mi	1.3 mi	>5.0 mi
15	NW	0.8 mi	1.8 mi ^l	>5.0 mi
16	NNW	0.6 mi	4.0 mi	4.2 mi

^a Chickens raised for consumption at this location.

^b Ducks raised for consumption at this location.

^c Eggs consumed from chickens at this location.

^d Geese raised for consumption at this location.

^e Pigs raised for consumption at this location.

^f Turkeys raised for consumption at this location.

^g Fruits/vegetables raised for consumption at this location.

^h Rabbits raised for consumption at this location.*

ⁱ Beef cattle raised for consumption at this location.

^j Goats raised for consumption at this location.*

^k Pheasants raised for consumption at this location.*

^l Sheep raised for consumption at this location.

*No locations were identified as raising rabbits, goats, and pheasants during 2002.

APPENDIX E

SUMMARY DESCRIPTION OF SSES REMP ANALYTICAL METHODS

TLD MEASUREMENTS

The PPL dosimetry system used for monitoring ambient radiation levels in the environment consists of Panasonic 710A readers and Panasonic UD-814 TLDs. The UD-814 TLD badges each contain four elements. Elements 2, 3, and 4 in each badge are made of calcium sulfate with 800 mg/cm² of filtering and element 1 is composed of lithium tetraborate with filtering of 25 mg/cm². Only the calcium sulfate elements are normally used for environmental measurements because of their higher light output per unit of radiation exposure relative to the lithium tetraborate and, consequently, greater sensitivity for the detection and measurement of radiation.

Note: Element 1 would be of value in the event of an unusually large release of noble gases, especially xenon, that would produce relatively low-energy X-ray or gamma emissions. This is because the lithium tetraborate does not over-respond to such low-energy emissions as does the calcium sulfate.

The TLD element manufacturers' attempt to make each element as similar as possible to each of the other elements in each batch that is produced. Nevertheless, each element ends up somewhat different in its response to radiation. In order to minimize the effect of these inherent differences when comparing actual monitoring results for different elements, Element Correction Factors (ECFs) are determined for each element. The ECFs are used to effectively normalize the readings of the field elements placed at particular monitoring locations for given monitoring periods to the average of the readings that would be expected if so-called reference elements were to be placed simultaneously at those individual locations. Reference elements are elements that have been demonstrated to display superior measurement performance.

The selection process for reference elements involves repeatedly irradiating a large set of elements, processing them, calculating the mean response for each set of elements, and evaluating the deviation of each individual element response from the mean response. After this process has been repeated at least several times, the elements with the least variability in their responses and with mean responses nearest to the mean response of the entire population of elements are chosen as reference elements.

To determine ECFs for individual field elements, the elements are first exposed to known amounts of radiation (100 mR) and processed, a minimum of three times each. Each element reading is then divided by the mean of the readings obtained from reference elements (typically 30 to 35) that were exposed to the same amounts of radiation as the elements for which the ECFs are being determined and that were processed at the same time as these elements. The mean quotient (ratio) is then calculated for each element by summing the quotients obtained for each processing and then dividing by the total number of the processings performed.

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The following equation shows how ECFs are calculated:

$$ECF = \left[\frac{\sum_{i=1}^n \frac{E_i}{\bar{E}_{ref}}}{n} \right]$$

where

E_i = an uncorrected exposure reading for the element.

n = the total number of individual element exposures averaged.

\bar{E}_{ref} = the mean of the ECF-corrected exposure readings of the reference elements.

Irradiated control TLDs are processed (read) with the batches of TLDs from the field to provide both processing calibration information and quality control. Field control TLDs, which accompany the field TLDs when they are being taken to their monitoring locations and subsequently retrieved from these locations, and cave control TLDs, which are stored with the field TLDs for the periods between annealing and field distribution and between retrieval from the field and processing, are also read with the field TLDs to provide checks on the exposures that the field TLDs might receive on their way to and from their monitoring locations and while in storage, respectively.

The raw data from the field TLD processings is Run Calibration Factor (RCF) corrected using the irradiated control TLD data. The irradiated control TLDs are exposed to 100 mR from a cesium-137 source at the University of Michigan. The irradiated TLDs are accompanied enroute to and from the University of Michigan by transit control TLDs. An estimate of the exposures received by the irradiated TLDs in-transit is obtained by processing the transit controls and determining the transit control mean by the following equation:

$$\bar{E}_{tc} = \frac{\sum_{i=1}^n \left[\frac{E_i}{ECF_i} \right]_{tc}}{n}$$

where

\bar{E}_{tc} = the mean of the elementally corrected exposure readings of all the transit control elements.

E_i = the uncorrected exposure reading of each individual transit control element.

ECF_i = the elemental correction factor of each individual transit control element.

n = the total number of individual element exposures averaged.

The mean of the transit control exposures is then subtracted from each of the elementally corrected exposures of the irradiated elements to obtain the net exposures for each element resulting from the irradiation. The mean of these net exposures is then divided by the known exposure (100 mR) from the irradiation to determine the RCF. The following equation describes the calculations performed:

$$RCF = \frac{\left[\frac{\sum_{i=1}^n \left(\frac{E_i}{ECF_i} - \bar{E}_{ic} \right)}{n} \right]}{KE_{ic}}$$

where

RCF = the run correction factor for an individual field monitoring element.

E_i = the exposure reading of each individual irradiated control element.

ECF_i = the elemental correction factor of each individual irradiated control element.

n = the total number of individual element exposures averaged.

KE_{ic} = the known exposure for each of the irradiated control elements.

Exposure readings for individual field monitoring elements are corrected using the appropriate mean transit exposure and the elemental and run correction factors as follows:

$$CE_x = \frac{UE_x - \bar{E}_{TC}}{ECF_x \times RCF_x}$$

where

CE_x = the corrected exposure reading for field monitoring element x.

UE_x = the uncorrected exposure reading for field monitoring element x.

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ECF_x = the elemental correction factor for field monitoring element x.

\bar{E}_{TC} = mean transit exposure

RCF_x = the run correction factor for field monitoring element x.

NOTE: The mean transit exposure is determined from the elements of the TLDs that accompany the field TLDs during transportation to and from the field locations.

The exposure representing each environmental monitoring location and monitoring period is normally the mean of the corrected exposure readings for a total of six calcium sulfate elements, three from each of two different TLDs at each location. The following equation shows the calculation of this exposure:

$$\bar{E}_c = \frac{\sum_{i=1}^n CE_i}{n}$$

where

\bar{E}_c = the mean of the corrected exposure readings for a given monitoring location and period.

CE_i = the corrected exposure reading of an individual element for a given monitoring location and period.

n = the total number of individual element exposures averaged.

The mean of the corrected exposure readings for a given location and period may be calculated using less than the six calcium sulfate elements if the reading from one of the elements is more than two standard deviations from the mean. In this situation, the mean would be recalculated with only five element readings, excluding the element reading that was more than two standard deviations from the originally calculated mean. The mean may be automatically calculated by the dosimetry software with as few as four element readings before the data is flagged. The following calculation is used to determine the standard deviation of the corrected elemental exposure readings:

$$S_{ce} = \sqrt{\frac{\sum_{i=1}^n (CE_i - \bar{E}_c)^2}{n-1}}$$

where

S_{ce} = the standard deviation of the corrected exposure readings from a given monitoring location and period for (n-1) degrees of freedom.

\bar{E}_c = the mean of the corrected exposure readings for a given monitoring location and period.

CE_i = the corrected exposure reading of an individual element for a given monitoring location and period.

n = the total number of individual element exposures averaged.

The standard monitoring period for the reporting of TLD exposures is the calendar quarter. The calendar quarter is defined as a period of 91.25 days. The actual monitoring periods for TLDs in the field are often for times other than 91.25 days. The means of the corrected exposures for these nonstandard periods must be normalized to the standard calendar quarter. The following equation shows how the normalization is performed:

$$NE = \frac{\bar{E}_c \times 91.25}{MP}$$

where

NE = mean corrected exposure normalized to a standard calendar quarter of 91.25 days.

\bar{E}_c = the mean of the corrected exposure readings for a given monitoring location and period.

MP = the actual TLD monitoring period (time in the field) in days.

TLD DATA INTERPRETATION

Pre-operational and operational data are compared for the purpose of determining whether or not TLD data may indicate a dose contribution from SSES operation. Between 1979 and 1994, both TLD types and TLD processing systems changed more than once. In order to avoid possible confusion in data interpretation as a result of these changes, ratios of TLD doses for specific indicator locations to the average of the TLD doses for control locations from operational periods compared to their counterparts from the preoperational period. Comparison of these ratios is performed in lieu of comparing the actual operational and preoperational doses. The following equation shows how these ratios are calculated:

$$r_i = d_i \div \bar{d}_c$$

where

r_i = the indicator-to-control-average dose ratio for a particular location and calendar quarter,

d_i = the quarterly dose for a particular indicator location, and

\bar{d}_c = the average quarterly dose for certain control locations.

Note:

The r_i are the quotients of the indicator doses to the average doses of the following control locations: 3G4, 4G1, 7G1, 12G1, and 12G4. Only these control locations are used because they were the only ones existing during the preoperational period.

Operational r_i for indicator locations that do not have preoperational histories are compared with the range of preoperational control-to-control-average dose ratios (r_c) experienced at control locations. It can be safely assumed that the preoperational range of these r_c at control locations are the result of variations in the levels of background radiation at those locations. Any operational indicator r_i for an indicator location without a preoperational history that is above the uppermost range expected at control locations based on preoperational data is assumed to suggest a possible contribution from the SSES operation. The following equation shows how r_c is calculated:

$$r_c = d_c + \bar{d}_c$$

where

r_c - is the control-to-control-average dose ratio for a particular location and calendar quarter,

d_c - is the quarterly dose for a particular control location, and

\bar{d}_c - is the average quarterly dose for certain control locations.

Flagging Environmental TLD Measurements for Possible Non-Natural Dose Contributions

Confidence ranges, within which 95% of environmental TLD doses resulting from natural, background radiation are expected to be, have been derived for each location with a preoperational history by multiplying the standard deviation (S) of the r_i for the location by the appropriate t score (t) based on the applicable degrees of freedom for each location. (Degrees of freedom (df) are equal to the number of ratios that were averaged less one.) The product of the t score and the standard deviation (tS) was then subtracted from the mean (\bar{x}) to determine the lower end of the 95% confidence range (R) and added to the mean to obtain the upper end of the range (R) as indicated by the following equation:

$$R = \left(\bar{x} - t * S \right) \text{ to } \left(\bar{x} + t * S \right)$$

The following t scores were used in the range calculations:

t SCORES	
df	$t_{0.05}$
1	12.706
2	4.303
3	3.182
4	2.776
5	2.571
6	2.447
7	2.365

For indicator locations with no preoperational history, TLD results are flagged for potential non-natural dose contributions to TLD measurements based on comparisons to the maximum expected variation in control-to-control-average dose ratios (r_c) for control locations. The expected ranges of r_c for each control location for each calendar quarter during the 1980-81 preoperational period have been calculated. The highest expected r_c for all the preoperational control locations is 1.22.

Ratios for indicator locations greater than 1.22 are flagged for possible SSES direct radiation dose contributions.

Appendix E**Calculation of SSES Attributable Direct Radiation Dose based on Onsite Indicator TLD Measurements**

For TLD locations where direct radiation dose contributions from the SSES are indicated, these calendar quarter doses are estimated based on the amounts referred to as the excess ratios. Excess ratio for each location's r_i for a particular calendar quarter is the amount by which that r_i exceeds the high end of its range of preoperational r_u . The excess ratio at a specific location is multiplied times both the average dose for control locations measured during that calendar quarter and an occupancy factor based on a reasonable estimate of the portion of the calendar quarter that a MEMBER OF THE PUBLIC might spend near an onsite TLD location. The following is a table of occupancy factors that are used:

Environmental TLD Monitoring Locations	Occupancy Factors
Onsite	4.56E-4
Offsite (other than Private Residences)	3.65E-3
Private Residences	1

The following equation is used for obtaining direct radiation doses attributable to the SSES at indicator TLD locations when preoperational data exists for those locations:

$$D_{SSES} = (r_i - r_u) \times D_{CA} \times OF$$

where

- D_{SSES} = the dose attributable to SSES fuel cycle operations,
- r_i = the indicator-to-control average ratio for a particular location and calendar quarter,
- r_u = the indicator-to-control average ratio corresponding to the upper end of the 95% confidence range for a particular location for the preoperational period, and
- D_{CA} = the average quarterly dose for control locations.
- OF = the occupancy factor.

The equation below is used for obtaining direct radiation doses attributable to the SSES at indicator locations when preoperational data **does not** exist for those locations:

$$D_{SSES} = (r_i - 1.22) \times D_{CA} \times OF$$

where

- D_{SSES} = the dose attributable to SSES fuel cycle operations,
- r_i = the indicator-to-control average ratio for a particular location and calendar quarter,
- 1.22 = the highest expected r_c for control locations due to variations in natural radiation levels based on preoperational data. Refer to location 12G4 in Attachment 1.
- D_{CA} = the average quarterly dose for control locations.
- OF = the occupancy factor.

Each year, the SSES attributable doses calculated for each calendar quarter are summed for all calendar quarters at each location to obtain annual doses by location.

Appendix E

DETERMINATION OF GROSS ALPHA AND/OR GROSS BETA ACTIVITY

TELEDYNE BROWN ENGINEERING ENVIRONMENTAL SERVICES & PPL'S CORPORATE ENVIRONMENTAL RADIOACTIVITY MEASUREMENTS LABORATORY

Aliquots of water samples are evaporated to near dryness in beakers. The remaining volumes (approximately five milliliters or less) are transferred to stainless steel planchets and evaporated to dryness.

All planchets are counted in low background gas-flow proportional counters. Calculations of both gross alpha and beta activities include the use of empirical self-absorption correction curves to account for changes in effective counting efficiency occurring as a result of changes in the masses of residue being counted.

Weekly air particulate filters are placed into planchets as received and counted in low background gas-flow proportional counters. No corrections are made for beta self-absorption when calculating the gross beta activities of the air particulate filters because of the impracticality of weighing the deposit and because the penetration depth of the deposit into the filter is unknown.

CALCULATION OF THE SAMPLE ACTIVITY

$$\frac{pCi}{\text{unit volume or mass}} = \frac{\left[\frac{C}{t} - R_b \right]}{2.22 (V)(E)} \pm \frac{2 \sqrt{\frac{C}{t} + R_b}}{2.22 (V)(E)}$$

net activity **random uncertainty**

where: C = total counts for sample
t = count time for sample/background (minutes)
R_b = background count rate of counter (cpm)
2.22 = $\frac{\text{dpm}}{\text{pCi}}$
V(M) = volume or mass of sample analyzed
E = efficiency of the counter (cpm/dpm)
4.66 = sigma level

Calculation of the Minimum Detectable Concentration (MDC) Value

$$MDC = \frac{4.66 \sqrt{\frac{R_b}{t}}}{2.22 (V) (E)}$$

RADIOCHEMICAL DETERMINATION OF I-131 IN CHARCOAL AND VEGETATION SAMPLES

TELEDYNE BROWN ENGINEERING ENVIRONMENTAL SERVICES

Radioiodine is separated from the sample matrix to periodate solution.

Charcoal filters are opened and the exposed charcoal is emptied into a refluxing flask, iodide carrier is added, and the mixture is refluxed in sodium hydroxide to remove the iodine absorbed on the charcoal and bringing it into solution. The resulting iodide solution is oxidized with hypochlorite to periodate.

Vegetation samples are chopped, iodide carrier added, the mixture evaporated to dryness, leached with sodium hydroxide, and fused in a muffle furnace. The resulting melt is dissolved in distilled water and filtered. The resulting iodide solution is oxidized with hypochlorite to periodate.

The periodate solution is reduced to iodine with hydroxylamine hydrochloride, and extracted into toluene as free iodine. The iodine is back extracted into distilled water through reduction to iodide with aqueous sodium bisulfite and is ultimately precipitated as palladium iodide. The precipitate is weighed for chemical yield and is mounted on a nylon planchet for low level beta counting.

The dried precipitate is beta counted on a low-level counter.

CALCULATION OF THE SAMPLE ACTIVITY

$$A = \frac{\left[\frac{C}{t} - R_b \right]}{2.22(V)(y)(DF)(E)} \pm \frac{2\sqrt{\frac{C + R_b}{t}}}{2.22(V)(y)(DF)(E)}$$

net activity

random uncertainty

where: A = activity concentration (pCi/l)

C = total counts from sample

t = counting time for sample (min)

R_b = background count rate of counter (cpm)

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