Entergy

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

SUBJECT: Entergy Nuclear Operations, Inc.
Pilgrim Nuclear Power Station
Docket No. 50-293
License No. DPR-35

Radiological Environmental Monitoring Program Annual Report

LETTER NUMBER: 2.04.044

Dear Sir or Madam:

In accordance with Pilgrim Nuclear Power Station Technical Specification 5.6.2, Entergy Nuclear Operations, Inc. submits the PNPS "Radiological Environmental Monitoring Program Report" for January 1 through December 31, 2003.

Should you have questions or require additional information, I can be contacted at (508) 830-8403.

This letter contains no commitments.

Sincerely,

Bryan Ford

FXM/dm
Enclosure: Pilgrim Nuclear Power Station Radiological Environmental Monitoring Program Report for January 1 through December 31, 2003.

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PILGRIM NUCLEAR POWER STATION
Facility Operating License DPR-35

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM REPORT

JANUARY 01 THROUGH DECEMBER 31, 2003

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Pilgrim Nuclear Power Station
Radiological Environmental Monitoring Program Report
January-December 2003

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EXECUTIVE SUMMARY

ENTERGY NUCLEAR
PILGRIM NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM REPORT
JANUARY 01 THROUGH DECEMBER 31, 2003

INTRODUCTION

This report summarizes the results of the Entergy Nuclear Radiological Environmental Monitoring Program (REMP) conducted in the vicinity of Pilgrim Nuclear Power Station (PNPS) during the period from January 1 to December 31, 2003. This document has been prepared in accordance with the requirements of PNPS Technical Specifications section 5.6.2.

The REMP has been established to monitor the radiation and radioactivity released to the environment as a result of Pilgrim Station's operation. This program, initiated in August 1968, includes the collection, analysis, and evaluation of radiological data in order to assess the impact of Pilgrim Station on the environment and on the general public.

SAMPLING AND ANALYSIS

The environmental sampling media collected in the vicinity of PNPS and at distant locations included air particulate filters, charcoal cartridges, seawater, shellfish, Irish moss, American lobster, fishes, sediment, milk, cranberries, vegetation, and animal forage.

During 2003, there were 1,370 samples collected from the atmospheric, aquatic and terrestrial environments. In addition, 431 exposure measurements were obtained using environmental thermoluminescent dosimeters (TLDs).

Beginning in July 2002, Pilgrim Station began to use Entergy's J.A. Fitzpatrick Environmental Laboratory for analysis of environmental samples. Initially, air particulate and charcoal samples were submitted to the JAF Lab, and other sample streams were gradually shifted over during the second half of the year. By the end of 2002, all radioanalytical services were being performed by the JAF Lab, and only TLDs were being processed by Framatome ANP. The processing of TLDs by the J.A. Fitzpatrick Environmental Laboratory was initiated in July 2003, and all TLDs were being processed by the Entergy facility by the end of 2003.

A small number of inadvertent issues were encountered during 2003 in the collection of environmental samples in accordance with the PNPS Offsite Dose Calculation Manual (ODCM). Nine out of 440 TLDs were unaccounted for during the quarterly retrieval process. However, the 431 TLDs that were collected provided the information necessary to assess ambient radiation levels in the vicinity of Pilgrim Station. Equipment failures and power outages resulted in a small number of instances in which lower than normal volumes were collected at the airborne sampling stations. In some cases, outages were of sufficient duration to yield no sample, and 566 of 572 air particulate and charcoal cartridges were collected and analyzed as required. A full description of any discrepancies encountered with the environmental monitoring program is presented in Appendix D of this report.

There were 1,432 analyses performed on the environmental media samples. Analyses were performed by the J.A. Fitzpatrick Environmental Laboratory in Fulton, New York, and the Framatome ANP Environmental Laboratory in Westborough, Massachusetts. Samples were analyzed as required by the PNPS ODCM.

LAND USE CENSUS

The annual land use census in the vicinity of Pilgrim Station was conducted as required by the PNPS ODCM between September 26 and November 17, 2003. A total of 27 vegetable gardens having an area of more than 500 square feet were identified within five kilometers (three miles) of PNPS. No new milk or meat animals were located during the census. Of the 27 garden locations identified, samples were collected at or near five of the gardens as part of the environmental monitoring program.

RADIOLOGICAL IMPACT TO THE ENVIRONMENT

During 2003, samples (except charcoal cartridges) collected as part of the REMP at Pilgrim Station continued to contain detectable amounts of naturally-occurring and man-made radioactive materials. The only environmental media collected in 2003 which showed any detectable activity attributable to PNPS operations was shellfish, which indicated low-levels of Mn-54, Co-60, and Zn-65, yielding a maximum whole body dose to the maximum-exposed member of the public of 0.0004 mrem. Offsite ambient radiation measurements using environmental TLDs beyond the site boundary ranged between 50 and 84 milliRoentgens per year. The range of ambient radiation levels observed with the TLDs is consistent with natural background radiation levels for Massachusetts as determined by the Environmental Protection Agency (EPA).

RADIOLOGICAL IMPACT TO THE GENERAL PUBLIC

During 2003, radiation doses to the general public as a result of Pilgrim Station's operation continued to be well below the federal limits and much less than the dose due to other sources of man-made (e.g., X-rays, medical, fallout) and naturally-occurring (e.g., cosmic, radon) radiation.

The calculated total body dose to the maximally exposed member of the general public from radioactive effluents and ambient radiation resulting from PNPS operations for 2003 was about 2.2 mrem for the year. This conservative estimate is well below the EPA's annual dose limit to any member of the general public and is a fraction of a percent of the typical dose received from natural and man-made radiation.

CONCLUSIONS

The 2003 Radiological Environmental Monitoring Program for Pilgrim Station resulted in the collection and analysis of hundreds of environmental samples and measurements. The data obtained were used to determine the impact of Pilgrim Station's operation on the environment and on the general public.

An evaluation of direct radiation measurements, environmental sample analyses, and dose calculations showed that all applicable federal criteria were met. Furthermore, radiation levels and resulting doses were a small fraction of those that are normally present due to natural and man-made background radiation.

Based on this information, there is no significant radiological impact on the environment or on the general public due to Pilgrim Station's operation.

1.0 INTRODUCTION

The Radiological Environmental Monitoring Program for 2003 performed by Entergy Nuclear Company for Pilgrim Nuclear Power Station (PNPS) is discussed in this report. Since the operation of a nuclear power plant results in the release of small amounts of radioactivity and low levels of radiation, the Nuclear Regulatory Commission (NRC) requires a program to be established to monitor radiation and radioactivity in the environment (Reference 1). This report, which is required to be published annually by Pilgrim Station's Technical Specifications section 5.6.2, summarizes the results of measurements of radiation and radioactivity in the environment in the vicinity of the Pilgrim Station and at distant locations during the period January 1 to December 31, 2003.

The Radiological Environmental Monitoring Program consists of taking radiation measurements and collecting samples from the environment, analyzing them for radioactivity content, and interpreting the results. With emphasis on the critical radiation exposure pathways to humans, samples from the aquatic, atmospheric, and terrestrial environments are collected. These samples include, but are not limited to: air, soil, seawater, shellfish, lobster, fishes, milk, cranberries, vegetables, and forage. Thermoluminescent dosimeters (TLDs) are placed in the environment to measure gamma radiation levels. The TLDs are processed and the environmental samples are analyzed to measure the very low levels of radiation and radioactivity present in the environment as a result of PNPS operation and other natural and man-made sources. These results are reviewed by PNPS's radiological staff and have been reported semiannually or annually to the Nuclear Regulatory Commission and others since 1972.

In order to more fully understand how a nuclear power plant impacts humans and the environment, background information on radiation and radioactivity, natural and man-made sources of radiation, reactor operations, radioactive effluent controls, and radiological impact on humans is provided. It is believed that this information will assist the reader in understanding the radiological impact on the environment and humans from the operation of Pilgrim Station.

1.1 Radiation and Radioactivity

All matter is made of atoms. An atom is the smallest part into which matter can be broken down and still maintain all its chemical properties. Nuclear radiation is energy, in the form of waves or particles that is given off by unstable, radioactive atoms.

Radioactive material exists naturally and has always been a part of our environment. The earth's crust, for example, contains radioactive uranium, radium, thorium, and potassium. Some radioactivity is a result of nuclear weapons testing. Examples of radioactive fallout that is normally present in environmental samples are cesium-137 and strontium-90. Some examples of radioactive materials released from a nuclear power plant are cesium-137, iodine-131, strontium-90, and cobalt-60.

Radiation is measured in units of millirem, much like temperature is measured in degrees. A millirem is a measure of the biological effect of the energy deposited in tissue. The natural and man-made radiation dose received in one year by the average American is 300 to 400 mrem (References 2, 3, 4).

Radioactivity is measured in curies. A curie is that amount of radioactive material needed to produce 37,000,000,000 nuclear disintegrations per second. This is an extremely large amount of radioactivity in comparison to environmental radioactivity. That is why radioactivity in the environment is measured in picocuries. One picocurie is equal to one trillionth of a curie.

1.2 Sources of Radiation

As mentioned previously, naturally occurring radioactivity has always been a part of our environment. Table 1.2-1 shows the sources and doses of radiation from natural and man-made sources.

Table 1.2-1

Radiation Sources and Corresponding Doses

NATURAL		MAN-MADE	
Source	Radiation Dose (millirem/year)	Source	Radiation Dose (millirem/year)
Cosmic/cosmogenic	30	Medical/Dental X-Rays	39
Internal	40	Nuclear Medicine	14
Terrestrial	30	Consumer Products	10
Radon/Thoron	200	Weapons Fallout	1
		Nuclear Power Plants	1
Approximate Total	300	Approximate Total	60

Cosmic radiation from the sun and outer space penetrates the earth's atmosphere and continuously bombards us with rays and charged particles. Some of this cosmic radiation interacts with gases and particles in the atmosphere, making them radioactive in turn. These radioactive byproducts from cosmic ray bombardment are referred to as cosmogenic radionuclides. Isotopes such as beryllium-7 and carbon-14 are formed in this way. Exposure to cosmic and cosmogenic sources of radioactivity results in about 30 mrem of radiation dose per year.

Additionally, natural radioactivity is in our body and in the food we eat (about 40 millirem/yr), the ground we walk on (about 30 millirem/yr) and the air we breathe (about 200 millirem/yr). The majority of a person's annual dose results from exposure to radon and thoron in the air we breathe. These gases and their radioactive decay products arise from the decay of naturally occurring uranium, thorium and radium in the soil and building products such as brick, stone, and concrete. Radon and thoron levels vary greatly with location, primarily due to changes in the concentration of uranium and thorium in the soil. Residents at some locations in Colorado, New York, Pennsylvania, and New Jersey have a higher annual dose as a result of higher levels of radon/thoron gases in these areas. In total, these various sources of naturally-occurring radiation and radioactivity contribute to a total dose of about 300 mrem per year.

In addition to natural radiation, we are normally exposed to radiation from a number of man-made sources. The single largest doses from man-made sources result from therapeutic and diagnostic applications of x-rays and radiopharmaceuticals. The annual dose to an individual in the U.S. from medical and dental exposure is about 50 mrem. Consumer products, such as televisions and smoke detectors, contribute about 10 mrem/yr. Much smaller doses result from weapons fallout (less than 1 mrem/yr) and nuclear power plants (less than 1 mrem/yr). Typically, the average person in the United States receives about 60 mrem per year from man-made sources.

1.3 Nuclear Reactor Operations

Pilgrim Station generates about 700 megawatts of electricity at full power, which is enough electricity to supply the entire city of Boston, Massachusetts. Pilgrim Station is a boiling water reactor whose nuclear steam supply system was provided by General Electric Co. The nuclear station is located on a 1600-acre site about eight kilometers (five miles) east-southeast of Plymouth Center. Commercial operation began in December 1972.

Pilgrim Station was operational during most of 2003. The plant was shut down from mid-April through mid-May 2003 for a refueling outage. The resulting monthly capacity factors are presented in Table 1.3-1.

TABLE 1.3-1

PNPS OPERATING CAPACITY FACTOR DURING 2003
(Based on rated reactor thermal power)

Month	Percent Capacity
January	98.9%
February	70.1%
March	93.3%
April	58.9%
May	36.8%
June	88.8%
July	99.7%
August	98.1%
September	93.1%
October	65.9%
November	99.1%
December	99.2%
Annual Average	83.5%

Nuclear-generated electricity is produced at Pilgrim Station by many of the same techniques used for conventional oil and coal-generated electricity. Both systems use heat to boil water to produce steam. The steam turns a turbine, which turns a generator, producing electricity. In both cases, the steam passes through a condenser where it changes back into water and recirculates back through the system. The cooling water source for Pilgrim Station is the Cape Cod Bay.

The key difference between Pilgrim's nuclear power and conventional power is the source of heat used to boil the water. Conventional plants burn fossil fuels in a boiler, while nuclear plants make use of uranium in a nuclear reactor.

Inside the reactor, a nuclear reaction called fission takes place. Particles, called neutrons, strike the nucleus of a uranium-235 atom, causing it to split into fragments called radioactive fission products. The splitting of the atoms releases both heat and more neutrons. The newly-released neutrons then collide with and split other uranium atoms, thus making more heat and releasing even more neutrons, and on and on until the uranium fuel is depleted or spent. This process is called a chain reaction.

The operation of a nuclear reactor results in the release of small amounts of radioactivity and low levels of radiation. The radioactivity originates from two major sources, radioactive fission products and radioactive activation products.

Radioactive fission products, as illustrated in Figure 1.3-1 (Reference 5), originate from the fissioning of the nuclear fuel. These fission products get into the reactor coolant from their release by minute amounts of uranium on the outside surfaces of the fuel cladding, by diffusion through the fuel pellets and cladding and, on occasion, through defects or failures in the fuel cladding. These fission products circulate along with the reactor coolant water and will deposit on the internal surfaces of pipes and equipment. The radioactive fission products on the pipes and equipment emit radiation. Examples of some fission products are krypton-85 (Kr-85), strontium-90 (Sr-90), iodine-131 (I-131), xenon-133 (Xe-133), and cesium-137 (Cs-137).

Nuclear Fission

Fission is the splitting of the uranium-235 atom by a neutron to release heat and more neutrons, creating a chain reaction. Radiation and fission products are by-products of the process.

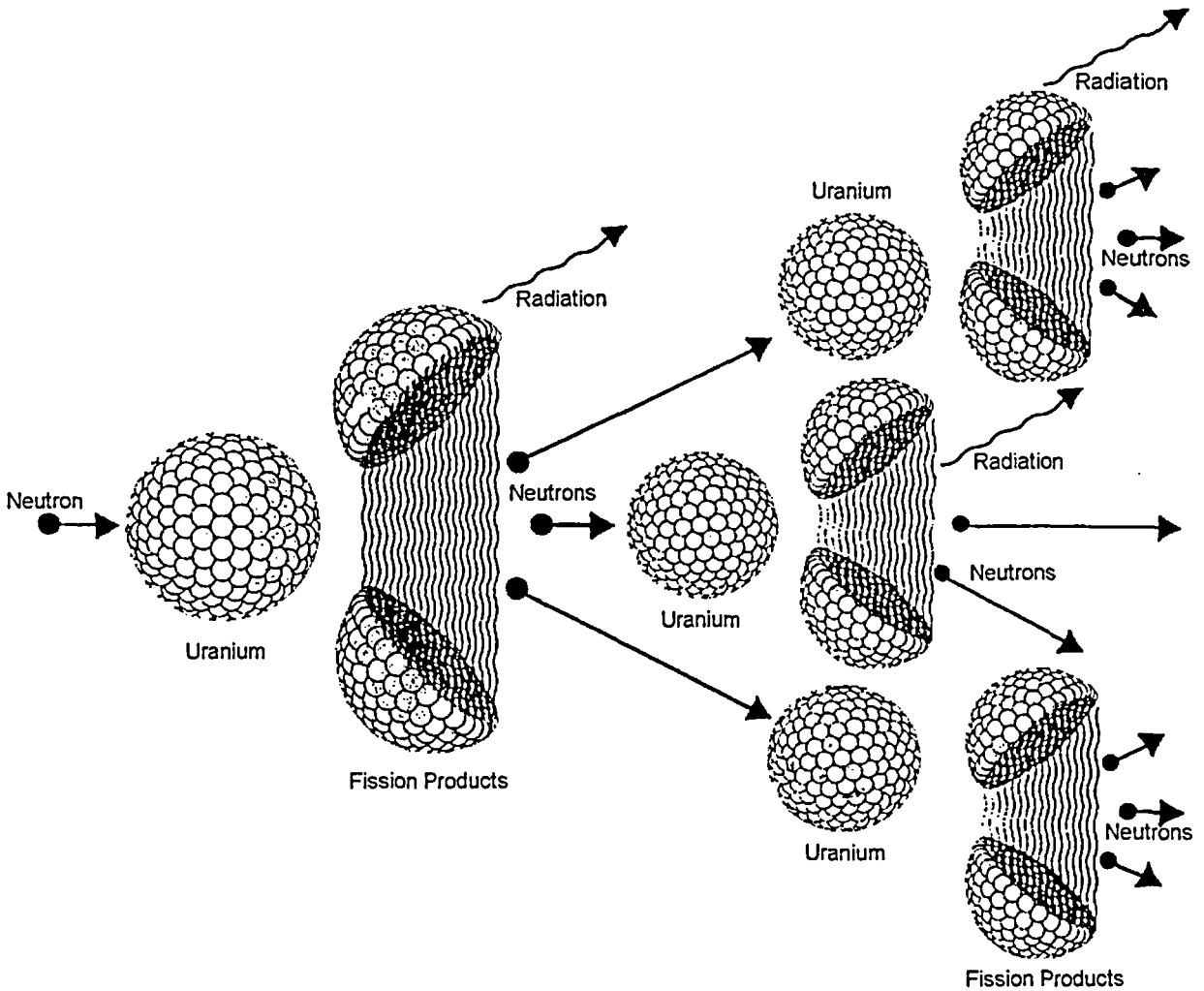


Figure 1.3-1
Radioactive Fission Product Formation

Radioactive activation products (see Figure 1.3-2), on the other hand, originate from two sources. The first is by neutron bombardment of the hydrogen, oxygen and other gas (helium, argon, nitrogen) molecules in the reactor cooling water. The second is a result of the fact that the internals of any piping system or component are subject to minute yet constant corrosion from the reactor cooling water. These minute metallic particles (for example: nickel, iron, cobalt, or magnesium) are transported through the reactor core into the fuel region, where neutrons may react with the nuclei of these particles, producing radioactive products. So, activation products are nothing more than ordinary naturally-occurring atoms that are made unstable or radioactive by neutron bombardment. These activation products circulate along with the reactor coolant water and will deposit on the internal surfaces of pipes and equipment. The radioactive activation products on the pipes and equipment emit radiation. Examples of some activation products are manganese-54 (Mn-54), iron-59 (Fe-59), cobalt-60 (Co-60), and zinc-65 (Zn-65).

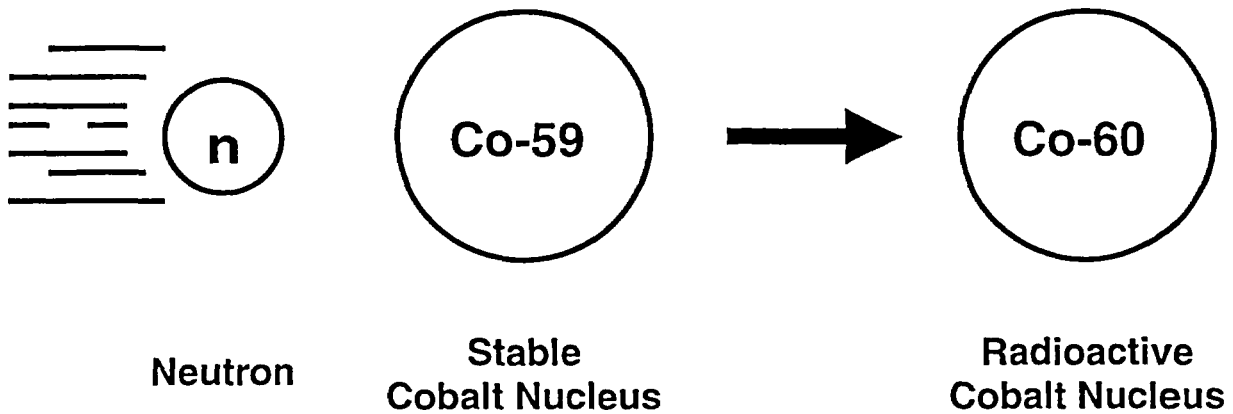


Figure 1.3-2
Radioactive Activation Product Formation

At Pilgrim Nuclear Power Station there are five independent protective barriers that confine these radioactive materials. These five barriers, which are shown in Figure 1.3-3 (Reference 5), are:

- fuel pellets;
- fuel cladding;
- reactor vessel and piping;
- primary containment (drywell and torus); and,
- secondary containment (reactor building).

SIMPLIFIED DIAGRAM OF A BOILING WATER REACTOR

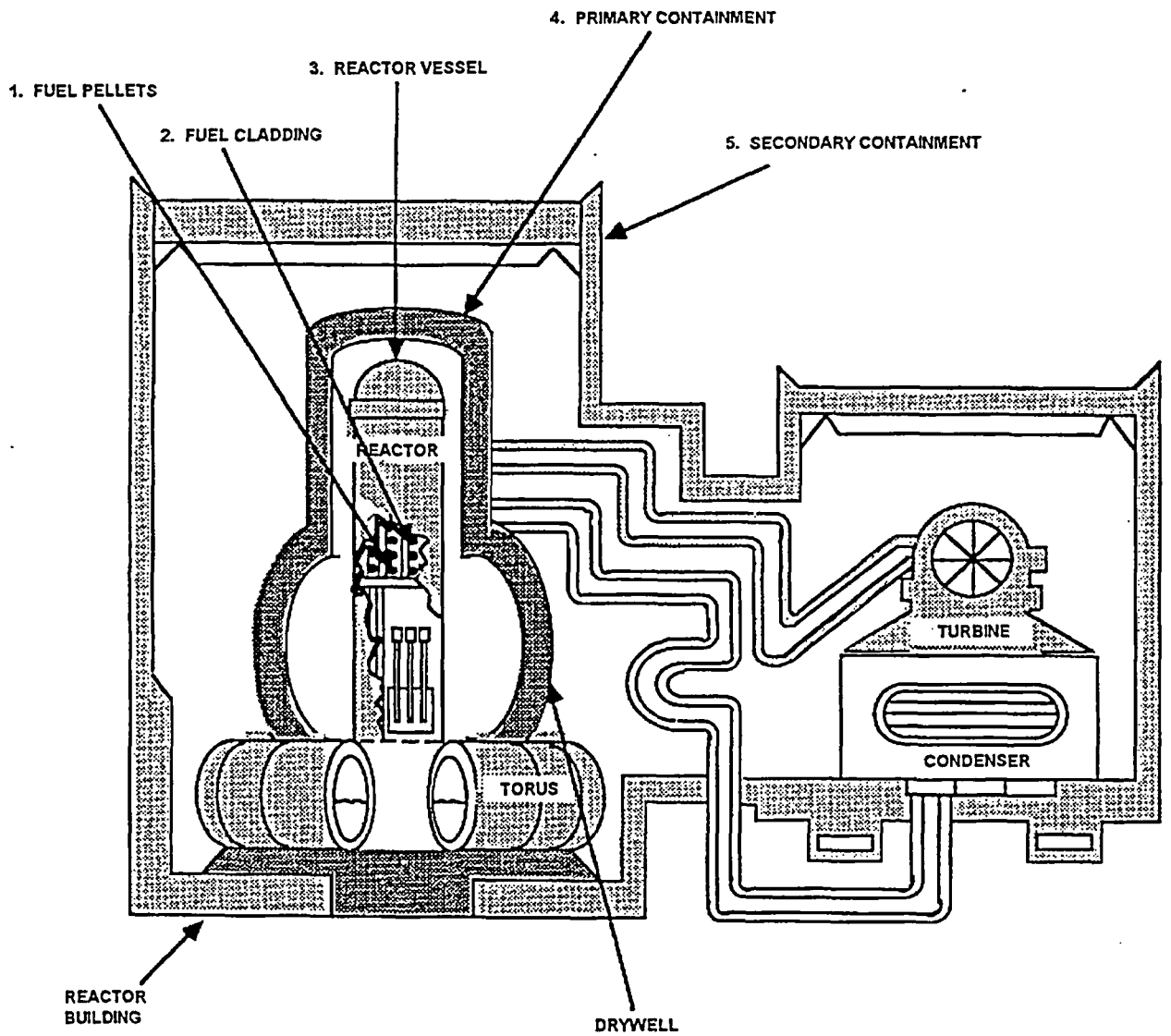


Figure 1.3-3
Barriers To Confine Radioactive Materials

The ceramic uranium fuel pellets provide the first barrier. Most of the radioactive fission products are either physically trapped or chemically bound between the uranium atoms, where they will remain. However, a few fission products that are volatile or gaseous may diffuse through the fuel pellets into small gaps between the pellets and the fuel cladding.

The second barrier, the fuel cladding, consists of zirconium alloy tubes that confine the fuel pellets. The small gaps between the fuel and the cladding contain the noble gases and volatile iodines that are types of radioactive fission products. This radioactivity can diffuse to a small extent through the fuel cladding into the reactor coolant water.

The third barrier consists of the reactor pressure vessel, steel piping and equipment that confine the reactor cooling water. The reactor pressure vessel, which holds the reactor fuel, is a 65-foot high by 19-foot diameter tank with steel walls about nine inches thick. This provides containment for radioactivity in the primary coolant and the reactor core. However, during the course of operations and maintenance, small amounts of radioactive fission and activation products can escape through valve leaks or upon breaching of the primary coolant system for maintenance.

The fourth barrier is the primary containment. This consists of the drywell and the torus. The drywell is a steel lined enclosure that is shaped like an inverted light bulb. An approximately five foot thick concrete wall encloses the drywell's steel pressure vessel. The torus is a donut-shaped pressure suppression chamber. The steel walls of the torus are nine feet in diameter with the donut itself having an outside diameter of about 130 feet. Small amounts of radioactivity may be released from primary containment during maintenance.

The fifth barrier is the secondary containment or reactor building. The reactor building is the concrete building that surrounds the primary containment. This barrier is an additional safety feature to contain radioactivity that may escape from the primary containment. This reactor building is equipped with a filtered ventilation system that is used when needed to reduce the radioactivity that escapes from the primary containment.

The five barriers confine most of the radioactive fission and activation products. However, small amounts of radioactivity do escape via mechanical failures and maintenance on valves, piping, and equipment associated with the reactor cooling water system. The small amounts of radioactive liquids and gases that do escape the various containment systems are further controlled by the liquid purification and ventilation filtration systems. Also, prior to a release to the environment, control systems exist to collect and purify the radioactive effluents in order to reduce releases to the environment to as low as is reasonably achievable. The control of radioactive effluents at Pilgrim Station will be discussed in more detail in the next section.

1.4 Radioactive Effluent Control

The small amounts of radioactive liquids and gases that might escape the five barriers are purified in the liquid and gaseous waste treatment systems, then monitored for radioactivity, and released only if the radioactivity levels are below the federal release limits.

Radioactivity released from the liquid effluent system to the environment is limited, controlled, and monitored by a variety of systems and procedures which include:

- reactor water cleanup system;
- liquid radwaste treatment system;
- sampling and analysis of the liquid radwaste tanks; and,
- liquid waste effluent discharge header radioactivity monitor.

The purpose of the reactor water cleanup system is to continuously purify the reactor cooling water by removing radioactive atoms and non-radioactive impurities that may become activated by neutron bombardment. A portion of the reactor coolant water is diverted from the primary coolant system and is directed through ion exchange resins where radioactive elements, dissolved and suspended in the water, are removed through chemical processes. The net effect is a substantial reduction of the radioactive material that is present in the primary coolant water and consequently the amount of radioactive material that might escape from the system.

Reactor cooling water that might escape the primary cooling system and other radioactive water sources are collected in floor and equipment drains. These drains direct this radioactive liquid waste to large holdup tanks. The liquid waste collected in the tanks is purified again using the liquid radwaste treatment system, which consists of a filter and ion exchange resins.

Processing of liquid radioactive waste results in large reductions of radioactive liquids discharged into Cape Cod Bay. Of all wastes processed through liquid radwaste treatment, 90 to 95 percent of all wastes are purified and the processed liquid is re-used in plant systems.

Prior to release, the radioactivity in the liquid radwaste tank is sampled and analyzed to determine if the level of radioactivity is below the release limits and to quantify the total amount of radioactive liquid effluent that would be released. If the levels are below the federal release limits, the tank is drained to the liquid effluent discharge header.

This liquid waste effluent discharge header is provided with a shielded radioactivity monitor. This detector is connected to a radiation level meter and a strip chart recorder in the Control Room. The radiation alarm is set so that the detector will alarm before radioactivity levels exceed the release limits. The liquid effluent discharge header has an isolation valve. If an alarm is received, the liquid effluent discharge valve will automatically close, thereby terminating the release to the Cape Cod Bay and preventing any liquid radioactivity from being released that may exceed the release limits. An audible alarm notifies the Control Room operator that this has occurred.

Some liquid waste sources which have a low potential for containing radioactivity, and/or may contain very low levels of contamination, may be discharged directly to the discharge canal without passing through the liquid radwaste discharge header. One such source of liquids is the neutralizing sump. However, prior to discharging such liquid wastes, the tank is thoroughly mixed and a representative sample is collected for analysis of radioactivity content prior to being discharged.

Another means for adjusting liquid effluent concentrations to below federal limits is by mixing plant cooling water from the condenser with the liquid effluents in the discharge canal. This larger volume of cooling water further dilutes the radioactivity levels far below the release limits.

The preceding discussion illustrates that many controls exist to reduce the radioactive liquid effluents released to the Cape Cod Bay to as far below the release limits as is reasonably achievable.

Radioactive releases from the radioactive gaseous effluent system to the environment are limited, controlled, and monitored by a variety of systems and procedures which include:

- reactor building ventilation system;
- reactor building vent effluent radioactivity monitor;
- sampling and analysis of reactor building vent effluents;
- standby gas treatment system;
- main stack effluent radioactivity monitor and sampling;
- sampling and analysis of main stack effluents;
- augmented off-gas system;
- steam jet air ejector (SJAE) monitor; and,
- off-gas radiation monitor.

The purpose of the reactor building ventilation system is to collect and exhaust reactor building air. Air collected from contaminated areas is filtered prior to combining it with air collected from other parts of the building. This combined airflow is then directed to the reactor building ventilation plenum that is located on the side of the reactor building. This plenum, which vents to the atmosphere, is equipped with a radiation detector. The radiation level meter and strip chart recorder for the reactor building vent effluent radioactivity monitor is located in the Control Room. To supplement the information continuously provided by the detector, air samples are taken periodically from the reactor building vent and are analyzed to quantify the total amount of tritium and radioactive gaseous and particulate effluents released.

If air containing elevated amounts of noble gases is routed past the reactor building vent's effluent radioactivity monitor, an alarm will alert the Control Room operators that release limits are being approached. The Control Room operators, according to procedure, will isolate the reactor building ventilation system and initiate the standby gas treatment system to remove airborne particulates and gaseous halogen radioactivity from the reactor building exhaust. This filtration assembly consists of high-efficiency particulate air filters and charcoal adsorber beds. The purified air is then directed to the main stack. The main stack has dilution flow that further reduces concentration levels of gaseous releases to the environment to as far below the release limits as is reasonably achievable.

The approximately 335 foot tall main stack has a special probe inside it that withdraws a portion of the air and passes it through a radioactivity monitoring system. This main stack effluent radioactivity monitoring system continuously samples radioactive particulates, iodines, and noble gases. Grab samples for a tritium analysis are also collected at this location. The system also contains radioactivity detectors that monitor the levels of radioactive noble gases in the stack flow and display the result on radiation level meters and strip chart recorders located in the Control Room. To supplement the information continuously provided by the detectors, the particulate, iodine, tritium, and gas samples are analyzed periodically to quantify the total amount of radioactive gaseous effluent being released.

The purpose of the augmented off-gas system is to reduce the radioactivity from the gases that are removed from the condenser. This purification system consists of two 30-minute holdup lines to reduce the radioactive gases with short half-lives, several charcoal adsorbers to remove radioactive iodines and further retard the short half-life gases, and offgas filters to remove radioactive particulates. The recombiner collects free hydrogen and oxygen gas and recombines them into water. This helps reduce the gaseous releases of short-lived isotopes of oxygen that have been made radioactive by neutron activation.

The radioactive off-gas from the condenser is then directed into a ventilation pipe to which the off-gas radiation monitors are attached. The radiation level meters and strip chart recorders for this detector are also located in the Control Room. If a radiation alarm setpoint is exceeded, an audible alarm will sound to

alert the Control Room operators. In addition, the off-gas bypass and charcoal adsorber inlet valve will automatically re-direct the off-gas into the charcoal adsorbers if they are temporarily being bypassed. If the radioactivity levels are not returned to below the alarm setpoint within 13 minutes, the off-gas releases will be automatically isolated, thereby preventing any gaseous radioactivity from being released that may exceed the release limits.

Therefore, for both liquid and gaseous releases, radioactive effluent control systems exist to collect and purify the radioactive effluents in order to reduce releases to the environment to as low as is reasonably achievable. The effluents are always monitored, sampled and analyzed prior to release to make sure that radioactivity levels are below the release limits. If the release limits are being approached, isolation valves in some of the waste effluent lines will automatically shut to stop the release, or Control Room operators will implement procedures to ensure that federal regulatory limits are always met.

1.5 Radiological Impact on Humans

The final step in the effluent control process is the determination of the radiological dose impact to humans and comparison with the federal dose limits to the public. As mentioned previously, the purpose of continuous radiation monitoring and periodic sampling and analysis is to measure the quantities of radioactivity being released to determine compliance with the radioactivity release limits. This is the first stage for assessing releases to the environment.

Next, calculations of the dose impact to the general public from Pilgrim Station's radioactive effluents are performed. The purpose of these calculations is to periodically assess the doses to the general public resulting from radioactive effluents to ensure that these doses are being maintained as far below the federal dose limits as is reasonably achievable. This is the second stage for assessing releases to the environment.

The types and quantities of radioactive liquid and gaseous effluents released from Pilgrim Station during each given year are reported to the Nuclear Regulatory Commission annually. The 2003 Radioactive Effluents are provided in Appendix B and will be discussed in more detail in Section 3 of this report. These liquid and gaseous effluents were well below the federal release limits and were a small percentage of the PNPS ODCM effluent control limits.

These measurements of the physical and chemical nature of the effluents are used to determine how the radionuclides will interact with the environment and how they can result in radiation exposure to humans. The environmental interaction mechanisms depend upon factors such as the hydrological (water) and meteorological (atmospheric) characteristics in the area. Information on the water flow, wind speed, wind direction, and atmospheric mixing characteristics are used to estimate how radioactivity will distribute and disperse in the ocean and the atmosphere.

The most important type of information that is used to evaluate the radiological impact on humans is data on the use of the environment. Information on fish and shellfish consumption, boating usage, beach usage, locations of cows and goats, locations of residences, locations of gardens, drinking water supplies, and other usage information are utilized to estimate the amount of radiation and radioactivity received by the general public.

The radiation exposure pathway to humans is the path radioactivity takes from its release point at Pilgrim Station to its effect on man. The movement of radioactivity through the environment and its transport to humans is portrayed in Figure 1.5-1.

EXAMPLES OF PILGRIM STATION'S RADIATION EXPOSURE PATHWAYS

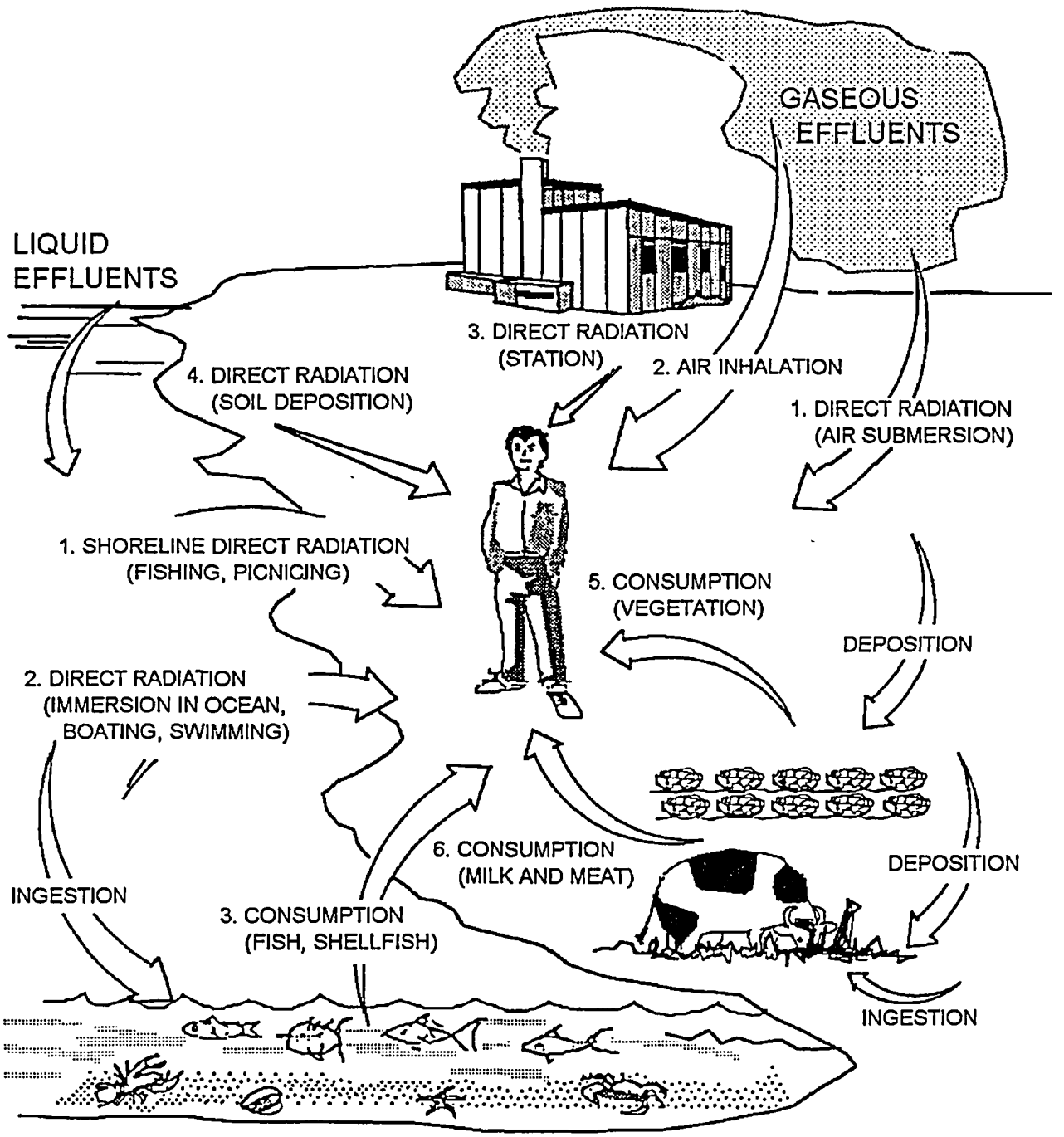


Figure 1.5-1
Radiation Exposure Pathways

There are three major ways in which liquid effluents affect humans:

- external radiation from liquid effluents that deposit and accumulate on the shoreline;
- external radiation from immersion in ocean water containing radioactive liquids; and,
- internal radiation from consumption of fish and shellfish containing radioactivity absorbed from the liquid effluents.

There are six major ways in which gaseous effluents affect humans:

- external radiation from an airborne plume of radioactivity;
- internal radiation from inhalation of airborne radioactivity;
- external radiation from deposition of radioactive effluents on soil;
- ambient (direct) radiation from contained sources at the power plant;
- internal radiation from consumption of vegetation containing radioactivity absorbed from the soil due to ground deposition of radioactive effluents; and,
- internal radiation from consumption of milk and meat containing radioactivity deposited on forage that is eaten by cattle and other livestock.

In addition, ambient (direct) radiation emitted from contained sources of radioactivity at PNPS contributes to radiation exposure in the vicinity of the plant. Radioactive nitrogen-16 contained in the steam flowing through the turbine accounts for the majority of this "sky shine" radiation exposure immediately adjacent to the plant. Smaller amounts of ambient radiation result from low-level radioactive waste stored at the site prior to shipping and disposal.

To the extent possible, the radiological dose impact on humans is based on direct measurements of radiation and radioactivity in the environment. When PNPS-related activity is detected in samples that represent a plausible exposure pathway, the resulting dose from such exposure is assessed (see Appendix A). However, the operation of Pilgrim Nuclear Power Station results in releases of only small amounts of radioactivity, and, as a result of dilution in the atmosphere and ocean, even the most sensitive radioactivity measurement and analysis techniques cannot usually detect these tiny amounts of radioactivity above that which is naturally present in the environment. Therefore, radiation doses are calculated using radioactive effluent release data and computerized dose calculations that are based on very conservative NRC-recommended models that tend to result in over-estimates of resulting dose. These computerized dose calculations are performed by or for Entergy Nuclear personnel. These computer codes use the guidelines and methodology set forth by the NRC in Regulatory Guide 1.109 (Reference 6). The dose calculations are documented and described in detail in the Pilgrim Nuclear Power Station's Offsite Dose Calculation Manual (Reference 7), which has been reviewed by the NRC.

Monthly dose calculations are performed by PNPS personnel. It should be emphasized that because of the very conservative assumptions made in the computer code calculations, the maximum hypothetical dose to an individual is considerably higher than the dose that would actually be received by a real individual.

After dose calculations are performed, the results are compared to the federal dose limits for the public. The two federal agencies that are charged with the responsibility of protecting the public from radiation and radioactivity are the Nuclear Regulatory Commission (NRC) and The Environmental Protection Agency (EPA).

The NRC, in 10CFR 20.1301 (Reference 8) limits the levels of radiation to unrestricted areas resulting from the possession or use of radioactive materials such that they limit any individual to a dose of:

- less than or equal to 100 mrem per year to the total body.

In addition to this dose limit, the NRC has established design objectives for nuclear plant licensees. Conformance to these guidelines ensures that nuclear power reactor effluents are maintained as far below the legal limits as is reasonably achievable.

The NRC, in 10CFR 50 Appendix I (Reference 9) establishes design objectives for the dose to a member of the general public from radioactive material in liquid effluents released to unrestricted areas to be limited to:

- less than or equal to 3 mrem per year to the total body; and,
- less than or equal to 10 mrem per year to any organ.

The air dose due to release of noble gases in gaseous effluents is restricted to:

- less than or equal to 10 mrad per year for gamma radiation; and,
- less than or equal to 20 mrad per year for beta radiation.

The dose to a member of the general public from iodine-131, tritium, and all particulate radionuclides with half-lives greater than 8 days in gaseous effluents is limited to:

- less than or equal to 15 mrem per year to any organ.

The EPA, in 40CFR190.10 Subpart B (Reference 10), sets forth the environmental standards for the uranium fuel cycle. During normal operation, the annual dose to any member of the public from the entire uranium fuel cycle shall be limited to:

- less than or equal to 25 mrem per year to the total body;
- less than or equal to 75 mrem per year to the thyroid; and,
- less than or equal to 25 mrem per year to any other organ.

The summary of the 2003 radiological impact for Pilgrim Station and comparison with the EPA dose limits and guidelines, as well as a comparison with natural/man-made radiation levels, is presented in Section 3 of this report.

The third stage of assessing releases to the environment is the Radiological Environmental Monitoring Program (REMP). The description and results of the REMP at Pilgrim Nuclear Power Station during 2003 is discussed in Section 2 of this report.

2.0 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

2.1 Pre-Operational Monitoring Results

The Radiological Environmental Monitoring Program (REMP) at Pilgrim Nuclear Power Station was first initiated in August 1968, in the form of a pre-operational monitoring program prior to bringing the station on-line. The NRC's intent (Reference 11) with performing a pre-operational environmental monitoring program is to:

- measure background levels and their variations in the environment in the area surrounding the licensee's station; and,
- evaluate procedures, equipment, and techniques for monitoring radiation and radioactivity in the environment.

The pre-operational program (Reference 12) continued for approximately three and a half years, from August 1968 to June 1972. Examples of background radiation and radioactivity levels measured during this time period are as follows:

- Airborne Radioactivity Particulate Concentration (gross beta): 0.02 - 1.11 pCi/m^3;
- Ambient Radiation (TLDs): 4.2 - 22 micro-R/hr (37 - 190 mR/yr);
- Seawater Radioactivity Concentrations (gross beta): 12 - 31 pCi/liter;
- Fish Radioactivity Concentrations (gross beta): 2,200 - 11,300 pCi/kg;
- Milk Radioactive Cesium-137 Concentrations: 9.3 - 32 pCi/liter;
- Milk Radioactive Strontium-90 Concentrations: 4.7 - 17.6 pCi/liter;
- Cranberries Radioactive Cesium-137 Concentrations: 140 - 450 pCi/kg;
- Forage Radioactive Cesium-137 Concentrations: 150 - 290 pCi/kg.

This information from the pre-operational phase is used as a basis for evaluating changes in radiation and radioactivity levels in the vicinity of the plant following plant operation. In April 1972, just prior to initial reactor startup (June 12, 1972), Boston Edison Company implemented a comprehensive operational environmental monitoring program at Pilgrim Nuclear Power Station. This program (Reference 13) provides information on radioactivity and radiation levels in the environment for the purpose of:

- demonstrating that doses to the general public and levels of radioactivity in the environment are within established limits and legal requirements;
- monitoring the transfer and long-term buildup of specific radionuclides in the environment to revise the monitoring program and environmental models in response to changing conditions;
- checking the condition of the station's operation, the adequacy of operation in relation to the adequacy of containment, and the effectiveness of effluent treatment so as to provide a mechanism of determining unusual or unforeseen conditions and, where appropriate, to trigger special environmental monitoring studies;
- assessing the dose equivalent to the general public and the behavior of radioactivity released during the unlikely event of an accidental release; and,
- determining whether or not the radiological impact on the environment and humans is significant.

The Nuclear Regulatory Commission requires that Pilgrim Station provide monitoring of the plant environs for radioactivity that will be released as a result of normal operations, including anticipated operational occurrences, and from postulated accidents. The NRC has established guidelines (Reference 14) that specify an acceptable monitoring program. The PNPS Radiological Environmental Monitoring Program was designed to meet and exceed these guidelines. Guidance contained in the NRC's Radiological Assessment Branch Technical Position on Environmental Monitoring (Reference 15) has been used to improve the program. In addition, the program has incorporated the provisions of an agreement made with the Massachusetts Wildlife Federation (Reference 16). The program was supplemented by including improved analysis of shellfish and sediment at substantially higher sensitivity levels to verify the adequacy of effluent controls at Pilgrim Station.

2.2 Environmental Monitoring Locations

Sampling locations have been established by considering meteorology, population distribution, hydrology, and land use characteristics of the Plymouth area. The sampling locations are divided into two classes, indicator and control. Indicator locations are those that are expected to show effects from PNPS operations, if any exist. These locations were primarily selected on the basis of where the highest predicted environmental concentrations would occur. While the indicator locations are typically within a few kilometers of the plant, the control stations are generally located so as to be outside the influence of Pilgrim Station. They provide a basis on which to evaluate fluctuations at indicator locations relative to natural background radiation and natural radioactivity and fallout from prior nuclear weapons tests.

The environmental sampling media collected in the vicinity of Pilgrim Station during 2003 included air particulate filters, charcoal cartridges, seawater, shellfish, Irish moss, American lobster, fishes, sediment, milk, cranberries, vegetation, and forage. The sampling medium, station description, station number, distance, and direction for indicator and control samples are listed in Table 2.2-1. These sampling locations are also displayed on the maps shown in Figures 2.2-1 through 2.2-6.

The radiation monitoring locations for the environmental TLDs are shown in Figures 2.2-1 through 2.2-4. The frequency of collection and types of radioactivity analysis are described in Pilgrim Station's ODCM, Sections 3/4.5.

The land-based (terrestrial) samples and monitoring devices are collected by Entergy personnel. The aquatic samples are collected by Marine Research, Inc. The radioactivity analysis of samples and the processing of the environmental TLDs are performed by Entergy's J.A. Fitzpatrick Environmental Laboratory, and the Framatome ANP Environmental Laboratory.

The frequency, types, minimum number of samples, and maximum lower limits of detection (LLD) for the analytical measurements, are specified in the PNPS ODCM. During 2003, a revision was made to the PNPS ODCM to standardize it to the model program described in NUREG-1302 (Reference 14) and the Branch Technical Position of 1979 (Reference 15). In accordance with this standardization, a number of changes occurred regarding the types and frequencies of sample collections.

In regard to terrestrial REMP sampling, routine collection and analysis of soil samples was discontinued in lieu of the extensive network of environmental TLDs around PNPS, and the weekly collection of air samples at 11 locations. Such TLD monitoring and air sampling would provide an early indication of any potential deposition of radioactivity, and follow-up soil sampling could be performed on an as-needed basis. Also, with the loss of the indicator milk sample at the Plymouth County Farm, it was deemed unnecessary to continue to collect and analyze control samples of milk. Consequently, routine milk sampling was also dropped from the terrestrial sampling program.

In the area of marine sampling, a number of the specialized sampling and analysis requirements implemented as part of the Agreement with the Massachusetts Wildlife Federation (Reference 16) for licensing of a second reactor at PNPS were dropped. This agreement, made in 1977, was predicated on the construction of a second nuclear unit, and was set to expire in 1987. However, since the specialized requirements were incorporated into the PNPS Technical Specifications at the time, the requirements were continued. When the ODCM was revised in 1999 in accordance with NRC Generic Letter 89-01, the

sampling program description was relocated to the ODCM. When steps were taken in 2003 to standardize the PNPS ODCM to the NUREG-1302 model, the specialized marine sampling requirements were changed to those of the model program. These changes include the following:

- A sample of the surface layer of sediment is collected, as opposed to specialized depth-incremental sampling to 30 cm and subdividing cores into 2 cm increments.
- Standard LLD levels of about 150 to 180 pCi/kg were established for sediment, as opposed to the specialized LLDs of 50 pCi/kg.
- Specialized analysis of sediment for plutonium isotopes was removed.
- Sampling of Irish moss, shellfish, and fish was rescheduled to a semiannual period, as opposed to a specialized quarterly sampling interval.
- Analysis of only the edible portions of shellfish (mussels and clams), as opposed to specialized additional analysis of the shell portions.
- Standard LLD levels of 130 to 260 pCi/kg were established for edible portions of shellfish, as opposed to specialized LLDs of 5 pCi/kg.

Upon receipt of the analysis results from the analytical laboratories, the PNPS staff reviews the results. If the radioactivity concentrations are above the reporting levels, the NRC must be notified within 30 days. For radioactivity that is detected that is attributable to Pilgrim Station's operation, calculations are performed to determine the cumulative dose contribution for the current year. Depending upon the circumstances, a special study may also be completed (see Appendix A for 2003 special studies). Most importantly, if radioactivity levels in the environment become elevated as a result of the station's operation, an investigation is performed and corrective actions are recommended to reduce the amount of radioactivity to as far below the legal limits as is reasonably achievable.

The radiological environmental sampling locations are reviewed annually, and modified if necessary. A garden and milk animal census is performed every year to identify changes in the use of the environment in the vicinity of the station to permit modification of the monitoring and sampling locations. The results of the 2003 Garden and Milk Animal Census are reported in Appendix C.

The accuracy of the data obtained through Pilgrim Station's Radiological Environmental Monitoring Program is ensured through a comprehensive Quality Assurance (QA) programs. PNPS's QA program has been established to ensure confidence in the measurements and results of the radiological monitoring program through:

- Regular surveillances of the sampling and monitoring program;
- An annual audit of the analytical laboratory by the sponsor companies;
- Participation in cross-check programs;
- Use of blind duplicates for comparing separate analyses of the same sample; and,
- Spiked sample analyses by the analytical laboratory.

QA audits and inspections of the Radiological Environmental Monitoring Program are performed by the NRC, American Nuclear Insurers, and by the PNPS Quality Assurance Department.

Both the Framatome ANP Environmental Laboratory and J.A. Fitzpatrick Environmental Laboratory conduct extensive quality assurance and quality control programs. The 2003 results of these programs are summarized in Appendices E and F. These results indicate that the analyses and measurements performed during 2003 exhibited acceptable precision and accuracy.

2.3 Interpretation of Radioactivity Analyses Results

The following pages summarize the analytical results of the environmental samples collected during 2003. Data for each environmental medium are included in a separate section. A table that summarizes the year's data for each type of medium follows a discussion of the sampling program and results. The unit of measurement for each medium is listed at the top of each table. The left hand column contains the radionuclides being reported, total number of analyses of that radionuclide, and the number of measurements that exceed ten times the yearly average for the control station(s). The latter are classified as "non-routine" measurements. The next column lists the Lower Limit of Detection (LLD) for those radionuclides that have detection capability requirements specified in the PNPS ODCM.

Those sampling stations within the range of influence of Pilgrim Station and which could conceivably be affected by its operation are called "indicator" stations. Distant stations, which are beyond plant influence, are called "control" stations. Ambient radiation monitoring stations are broken down into four separate zones to aid in data analysis.

For each sampling medium, each radionuclide is presented with a set of statistical parameters. This set of statistical parameters includes separate analyses for (1) the indicator stations, (2) the station having the highest annual mean concentration, and (3) the control stations. For each of these three groups of data, the following values are calculated:

- The mean value of detectable concentrations, including only those values above LLD;
- The standard deviation of the detectable measurements;
- The lowest and highest concentrations; and,
- The number of positive measurements (activity which is three times greater than the standard deviation), out of the total number of measurements.

Each single radioactivity measurement datum is based on a single measurement and is reported as a concentration plus or minus one standard deviation. The quoted uncertainty represents only the random uncertainty associated with the measurement of the radioactive decay process (counting statistics), and not the propagation of all possible uncertainties in the sampling and analysis process. A sample or measurement is considered to contain detectable radioactivity if the measured value (e.g., concentration) exceeds three times its associated standard deviation. For example, a milk sample with a strontium-90 concentration of 3.5 ± 0.8 pCi/liter would be considered "positive" (detectable Sr-90), whereas another sample with a concentration of 2.1 ± 0.9 pCi/liter would be considered "negative", indicating no detectable strontium-90. The latter sample may actually contain strontium-90, but the levels counted during its analysis were not significantly different than background levels.

As an example of how to interpret data presented in the results tables, refer to the first entry on the table for air particulate filters (page 38). Gross beta (GR-B) analyses were performed on 566 routine samples. None of the samples exceeded ten times the average concentration at the control location. The lower limit of detection (LLD) required by the ODCM is 0.01 pCi/m^3.

For samples collected from the ten indicator stations, 515 out of 515 samples indicated detectable activity at the three-sigma (standard deviation) level. The mean concentration of gross beta activity in these 515 indicator station samples was 0.013 ± 0.005 (1.3E-2 ± 5.5 E-3) pCi/m^3. Individual values ranged from 0.0027 to 0.032 (2.7E-3 – 3.2E-2) pCi/m^3.

The monitoring station which yielded the highest mean concentration was station WR (West Rocky Hill Road), which yielded a mean concentration of 0.015 ± 0.005 pCi/m^3, based on 52 observations. Individual values ranged from 0.0051 to 0.023 pCi/m^3. Fifty-two of the fifty-two samples showed detectable activity at the three-sigma level.

At the control location, 51 out of 51 samples yielded detectable gross beta activity, for an average concentration of 0.012 ± 0.005 pCi/m^3. Individual samples at the control location ranged from 0.0032 to 0.025 pCi/m^3.

Referring to the last entry in the table, analyses for cesium-137 (Cs-137) were performed 44 times (quarterly composites for 11 stations * 4 quarters). No samples exceeded ten times the mean control station concentration. The required LLD value Cs-137 in the PNPS ODCM is 0.06 pCi/m^3.

At the indicator stations, all 40 of the Cs-137 measurements were below the detection level. The same was true for the four measurements made on samples collected from the control location.

2.4 Ambient Radiation Measurements

The primary technique for measuring ambient radiation exposure in the vicinity of Pilgrim Station involves posting environmental thermoluminescent dosimeters (TLDs) at given monitoring locations and retrieving the TLDs after a specified time period. The TLDs are then taken to a laboratory and processed to determine the total amount of radiation exposure received over the period. Although TLDs can be used to monitor radiation exposure for short time periods, environmental TLDs are typically posted for periods of one to three months. Such TLD monitoring yields average exposure rate measurements over a relatively long time period. The PNPS environmental TLD monitoring program is based on a quarterly (three month) posting period, and a total of 110 locations are monitored using this technique. In addition, 27 of the 110 TLDs are located onsite, within the PNPS protected/restricted area, where the general public does not have access.

Out of the 440 TLDs (110 locations * 4 quarters) posted during 2003, 431 were retrieved and processed. Those TLDs missing from their monitoring locations were lost to storm damage, vandalism, and/or replacement of the utility poles to which they were attached, and their absence is discussed in Appendix D. The results for environmental TLDs located offsite, beyond the PNPS protected/restricted area fence, are presented in Table 2.4-1. Results from onsite TLDs posted within the restricted area are presented in Table 2.4-2. In addition to TLD results for individual locations, results from offsite TLDs were grouped according to geographic zone to determine average exposure rates as a function of distance. These results are summarized in Table 2.4-3. All of the listed exposure values represent continuous occupancy (2190 hr/qtr or 8760 hr/yr).

Annual exposure rates measured at offsite locations ranged from 50 to 535 mR/yr. The average exposure rate at control locations greater than 15 km from Pilgrim Station (i.e., Zone 4) was 64.8 ± 15.6 mR/yr. When the 3-sigma confidence interval is calculated based on these control measurements, 99% of all measurements of background ambient exposure would be expected to be between 18 and 112 mR/yr. The results for all TLDs within 15 km (excluding those Zone 1 TLDs posted within the site boundary) ranged from 50 to 82 mR/hr, which compares favorably with the preoperational results of 37 - 190 mR/yr.

Inspection of onsite TLD results listed in Table 2.4-2 indicates that all of those TLDs located within the PNPS protected/restricted area yield exposure measurements higher than the expected background. Such results are expected due to the close proximity of these locations to radiation sources onsite. The radionuclide nitrogen-16 (N-16) contained in steam flowing through the turbine accounts for most of the exposure onsite. Although this radioactivity is contained within the turbine and is not released to the atmosphere, the "sky shine" which occurs from the turbine increases the ambient radiation levels in areas near the turbine building.

A small number of offsite TLD locations in close proximity to the protected/restricted area indicated ambient radiation exposure above expected background levels. All of these locations are on Pilgrim Station controlled property, and experience exposure increases due to turbine sky shine (e.g., locations OA, TC, P01, and WS) and/or transit and storage of radwaste onsite (e.g., location BLW). A hypothetical maximum exposed member of the public accessing these near-site areas on Pilgrim Station controlled property for limited periods of time would receive a maximum dose of about 2.2 mrem/yr above their average ambient background dose of 65 mrem/yr.

One TLD, normally located in the basement of the Plymouth Memorial Hall, indicated an annual exposure of 77 mR in 2003, compared to 38 mR in 2002. Construction in this building during 2002 led PNPS personnel to relocate the TLD outside the building during construction. In the fourth quarter of 2002, and during all of 2003, it was relocated within the basement. This relocation caused the exposure to increase to about 19 mR/quarter during 2003, similar to exposure levels observed in 200 and 2001. The higher exposure within the building at this location is due to the close proximity of stone building material, which contains higher levels of naturally-occurring radioactivity, as well as from the buildup of radon in this area of the building.

It should be noted that several of the TLDs used to calculate the Zone 1 averages presented in Table 2.4-3 are located on Pilgrim Station property. If the Zone 1 value is corrected for the near-site TLDs (those less than 0.6 km from the Reactor Building), the Zone 1 mean falls from a value of 96.5 ± 80.0 mR/yr to 66.5 ± 14.5 mR/yr. Additionally, exposure rates measured at areas beyond Entergy's control did not indicate any increase in ambient exposure from Pilgrim Station operation. For example, the annual exposure rate near the nearest offsite resident (location HB, 0.6 km SE) was 65.2 ± 8.3 mR/yr, which compares quite well with the average control location exposure of 64.8 ± 15.6 mR/yr.

A second technique for measuring ambient radiation exposure utilizes a sensitive high-pressure ion chamber to make "real time" exposure rate measurements. This technique allows for instantaneous assessments, with the instrument providing a direct readout of exposure rates. Such monitoring with a high-pressure ion chamber can be used to perform rapid, short-term measurements at locations where it may be impractical to post long-term TLD monitors.

In past years, annual measurements had been taken with a high-pressure ion chamber at five locations on beaches in the Plymouth area, and at the control location in Duxbury. However, in conjunction with standardization of the ODCM during 2003, the beach survey effort was abandoned in favor of the extensive TLD monitoring effort at Pilgrim Station. Prior to dropping the high-pressure ion chamber surveys, there had been no apparent trends in exposure levels at these locations.

In conclusion, measurements of ambient radiation exposure around Pilgrim Station do not indicate any significant increase in exposure levels. Although some increases in ambient radiation exposure level were apparent on Entergy property very close to Pilgrim Station, there were no measurable increases at areas beyond Entergy's control.

2.5 Air Particulate Filter Radioactivity Analyses

Airborne particulate radioactivity is sampled by drawing a stream of air through a glass fiber filter that has a very high efficiency for collecting airborne particulates. These samplers are operated continuously, and the resulting filters are collected weekly for analysis. Weekly filter samples are analyzed for gross beta radioactivity, and the filters are then composited on a quarterly basis for each location for gamma spectroscopy analysis. PNPS uses this technique to monitor 10 locations in the Plymouth area, along with the control location in East Weymouth.

Out of 572 filters (11 locations * 52 weeks), 566 samples were collected and analyzed during 2003. There were a few instances where power was lost or pumps failed during the course of the sampling period at some of the air sampling stations, resulting in lower than normal sample volumes. In two of the cases, sampling locations were inaccessible due to snow, and the filters were left on until the collection during the following week. Thus, sampling capability continued, but only one filter was recovered for a two-week period in these two cases. All of these discrepancies are noted in Appendix D. These occurrences did not adversely affect the monitoring results.

The results of the analyses performed on these 566 filter samples are summarized in Table 2.5-1. Trend plots for the gross beta radioactivity levels at the near station, property line, and offsite airborne monitoring locations are shown in Figures 2.5-1, 2.5-2 and 2.5-3, respectively. Gross beta radioactivity was detected in 565 of the filter samples collected, including 51 of the 51 control location samples. This gross beta activity arises from naturally-occurring radionuclides such as radon decay daughter products. Naturally-occurring beryllium-7 was detected in 43 out of 44 of the quarterly composites analyzed with gamma spectroscopy. Naturally-occurring potassium-40 (K-40) was detected in 23 of 40 indicator samples, and in three of four control samples. No airborne radioactivity attributable to Pilgrim Station was detected in any of the samples collected during 2003, and results of any detectable naturally-occurring radioactivity were similar to those observed in the preoperational monitoring program.

2.6 Charcoal Cartridge Radioactivity Analyses

Airborne radioactive iodine is sampled by drawing a stream of air through a charcoal cartridge after it has passed through the high efficiency glass fiber filter. As is the case with the air particulate filters, these samplers are operated continuously, and the resulting cartridges are collected weekly for analysis. Weekly cartridge samples are analyzed for radioactive iodine. The same eleven locations monitored for airborne particulate radioactivity are also sampled for airborne radioiodine.

Out of 572 cartridges (11 locations * 52 weeks), 566 samples were collected and analyzed during 2003. There were a few instances where power was lost or pumps failed during the course of the sampling period at some of the air sampling stations, resulting in lower than normal sample volumes. In two of the cases, sampling locations were inaccessible due to snow, and the filters were left on until the collection during the following week. Thus, sampling capability continued, but only one filter was recovered for a two-week period in these two cases. All of these discrepancies are noted in Appendix D. Despite such events during 2003, required LLDs were met on 565 of the 566 filters collected during 2003.

The results of the analyses performed on these 566 charcoal cartridges are summarized in Table 2.6-1. No airborne radioactive iodine was detected in any of the charcoal cartridges collected.

2.7 Milk Radioactivity Analyses

Samples of unprocessed milk are collected from the control location in Whitman. The Annual Land Use Census conducted within five kilometers of Pilgrim Station did not identify any additional milk animals requiring sampling. Results of this census are summarized in Appendix C. Milk samples are collected monthly from November through April, and once every two weeks when animals are assumed to be on pasture during the period May through October. These milk samples are analyzed by gamma spectroscopy.

Eighteen samples scheduled for collection during the year were obtained and analyzed. In July 2003, the Plymouth County Farm ceased operation of its dairy facility. This was historically the only dairy facility near Pilgrim Station, and had been sampled continuously since Pilgrim Station began operation in 1972. Although attempts were made to obtain samples from an alternate indicator location, a suitable substitute could not be found. Thus, milk collection at an indicator location was discontinued in July 2002, but control samples of milk continued to be collected and analyzed in the event an indicator location could be secured. In conjunction with the standardization of the ODCM during 2003, the decision was made to remove milk sampling from the PNPS Radiological Environmental Monitoring Program since no milk ingestion pathway existed in the vicinity of Pilgrim Station.

The results of the analyses performed on the 18 milk samples are summarized in Table 2.7-1. Naturally-occurring potassium-40 was detected in all 18 samples. No radioactive iodine was detected in any of the samples. Cesium-137 was not detected in any of the samples collected during the year. No radioactivity attributable to Pilgrim Station was detected in any of the samples collected during 2003, and results of any detectable naturally-occurring radioactivity were similar to those observed in the preoperational monitoring program.

2.8 Forage Radioactivity Analyses

Samples of animal forage (hay) are collected from the Plymouth County Farm and from the control location in Whitman. Samples are collected annually and analyzed by gamma spectroscopy.

All samples of forage were collected and analyzed as required during 2003. Results of the gamma analyses of forage samples are summarized in Table 2.8-1. Naturally-occurring beryllium-7, potassium-40, and actinium/thorium-228 were detected in forage samples collected during 2003, and the sample collected at the control location at Whitman Farm indicated detectable cesium-137. Such Cs-137 concentrations (45 pCi/kg) are indicative of fallout from past nuclear weapons testing. No radioactivity attributable to Pilgrim Station was detected in any of the samples collected during 2003, and results of any detectable naturally-occurring radioactivity were similar to those observed in the preoperational monitoring program.

Cesium-137 is a product of nuclear weapons testing, and was routinely detected in the preoperational monitoring program at levels of 150 to 290 pCi/kg. When the preoperational values are corrected for radioactive decay, the concentration in samples of naturally-growing vegetation collected during 2003 would be expected to be between 75 and 145 pCi/kg. The average Cs-137 concentration of 45 pCi/kg observed in the samples collected is indicative of radioactivity arising from weapons fallout, and not Pilgrim Station operations.

2.9 Vegetable/Vegetation Radioactivity Analyses

Samples of vegetables had historically been collected from the Plymouth County Farm and from the control location in Bridgewater. However, some problems were encountered in collection of crop samples during 2003. Crops were not grown at the Plymouth County Farm (CF) during 2003. Due to a loss of state funding at the Bridgewater Correctional Facility, garden samples were not available from this source. An alternate sampling location (Hanson Farm) was identified in the general vicinity in Bridgewater, and was used as a source of control vegetable samples. In addition, samples of vegetables or leafy vegetation were

collected at or near a number of gardens identified during the Annual Land Use Census. Results of this census are discussed in Appendix C. Samples of vegetables are collected annually and analyzed by gamma spectroscopy.

Thirteen samples of vegetables/vegetation were collected and analyzed as required during 2003. Results of the gamma analyses of these samples are summarized in Table 2.9-1. Naturally-occurring beryllium-7, potassium-40, and actinium/thorium-228 were identified in most of the samples collected. Cesium-137 was also detected in two out of 10 samples of naturally-growing vegetation collected, with concentrations ranging from 27 to 42 pCi/kg. As described previously in the section regarding forage analyses, these Cs-137 results are in the range expected for weapons-testing fallout (75 to 145 pCi/kg), and are not indicative of any releases associated with Pilgrim Station. No radioactivity attributable to Pilgrim Station was detected in any of the samples collected during 2003, and results of any detectable naturally-occurring radioactivity were similar to those observed in the preoperational monitoring program.

2.10 Cranberry Radioactivity Analyses

Samples of cranberries are routinely collected from two bogs in the Plymouth area and from the control location in Halifax. Samples of cranberries are collected annually and analyzed by gamma spectroscopy. In 2002, the bog at Manomet Point ceased harvesting operations, and a sample was collected from an alternate location along Beaverdam Road. This discrepancy is noted in Appendix D.

Three samples of cranberries were collected and analyzed during 2003. Results of the gamma analyses of cranberry samples are summarized in Table 2.10-1. Cranberry samples collected during 2003 yielded detectable levels of naturally-occurring beryllium-7, potassium-40, and actinium/thorium-228. No radioactivity attributable to Pilgrim Station was detected in any of the samples collected during 2003, and results of any detectable naturally-occurring radioactivity were similar to those observed in the preoperational monitoring program.

2.11 Soil Radioactivity Analyses

In the past, a survey of radioactivity in soil had been conducted once every three years at the 10 air sampling stations in the Plymouth area and the control location in East Weymouth. However, in conjunction with standardization of the ODCM during 2003, the soil survey effort was abandoned in favor of the extensive TLD monitoring effort at Pilgrim Station. Prior to ending the soil survey effort, there had been no apparent trends in radioactivity measurements at these locations.

2.12 Surface Water Radioactivity Analyses

Samples of surface water are routinely collected from the discharge canal, Bartlett Pond in Manomet and from the control location at Powder Point Bridge in Duxbury. The discharge canal is normally sampled continuously by a composite sampler, but a storm surge in early January washed the sample line from the discharge canal, necessitating the institution of weekly grab sampling at this location. This discrepancy is noted in Appendix D. Grab samples are collected weekly from the Bartlett Pond and Powder Point Bridge locations. Samples of surface water are composited every four weeks and analyzed by gamma spectroscopy and low-level iodine analysis. These monthly composites are further composited on a quarterly basis and tritium analysis is performed on this quarterly sample.

A total of 36 samples (3 locations * 12 sampling periods) of surface water were collected and analyzed as required during 2003. Results of the analyses of water samples are summarized in Table 2.12-1. Naturally-occurring potassium-40, radium-226, and actinium/thorium-228 were detected in several of the samples, especially those composed primarily of seawater. No radioactivity attributable to Pilgrim Station was detected in any of the samples collected during 2003, and results of any detectable naturally-occurring radioactivity were similar to those observed in the preoperational monitoring program.

2.13 Sediment Radioactivity Analyses

Samples of sediment are routinely collected from the outfall area of the discharge canal and from three other locations in the Plymouth area (Manomet Point, Plymouth Harbor and Plymouth Beach), and from control locations in Duxbury and Marshfield. Samples are collected twice per year and are analyzed by gamma spectroscopy. Sediment cores are subdivided into depth increments for analysis of radionuclide distribution by depth. During the first half of the year, samples were divided into 2 cm increments, whereas samples for the second half of the year are divided into 5 cm increments. In addition to the gamma analyses, plutonium analyses are performed on the surface layer samples collected during the first half of the year from the discharge canal outfall, Plymouth Harbor, Manomet Point and Duxbury. Plutonium analyses are also performed on a mid-depth section from the discharge canal sample and Duxbury sample.

Seventy-two samples of sediment were collected during 2003. Gamma analyses were performed on these samples. Results of the gamma analyses of sediment samples are summarized in Table 2.13-1. Results of the plutonium analyses are presented in Table 2.13-2. Naturally-occurring potassium-40 and actinium/thorium-228 were detected in a number of the samples. No cobalt-60 was detected in any of the 24 indicator samples. Cesium-137 was detected in 14 of 52 indicator station samples and in 6 of 20 control station samples. No plutonium was detected in the samples analyzed.

Cesium-137 levels in indicator samples ranged from non-detectable to a maximum concentration of 5.4 pCi/kg. Concentrations in samples collected from the control locations beyond the influence of Pilgrim Station ranged from non-detectable to a maximum concentration of 4.8 pCi/kg. The comparability of the results from indicator and control stations indicates that the source of this activity is not Pilgrim Station. The levels detected are also comparable to concentrations observed in the past few years and are indicative of Cs-137 resulting from nuclear weapons testing.

2.14 Irish Moss Radioactivity Analyses

Samples of Irish moss are collected from the discharge canal outfall and two other locations in the Plymouth area (Manomet Point, Ellisville), and from a control location in Marshfield (Green Harbor). All samples are collected on a quarterly basis, and processed in the laboratory for gamma spectroscopy analysis.

Sixteen samples of Irish moss scheduled for collection during 2003 were obtained and analyzed. Results of the gamma analyses of these samples are summarized in Table 2.14-1. Naturally-occurring beryllium-7, potassium-40, radium-226, and actinium/thorium-228 were detected in a number of the samples. No radioactivity attributable to Pilgrim Station was detected in any of the samples collected during 2003, and results of any detectable naturally-occurring radioactivity were similar to those observed in the preoperational monitoring program.

2.15 Shellfish Radioactivity Analyses

Samples of blue mussels, soft-shell clams and quahogs are collected from the discharge canal outfall and two other locations in the Plymouth area (Manomet Point, Plymouth Harbor), and from control locations in Duxbury and Marshfield. All samples are collected on a quarterly basis, and processed in the laboratory for gamma spectroscopy analysis. In addition to analyzing the edible portion (meat) from each of the samples, the shells from samples collected from the discharge canal outfall and from all control location samples are also analyzed.

All 54 samples of shellfish meat and shells scheduled for collection during 2003 were obtained and analyzed. Results of the gamma analyses of these samples are summarized in Table 2.15-1. Naturally-occurring beryllium-7, potassium-40, and actinium/thorium-228 were detected in a number of the samples. Cesium-137 was detected at levels of less than 2 pCi/kg in both indicator and control samples, and the levels observed are indicative of Cs-137 resulting from weapons testing.

Low levels of manganese-54, cobalt-60, and zinc-65 were detected in some of the samples of blue mussels collected during the second and fourth quarters of 2003. All of these samples were collected following the PNPS refueling outage, during which a number of permitted liquid discharges were performed. The low levels (less than 3 pCi/kg) of Mn-54 and Co-60 were only detected in the non-edible shells, whereas Zn-65 was detected in one sample of mussel meat, at a concentration of 5.5 pCi/kg. A special assessment was performed to determine the maximum dose resulting from ingestion of mussels containing low levels of Zn-65, and is documented in Appendix A. Based on this assessment, the maximum total body dose resulting from ingestion of shellfish containing low-levels of Zn-65 was 0.0004 mrem.

2.16 Lobster Radioactivity Analyses

Samples of lobsters are routinely collected from the outfall area of the discharge canal and from the control location in Duxbury. Samples are collected monthly from the discharge canal outfall from June through September and annually from the control location. Due to inclement weather in July, the collection of the July lobster sample was delayed into the earlier part of August. This discrepancy is noted in Appendix D. All lobster samples are analyzed by gamma spectroscopy.

All five samples of lobsters were collected and analyzed as required during 2003. Results of the gamma analyses of lobster samples are summarized in Table 2.16-1. The only radionuclides detected in any of the samples were naturally-occurring potassium-40 and actinium/thorium-228. No radioactivity attributable to Pilgrim Station was detected in any of the samples collected during 2003, and results of any detectable naturally-occurring radioactivity were similar to those observed in the preoperational monitoring program.

2.17 Fish Radioactivity Analyses

Samples of fish are routinely collected from the area at the outfall of the discharge canal and from the control locations in Cape Cod Bay and Buzzard's Bay. Fish species are grouped into four major categories according to their biological requirements and mode of life. These major categories and the representative species are as follows:

- Group I - Bottom Oriented: Winter Flounder, Yellowtail Flounder
- Group II - Near-Bottom Distribution: Tautog, Cunner, Pollock, Atlantic Cod, Hake
- Group III - Anadromous: Alewife, Smelt, Striped Bass
- Group IV - Coastal Migratory: Bluefish, Herring, Menhaden, Mackerel

Two subsamples of each category of fish are typically collected during each collection period. Group I and II fishes are sampled on a quarterly basis from the outfall area of the discharge canal, and on an annual basis from a control location. Group III and IV fishes are sampled annually from the discharge canal outfall and control location. All samples of fish are analyzed by gamma spectroscopy.

Due to declining fish stock and the migration of fish to deeper water during colder seasons, samples of Groups I and II fishes could not be collected during the first and fourth quarters of the year. Although repeated and concerted efforts were made to collect the fish in the vicinity of the Discharge Canal Outfall, no samples could be obtained. In addition, only a single subsample of bluefish (Group IV) was collected at the control location during the year. Additional details regarding these discrepancies can be found in Appendix D.

Twenty samples of fish were collected during 2003. Results of the gamma analyses of fish samples collected are summarized in Table 2.17-1. The only radionuclides detected in any of the samples were naturally-occurring potassium-40 and actinium/thorium-228. No radioactivity attributable to Pilgrim Station was detected in any of the samples collected during 2003, and results of any detectable naturally-occurring radioactivity were similar to those observed in the preoperational monitoring program.

Table 2.2-1

Routine Radiological Environmental Sampling Locations
Pilgrim Nuclear Power Station, Plymouth, MA

Description	No	Code	Distance	Direction
Air Particulate Filters, Charcoal Cartridges				
Medical Building	00	WS	0.2 km	SSE
East Rocky Hill Road	01	ER	0.9 km	SE
West Rocky Hill Road	03	WR	0.8 km	WNW
Property Line	06	PL	0.5 km	NNW
Pedestrian Bridge	07	PB	0.2 km	N
Overlook Area	08	OA	0.1 km	W
East Breakwater	09	EB	0.5 km	ESE
Cleft Rock	10	CR	1.3 km	SSW
Plymouth Center	15	PC	6.7 km	W
Manomet Substation	17	MS	3.6 km	SSE
East Weymouth Control	21	EW	40 km	NW
Milk				
Plymouth County Farm	11	CF	5.6 km	W
Whitman Farm Control	21	WF	34 km	WNW
Forage				
Plymouth County Farm	11	CF	5.6 km	W
Whitman Farm Control	12	WF	34 km	WNW
Whipple Farm	43	WH	2.9 km	SW
Vegetation				
Plymouth County Farm	11	CF	5.6 km	W
Bridgewater Farm Control	27	BF	31 km	W
Cranberries				
Manomet Point Bog	13	MR	3.9 km	SE
Bartlett Road Bog	14	BR	4.3 km	SSE
Pine Street Bog Control	23	PS	26 km	WNW

Table 2.2-1 (continued)

Routine Radiological Environmental Sampling Locations
Pilgrim Nuclear Power Station, Plymouth, MA

Description	No	Code	Distance	Direction
Surface Water				
Discharge Canal	11	DIS	0.2 km	N
Bartlett Pond	17	BP	2.7 km	SE
Powder Point Control	23	PP	13 km	NNW
Sediment				
Discharge Canal Outfall	11	DIS	0.8 km	NE
Plymouth Harbor	12	Ply-H	4.1 km	W
Duxbury Bay Control	13	Dux-Bay	14 km	NNW
Plymouth Beach	14	PLB	4.0 km	WNW
Manomet Point	15	MP	3.3 km	ESE
Green Harbor Control	24	GH	16 km	NNW
Irish Moss				
Discharge Canal Outfall	11	DIS	0.7 km	NNE
Manomet Point	15	MP	4.0 km	ESE
Ellisville	22	EL	12 km	SSE
Brant Rock Control	34	BR	18 km	NNW
Shellfish				
Discharge Canal Outfall	11	DIS	0.7 km	NNE
Plymouth Harbor	12	Ply-H	4.1 km	W
Duxbury Bay Control	13	Dux-Bay	13 km	NNW
Manomet Point	15	MP	4.0 km	ESE
Green Harbor Control	24	GH	16 km	NNW
Lobster				
Discharge Canal Outfall	11	DIS	0.5 km	N
Plymouth Harbor	15	Ply-H	6.4 km	WNW
Duxbury Bay Control	13	Dux-Bay	11 km	NNW
Fishes				
Discharge Canal Outfall	11	DIS	0.5 km	N
Priest Cove Control	29	PC	48 km	SW
Jones River Control	30	JR	13 km	WNW
Vineyard Sound Control	92	MV	64 km	SSW
Buzzard's Bay Control	90	BB	40 km	SSW
Cape Cod Bay Control	98	CC-Bay	24 km	ESE

Table 2.4-1

Offsite Environmental TLD Results

TLD Station		TLD Location*	Quarterly Exposure - mR/quarter (Value ± Std.Dev.)				2003 Annual** Exposure mR/year
ID	Description	Distance/Direction	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	
Zone 1 TLDs: 0-3 km		0-3 km	20.1 ± 21.8	21.4 ± 14.2	25.5 ± 16.4	29.6 ± 24.8	96.5 ± 80.0
BLW	BOAT LAUNCH WEST	0.11 km E	59.9 ± 4.6	50.8 ± 2.9	51.4 ± 3.0	60.2 ± 2.7	222.4 ± 21.8
OA	OVERLOOK AREA	0.15 km W	147.4 ± 12.3	98.5 ± 6.1	119.5 ± 5.5	169.7 ± 9.1	535.2 ± 126.1
TC	HEALTH CLUB	0.15 km WSW	44.2 ± 2.1	37.2 ± 1.4	40.5 ± 0.3	60.8 ± 1.8	182.7 ± 42.1
BLE	BOAT LAUNCH EAST	0.16 km ESE	39.1 ± 4.0	36.6 ± 2.6	35.3 ± 2.1	56.9 ± 7.0	167.8 ± 41.2
PB	PEDESTRIAN BRIDGE	0.21 km N	32.6 ± 1.9	32.7 ± 2.0	33.8 ± 1.8	46.5 ± 2.1	145.6 ± 27.4
P01	SHOREFRONT SECURITY	0.22 km NNW	30.9 ± 2.3	28.7 ± 1.6	33.2 ± 1.8	42.3 ± 0.9	135.1 ± 24.1
WS	MEDICAL BUILDING	0.23 km SSE	29.6 ± 1.9	28.7 ± 1.2	33.2 ± 2.7	44.1 ± 0.9	135.5 ± 28.5
CT	PARKING LOT	0.31 km SE	18.0 ± 1.1	20.0 ± 1.5	24.0 ± 0.9	35.0 ± 2.1	97.1 ± 30.4
PA	SHOREFRONT PARKING	0.35 km NNW	17.5 ± 1.6	21.4 ± 1.0	23.1 ± 1.2	28.3 ± 1.2	90.3 ± 18.1
A	STATION A	0.37 km WSW	18.3 ± 2.0	20.4 ± 1.0	22.5 ± 0.9	31.0 ± 1.2	92.2 ± 22.5
F	STATION F	0.43 km NW	15.5 ± 1.2	19.6 ± 0.9	24.0 ± 0.9	28.6 ± 0.6	87.6 ± 22.7
EB	EAST BREAKWATER	0.44 km ESE	14.4 ± 1.0	16.0 ± 1.2	21.3 ± 1.2	26.5 ± 1.8	78.1 ± 22.1
B	STATION B	0.44 km S	19.6 ± 1.4	23.4 ± 1.1	26.8 ± 1.2	32.2 ± 0.6	102.0 ± 21.5
PMT	PNPS MET TOWER	0.44 km WNW	14.5 ± 1.0	18.3 ± 0.8	22.5 ± 0.3	25.6 ± 0.9	80.9 ± 19.4
H	STATION H	0.47 km SW	18.2 ± 1.3	23.1 ± 1.0	24.9 ± 0.6	Missing	88.3 ± 14.1
I	STATION I	0.48 km WNW	14.9 ± 1.2	18.2 ± 0.7	21.9 ± 0.6	27.7 ± 0.6	82.7 ± 22.0
L	STATION L	0.50 km ESE	17.3 ± 1.1	19.7 ± 1.2	20.7 ± 1.2	31.3 ± 1.5	89.0 ± 25.0
G	STATION G	0.53 km W	14.0 ± 1.0	16.3 ± 0.8	18.3 ± 1.5	18.9 ± 0.3	67.5 ± 9.0
D	STATION D	0.54 km NNW	15.2 ± 1.4	19.1 ± 1.7	25.9 ± 5.2	19.5 ± 0.9	79.6 ± 18.6
PL	PROPERTY LINE	0.54 km NW	14.4 ± 1.0	19.1 ± 0.7	17.9 ± 0.9	20.4 ± 0.6	71.8 ± 10.4
C	STATION C	0.57 km ESE	14.2 ± 1.5	15.7 ± 1.2	19.2 ± 1.8	19.5 ± 0.9	68.5 ± 10.8
HB	HALL'S BOG	0.63 km SE	14.3 ± 1.7	16.3 ± 0.8	Missing	18.3 ± 0.6	65.2 ± 8.3
GH	GREENWOOD HOUSE	0.65 km ESE	15.1 ± 1.0	17.8 ± 1.0	20.7 ± 1.8	19.5 ± 0.3	73.0 ± 10.0
WR	W ROCKY HILL ROAD	0.83 km WNW	17.2 ± 1.6	18.9 ± 1.0	22.5 ± 1.2	23.7 ± 0.6	82.4 ± 12.4
ER	E ROCKY HILL ROAD	0.89 km SE	11.1 ± 0.9	14.2 ± 0.9	18.6 ± 1.2	17.9 ± 0.6	61.8 ± 14.1
MT	MICROWAVE TOWER	1.03 km SSW	13.9 ± 1.0	16.9 ± 0.8	21.0 ± 0.6	20.7 ± 1.5	72.5 ± 13.6
CR	CLEFT ROCK	1.27 km SSW	17.2 ± 3.4	16.3 ± 1.7	19.2 ± 0.9	21.0 ± 0.3	73.7 ± 9.3
BD	BAYSHORE/GATE RD	1.34 km WNW	13.5 ± 1.2	15.5 ± 1.1	20.4 ± 1.2	19.5 ± 1.5	68.8 ± 13.3
MR	MANOMET ROAD	1.38 km S	11.5 ± 0.9	14.7 ± 1.2	18.6 ± 0.3	18.3 ± 3.7	63.0 ± 14.0
DR	DIRT ROAD	1.48 km SW	10.9 ± 0.9	13.5 ± 0.7	17.3 ± 0.9	19.2 ± 2.1	60.9 ± 15.2
EM	EMERSON ROAD	1.53 km SSE	11.8 ± 0.9	16.2 ± 1.3	16.7 ± 1.2	16.7 ± 2.1	61.4 ± 10.0
EP	EMERSON/PRISCILLA	1.55 km SE	11.8 ± 1.0	Missing	Missing	18.3 ± 2.4	60.1 ± 19.0
AR	EDISON ACCESS ROAD	1.59 km SSE	11.3 ± 0.9	14.7 ± 0.9	18.6 ± 0.9	20.1 ± 2.4	64.6 ± 16.1
BS	BAYSHORE	1.76 km W	13.9 ± 0.9	16.4 ± 1.0	21.9 ± 1.8	21.9 ± 0.9	74.1 ± 16.3
E	STATION E	1.86 km S	13.2 ± 1.0	16.2 ± 1.0	24.0 ± 2.7	20.7 ± 1.5	74.1 ± 19.4
JG	JOHN GAULEY	1.99 km W	12.9 ± 1.0	15.3 ± 1.3	23.1 ± 2.4	20.4 ± 1.2	71.8 ± 18.8
J	STATION J	2.04 km SSE	11.5 ± 1.2	15.3 ± 0.7	18.6 ± 2.1	17.9 ± 1.2	63.2 ± 13.2
WH	WHITEHORSE ROAD	2.09 km SSE	11.3 ± 0.8	16.5 ± 1.2	21.0 ± 3.0	18.6 ± 0.9	67.4 ± 16.8
RC	PLYMOUTH YMCA	2.09 km WSW	11.8 ± 1.1	15.0 ± 1.1	19.8 ± 1.2	20.1 ± 1.2	66.6 ± 16.2
K	STATION K	2.17 km S	11.4 ± 1.0	15.0 ± 0.9	19.5 ± 1.2	20.1 ± 0.9	65.9 ± 16.5
TT	TAYLOR/THOMAS	2.26 km SE	10.7 ± 1.0	Missing	17.0 ± 1.2	20.1 ± 1.8	63.8 ± 19.3
YV	YANKEE VILLAGE	2.28 km WSW	12.3 ± 0.8	14.8 ± 1.3	20.7 ± 1.8	20.7 ± 0.6	68.5 ± 17.1
GN	GOODWIN PROPERTY	2.38 km SW	9.2 ± 0.8	11.3 ± 0.8	16.1 ± 1.5	19.2 ± 0.9	55.8 ± 18.3
RW	RIGHT OF WAY	2.83 km S	8.2 ± 0.8	13.2 ± 0.8	Missing	17.0 ± 1.8	51.3 ± 17.9
TP	TAYLOR/PEARL	2.98 km SE	10.7 ± 0.9	14.9 ± 0.8	16.7 ± 1.8	Missing	56.5 ± 12.8

* Distance and direction are measured from centerline of Reactor Building to the monitoring location.
** Annual value is based on arithmetic mean of the observed quarterly values multiplied by four quarters/year.

Table 2.4-1 (continued)

Offsite Environmental TLD Results

TLD Station		TLD Location*	Quarterly Exposure - mR/quarter (Value ± Std.Dev.)				2003 Annual** Exposure mR/year
ID	Description	Distance/Direction	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	
Zone 2 TLDs: 3-8 km		3-8 km	10.7 ± 1.9	15.0 ± 1.7	17.2 ± 2.3	18.9 ± 3.2	61.8 ± 15.4
VR	VALLEY ROAD	3.26 km SSW	9.3 ± 0.9	13.8 ± 1.0	16.4 ± 1.8	19.8 ± 2.1	59.3 ± 18.0
ME	MANOMET ELEM	3.29 km SE	13.2 ± 0.9	16.2 ± 1.0	16.7 ± 1.2	17.9 ± 0.6	64.2 ± 8.2
WC	WARREN/CLIFFORD	3.31 km W	11.0 ± 0.9	13.3 ± 0.8	17.6 ± 1.8	22.2 ± 0.6	64.2 ± 19.9
BB	RT.3A/BARTLETT RD	3.33 km SSE	11.4 ± 0.9	15.5 ± 1.3	20.1 ± 1.2	24.6 ± 0.6	71.7 ± 22.9
MP	MANOMET POINT	3.57 km SE	10.9 ± 0.8	15.5 ± 0.9	16.7 ± 0.9	25.6 ± 3.3	68.7 ± 24.7
MS	MANOMET SUBSTATION	3.60 km SSE	14.6 ± 1.1	18.0 ± 1.5	21.6 ± 2.4	20.7 ± 0.3	74.9 ± 13.0
BW	BEACHWOOD ROAD	3.93 km SE	10.0 ± 1.1	15.7 ± 0.8	18.3 ± 0.9	16.7 ± 0.0	60.7 ± 14.5
PT	PINES ESTATE	4.44 km SSW	9.5 ± 0.7	14.4 ± 0.8	13.1 ± 1.5	16.1 ± 1.2	53.2 ± 11.4
EA	EARL ROAD	4.60 km SSE	8.7 ± 0.9	13.4 ± 0.7	17.9 ± 1.5	17.6 ± 1.5	57.7 ± 17.6
SP	S PLYMOUTH SUBST	4.62 km W	11.1 ± 0.9	15.9 ± 1.3	19.5 ± 1.2	18.3 ± 0.9	64.7 ± 15.0
RP	ROUTE 3 OVERPASS	4.81 km SW	10.3 ± 1.0	14.5 ± 1.1	16.4 ± 1.5	17.0 ± 1.2	58.2 ± 12.4
RM	RUSSELL MILLS RD	4.85 km WSW	9.6 ± 1.0	15.1 ± 1.0	17.0 ± 0.6	17.3 ± 1.2	59.0 ± 14.6
HD	HILLDALE ROAD	5.18 km W	12.0 ± 0.9	14.2 ± 1.3	18.6 ± 1.2	18.6 ± 0.9	63.3 ± 13.3
MB	MANOMET BEACH	5.43 km SSE	10.0 ± 0.8	15.0 ± 1.5	15.5 ± 1.2	24.6 ± 0.6	65.1 ± 24.5
BR	BEAVERDAM ROAD	5.52 km S	10.3 ± 0.9	15.0 ± 0.6	16.7 ± 0.9	19.5 ± 0.9	61.5 ± 15.4
PC	PLYMOUTH CENTER	6.69 km W	8.1 ± 0.7	13.9 ± 0.7	14.0 ± 0.6	13.7 ± 0.9	49.6 ± 11.7
LD	LONG POND/DREW RD	6.97 km WSW	9.9 ± 0.8	12.6 ± 1.0	17.6 ± 1.5	17.3 ± 0.6	57.5 ± 15.3
HR	HYANNIS ROAD	7.33 km SSE	10.8 ± 0.9	14.6 ± 1.2	15.8 ± 0.9	16.4 ± 1.5	57.6 ± 10.3
SN	SAQUISH NECK	7.58 km NNW	8.2 ± 0.7	13.4 ± 0.9	13.4 ± 1.2	15.5 ± 0.3	50.5 ± 12.5
MH	MEMORIAL HALL	7.58 km WNW	15.3 ± 1.0	20.4 ± 0.9	21.0 ± 2.7	20.4 ± 2.1	77.1 ± 11.2
CP	COLLEGE POND	7.59 km SW	10.0 ± 0.9	15.0 ± 1.0	16.7 ± 0.9	16.4 ± 1.2	58.2 ± 12.6
Zone 3 TLDs: 8-15 km		8-15 km	10.5 ± 1.5	15.1 ± 1.0	16.7 ± 2.1	17.7 ± 1.8	59.7 ± 12.9
DW	DEEP WATER POND	8.59 km W	12.6 ± 0.9	16.9 ± 1.4	18.6 ± 1.2	21.0 ± 0.6	69.1 ± 14.2
LP	LONG POND ROAD	8.88 km SSW	9.2 ± 0.9	13.8 ± 0.9	15.2 ± 0.6	15.8 ± 0.3	54.0 ± 12.1
NP	NORTH PLYMOUTH	9.38 km WNW	13.6 ± 0.9	16.1 ± 1.3	21.6 ± 1.8	20.1 ± 0.9	71.4 ± 14.8
SS	STANDISH SHORES	10.39 km NW	10.2 ± 0.7	15.4 ± 1.3	15.2 ± 0.9	17.0 ± 0.3	57.8 ± 12.0
EL	ELLISVILLE ROAD	11.52 km SSE	10.0 ± 0.7	15.0 ± 0.8	17.9 ± 0.9	17.6 ± 0.6	60.6 ± 14.8
UC	UP COLLEGE POND RD	11.78 km SW	9.1 ± 1.1	13.9 ± 0.6	15.8 ± 0.9	15.8 ± 0.6	54.7 ± 12.7
SH	SACRED HEART	12.92 km W	10.6 ± 0.8	14.9 ± 0.7	15.8 ± 0.9	17.6 ± 0.6	58.9 ± 12.1
KC	KING CAESAR ROAD	13.11 km NNW	9.9 ± 0.7	15.7 ± 1.1	15.5 ± 0.6	17.9 ± 0.6	59.0 ± 13.7
BE	BOURNE ROAD	13.37 km S	9.1 ± 0.8	14.4 ± 0.7	15.2 ± 0.6	16.7 ± 1.2	55.4 ± 13.5
SA	SHERMAN AIRPORT	13.43 km WSW	10.5 ± 1.1	14.6 ± 0.9	15.8 ± 0.6	Missing	54.5 ± 11.3
Zone 4 TLDs: >15 km		>15 km	11.3 ± 1.8	16.0 ± 1.3	17.5 ± 2.2	20.2 ± 3.1	64.8 ± 15.6
CS	CEDARVILLE SUBST	15.93 km S	11.1 ± 0.8	16.0 ± 0.6	Missing	23.4 ± 1.5	67.3 ± 24.9
KS	KINGSTON SUBST	16.15 km WNW	10.2 ± 0.8	15.1 ± 0.7	15.5 ± 0.9	16.4 ± 0.3	57.2 ± 11.3
LR	LANDING ROAD	16.46 km NNW	10.9 ± 0.9	16.1 ± 1.3	19.2 ± 2.1	17.0 ± 0.9	63.2 ± 14.3
CW	CHURCH/WEST	16.56 km NW	9.4 ± 0.9	14.7 ± 1.6	14.9 ± 0.9	17.6 ± 0.6	56.6 ± 14.0
MM	MAIN/MEADOW	17.02 km WSW	10.7 ± 0.8	15.6 ± 0.7	16.4 ± 0.6	22.2 ± 1.5	64.9 ± 19.0
DMF	DIV MARINE FISH	20.97 km SSE	14.9 ± 1.2	16.2 ± 0.8	18.9 ± 1.2	23.1 ± 1.2	73.2 ± 14.6
EW	E WEYMOUTH SUBST	39.69 km NW	12.2 ± 0.9	18.4 ± 1.3	20.1 ± 0.9	21.3 ± 1.2	72.0 ± 16.4

* Distance and direction are measured from centerline of Reactor Building to the monitoring location.
** Annual value is based on arithmetic mean of the observed quarterly values multiplied by four quarters/year.

Table 2.4-2

Onsite Environmental TLD Results

TLD Station		TLD Location*	Quarterly Exposure - mR/quarter (Value ± Std.Dev.)				2003 Annual** Exposure mR/year
ID	Description	Distance/Direction	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	
Onsite TLDs							
P21	O&M/RXB. BREEZEWAY	50 m SE	21.9 ± 1.8	25.2 ± 1.5	25.9 ± 1.2	42.0 ± 2.7	114.9 ± 36.2
P24	EXEC.BUILDING	57 m W	71.8 ± 6.3	61.3 ± 2.6	62.4 ± 5.8	85.5 ± 5.2	280.8 ± 46.0
P04	FENCE-R SCREENHOUSE	66 m N	94.7 ± 7.2	82.0 ± 2.9	80.3 ± 6.1	100.4 ± 2.1	357.4 ± 40.3
P20	O&M - 2ND W WALL	67 m SE	60.6 ± 6.7	57.9 ± 4.5	59.9 ± 5.8	84.0 ± 3.0	262.3 ± 50.3
P25	EXEC.BUILDING LAWN	76 m WNW	121.6 ± 6.8	242.5 ± 7.8	90.0 ± 6.1	123.5 ± 6.1	577.6 ± 269.0
P05	FENCE-WATER TANK	81 m NNE	34.1 ± 3.5	31.7 ± 1.8	30.7 ± 2.1	40.2 ± 2.4	136.6 ± 17.7
P06	FENCE-OIL STORAGE	85 m NE	54.5 ± 4.3	53.6 ± 3.1	51.4 ± 4.9	72.1 ± 3.3	231.5 ± 39.0
P19	O&M - 2ND SW CORNER	86 m S	92.3 ± 8.8	71.6 ± 3.8	74.2 ± 4.6	111.6 ± 5.5	349.7 ± 75.3
P18	O&M - 1ST SW CORNER	90 m S	63.7 ± 10.3	51.4 ± 3.6	55.4 ± 4.9	69.4 ± 6.1	239.9 ± 35.1
P08	COMPRESSED GAS STOR	92 m E	60.0 ± 4.2	49.4 ± 2.0	49.9 ± 4.3	94.0 ± 7.0	253.3 ± 84.6
P03	FENCE-L SCREENHOUSE	100 m NW	87.4 ± 6.8	89.5 ± 4.1	75.4 ± 4.3	118.0 ± 5.5	370.3 ± 73.0
P17	FENCE-EXEC.BUILDING	107 m W	169.9 ± 13.0	143.1 ± 12.1	129.0 ± 5.5	214.1 ± 9.8	656.1 ± 151.4
P07	FENCE-INTAKE BAY	121 m ENE	40.2 ± 2.8	39.7 ± 2.4	41.7 ± 3.3	52.9 ± 1.5	174.5 ± 25.5
P23	O&M - 2ND S WALL	121 m SSE	41.0 ± 3.2	39.7 ± 1.6	41.1 ± 1.2	55.1 ± 1.8	176.9 ± 29.3
P26	FENCE-WAREHOUSE	134 m ESE	51.3 ± 3.2	47.4 ± 3.4	47.8 ± 5.2	65.1 ± 7.9	211.5 ± 34.9
P02	FENCE-SHOREFRONT	135 m NW	59.9 ± 4.7	52.0 ± 1.8	53.2 ± 3.7	70.0 ± 0.9	235.1 ± 33.5
P09	FENCE-W BOAT RAMP	136 m E	41.5 ± 3.1	41.8 ± 2.7	40.2 ± 2.7	52.9 ± 3.3	176.3 ± 24.5
P22	O&M - 2ND N WALL	137 m SE	34.1 ± 2.7	33.4 ± 2.1	36.5 ± 3.0	51.7 ± 2.1	155.6 ± 34.9
P16	FENCE-W SWITCHYARD	172 m SW	136.7 ± 8.8	106.3 ± 5.5	105.2 ± 1.2	190.1 ± 10.6	538.4 ± 159.8
P11	FENCE-TCF GATE	183 m ESE	83.4 ± 7.0	78.8 ± 2.5	52.0 ± 4.6	84.0 ± 2.4	298.2 ± 61.4
P27	FENCE-TCF/BOAT RAMP	185 m ESE	82.6 ± 4.6	69.9 ± 3.7	46.8 ± 3.0	61.4 ± 3.3	260.7 ± 60.4
P12	FENCE-ACCESS GATE	202 m SE	38.2 ± 3.5	34.5 ± 3.3	33.2 ± 3.3	75.1 ± 2.1	181.0 ± 80.4
P15	FENCE-E SWITCHYARD	220 m S	41.9 ± 2.5	53.8 ± 2.3	42.6 ± 1.5	63.6 ± 6.1	201.8 ± 41.8
P10	FENCE-TCF/INTAKE BAY	223 m E	39.0 ± 2.5	42.0 ± 2.1	35.9 ± 3.7	53.5 ± 2.1	170.5 ± 31.2
P13	FENCE-MEDICAL BLDG.	224 m SSE	31.9 ± 3.0	30.3 ± 2.0	31.6 ± 2.4	55.1 ± 6.1	148.8 ± 48.3
P14	FENCE-BUTLER BLDG	228 m S	31.3 ± 2.3	31.0 ± 2.0	31.6 ± 2.7	129.9 ± 5.8	223.8 ± 197.3
P28	FENCE-TCF/PRKNG LOT	259 m ESE	54.6 ± 3.2	94.9 ± 4.7	75.1 ± 5.5	94.9 ± 1.8	319.4 ± 77.5

* Distance and direction are measured from centerline of Reactor Building to the monitoring location.
** Annual value is based on arithmetic mean of the observed quarterly values multiplied by four quarters/year.

Table 2.4-3

Average TLD Exposures By Distance Zone During 2003

Exposure Period	Average Exposure ± Standard Deviation: mR/period			
	Zone 1* 0-3 km	Zone 2 3-8 km	Zone 3 8-15 km	Zone 4 >15 km
Jan-Mar	20.1 ± 21.8	10.7 ± 1.9	10.5 ± 1.5	11.3 ± 1.8
Apr-Jun	21.4 ± 14.2	15.0 ± 1.7	15.1 ± 1.0	16.0 ± 1.3
Jul-Sep	25.5 ± 16.4	17.2 ± 2.3	16.7 ± 2.1	17.5 ± 2.2
Oct-Dec	29.6 ± 24.8	18.9 ± 3.2	17.7 ± 1.8	20.2 ± 3.1
Jan-Dec	96.5 ± 80.0**	61.8 ± 15.4	59.7 ± 12.9	64.8 ± 15.6

* Zone 1 extends from the PNPS restricted/protected area boundary outward to 3 kilometers (2 miles), and includes several TLDs located within the site boundary.

** When corrected for TLDs located within the site boundary, the Zone 1 annual average is calculated to be 66.5 ± 14.5 mR/yr.

Table 2.5-1
Air Particulate Filter Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2003)

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

Radionuclide	No. Analyses Non-routine*	Required LLD	Indicator Stations Mean ± Std.Dev. Range Fraction>LLD	Station with Highest Mean Station: Mean ± Std.Dev. Range Fraction>LLD	Control Stations Mean ± Std.Dev. Range Fraction>LLD
Gross Beta	566 0	0.01	1.3E-2 ± 5.7E-3 2.7E-3 - 3.2E-2 514 / 515	WR: 1.5E-2 ± 4.8E-3 5.1E-3 - 2.3E-2 52 / 52	1.2E-2 ± 5.0E-3 3.2E-3 - 2.5E-2 51 / 51
Be-7	44 0		6.1E-2 ± 2.3E-2 1.4E-2 - 1.2E-1 39 / 40	MS: 7.8E-2 ± 3.0E-2 5.6E-2 - 1.2E-1 4 / 4	5.2E-2 ± 9.1E-3 6.0E-3 - 5.9E-2 4 / 4
K-40	44 0		3.3E-2 ± 1.3E-2 1.4E-2 - 5.5E-2 23 / 40	EB: 4.2E-2 ± 2.0E-2 2.9E-2 - 5.5E-2 2 / 4	3.3E-2 ± 9.1E-3 4.0E-3 – 3.2E-2 3 / 4
Cs-134	44 0	0.05	<LLD <LLD 0 / 40	<LLD <LLD 0 / 4	<LLD <LLD 0 / 4
Cs-137	44 0	0.06	<LLD <LLD 0 / 40	<LLD <LLD 0 / 4	<LLD <LLD 0 / 4

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

Table 2.6-1
Charcoal Cartridge Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2003)

MEDIUM: Charcoal Cartridge (CF) UNITS: pCi/cubic meter

Radionuclide	No. Analyses Non-routine*	Required LLD	Indicator Stations Mean ± Std.Dev. Range Fraction>LLD	Station with Highest Mean Station: Mean ± Std.Dev. Range Fraction>LLD	Control Stations Mean ± Std.Dev. Range Fraction>LLD
I-131	566 0	0.07	<LLD <LLD 0 / 515	<LLD <LLD 0 / 52	<LLD <LLD 0 / 51

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

Table 2.7-1
Milk Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2003)

MEDIUM: Milk (TM) UNITS: pCi/kg

Radionuclide	No. Analyses Non-routine*	Required LLD	Indicator Stations Mean ± Std.Dev. Range Fraction>LLD	Station with Highest Mean Station: Mean ± Std.Dev. Range Fraction>LLD	Control Stations Mean ± Std.Dev. Range Fraction>LLD
K-40	18		Not Applicable	WF: 1.5E3 ± 1.3E2	1.5E3 ± 1.3E2
	0		Not Applicable	1.2E3 - 1.7E3	1.2E3 - 1.7E3
			Not Applicable	18 / 18	18 / 18
I-131	18	1	Not Applicable	<LLD	<LLD
	0		Not Applicable	<LLD	<LLD
			Not Applicable	0 /18	0 / 18
Cs-134	18	15	Not Applicable	<LLD	<LLD
	0		Not Applicable	<LLD	<LLD
			Not Applicable	0 /18	0 / 18
Cs-137	18	18	Not Applicable	<LLD	<LLD
	0		Not Applicable	<LLD	<LLD
			Not Applicable	0 /18	0 / 18
Ba-140	18	60	Not Applicable	<LLD	<LLD
	0		Not Applicable	<LLD	<LLD
			Not Applicable	0 /18	0 / 18
La-140	18	15	Not Applicable	<LLD	<LLD
	0		Not Applicable	<LLD	<LLD
			Not Applicable	0 /18	0 / 18

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

Table 2.8-1
Forage Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2003)

MEDIUM: Forage (TC) UNITS: pCi/kg wet

Radionuclide	No. Analyses Non-routine*	Required LLD	Indicator Stations Mean ± Std.Dev. Range Fraction>LLD	Station with Highest Mean Station: Mean ± Std.Dev. Range Fraction>LLD	Control Stations Mean ± Std.Dev. Range Fraction>LLD
Be-7	2 0		5.1E+3 ± 2.3E+2 5.1E+3 - 5.1E+3 1 / 1	CF: 5.1E+3 ± 2.3E+2 5.1E+3 - 5.1E+3 1 / 1	1.3E+3 ± 1.1E+2 1.3E+3 - 1.3E+3 1 / 1
K-40	2 0		1.7E+4 ± 6.0E+2 1.7E+4 - 1.7E+4 1 / 1	CF: 1.7E+4 ± 6.0E+2 1.7E+4 - 1.7E+4 1 / 1	9.7E+3 ± 3.0E+2 9.7E+3 - 9.7E+3 1 / 1
I-131	2 0		<LLD <LLD 0 / 1	<LLD <LLD 0 / 1	<LLD <LLD 0 / 1
Cs-134	2 0		<LLD <LLD 0 / 1	<LLD <LLD 0 / 1	<LLD <LLD 0 / 1
Cs-137	2 0		<LLD <LLD 0 / 1	WF: 4.5E+1 ± 1.1E+1 4.5E+1 - 4.5E+1 1 / 1	WF: 4.5E+1 ± 1.1E+1 4.5E+1 - 4.5E+1 1 / 1
AcTh-228	2 0		<LLD <LLD 0 / 1	WF: 1.4E+2 ± 4.3E+1 1.4E+2 - 1.4E+2 1 / 1	WF: 1.4E+2 ± 4.3E+1 1.4E+2 - 1.4E+2 1 / 1

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

Table 2.9-1
Vegetable/Vegetation Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2003)

MEDIUM: Vegetation (TF) UNITS: pCi/kg wet

Radionuclide	No. Analyses Non-routine*	Required LLD	Indicator Stations Mean ± Std.Dev. Range Fraction>LLD	Station with Highest Mean Station: Mean ± Std.Dev. Range Fraction>LLD	Control Stations Mean ± Std.Dev. Range Fraction>LLD
Be-7	13 0		1.2E+3 ± 7.3E+2 1.9E+2 - 2.6E+3 10 / 11	MetTwr: 2.6E+3 ± 1.0E+2 2.6E+3 - 2.6E+3 1 / 1	<LLD <LLD 0 / 2
K-40	13 0		5.3E+3 ± 1.2E+3 2.8E+3 - 6.9E+3 11 / 11	Gnwd: 6.9E+3 ± 1.6E+2 6.9E+3 - 6.9E+3 1 / 1	3.1E+3 ± 1.8E+2 3.0E+3 - 3.2E+3 2 / 2
I-131	13 0	60	<LLD <LLD 0 / 11	<LLD <LLD 0 / 2	<LLD <LLD 0 / 2
Cs-134	13 0	60	<LLD <LLD 0 / 11	<LLD <LLD 0 / 2	<LLD <LLD 0 / 2
Cs-137	13 0	80	3.4E+1 ± 1.2E+1 2.7E+1 - 4.2E+1 2 / 11	PinHil: 4.2E+1 ± 8.1E+0 4.2E+1 - 4.2E+1 1 / 1	<LLD <LLD 0 / 2
AcTh-228	13 0		1.3E+2 ± 7.0E+1 4.3E+1 - 2.1E+2 8 / 11	MetTwr: 2.1E+2 ± 2.8E+1 2.1E+2 - 2.1E+2 1 / 1	3.5E+1 ± 1.6E+1 3.5E+1 - 3.5E+1 1 / 2

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

Table 2.10-1
Cranberry Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2003)

MEDIUM: Cranberries (CB) UNITS: pCi/kg wet

Radionuclide	No. Analyses Non-routine*	Required LLD	Indicator Stations Mean ± Std.Dev. Range Fraction>LLD	Station with Highest Mean Station: Mean ± Std.Dev. Range Fraction>LLD	Control Stations Mean ± Std.Dev. Range Fraction>LLD
Be-7	3 0		<LLD <LLD 0 / 2	PS: 1.6E+2 ± 3.4E1 1.5E2 - 1.5E2 1 / 1	1.6E+2 ± 3.4E1 1.5E2 - 1.5E2 1 / 1
K-40	3 0		1.3E3 ± 1.1E2 1.3E3 - 1.4E3 2 / 2	PS: 1.9E3 ± 8.3E1 1.9E3 - 1.9E3 1 / 1	1.9E3 ± 8.3E1 1.9E3 - 1.9E3 1 / 1
I-131	3 0	60	<LLD <LLD 0 / 2	<LLD <LLD 0 / 1	<LLD <LLD 0 / 1
Cs-134	3 0	60	<LLD <LLD 0 / 2	<LLD <LLD 0 / 1	<LLD <LLD 0 / 1
Cs-137	3 0	80	<LLD <LLD 0 / 2	<LLD <LLD 0 / 1	<LLD <LLD 0 / 1
AcTh-228	3 0		3.0E1 ± 1.1E1 3.0E1 - 3.0E1 1 / 2	PS: 1.1E2 ± 1.7E1 1.1E2 - 1.1E2 1 / 1	1.1E2 ± 1.7E1 1.1E2 - 1.1E2 1 / 1

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels In ODCM Table 3.5-4.

Table 2.12-1
Surface Water Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2003)

MEDIUM: Surface Water (WS) UNITS: pCi/kg

Radionuclide	No. Analyses Non-routine*	Required LLD	Indicator Stations Mean ± Std.Dev. Range Fraction>LLD	Station with Highest Mean Station: Mean ± Std.Dev. Range Fraction>LLD	Control Stations Mean ± Std.Dev. Range Fraction>LLD
H-3	12 0	3000	<LLD <LLD 0 / 8	<LLD <LLD 0 / 4	<LLD <LLD 0 / 4
K-40	36 0		3.8E+2 ± 1.5E+2 1.4E+2 - 6.5E+2 24 / 24	DIS: 5.0E+2 ± 6.9E+1 4.4E+2 - 6.5E+2 12 / 12	4.8E+2 ± 4.4E+1 4.3E+2 - 5.7E+2 12 / 12
Mn-54	36 0	15	<LLD <LLD 0 / 24	<LLD <LLD 0 / 12	<LLD <LLD 0 / 12
Fe-59	36 0	30	<LLD <LLD 0 / 24	<LLD <LLD 0 / 12	<LLD <LLD 0 / 12
Co-58	36 0	15	<LLD <LLD 0 / 24	<LLD <LLD 0 / 12	<LLD <LLD 0 / 12
Co-60	36 0	15	<LLD <LLD 0 / 24	<LLD <LLD 0 / 12	<LLD <LLD 0 / 12
Zn-65	36 0	30	<LLD <LLD 0 / 24	<LLD <LLD 0 / 12	<LLD <LLD 0 / 12
Zr-95	36 0	30	<LLD <LLD 0 / 24	<LLD <LLD 0 / 12	<LLD <LLD 0 / 12
Nb-95	36 0	15	<LLD <LLD 0 / 24	<LLD <LLD 0 / 12	<LLD <LLD 0 / 12
I-131	36 0	15	<LLD <LLD 0 / 24	<LLD <LLD 0 / 12	<LLD <LLD 0 / 12
Cs-134	36 0	15	<LLD <LLD 0 / 24	<LLD <LLD 0 / 12	<LLD <LLD 0 / 12
Cs-137	36 0	18	<LLD <LLD 0 / 24	<LLD <LLD 0 / 12	<LLD <LLD 0 / 12
Ba-140	36 0	60	<LLD <LLD 0 / 24	<LLD <LLD 0 / 12	<LLD <LLD 0 / 12
La-140	36 0	15	<LLD <LLD 0 / 24	<LLD <LLD 0 / 12	<LLD <LLD 0 / 12
Ra-226	36 0		9.3E+1 ± 3.0E+1 3.4E+1 - 1.4E+2 22 / 24	BP: 1.0E+2 ± 2.6E+1 6.0E+1 - 1.4E+2 11 / 12	9.4E+1 ± 2.8E+1 4.8E+1 - 1.2E+2 9 / 12
AcTh-228	36 0		1.0E+1 ± 2.6E+0 5.7E+0 - 1.3E+1 12 / 24	BP: 1.1E+1 ± 2.7E+0 8.2E+0 - 1.3E+1 6 / 12	9.8E+0 ± 2.8E+0 8.5E+0 - 1.2E+1 3 / 12

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

Table 2.13-1
Sediment Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2003)

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

Radionuclide	No. Analyses Non-routine*	Required LLD	Indicator Stations Mean ± Std.Dev. Range Fraction>LLD	Station with Highest Mean Station: Mean ± Std.Dev. Range Fraction>LLD	Control Stations Mean ± Std.Dev. Range Fraction>LLD
Be-7	72 0		1.0E+2 ± 5.9E+1 6.7E+1 - 1.8E+2 4 / 52	Dux: 2.4E+2 ± 6.0E+1 2.4E+2 - 2.4E+2 1 / 16	2.4E+2 ± 6.0E+1 2.4E+2 - 2.4E+2 1 / 20
K-40	72 0		1.2E+4 ± 1.7E+3 9.8E+3 - 2.1E+4 52 / 52	Dis: 1.3E+4 ± 2.3E+3 1.1E+4 - 2.1E+4 16 / 16	1.2E+4 ± 1.0E+3 9.8E+3 - 1.4E+4 20 / 20
Co-58	72 0	50	<LLD <LLD 0 / 24	<LLD <LLD 0 / 16	<LLD <LLD 0 / 20
Co-60	72 0	50	<LLD <LLD 0 / 24	<LLD <LLD 0 / 16	<LLD <LLD 0 / 20
Zn-65	72 0	50	<LLD <LLD 0 / 24	<LLD <LLD 0 / 16	<LLD <LLD 0 / 20
Zr-95	72 0	50	<LLD <LLD 0 / 24	<LLD <LLD 0 / 16	<LLD <LLD 0 / 20
Cs-134	72 0	50	<LLD <LLD 0 / 24	<LLD <LLD 0 / 16	<LLD <LLD 0 / 20
Cs-137	72 0	50	1.8E+1 ± 5.4E+0 1.2E+1 - 2.8E+1 14 / 52	PlyH: 1.8E+1 ± 5.4E+0 1.2E+1 - 2.8E+1 14 / 16	1.2E+1 ± 4.8E+0 8.7E+0 - 2.1E+1 6 / 20
Ce-144	72 0	150	<LLD <LLD 0 / 24	<LLD <LLD 0 / 16	<LLD <LLD 0 / 20
AcTh-228	72 0		3.7E+2 ± 1.7E+2 6.5E+1 - 8.6E+2 52 / 52	PlyH: 5.5E+2 ± 1.8E+2 6.5E+1 - 8.6E+2 16 / 16	4.6E+2 ± 6.1E+1 3.8E+2 - 5.7E+2 20 / 20
Pu-238	6 0	25	<LLD <LLD 0 / 4	<LLD <LLD 0 / 4	<LLD <LLD 0 / 2
Pu-239	6 0	25	<LLD <LLD 0 / 4	<LLD <LLD 0 / 4	<LLD <LLD 0 / 2

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

Table 2.13-2
Sediment Plutonium Analyses

Environmental Radiological Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2003)

Location	Core Depth (cm)	pCi/kg (dry) ± 1 S.D.	
		Plutonium-238	Plutonium-239/240
Discharge Canal Outfall	0 - 2	NDA	NDA
Discharge Canal Outfall	12 - 14	NDA	NDA
Plymouth Harbor	0 - 2	NDA	NDA
Manomet Point	0 - 2	NDA	NDA
Duxbury Bay - Control	0 - 2	NDA	NDA
Duxbury Bay - Control	12 - 14	NDA	NDA

* NDA indicates no detectable activity.

Table 2.14-1
Irish Moss Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2003)

MEDIUM: Irish Moss (AL) UNITS: pCi/kg wet

Radionuclide	No. Analyses Non-routine*	Required LLD	Indicator Stations Mean ± Std.Dev. Range Fraction>LLD	Station with Highest Mean Station: Mean ± Std.Dev. Range Fraction>LLD	Control Stations Mean ± Std.Dev. Range Fraction>LLD
Be-7	16 0		2.0E+2 ± 8.7E+1 9.7E+1 - 3.5E+2 10 / 12	MP: 3.2E+2 ± 5.2E+1 3.0E+2 - 3.5E+2 2 / 4	9.2E+1 ± 5.8E+1 5.6E+1 - 1.3E+2 2 / 4
K-40	16 0		7.9E+3 ± 1.7E+3 5.9E+3 - 1.2E+4 12 / 12	DIS: 9.6E+3 ± 1.5E+3 8.7E+3 - 1.2E+4 4 / 4	8.7E+3 ± 9.0E+2 7.4E+3 - 9.2E+3 4 / 4
Mn-54	16 0	130	<LLD <LLD 0 / 12	<LLD <LLD 0 / 4	<LLD <LLD 0 / 4
Fe-59	16 0	260	<LLD <LLD 0 / 12	<LLD <LLD 0 / 4	<LLD <LLD 0 / 4
Co-58	16 0	130	<LLD <LLD 0 / 12	<LLD <LLD 0 / 4	<LLD <LLD 0 / 4
Co-60	16 0	130	<LLD <LLD 0 / 12	<LLD <LLD 0 / 4	<LLD <LLD 0 / 4
Zn-65	16 0	260	<LLD <LLD 0 / 12	<LLD <LLD 0 / 4	<LLD <LLD 0 / 4
Cs-134	16 0	130	<LLD <LLD 0 / 12	<LLD <LLD 0 / 4	<LLD <LLD 0 / 4
Cs-137	16 0	130	<LLD <LLD 0 / 12	<LLD <LLD 0 / 4	<LLD <LLD 0 / 4
Ra-226	16 0		3.1E+2 ± 1.2E+2 2.0E+2 - 5.0E+2 12 / 12	DIS: 3.7E+2 ± 1.4E+2 2.2E+2 - 5.0E+2 4 / 4	2.5E+2 ± 8.8E+1 1.8E+2 - 3.5E+2 4 / 4
AcTh-228	16 0		4.7E+1 ± 1.4E+1 2.9E+1 - 6.3E+1 9 / 12	BR: 5.4E+1 ± 1.7E+1 3.9E+1 - 6.2E+1 3 / 4	5.4E+1 ± 1.7E+1 3.9E+1 - 6.2E+1 3 / 4

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

Table 2.15-1
Shellfish Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2003)

MEDIUM: Shellfish (SF) UNITS: pCi/kg wet

Radionuclide	No. Analyses Non-routine*	Required LLD	Indicator Stations Mean ± Std.Dev. Range Fraction>LLD	Station with Highest Mean Station: Mean ± Std.Dev. Range Fraction>LLD	Control Stations Mean ± Std.Dev. Range Fraction>LLD
Be-7	54 0		3.9E+1 ± 2.8E+1 1.3E+1 - 1.6E+2 27 / 32	Dis: 5.1E+1 ± 4.6E+1 1.5E+1 - 1.6E+2 8 / 8	3.7E+1 ± 6.5E+0 9.7E+0 - 1.1E+2 15 / 22
K-40	54 0		1.5E+3 ± 7.7E+2 4.5E+2 - 2.8E+3 32 / 32	Dis: 1.6E+3 ± 9.8E+2 5.0E+2 - 2.8E+3 8 / 8	1.4E+3 ± 8.7E+2 3.1E+2 - 3.3E+3 22 / 22
Mn-54	54 0	130	2.9E+0 ± 6.0E-1 2.9E+0 - 2.9E+0 1 / 32	Dis: 2.9E+0 ± 6.0E-1 2.9E+0 - 2.9E+0 1 / 8	<LLD <LLD 0 / 22
Fe-59	54 0	260	<LLD <LLD 0 / 24	<LLD <LLD 0 / 12	<LLD <LLD 0 / 22
Co-58	54 0	130	<LLD <LLD 0 / 24	<LLD <LLD 0 / 12	<LLD <LLD 0 / 22
Co-60	54 0	5	1.4E+0 ± 5.3E-1 1.1E+0 - 1.6E+0 2 / 32	Dis: 1.4E+0 ± 5.3E-1 1.1E+0 - 1.6E+0 2 / 8	<LLD <LLD 0 / 22
Zn-65	54 0	5	5.5E+0 ± 1.8E+0 5.5E+0 - 5.5E+0 1 / 32	Dis: 5.5E+0 ± 1.8E+0 5.5E+0 - 5.5E+0 1 / 8	<LLD <LLD 0 / 22
Zr-95	54 0	5	<LLD <LLD 0 / 24	<LLD <LLD 0 / 12	<LLD <LLD 0 / 22
Cs-134	54 0	5	<LLD <LLD 0 / 24	<LLD <LLD 0 / 12	<LLD <LLD 0 / 22
Cs-137	54 0	5	1.5E+0 ± 5.1E-1 1.2E+0 - 1.8E+0 3 / 32	Ply-H: 1.6E+0 ± 5.8E-1 1.4E+0 - 1.8E+0 2 / 16	1.4E+0 ± 0.0E+0 1.2E+0 - 1.6E+0 3 / 22
Ce-144	54 0	15	<LLD <LLD 0 / 24	<LLD <LLD 0 / 12	<LLD <LLD 0 / 22
AcTh-228	54 0		4.7E+1 ± 2.6E+1 8.6E+0 - 1.2E+2 32 / 32	Dux-B: 9.4E+1 ± 8.5E+1 1.5E+1 - 2.6E+2 14 / 14	7.6E+1 ± 1.9E+1 1.1E+1 - 2.6E+2 22 / 22

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

Table 2.16-1
Lobster Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2003)

MEDIUM: American Lobster (HA) UNITS: pCi/kg wet

Radionuclide	No. Analyses Non-routine*	Required LLD	Indicator Stations Mean ± Std.Dev. Range Fraction>LLD	Station with Highest Mean Station: Mean ± Std.Dev. Range Fraction>LLD	Control Stations Mean ± Std.Dev. Range Fraction>LLD
Be-7	5 0		<LLD <LLD 0 / 4	<LLD <LLD 0 / 4	<LLD <LLD 0 / 1
K-40	5 0		3.7E+3 ± 3.2E+2 3.3E+3 - 4.0E+3 4 / 4	CC-Bay: 5.9E+3 ± 5.7E+1 5.9E+3 - 5.9E+3 1 / 1	5.9E+3 ± 5.7E+1 5.9E+3 - 5.9E+3 1 / 1
Mn-54	5 0	130	<LLD <LLD 0 / 4	<LLD <LLD 0 / 4	<LLD <LLD 0 / 1
Fe-59	5 0	260	<LLD <LLD 0 / 4	<LLD <LLD 0 / 4	<LLD <LLD 0 / 1
Co-58	5 0	130	<LLD <LLD 0 / 4	<LLD <LLD 0 / 4	<LLD <LLD 0 / 1
Co-60	5 0	130	<LLD <LLD 0 / 4	<LLD <LLD 0 / 4	<LLD <LLD 0 / 1
Zn-65	5 0	260	<LLD <LLD 0 / 4	<LLD <LLD 0 / 4	<LLD <LLD 0 / 1
Cs-134	5 0	130	<LLD <LLD 0 / 4	<LLD <LLD 0 / 4	<LLD <LLD 0 / 1
Cs-137	5 0	130	<LLD <LLD 0 / 4	<LLD <LLD 0 / 4	<LLD <LLD 0 / 1
AcTh-228	5 0		1.2E+2 ± 2.8E+1 1.2E+2 - 1.2E+2 1 / 4	DIS: 1.2E+2 ± 2.8E+1 1.2E+2 - 1.2E+2 1 / 4	<LLD <LLD 0 / 1

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

Table 2.17-1
Fish Radioactivity Analyses

Radiological Environmental Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 2003)

MEDIUM: Fish (FH) UNITS: pCi/kg wet

Radionuclide	No. Analyses Non-routine*	Required LLD	Indicator Stations Mean ± Std.Dev. Range Fraction>LLD	Station with Highest Mean Station: Mean ± Std.Dev. Range Fraction>LLD	Control Stations Mean ± Std.Dev. Range Fraction>LLD
Be-7	20 0		<LLD <LLD 0 / 11	<LLD <LLD 0 / 11	<LLD <LLD 0 / 8
K-40	20 0		5.6E+3 ± 9.2E+2 4.4E+3 - 7.2E+3 13 / 13	CC-Bay: 5.6E+3 ± 9.2E+2 4.6E+3 - 6.8E+3 7 / 7	5.6E+3 ± 9.2E+2 4.6E+3 - 6.8E+3 7 / 7
Mn-54	20 0	130	<LLD <LLD 0 / 11	<LLD <LLD 0 / 11	<LLD <LLD 0 / 8
Fe-59	20 0	260	<LLD <LLD 0 / 11	<LLD <LLD 0 / 11	<LLD <LLD 0 / 8
Co-58	20 0	130	<LLD <LLD 0 / 11	<LLD <LLD 0 / 11	<LLD <LLD 0 / 8
Co-60	20 0	130	<LLD <LLD 0 / 11	<LLD <LLD 0 / 11	<LLD <LLD 0 / 8
Zn-65	20 0	260	<LLD <LLD 0 / 11	<LLD <LLD 0 / 11	<LLD <LLD 0 / 8
Cs-134	20 0	130	<LLD <LLD 0 / 11	<LLD <LLD 0 / 11	<LLD <LLD 0 / 8
Cs-137	20 0	130	<LLD <LLD 0 / 11	<LLD <LLD 0 / 11	<LLD <LLD 0 / 8
AcTh-228	20 0		8.3E+1 ± 2.2E+1 7.7E+1 - 8.9E+1 2 / 7	CC-Bay: 1.0E+2 ± 3.8E+1 5.5E+1 - 1.3E+2 4 / 7	1.0E+2 ± 3.8E+1 5.5E+1 - 1.3E+2 4 / 7

* Non-Routine refers to those radionuclides that exceeded the Reporting Levels in ODCM Table 3.5-4.

Figure 2.2-1

Environmental TLD Locations Within the PNPS Protected Area

TLD Station		Location*
Description	Code	Distance/Direction
TLDs Within Protected Area		
O&M/RXB. BREEZEWAY	P21	50 m SE
EXEC.BUILDING	P24	57 m W
FENCE-R SCREENHOUSE	P04	66 m N
O&M - 2ND W WALL	P20	67 m SE
EXEC.BUILDING LAWN	P25	76 m WNW
FENCE-WATER TANK	P05	81 m NNE
FENCE-OIL STORAGE	P06	85 m NE
O&M - 2ND SW CORNER	P19	86 m S
O&M - 1ST SW CORNER	P18	90 m S
COMPRESSED GAS STOR	P08	92 m E
FENCE-L SCREENHOUSE	P03	100 m NW
FENCE-EXEC.BUILDING	P17	107 m W
O&M - 2ND S WALL	P23	121 m ENE
FENCE-INTAKE BAY	P07	121 m SSE
FENCE-WAREHOUSE	P26	134 m ESE
FENCE-SHOREFRONT	P02	135 m NW
FENCE-W BOAT RAMP	P09	136 m E
O&M - 2ND N WALL	P22	137 m SE
FENCE-W SWITCHYARD	P16	172 m SW
FENCE-TCF GATE	P11	183 m ESE
FENCE-TCF/BOAT RAMP	P27	185 m ESE
FENCE-ACCESS GATE	P12	202 m SE
FENCE-E SWITCHYARD	P15	220 m S
FENCE-TCF/INTAKE BAY	P10	223 m E
FENCE-MEDICAL BLDG.	P13	224 m SSE
FENCE-BUTLER BLDG	P14	228 m S
FENCE-TCF/PRKNG LOT	P28	259 m ESE

* Distance and direction are measured from centerline of Reactor Building to the monitoring location.

Figure 2.2-1 (continued)
Environmental TLD Locations Within the PNPS Protected Area

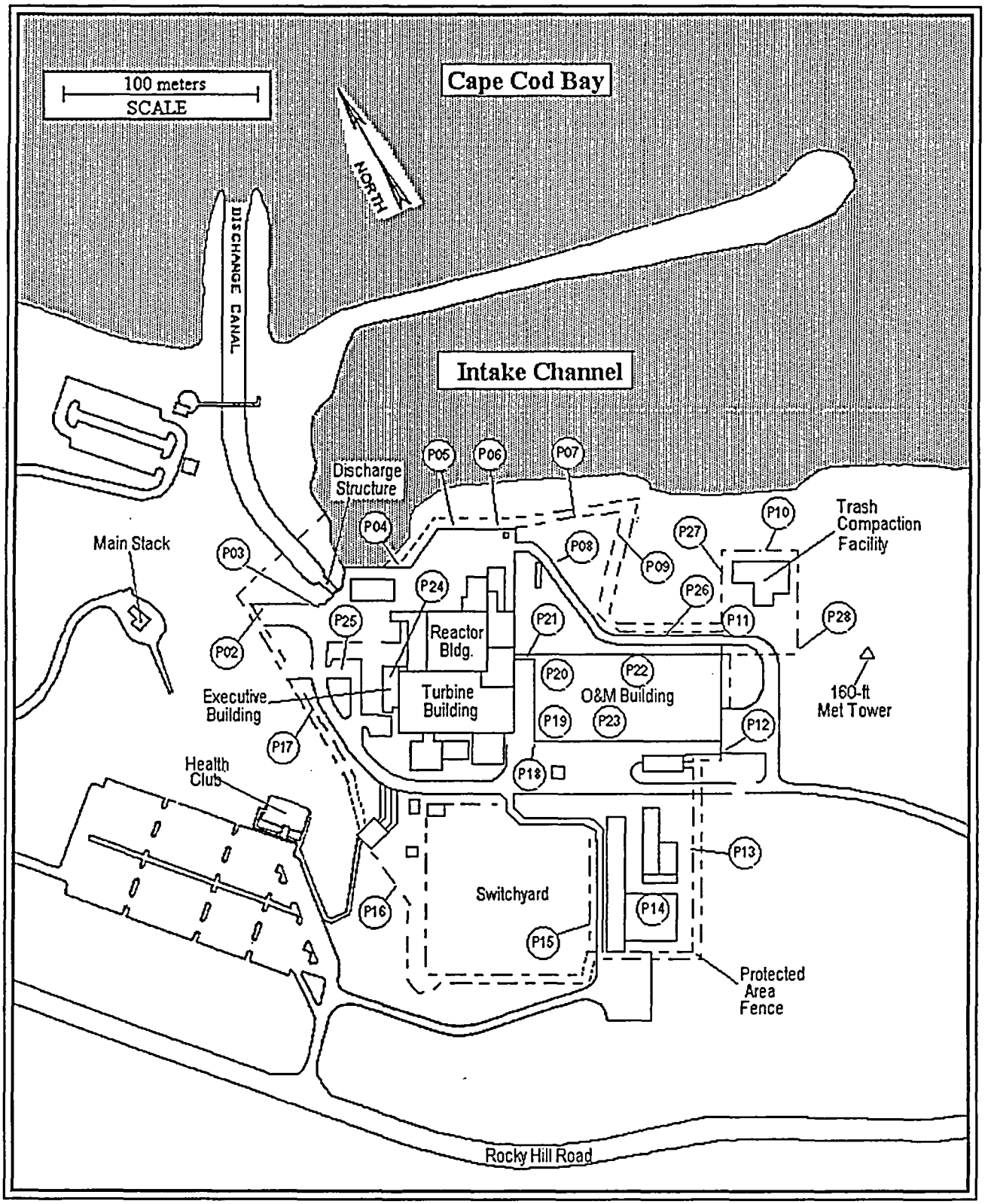


Figure 2.2-2

TLD and Air Sampling Locations: Within 1 Kilometer

TLD Station		Location*	Air Sampling Station		Location*
Description	Code	Distance/Direction	Description	Code	Distance/Direction
Zone 1 TLDs: 0-3 km					
BOAT LAUNCH WEST	BLW	0.11 km E	OVERLOOK AREA	OA	0.15 km W
OVERLOOK AREA	OA	0.15 km W	PEDESTRIAN BRIDGE	PB	0.21 km N
HEALTH CLUB	TC	0.15 km WSW	MEDICAL BUILDING	WS	0.23 km SSE
BOAT LAUNCH EAST	BLE	0.16 km ESE	EAST BREAKWATER	EB	0.44 km ESE
PEDESTRIAN BRIDGE	PB	0.21 km N	PROPERTY LINE	PL	0.54 km NNW
SHOREFRONT SECURITY	P01	0.22 km NNW	W ROCKY HILL ROAD	WR	0.83 km WNW
MEDICAL BUILDING	WS	0.23 km SSE	E ROCKY HILL ROAD	ER	0.89 km SE
PARKING LOT	CT	0.31 km SE			
SHOREFRONT PARKING	PA	0.35 km NNW			
STATION A	A	0.37 km WSW			
STATION F	F	0.43 km NW			
STATION B	B	0.44 km S			
EAST BREAKWATER	EB	0.44 km ESE			
PNPS MET TOWER	PMT	0.44 km WNW			
STATION H	H	0.47 km SW			
STATION I	I	0.48 km WNW			
STATION L	L	0.50 km ESE			
STATION G	G	0.53 km W			
STATION D	D	0.54 km NW			
PROPERTY LINE	PL	0.54 km NNW			
STATION C	C	0.57 km ESE			
HALL'S BOG	HB	0.63 km SE			
GREENWOOD HOUSE	GH	0.65 km ESE			
W ROCKY HILL ROAD	WR	0.83 km WNW			
E ROCKY HILL ROAD	ER	0.89 km SE			

Figure 2.2-2 (continued)

TLD and Air Sampling Locations: Within 1 Kilometer

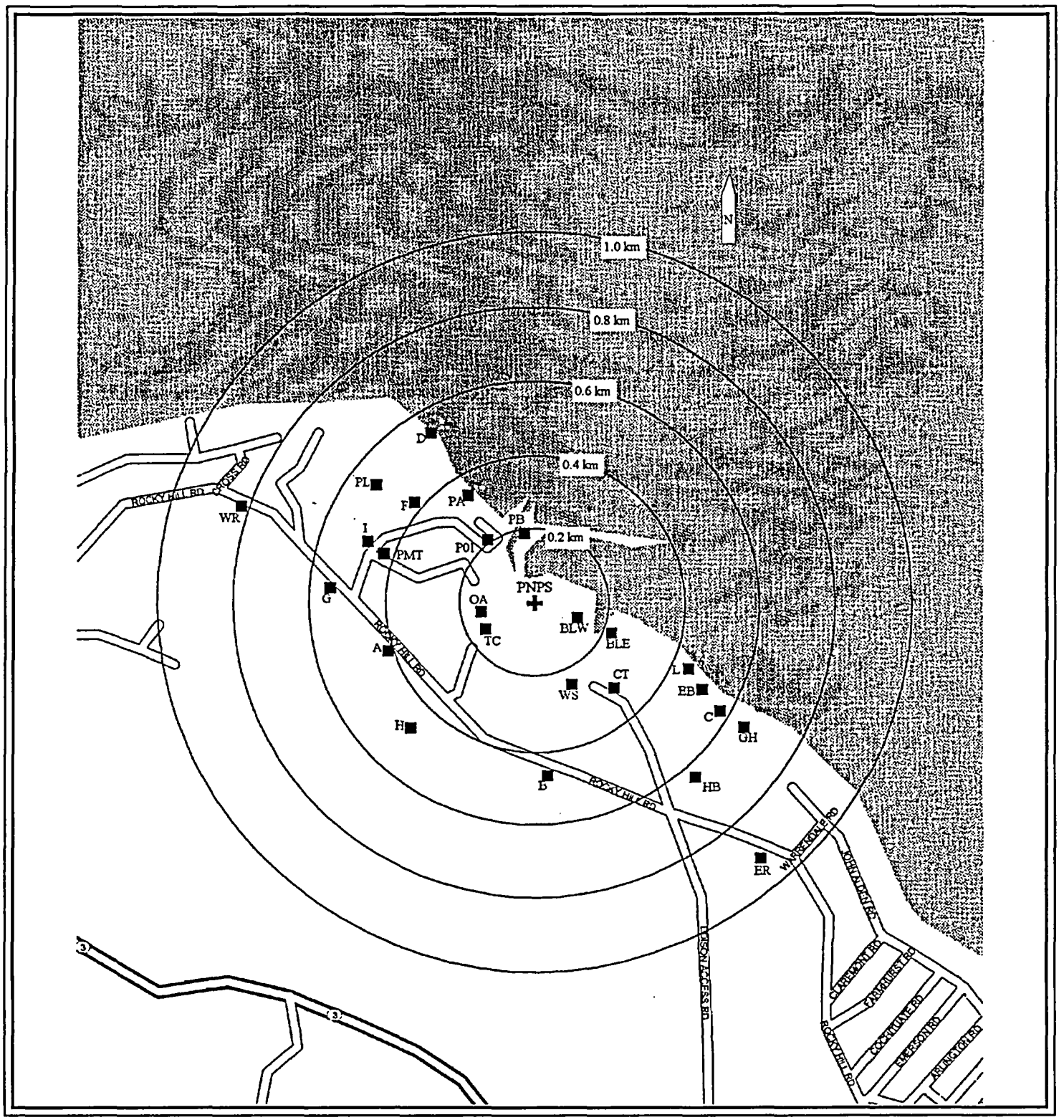


Figure 2.2-3

TLD and Air Sampling Locations: 1 to 5 Kilometers

TLD Station		Location*	Air Sampling Station		Location*
Description	Code	Distance/Direction	Description	Code	Distance/Direction
Zone 1 TLDs: 0-3 km					
MICROWAVE TOWER	MT	1.03 km SSW	CLEFT ROCK	CR	1.27 km SSW
CLEFT ROCK	CR	1.27 km SSW	MANOMET SUBSTATION	MS	3.60 km SSE
BAYSHORE/GATE RD	BD	1.34 km WNW			
MANOMET ROAD	MR	1.38 km S			
DIRT ROAD	DR	1.48 km SW			
EMERSON ROAD	EM	1.53 km SSE			
EMERSON/PRISCILLA	EP	1.55 km SE			
EDISON ACCESS ROAD	AR	1.59 km SSE			
BAYSHORE	BS	1.76 km W			
STATION E	E	1.86 km S			
JOHN GAULEY	JG	1.99 km W			
STATION J	J	2.04 km SSE			
WHITEHORSE ROAD	WH	2.09 km SSE			
PLYMOUTH YMCA	RC	2.09 km WSW			
STATION K	K	2.17 km S			
TAYLOR/THOMAS	TT	2.26 km SE			
YANKEE VILLAGE	YV	2.28 km WSW			
GOODWIN PROPERTY	GN	2.38 km SW			
RIGHT OF WAY	RW	2.83 km S			
TAYLOR/PEARL	TP	2.98 km SE			
Zone 2 TLDs: 3-8 km					
VALLEY ROAD	VR	3.26 km SSW			
MANOMET ELEM	ME	3.29 km SE			
WARREN/CLIFFORD	WC	3.31 km W			
RT.3A/BARTLETT RD	BB	3.33 km SSE			
MANOMET POINT	MP	3.57 km SE			
MANOMET SUBSTATION	MS	3.60 km SSE			
BEACHWOOD ROAD	BW	3.93 km SE			
PINES ESTATE	PT	4.44 km SSW			
EARL ROAD	EA	4.60 km SSE			
S PLYMOUTH SUBST	SP	4.62 km W			
ROUTE 3 OVERPASS	RP	4.81 km SW			
RUSSELL MILLS RD	RM	4.85 km WSW			

* Distance and direction are measured from centerline of Reactor Building to the monitoring location.

Figure 2.2-3 (continued)

TLD and Air Sampling Locations: 1 to 5 Kilometers

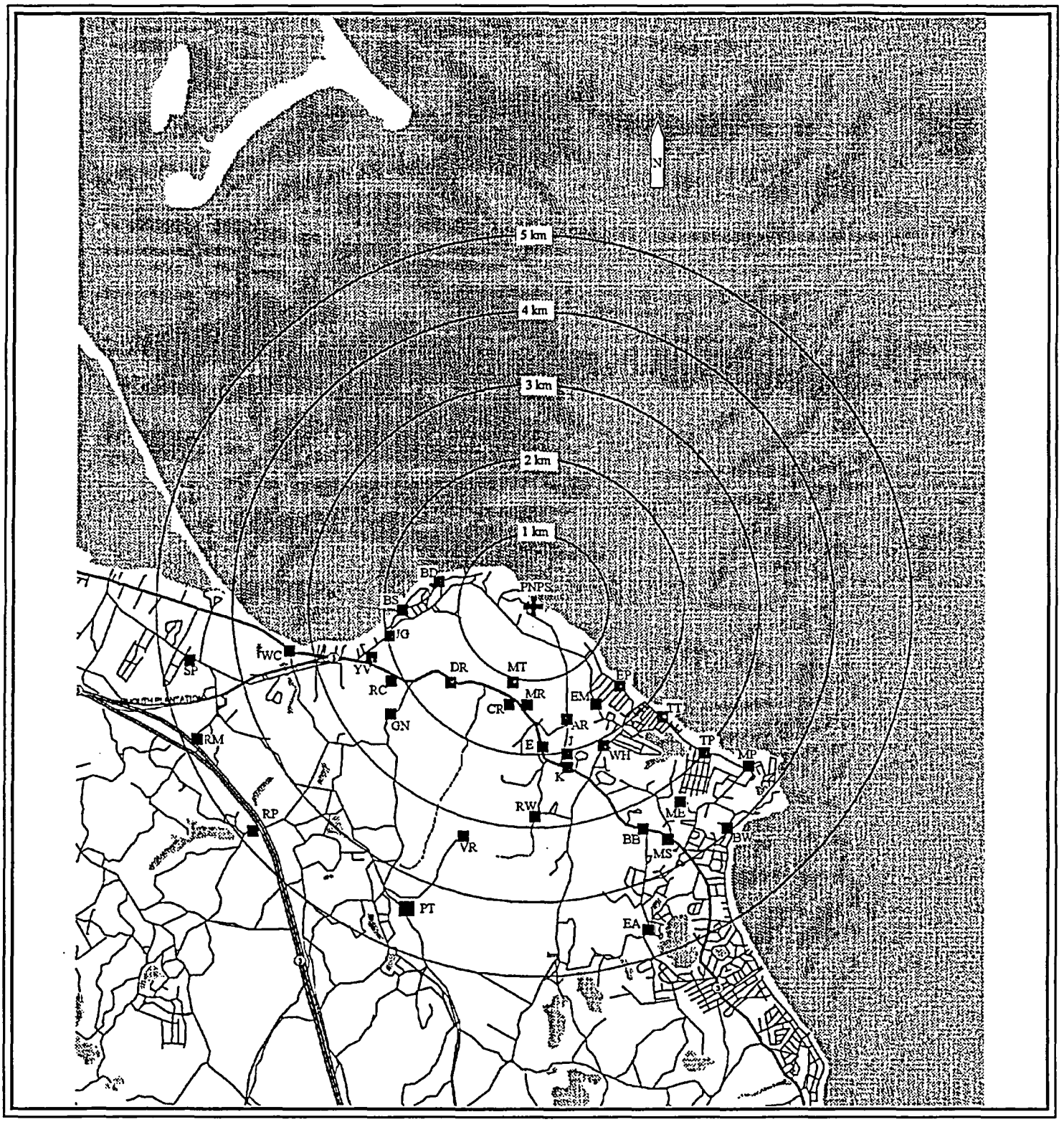


Figure 2.2-4

TLD and Air Sampling Locations: 5 to 25 Kilometers

TLD Station		Location*	Air Sampling Station		Location*
Description	Code	Distance/Direction	Description	Code	Distance/Direction
Zone 2 TLDs: 3-8 km					
HILLDALE ROAD	HD	5.18 km W	PLYMOUTH CENTER	PC	6.69 km W
MANOMET BEACH	MB	5.43 km SSE			
BEAVERDAM ROAD	BR	5.52 km S			
PLYMOUTH CENTER	PC	6.69 km W			
LONG POND/DREW RD	LD	6.97 km WSW			
HYANNIS ROAD	HR	7.33 km SSE			
MEMORIAL HALL	MH	7.58 km WNW			
SAQUISH NECK	SN	7.58 km NNW			
COLLEGE POND	CP	7.59 km SW			
Zone 3 TLDs: 8-15 km					
DEEP WATER POND	DW	8.59 km W			
LONG POND ROAD	LP	8.88 km SSW			
NORTH PLYMOUTH	NP	9.38 km WNW			
STANDISH SHORES	SS	10.39 km NW			
ELLISVILLE ROAD	EL	11.52 km SSE			
UP COLLEGE POND RD	UC	11.78 km SW			
SACRED HEART	SH	12.92 km W			
KING CAESAR ROAD	KC	13.11 km NNW			
BOURNE ROAD	BE	13.37 km S			
SHERMAN AIRPORT	SA	13.43 km WSW			
Zone 4 TLDs: >15 km					
CEDARVILLE SUBST	CS	15.93 km S			
KINGSTON SUBST	KS	16.15 km WNW			
LANDING ROAD	LR	16.46 km NNW			
CHURCH/WEST	CW	16.56 km NW			
MAIN/MEADOW	MM	17.02 km WSW			
DIV MARINE FISH	DMF	20.97 km SSE			

* Distance and direction are measured from centerline of Reactor Building to the monitoring location.

Figure 2.2-4 (continued)

TLD and Air Sampling Locations: 5 to 25 Kilometers

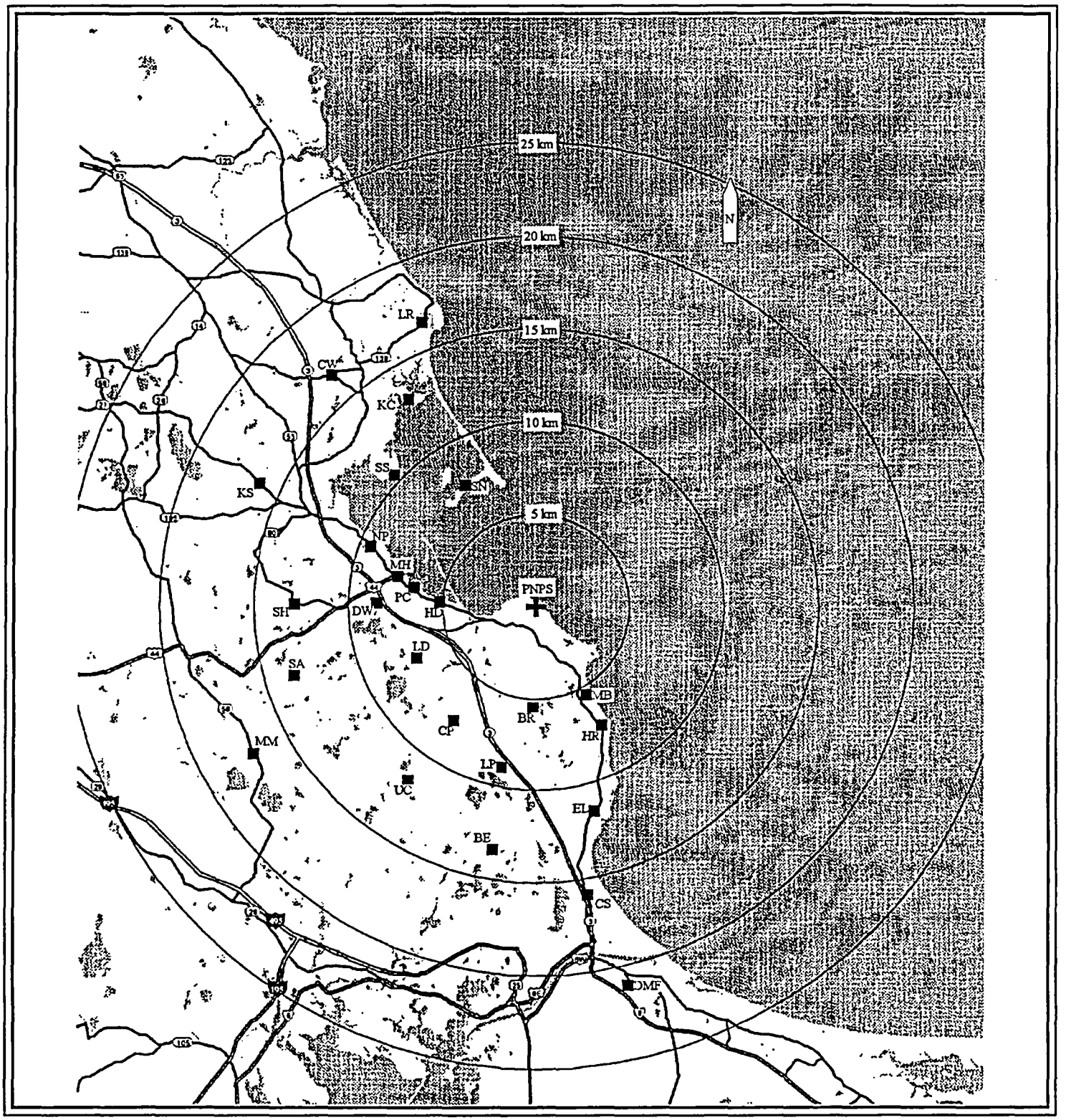


Figure 2.2-5

Terrestrial and Aquatic Sampling Locations

Description	Code	Distance/Direction*
MILK		
Plymouth County Farm	CF	5.6 km W
Whitman Farm Control	WF	34 km WNW
FORAGE		
Whipple Farm	WH	2.9 km SW
Plymouth County Farm	CF	5.6 km W
Whitman Farm Control	WF	34 km WNW
VEGETABLES/VEGETATION		
Site Boundary C	BC	0.5 km SW
Site Boundary B	BB	0.5 km ESE
Rocky Hill Road	RH	0.9 km SE
Site Boundary D	Bd	1.1 km SSW
Site Boundary A	BA	1.5 km SSW
Clay Hill Road	CH	1.6 km W
Brook Road	BK	2.9 km SSE
Beaverdam Road	BD	3.4 km S
Plymouth County Farm	CF	5.6 km W
Div. Marine Fisheries	DMF	21 km SSE
Bridgewater Control	BF	31 km W
CRANBERRIES		
Manomet Point Bog	MR	3.9 km SE
Bartlett Road Bog	BT	4.3 km SSE
Pine Street Bog Control	PS	26 km WNW

Description	Code	Distance/Direction*
SURFACE WATER		
Discharge Canal	DIS	0.2 km N
Bartlett Pond	BP	2.7 km SE
Powder Point Control	PP	13 km NNW
SEDIMENT		
Discharge Canal Outfall	DIS	0.8 km NE
Plymouth Beach	PLB	4.0 km W
Manomet Point	MP	3.3 km ESE
Plymouth Harbor	PLY-H	4.1 km W
Duxbury Bay Control	DUX-BAY	14 km NNW
Green Harbor Control	GH	16 km NNW
IRISH MOSS		
Discharge Canal Outfall	DIS	0.7 km NNE
Manomet Point	MP	4.0 km ESE
Ellisville	EL	12 km SSE
Brant Rock Control	BK	18 km NNW
SHELLFISH		
Discharge Canal Outfall	DIS	0.7 km NNE
Plymouth Harbor	PLY-H	4.1 km W
Manomet Point	MP	4.0 km ESE
Duxbury Bay Control	DUX-BAY	13 km NNW
Powder Point Control	PP	13 km NNW
Green Harbor Control	GH	16 km NNW
LOBSTER		
Discharge Canal Outfall	DIS	0.5 km N
Plymouth Beach	PLB	4.0 km W
Plymouth Harbor	PLY-H	6.4 km WNW
Duxbury Bay Control	DUX-BAY	11 km NNW
FISHES		
Discharge Canal Outfall	DIS	0.5 km N
Plymouth Beach	PLB	4.0 km W
Jones River Control	JR	13 km WNW
Cape Cod Bay Control	CC-BAY	24 km ESE
N River-Hanover Control	NR	24 km NNW
Cataumet Control	CA	32 km SSW
Provincetown Control	PT	32 km NE
Buzzards Bay Control	BB	40 km SSW
Priest Cove Control	PC	48 km SW
Nantucket Sound Control	NS	48 km SSE
Atlantic Ocean Control	AO	48 km E
Vineyard Sound Control	MV	64 km SSW

* Distance and direction are measured from the centerline of the reactor to the sampling/monitoring location.

Figure 2.2-5 (continued)

Terrestrial and Aquatic Sampling Locations

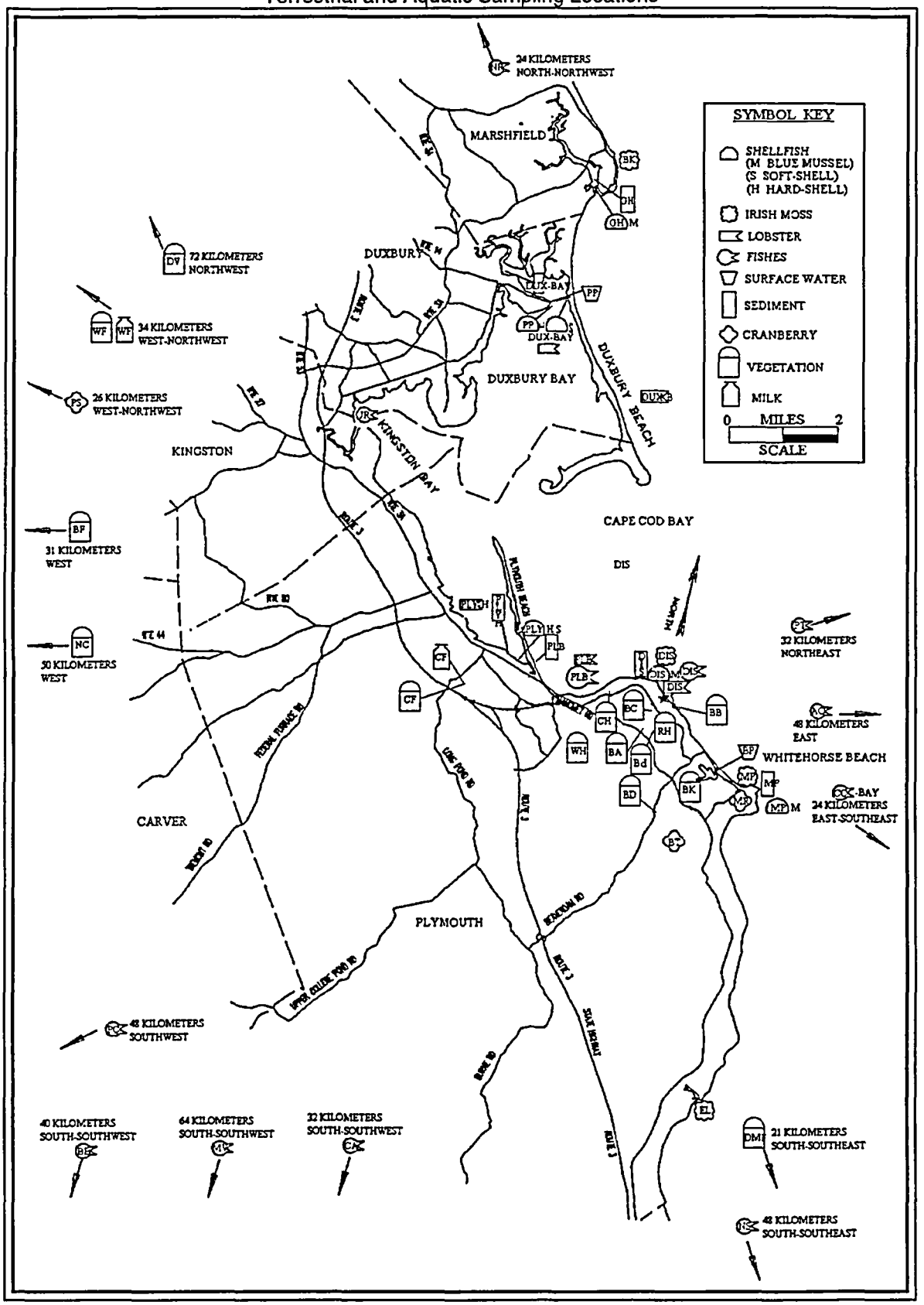


Figure 2.2-6

Environmental Sampling And Measurement Control Locations

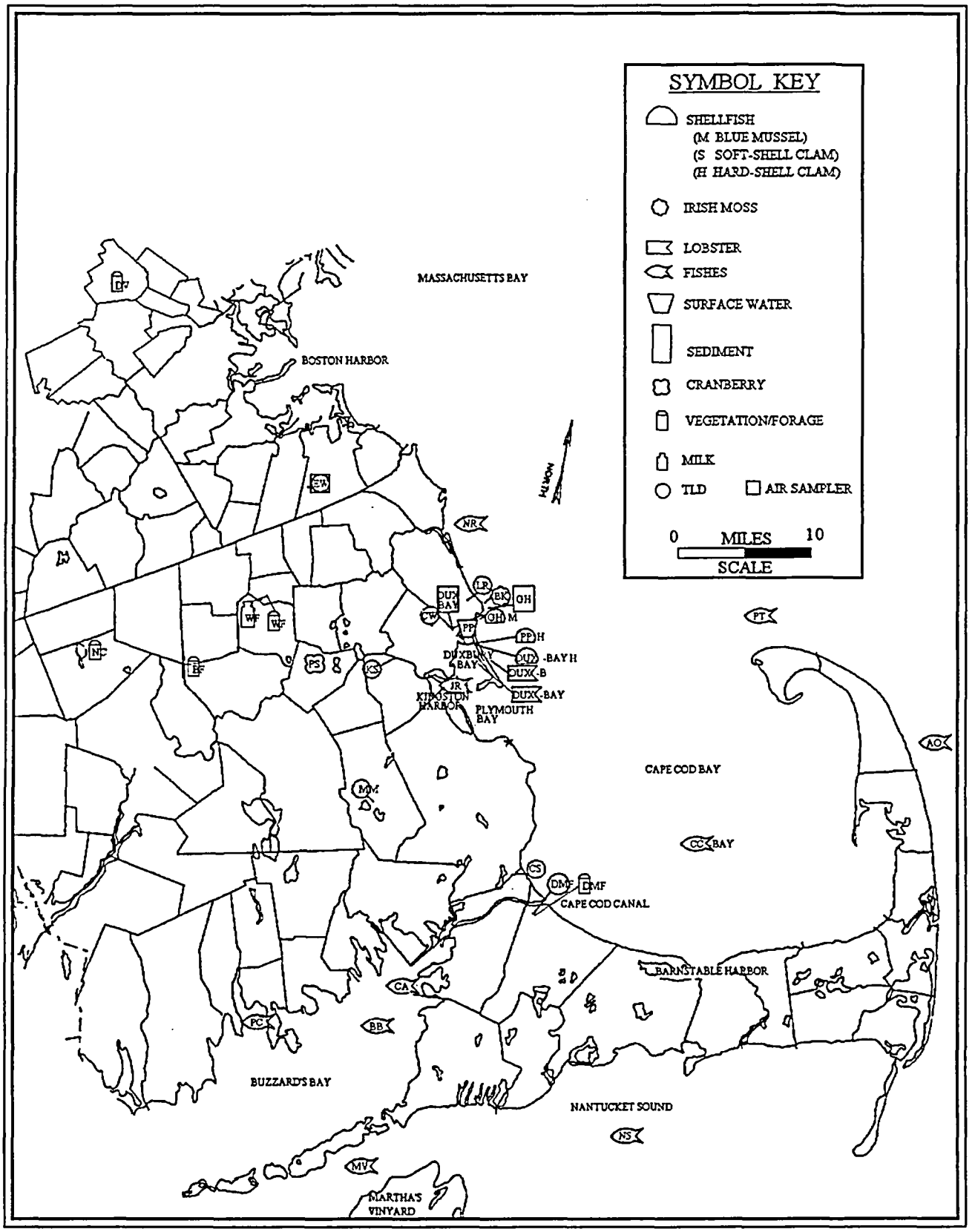
Description	Code	Distance/Direction*
TLD		
Cedarville Substation	CS	16 km S
Kingston Substation	KS	16 km WNW
Landing Road	LR	16 km NNW
Church & West Street	CW	17 km NW
Main & Meadow Street	MM	17 km WSW
Div. Marine Fisheries	DMF	21 km SSE
East Weymouth Substation	EW	40 km NW
AIR SAMPLER		
East Weymouth Substation	EW	40 km NW
MILK		
Whitman Farm Control	WF	34 km WNW
FORAGE		
Whitman Farm Control	WF	34 km WNW
VEGETABLES/VEGETATION		
Div. Marine Fish. Control	DMF	21 km SSE
Bridgewater Farm Control	BF	31 km W
CRANBERRIES		
Pine Street Bog Control	PS	26 km WNW

Description	Code	Distance/Direction*
SURFACE WATER		
Powder Point Control	PP	13 km NNW
SEDIMENT		
Duxbury Bay Control	DUX-BAY	14 km NNW
Green Harbor Control	GH	16 km NNW
IRISH MOSS		
Brant Rock Control	BK	18 km NNW
SHELLFISH		
Duxbury Bay Control	DUX-BAY	13 km NNW
Powder Point Control	PP	13 km NNW
Green Harbor Control	GH	16 km NNW
LOBSTER		
Duxbury Bay Control	DUX-BAY	11 km NNW
FISHES		
Jones River Control	JR	13 km WNW
Cape Cod Bay Control	CC-BAY	24 km ESE
N River-Hanover Control	NR	24 km NNW
Cataumet Control	CA	32 km SSW
Provincetown Control	PT	32 km NE
Buzzards Bay Control	BB	40 km SSW
Priest Cove Control	PC	48 km SW
Nantucket Sound Control	NS	48 km SSE
Atlantic Ocean Control	AO	48 km E
Vineyard Sound Control	MV	64 km SSW

* Distance and direction are measured from the centerline of the reactor to the sampling/monitoring location.

Figure 2.2-6 (continued)

Environmental Sampling And Measurement Control Locations



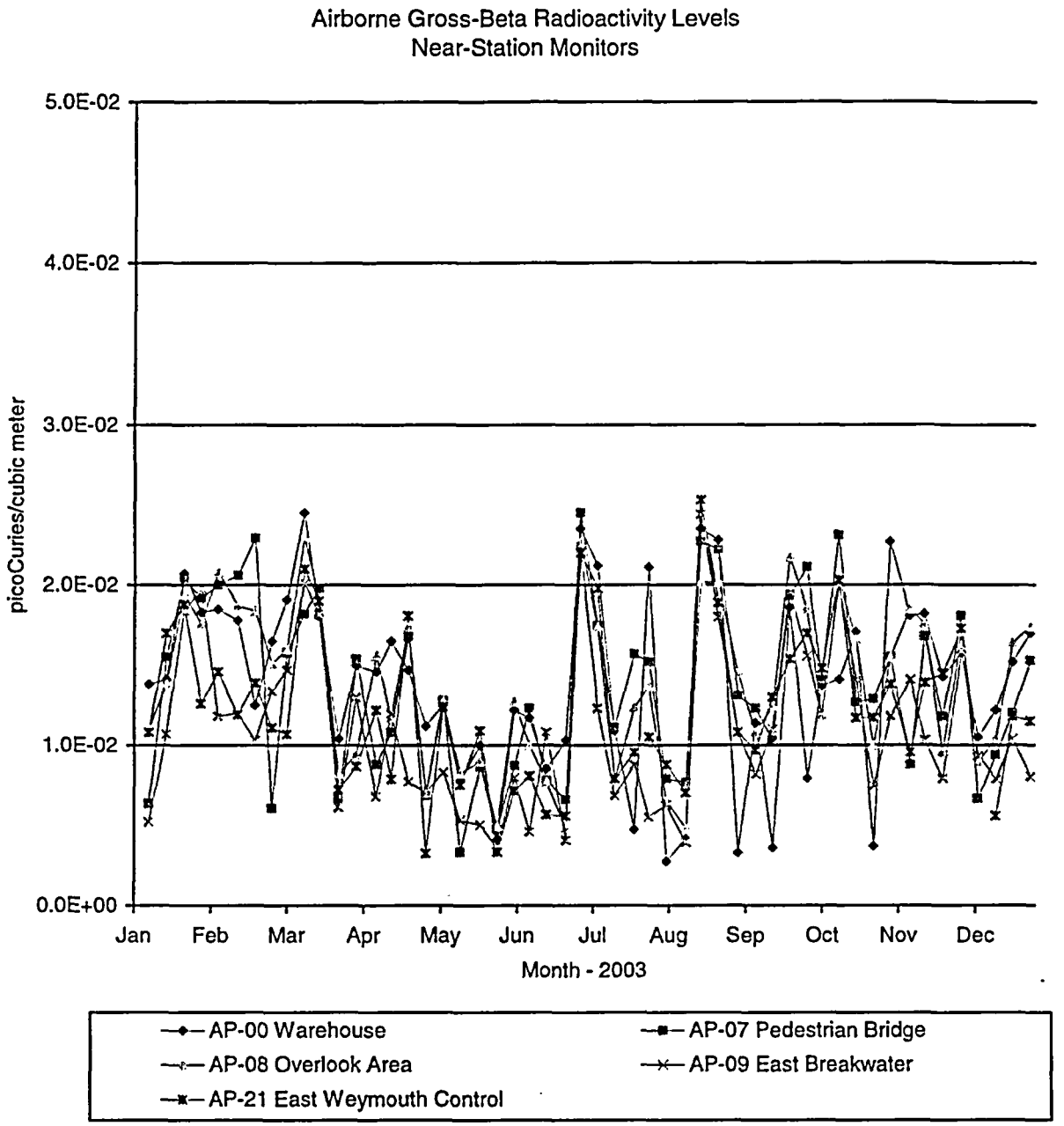


Figure 2.5-1
Airborne Gross-Beta Radioactivity Levels: Near Station Monitors

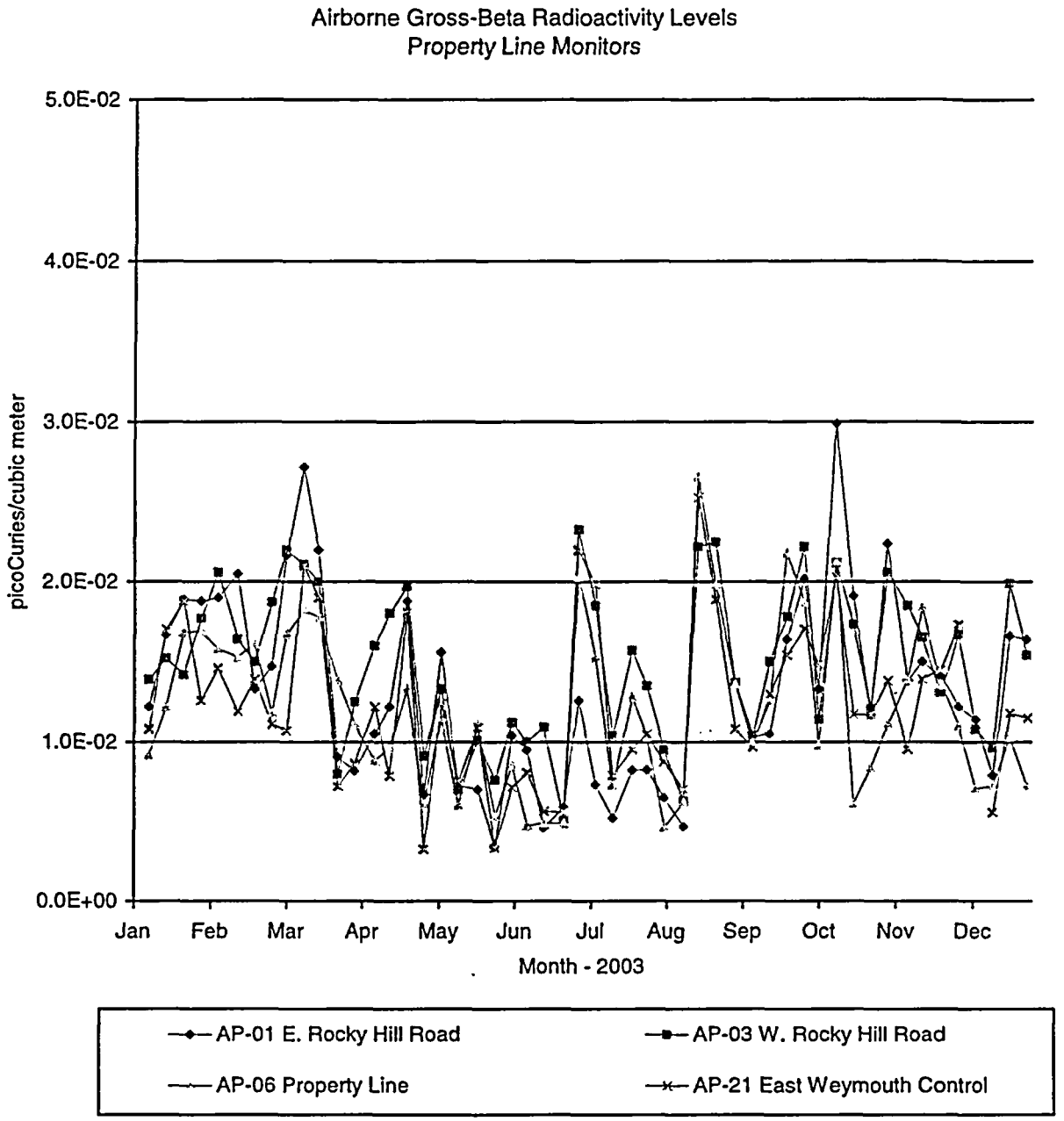


Figure 2.5-2
Airborne Gross-Beta Radioactivity Levels: Property Line Monitors

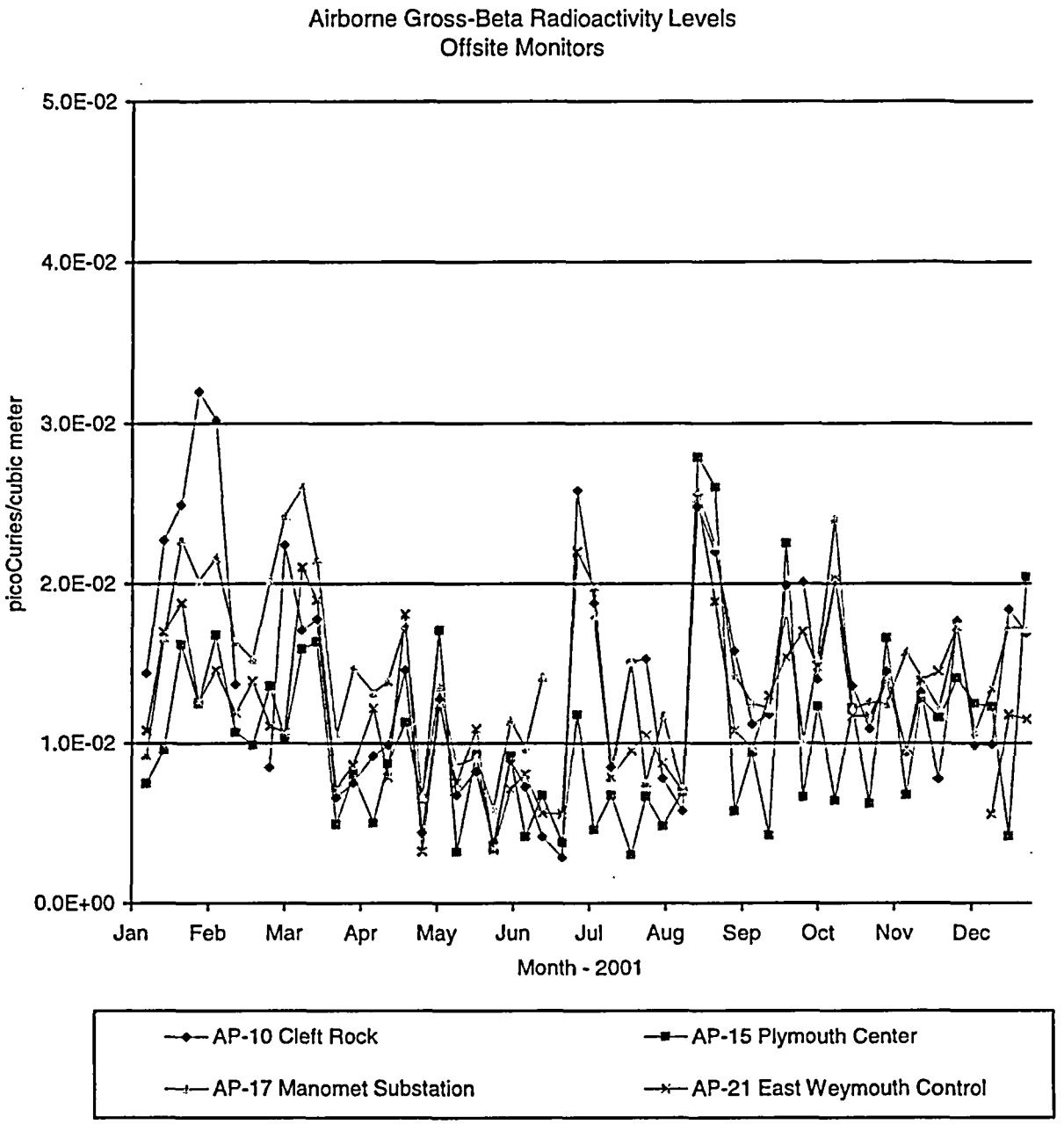


Figure 2.5-3
Airborne Gross-Beta Radioactivity Levels: Offsite Monitors

3.0 SUMMARY OF RADIOLOGICAL IMPACT ON HUMANS

The radiological impact to humans from the Pilgrim Station's radioactive liquid and gaseous releases has been estimated using two methods:

- calculations based on measurements of plant effluents; and
- calculations based on measurements of environmental samples.

The first method utilizes data from the radioactive effluents (measured at the point of release) together with conservative models that calculate the dispersion and transport of radioactivity through the environment to humans (Reference 7). The second method is based on actual measurements of radioactivity in the environmental samples and on dose conversion factors recommended by the Nuclear Regulatory Commission. The measured types and quantities of radioactive liquid and gaseous effluents released from Pilgrim Station during 2003 were reported to the Nuclear Regulatory Commission, copies of which are provided in Appendix B. The measured levels of radioactivity in the environmental samples that required dose calculations are listed in Appendix A.

The maximum individual dose from liquid effluents was calculated using the following radiation exposure pathways:

- shoreline external radiation during fishing and recreation at the Pilgrim Station Shorefront;
- external radiation from the ocean during boating and swimming; and
- ingestion of fish and shellfish.

For gaseous effluents, the maximum individual dose was calculated using the following radiation exposure pathways:

- external radiation from cloud shine and submersion in gaseous effluents;
- inhalation of airborne radioactivity;
- external radiation from soil deposition;
- consumption of vegetables; and
- consumption of milk and meat.

The results from the dose calculations based on PNPS operations are presented in Table 3.0-1. The dose assessment data presented were taken from the "Radioactive Effluent and Waste Disposal Report" for the period of January 1 through December 31, 2003.

Table 3.0-1

Radiation Doses from 2003 Pilgrim Station Operations

Receptor	Maximum Individual Dose From Exposure Pathway - mrem/yr			
	Gaseous Effluents*	Liquid Effluents	Ambient Radiation**	Total
Total Body	0.048	0.0030	2.2	2.2
Thyroid	0.052	0.000065	2.2	2.2
Max. Organ	0.052	0.0075	2.2	2.2

* Gaseous effluent exposure pathway includes combined dose from particulates, iodines and tritium in addition to noble gases.

** Ambient radiation dose for the hypothetical maximum-exposed individual at a location on PNPS property yielding highest ambient radiation exposure value as measured with TLDs.

Two federal agencies establish dose limits to protect the public from radiation and radioactivity. The Nuclear Regulatory Commission (NRC) specifies a whole body dose limit of 100 mrem/yr to be received by the maximum exposed member of the general public. This limit is set forth in Section 1301, Part 20, Title 10, of the U.S. Code of Federal Regulations (10CFR20). By comparison, the Environmental Protection Agency (EPA) limits the annual whole body dose to 25 mrem/yr, which is specified in Section 10, Part 190, Title 40, of the Code of Federal Regulations (40CFR190).

Another useful "gauge" of radiation exposure is provided by the amount of dose a typical individual receives each year from natural and man-made (e.g., diagnostic X-rays) sources of radiation. The typical American receives 300 to 400 mrem/yr from such sources.

As can be seen from the doses resulting from Pilgrim Station Operations during 2003, all values are well within the federal limits specified by the NRC and EPA. In addition, the calculated doses from PNPS operation represent only a fraction of a percent of doses from natural and man-made radiation.

A second method of dose estimation involves calculations based on radioactivity detected in environmental media. During 2003, the only environmental media which contained radioactivity potentially attributable to Pilgrim Station operation was shellfish, which contained low levels of zinc-65. The maximum calculated total body dose from this ingestion pathway was calculated as 0.0004 mrem, with a corresponding maximum organ dose of 0.0007 mrem.

In conclusion, the radiological impact of Pilgrim Station operations, whether based on actual environmental measurements or calculations made from effluent releases, would yield doses well within any federal dose limits set by the NRC or EPA. Such doses represent only a small percentage of the typical annual dose received from natural and man-made sources of radiation.

4.0 REFERENCES

1) United States of America, Code of Federal Regulations, Title 10, Part 50, Appendix A Criteria 64.

2) Donald T. Oakley, "Natural Radiation Exposure in the United States." U. S. Environmental Protection Agency, ORP/SID 72-1, June 1972.

3) National Council on Radiation Protection and Measurements, Report No. 93, "Ionizing Radiation Exposures of the Population of the United States," September 1987.

4) United States Nuclear Regulatory Commission, Regulatory Guide 8.29, "Instructions Concerning Risks from Occupational Radiation Exposure," Revision 0, July 1981.

5) Boston Edison Company, "Pilgrim Station" Public Information Brochure 100M, WNTHP, September 1989.

6) United States Nuclear Regulatory Commission, Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977.

7) Pilgrim Nuclear Power Station Offsite Dose Calculation Manual, Revision 8, August 1998.

8) United States of America, Code of Federal Regulations, Title 10, Part 20.1301.

9) United States of America, Code of Federal Regulations, Title 10, Part 50, Appendix I.

10) United States of America, Code of Federal Regulations, Title 40, Part 190.

11) United States Nuclear Regulatory Commission, Regulatory Guide 4.1, "Program for Monitoring Radioactivity in the Environs of Nuclear Power Plants," Revision 1, April 1975.

12) ICN/Tracerlab, "Pilgrim Nuclear Power Station Pre-operational Environmental Radiation Survey Program, Quarterly Reports," August 1968 to June 1972.

13) International Commission of Radiological Protection, Publication No. 43, "Principles of Monitoring for the Radiation Protection of the Population," May 1984.

14) United States Nuclear Regulatory Commission, NUREG-1302, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Boiling Water Reactors," April 1991.

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

16) Settlement Agreement Between Massachusetts Wildlife Federation and Boston Edison Company Relating to Offsite Radiological Monitoring - June 9, 1977.

APPENDIX A

SPECIAL STUDIES

Shellfish Radioactivity

The only environmental media which contained radioactivity potentially attributable to Pilgrim Station operations was shellfish. The only nuclide detected was zinc-65 (Zn-65), at concentrations ranging from non-detectable to a maximum concentration of 5.5 pCi/kg, which was detected in one out of four samples of edible mussel meat collected from the PNPS discharge outfall. This sample was collected in May 2003, shortly following the PNPS refueling outage, during which a number of permitted liquid discharges were performed.

To assess the potential dose impact from such Zn-65, standard equations found in Regulatory Guide 1.109 and the Pilgrim Station Offsite Dose Calculation Manual were used. The approach used calculates the total intake of Cs-137 based on ingestion/consumption rates, and multiplies that value by a dose conversion factor to derive the resulting dose. The following table outlines the approach taken and the resulting dose to the maximally-exposed organ in each of three age groups:

Maximum Total Body Dose

Age Class	Intake kg/yr	Concentration pCi/kg	Total Intake pCi	Ingestion Dose Factor mrem/pCi	Total Dose mrem
Adult	9	5.5	49.5	6.96E-6	3.45E-4
Teen	6	5.5	33.0	9.33E-6	3.08E-4
Child	3	5.5	16.5	2.27E-5	3.75E-4

Maximum Organ Dose

Age Class	Intake kg/yr	Concentration pCi/kg	Total Intake pCi	Ingestion Dose Factor mrem/pCi	Total Dose mrem
Adult	9	5.5	49.5	1.45E-5 (liver)	7.18E-4
Teen	6	5.5	33.0	2.00E-5 (liver)	6.60E-4
Child	3	5.5	16.5	3.65E-5 (liver)	6.02E-4

As can be seen in the above table, the maximum whole body dose received from ingestion of shellfish containing low-levels of Zn-65 would be 0.0004 mrem, while the maximum organ dose would be 0.0007 mrem. This can be compared to the 30-40 mrem/yr received from the ingestion of other radioactivity (e.g., potassium-40, uranium, thorium, etc.) naturally present in food.

APPENDIX B

Effluent Release Information

TABLE	TITLE	PAGE
B.1	Supplemental Information	72
B.2-A	Gaseous Effluents Summation of All Releases	73
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B.3-A	Liquid Effluents Summation of All Releases	78
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Table B.1
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Supplemental Information
January-December 2003

FACILITY: PILGRIM NUCLEAR POWER STATION **LICENSE: DPR-35**

1. REGULATORY LIMITS	
a. Fission and activation gases:	500 mrem/yr total body and 3000 mrem/yr for skin at site boundary
b,c. Iodines, particulates with half-life: >8 days, tritium	1500 mrem/yr to any organ at site boundary
d. Liquid effluents:	0.06 mrem/month for whole body and 0.2 mrem/month for any organ (without radwaste treatment)
2. EFFLUENT CONCENTRATION LIMITS	
a. Fission and activation gases:	10CFR20 Appendix B Table II
b. Iodines:	10CFR20 Appendix B Table II
c. Particulates with half-life > 8 days:	10CFR20 Appendix B Table II
d. Liquid effluents:	2E-04 µCi/mL for entrained noble gases; 10CFR20 Appendix B Table II values for all other radionuclides
3. AVERAGE ENERGY	Not Applicable
4. MEASUREMENTS AND APPROXIMATIONS OF TOTAL RADIOACTIVITY	
a. Fission and activation gases: b. Iodines: c. Particulates: d. Liquid effluents:	High purity germanium gamma spectroscopy for all gamma emitters; radiochemistry analysis for H-3, Fe-55 (liquid effluents), Sr-89, and Sr-90

5. BATCH RELEASES	Jan-Mar 2003	Apr-Jun 2003	Jul-Sep 2003	Oct-Dec 2003	Jan-Dec 2003
a. Liquid Effluents					
1. Total number of releases:	0	6	4	1	11
2. Total time period (minutes):	0	620	430	195	1245
3. Maximum time period (minutes):	0	160	150	195	195
4. Average time period (minutes):	0	103	108	195	113
5. Minimum time period (minutes):	0	90	90	195	90
6. Average stream flow (Liters/min): during periods of release of effluents into a flowing stream	0	1.17E+6	1.17E+6	1.17E+6	1.17E+6
b. Gaseous Effluents	None	None	None	None	None
6. ABNORMAL RELEASES					
a. Liquid Effluents	None	None	None	None	None
b. Gaseous Effluents	None	None	None	None	None

Table B.2-A
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Gaseous Effluents - Summation of All Releases
January-December 2003

RELEASE PERIOD	Jan-Mar 2003	Apr-Jun 2003	Jul-Sep 2003	Oct-Dec 2003	Jan-Dec 2003	Est. Total Error
A. FISSION AND ACTIVATION GASES						
Total Release: Ci	7.39E+00	1.22E+01	7.89E+00	5.10E+00	3.26E+01	
Average Release Rate: µCi/sec	9.37E-01	1.55E+00	1.00E+00	6.46E-01	1.03E+00	±22%
Percent of Effluent Control Limit	*	*	*	*	*	
B. IODINES						
Total Iodine-131 Release: Ci	6.31E-04	4.15E-04	3.12E-04	2.61E-04	1.62E-03	
Average Release Rate: µCi/sec	8.00E-05	5.26E-05	3.95E-05	3.31E-05	5.13E-05	±20%
Percent of Effluent Control Limit	*	*	*	*	*	
C. PARTICULATES						
Total Release: Ci	2.00E-04	9.36E-04	2.38E-04	9.49E-05	1.47E-03	
Average Release Rate: µCi/sec	2.53E-05	1.19E-04	3.02E-05	1.20E-05	4.65E-05	±21%
Percent of Effluent Control Limit	*	*	*	*	*	
Gross Alpha Radioactivity: Ci	NDA	NDA	NDA	NDA	NDA	
D. TRITIUM						
Total Release: Ci	2.74E+02	7.14E+01	7.65E+01	7.65E+01	4.98E+02	
Average Release Rate: µCi/sec	3.47E+01	9.04E+00	9.69E+00	9.70E+00	1.58E+01	±20%
Percent of Effluent Control Limit	*	*	*	*	*	

Notes for Table 2.2-A:

* Percent of Effluent Control Limit values based on dose assessments are provided in Section 7 of this report.

1. NDA stands for No Detectable Activity.
2. LLD for airborne gross alpha activity listed as NDA is 1E-11 µCi/cc.

Table B.2-B
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Gaseous Effluents – Elevated Release
July-December 2003

CONTINUOUS MODE RELEASES FROM ELEVATED RELEASE POINT					
Nuclide Released	Jan-Mar 2003	Apr-Jun 2003	Jul-Sep 2003	Oct-Dec 2003	Jan-Dec 2003
1. FISSION AND ACTIVATION GASES: Ci					
Ar-41	NDA	NDA	NDA	NDA	NDA
Kr-85	NDA	NDA	NDA	NDA	NDA
Kr-85m	NDA	8.75E-01	1.52E+00	1.96E+00	4.35E+00
Kr-87	NDA	NDA	NDA	NDA	NDA
Kr-88	NDA	NDA	NDA	NDA	NDA
Xe-131m	NDA	NDA	NDA	NDA	NDA
Xe-133	2.82E-01	1.71E+00	3.11E+00	1.65E+00	6.74E+00
Xe-133m	NDA	NDA	NDA	NDA	NDA
Xe-135	NDA	3.20E+00	NDA	3.84E-02	3.24E+00
Xe-135m	NDA	9.05E-01	NDA	NDA	9.05E-01
Xe-137	NDA	NDA	NDA	NDA	NDA
Xe-138	NDA	NDA	NDA	NDA	NDA
Total for Period	2.82E-01	6.69E+00	4.62E+00	3.64E+00	1.52E+01
2. IODINES: Ci					
I-131	1.53E-04	2.09E-04	1.21E-04	1.37E-04	6.20E-04
I-133	6.92E-04	9.61E-04	8.05E-04	8.97E-04	3.35E-03
Total for Period	8.45E-04	1.17E-03	9.26E-04	1.03E-03	3.98E-03
3. PARTICULATES: Ci					
Mn-54	NDA	8.46E-06	NDA	1.74E-06	1.02E-05
Co-60	NDA	NDA	NDA	NDA	NDA
Zn-65	NDA	NDA	NDA	NDA	NDA
Sr-89	9.74E-06	5.05E-05	6.98E-05	2.21E-05	1.52E-04
Sr-90	1.47E-07	1.88E-06	4.92E-07	NDA	2.52E-06
Cs-137	NDA	1.69E-06	NDA	NDA	1.69E-06
Ba/La-140	NDA	NDA	3.08E-05	NDA	3.08E-05
Total for Period	9.89E-06	6.25E-05	1.01E-04	2.38E-05	1.97E-04
4. TRITIUM: Ci					
H-3	1.57E+00	1.81E+00	2.31E+00	3.88E+00	9.57E+00

Notes for Table 2.2-B:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLDs for airborne radionuclides listed as NDA are as follows:
   Fission Gases: 1E-04 µCi/cc
   Iodines: 1E-12 µCi/cc
   Particulates: 1E-11 µCi/cc

Table B.2-B (continued)
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Gaseous Effluents – Elevated Release
July-December 2003

BATCH MODE RELEASES FROM ELEVATED RELEASE POINT					
Nuclide Released	Jan-Mar 2003	Apr-Jun 2003	Jul-Sep 2003	Oct-Dec 2003	Jan-Dec 2003
1. FISSION AND ACTIVATION GASES: Ci					
Ar-41	N/A	N/A	N/A	N/A	N/A
Kr-85	N/A	N/A	N/A	N/A	N/A
Kr-85m	N/A	N/A	N/A	N/A	N/A
Kr-87	N/A	N/A	N/A	N/A	N/A
Kr-88	N/A	N/A	N/A	N/A	N/A
Xe-131m	N/A	N/A	N/A	N/A	N/A
Xe-133	N/A	N/A	N/A	N/A	N/A
Xe-133m	N/A	N/A	N/A	N/A	N/A
Xe-135	N/A	N/A	N/A	N/A	N/A
Xe-135m	N/A	N/A	N/A	N/A	N/A
Xe-137	N/A	N/A	N/A	N/A	N/A
Xe-138	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A
2. IODINES: Ci					
I-131	N/A	N/A	N/A	N/A	N/A
I-133	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A
3. PARTICULATES: Ci					
Mn-54	N/A	N/A	N/A	N/A	N/A
Co-60	N/A	N/A	N/A	N/A	N/A
Sr-89	N/A	N/A	N/A	N/A	N/A
Sr-90	N/A	N/A	N/A	N/A	N/A
Cs-137	N/A	N/A	N/A	N/A	N/A
Ba/La-140	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A
4. TRITIUM: Ci					
H-3	N/A	N/A	N/A	N/A	N/A

Notes for Table 2.2-B:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLDs for airborne radionuclides listed as NDA are as follows:
   Fission Gases: 1E-04 µCi/cc
   Iodines: 1E-12 µCi/cc
   Particulates: 1E-11 µCi/cc

Table B.2-C
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Gaseous Effluents – Ground-Level Release
July-December 2003

CONTINUOUS MODE RELEASES FROM GROUND-LEVEL RELEASE POINT					
Nuclide Released	Jan-Mar 2003	Apr-Jun 2003	Jul-Sep 2003	Oct-Dec 2003	Jan-Dec 2003
1. FISSION AND ACTIVATION GASES: Ci					
Ar-41	NDA	NDA	NDA	NDA	NDA
Kr-85	NDA	NDA	NDA	NDA	NDA
Kr-85m	NDA	NDA	NDA	NDA	NDA
Kr-87	NDA	NDA	NDA	NDA	NDA
Kr-88	NDA	NDA	NDA	NDA	NDA
Xe-131m	NDA	NDA	NDA	NDA	NDA
Xe-133	NDA	NDA	NDA	NDA	NDA
Xe-133m	NDA	NDA	NDA	NDA	NDA
Xe-135	7.11E+00	2.92E+00	3.27E+00	1.45E+00	1.47E+01
Xe-135m	NDA	2.60E+00	NDA	NDA	2.60E+00
Xe-137	NDA	NDA	NDA	NDA	NDA
Xe-138	NDA	NDA	NDA	NDA	NDA
Total for period	7.11E+00	5.52E+00	3.27E+00	1.45E+00	1.73E+01
2. IODINES: Ci					
I-131	4.78E-04	2.06E-04	1.90E-04	1.24E-04	9.98E-04
I-133	3.64E-03	9.92E-04	1.10E-03	5.40E-04	6.27E-03
Total for period	4.12E-03	1.20E-03	1.29E-03	6.64E-04	7.27E-03
3. PARTICULATES: Ci					
Mn-54	NDA	9.95E-06	NDA	7.89E-06	1.78E-05
Co-60	NDA	NDA	NDA	NDA	NDA
Zn-65	NDA	2.06E-06	NDA	NDA	2.06E-06
Sr-89	1.63E-04	7.81E-04	1.37E-04	6.32E-05	1.14E-03
Sr-90	NDA	NDA	NDA	NDA	NDA
Cs-137	NDA	NDA	NDA	NDA	NDA
Ba/La-140	2.67E-05	8.06E-05	NDA	NDA	1.07E-04
Total	1.90E-04	8.74E-04	1.37E-04	7.10E-05	1.27E-03
4. TRITIUM: Ci					
H-3	2.72E+02	6.96E+01	7.42E+01	7.26E+01	4.89E+02

Notes for Table 2.2-C:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLDs for airborne radionuclides listed as NDA are as follows:
   Fission Gases: 1E-04 µCi/cc
   Iodines: 1E-12 µCi/cc
   Particulates: 1E-11 µCi/cc

Table B.2-C (continued)
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Gaseous Effluents – Ground-Level Release
July-December 2003

BATCH MODE RELEASES FROM GROUND-LEVEL RELEASE POINT					
Nuclide Released	Jan-Mar 2003	Apr-Jun 2003	Jul-Sep 2003	Oct-Dec 2003	Jan-Dec 2003
1. FISSION AND ACTIVATION GASES: Ci					
Ar-41	N/A	N/A	N/A	N/A	N/A
Kr-85	N/A	N/A	N/A	N/A	N/A
Kr-85m	N/A	N/A	N/A	N/A	N/A
Kr-87	N/A	N/A	N/A	N/A	N/A
Kr-88	N/A	N/A	N/A	N/A	N/A
Xe-131m	N/A	N/A	N/A	N/A	N/A
Xe-133	N/A	N/A	N/A	N/A	N/A
Xe-133m	N/A	N/A	N/A	N/A	N/A
Xe-135	N/A	N/A	N/A	N/A	N/A
Xe-135m	N/A	N/A	N/A	N/A	N/A
Xe-137	N/A	N/A	N/A	N/A	N/A
Xe-138	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A
2. IODINES: Ci					
I-131	N/A	N/A	N/A	N/A	N/A
I-133	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A
3. PARTICULATES: Ci					
Mn-54	N/A	N/A	N/A	N/A	N/A
Co-60	N/A	N/A	N/A	N/A	N/A
Sr-89	N/A	N/A	N/A	N/A	N/A
Sr-90	N/A	N/A	N/A	N/A	N/A
Cs-137	N/A	N/A	N/A	N/A	N/A
Ba/La-140	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A
4. TRITIUM: Ci					
H-3	N/A	N/A	N/A	N/A	N/A

Notes for Table 2.2-C:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLDs for airborne radionuclides listed as NDA are as follows:
   Fission Gases: 1E-04 µCi/cc
   Iodines: 1E-12 µCi/cc
   Particulates: 1E-11 µCi/cc

Table B.3-A
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Liquid Effluents - Summation of All Releases
January-June 2003

RELEASE PERIOD	Jan-Mar 2003	Apr-Jun 2003	Jul-Sep 2003	Oct-Dec 2003	Jan-Dec 2003	Est. Total Error
A. FISSION AND ACTIVATION PRODUCTS						
Total Release (not including H-3, noble gas, or alpha): Ci	N/A	1.39E-02	5.61E-03	4.56E-05	1.95E-02	±12%
Average Diluted Concentration During Period: µCi/mL	N/A	1.91E-08	1.11E-08	1.99E-10	1.34E-08	
Percent of Effluent Concentration Limit*	N/A	*	*	*	*	
B. TRITIUM						
Total Release: Ci	N/A	2.09E+01	1.65E+01	6.23E-01	3.80E+01	±9.4%
Average Diluted Concentration During Period: µCi/mL	N/A	2.87E-05	3.26E-05	2.72E-06	2.60E-05	
Percent of Effluent Concentration Limit*	N/A	*	*	*	*	
C. DISSOLVED AND ENTRAINED GASES						
Total Release: Ci	N/A	6.74E-06	3.51E-05	NDA	4.18E-05	±16%
Average Diluted Concentration During Period: µCi/mL	N/A	9.27E-12	6.95E-11	NDA	2.86E-11	
Percent of Effluent Concentration Limit	N/A	4.63E-06%	3.47E-05%	NDA	1.43E-05%	
D. GROSS ALPHA RADIOACTIVITY						
Total Release: Ci	N/A	NDA	NDA	NDA	NDA	±34%
E. VOLUME OF WASTE RELEASED PRIOR TO DILUTION						
Waste Volume: Liters	N/A	3.89E+05	2.72E+05	4.11E+04	7.02E+05	±5.7%
F. VOLUME OF DILUTION WATER USED DURING PERIOD						
Dilution Volume: Liters	1.50E+11	1.16E+11	1.55E+11	1.48E+11	5.69E+11	±10%

Notes for Table 2.3-A:

* Additional percent of Effluent Control Limit values based on dose assessments are provided in Section 7 of this report.

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLD for dissolved and entrained gases listed as NDA is 1E-05 µCi/mL.
4. LLD for liquid gross alpha activity listed as NDA is 1E-07 µCi/mL.

Table B.3-B
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Liquid Effluents
January-June 2003

CONTINUOUS MODE RELEASES					
Nuclide Released	Jan-Mar 2003	Apr-Jun 2003	Jul-Sep 2003	Oct-Dec 2003	Jan-Dec 2003
1. FISSION AND ACTIVATION PRODUCTS: Ci					
Cr-51	N/A	N/A	N/A	N/A	N/A
Mn-54	N/A	N/A	N/A	N/A	N/A
Fe-55	N/A	N/A	N/A	N/A	N/A
Fe-59	N/A	N/A	N/A	N/A	N/A
Co-58	N/A	N/A	N/A	N/A	N/A
Co-60	N/A	N/A	N/A	N/A	N/A
Zn-65	N/A	N/A	N/A	N/A	N/A
Zn-69m	N/A	N/A	N/A	N/A	N/A
Sr-89	N/A	N/A	N/A	N/A	N/A
Sr-90	N/A	N/A	N/A	N/A	N/A
Zr/Nb-95	N/A	N/A	N/A	N/A	N/A
Mo/Tc-99	N/A	N/A	N/A	N/A	N/A
Ag-110m	N/A	N/A	N/A	N/A	N/A
Sb-124	N/A	N/A	N/A	N/A	N/A
I-131	N/A	N/A	N/A	N/A	N/A
I-133	N/A	N/A	N/A	N/A	N/A
Cs-134	N/A	N/A	N/A	N/A	N/A
Cs-137	N/A	N/A	N/A	N/A	N/A
Ba/La-140	N/A	N/A	N/A	N/A	N/A
Ce-141	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A
2. DISSOLVED AND ENTRAINED GASES: Ci					
Xe-133	N/A	N/A	N/A	N/A	N/A
Xe-135	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A

Notes for Table 2.3-B:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLDs for liquid radionuclides listed as NDA are as follows:
   - Strontium: 5E-08 µCi/mL
   - Iodines: 1E-06 µCi/mL
   - Noble Gases: 1E-05 µCi/mL
   - All Others: 5E-07 µCi/mL

Table B.3-B (continued)
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Liquid Effluents
January-June 2003

BATCH MODE RELEASES					
Nuclide Released	Jan-Mar 2003	Apr-Jun 2003	Jul-Sep 2003	Oct-Dec 2003	Jan-Dec 2003
1. FISSION AND ACTIVATION PRODUCTS: Ci					
Cr-51	N/A	2.91E-03	4.79E-05	NDA	2.96E-03
Mn-54	N/A	4.18E-03	3.12E-04	1.59E-06	4.50E-03
Fe-55	N/A	2.40E-04	4.57E-03	NDA	4.81E-03
Fe-59	N/A	1.49E-03	5.64E-05	NDA	1.55E-03
Co-58	N/A	2.89E-04	3.62E-05	NDA	3.25E-04
Co-60	N/A	3.13E-03	2.73E-04	8.51E-06	3.41E-03
Zn-65	N/A	1.15E-03	1.72E-04	NDA	1.32E-03
Zn-69m	N/A	NDA	6.18E-05	NDA	6.18E-05
Sr-89	N/A	NDA	NDA	NDA	NDA
Sr-90	N/A	NDA	NDA	NDA	NDA
Zr/Nb-95	N/A	4.23E-05	NDA	NDA	4.23E-05
Mo/Tc-99	N/A	6.50E-06	NDA	NDA	6.50E-06
Ag-110m	N/A	2.91E-04	4.57E-05	NDA	3.37E-04
Sb-124	N/A	7.69E-05	NDA	NDA	7.69E-05
I-131	N/A	3.19E-06	NDA	NDA	3.19E-06
I-133	N/A	1.12E-05	NDA	NDA	1.12E-05
Cs-134	N/A	NDA	NDA	NDA	NDA
Cs-137	N/A	6.20E-05	1.44E-06	3.55E-05	9.89E-05
Ba/La-140	N/A	NDA	3.53E-05	NDA	3.53E-05
Ce-141	N/A	NDA	NDA	NDA	NDA
Total for period	N/A	1.39E-02	5.61E-03	4.56E-05	1.95E-02
2. DISSOLVED AND ENTRAINED GASES: Ci					
Xe-133	N/A	NDA	1.02E-05	NDA	1.02E-05
Xe-135	N/A	6.74E-06	2.49E-05	NDA	3.16E-05
Total for period	N/A	6.74E-06	3.51E-05	NDA	4.18E-05

Notes for Table 2.3-B:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLDs for liquid radionuclides listed as NDA are as follows:
   - Strontium: 5E-08 µCi/mL
   - Iodines: 1E-06 µCi/mL
   - Noble Gases: 1E-05 µCi/mL
   - All Others: 5E-07 µCi/mL

APPENDIX C

LAND USE CENSUS RESULTS

The annual land use census for gardens and milk and meat animals in the vicinity of Pilgrim Station was performed between September 26 and November 17, 2003. The census was conducted by driving along each improved road/street in the Plymouth area within 5 kilometers (3 miles) of Pilgrim Station to survey for visible gardens with an area of greater than 500 square feet. In compass sectors where no gardens were identified within 5 km (SSW, WNW, NW, and NNW sectors), the survey was extended to 8 km (5 mi). A total of 27 gardens were identified in the vicinity of Pilgrim Station. In addition, the Town of Plymouth Animal Inspector was contacted for information regarding milk and meat animals.

Atmospheric deposition (D/Q) values at the locations of the identified gardens were compared to those for the existing sampling program locations. These comparisons enabled PNPS personnel to ascertain the best locations for monitoring for releases of airborne radionuclides. Gardens yielding higher D/Q values than those currently in the sampling program were also sampled as part of the radiological environmental monitoring program.

Based on assessment of the gardens identified during the 2003 land use census, samples of garden-grown vegetables or naturally-growing vegetation (e.g. grass, leaves from bushes or trees, etc.) were collected at or near the closest gardens in each of the following landward compass sectors. These locations, and their distance and direction relative to the PNPS Reactor Building, are as follows:

Rocky Hill Road	0.9 km SE (garden not grown in 2003; however, historic location)
Brook Road	2.9 km SSE
Beaverdam Road	3.4 km S
Bay Colony Drive	3.1 km WSW
Clay Hill Road	1.6 km W

In addition to these special sampling locations identified and sampled in conjunction with the 2003 land use census, samples were also collected at or near the Plymouth County Farm (5.6 km W), Whipple Farm (2.9 km SW), and from a control location in Bridgewater (31 km W).

Samples of naturally-growing vegetation were also collected in the vicinity of the site boundary locations yielding the highest deposition (D/Q) factors for each of the two release points. These locations, and their distance and direction relative to the PNPS Reactor Building, are as follows:

Highest Main Stack D/Q:	1.5 km SSW
Highest Reactor Building Vent D/Q:	0.5 km ESE
2nd highest D/Q, both release points:	1.1 km S

No new milk or meat animals were identified during the land use census. In addition, the Town of Plymouth Animal Inspector stated that their office is not aware of any animals at locations other than the Plimoth Plantation and the Plymouth County Farm. Samples of milk and forage have historically been collected from the Plymouth County Farm and were part of the 2003 sampling program.

APPENDIX D

ENVIRONMENTAL MONITORING PROGRAM DISCREPANCIES

There were a number of instances during 2003 in which inadvertent issues were encountered in the collection of environmental samples. All of these issues were minor in nature and did not have an adverse effect on the results or integrity of the monitoring program. Details of these various problems are given below.

During 2003, nine thermoluminescent dosimeters (TLDs) were not recovered from their assigned locations during the quarterly retrieval process. During the second quarter retrieval, the TLD located at Emerson and Priscilla (EP) was presumably lost to storm damage or vandalism, whereas the TLD at Taylor & Thomas (TT) was lost when the utility pole was replaced. Vandalism or storm damage was assumed to be the cause of losses of the TLDs at Emerson and Priscilla (EP), Right of Way (RW) and Cedarville Substation (CS) during the third quarter, whereas the TLD at Halls' Bog (HB) was inaccessible during the third quarter change out and was retrieved during the following quarter. Vandalism or storm damage was also assumed to be the cause of losses of the TLDs at Taylor and Pearl (TP) and Sherman Airport (SA) during the fourth quarter, and the TLD at Station H was inaccessible during the fourth quarter change out and was retrieved during the following quarter. Despite these losses, the 431 TLDs that were collected (98%) allowed for adequate assessment of the ambient radiation levels in the vicinity of Pilgrim Station.

Within the air sampling program, there were a few instances in which continuous sampling was interrupted at the eleven airborne sampling locations during 2003. Most of these interruptions were due to short-term power losses and were sporadic and of limited duration (less than 24 hours out of the weekly sampling period). Such events did not have any significant impact on the scope and purpose of the sampling program, and all lower limits of detection (LLDs) were met for both particulates and iodine-131 on the filters.

Airborne salt spray at the Pedestrian Bridge (PB) air sampler resulted in loss of power when the ground fault circuit interrupter tripped on three different occasions during the weeks of 07-Jan through 14-Jan, 14-Jan through 21-Jan, and 29-Apr through 06-May. Total sampler run times were 57.3, 63.6, and 92.0 hours, respectively. Despite the low volumes, filters were collected and analyzed, and all LLDs were met.

During 2003, there were two instances when heavy snow made certain air sampling stations inaccessible. The air sampler at Cleft Rock (CR) was inaccessible during the filter collection on 19-Feb-2003, whereas the sampler at East Weymouth (EW) was inaccessible during the collection on 09-Dec-2003. In these two cases, the filter was left on the operational air sampler and was retrieved during the following weekly collection. Thus, sampling capability was not lost, but only a single set of filters was collected in each of these instances, instead of two sets of filters for two weeks. Appropriate corrections for radioactive decay were made to allow for the additional sampling time, and all LLDs were met.

During the 19-Aug filter collection, the air sampler at East Rocky Hill Road (ER) failed due to a seized bearing. Due to a backlog in the repair of spare air samplers, no replacement air samplers were available. This resulted in loss of sampling capability during the weeks of 19-Aug through 26-Aug, and 26-Aug through 03-Sep. A backup air sampler was refurbished, and sampling was resumed at this location on 03-Sep. Since no sampling occurred for these two weeks, no filters were collected or analyzed from this location during this incident.

During the week of 10-Jun through 17-Jun, construction activities at the Manomet Substation (MS) resulted in loss of power to the air sampler. Total sampler run time was 47.8 hours out of the nominal 168-hour sampling period. Despite the low volume, filters were collected and analyzed, and all required LLDs were met. However, due to the duration of construction activities, the loss of power continued through 01-Jul, and resulted in loss of sampling capability at this location during the weeks of 17-Jun through 25-Jun, and 25-Jun through 01-Jul. No filters were collected or analyzed during these two weeks. Additional construction activities at this location also resulted in a short-term loss of about 28 hours out of the

192-hour sampling period during the week of 05-Aug through 13-Aug. Filters were collected and analyzed, and all required LLDs were met.

A power surge caused the air sampler to fail at the Plymouth Town Hall (PC) during the week of 29-Apr through 06-May. Total sampler run time during this period was 46.5 hours. Despite the low sample volumes, all required LLDs were met on both the air particulate filter and iodine cartridge.

Despite the lower-than-normal sampling volumes in the various instances involving power interruptions and equipment failures, required LLDs were met on 566 of the 566 particulate filters and 566 of the 566 iodine cartridges collected during 2003. None of the sample analyses associated with limited pump run times indicated any questionable or anomalous results. When viewed collectively during the entire year of 2003, the following sampling recoveries were achieved in the airborne sampling program:

Location	Recovery	Location	Recovery	Location	Recovery
WS	99.9%	PB	96.4%	PC	98.5%
ER	95.1%	OA	100.0%	MS	94.4%
WR	99.7%	EB	100.0%	EW	100.0%
PL	100.0%	CR	99.9%		

During 2003, changes occurred in the work process involving repair and maintenance of air samplers. In past years, air samplers would be calibrated and refurbished on an annual basis, with the calibration considered valid for a full year forward from the calibration date. However, in an attempt to preclude premature pump failure, samplers were pulled from the field after nine months of service. After the change in work process, there were fewer backup air samplers available on the shelf, and it was necessary to extend field service time from nine months to twelve months. There was one instance in which a sampler was left in service past its one year calibration date, as there were no spare units available, and it was deemed preferable to continue sampling efforts with a sampler beyond its calibration due date, versus removing the sampler from service and not sampling at all. Past experience from over 20 years of operating the air sampling program at Pilgrim Station has demonstrated that the air samplers show very little change in their calibrations from one cycle to the next.

In July 2003, the Plymouth County Farm ceased operation of its dairy and garden facilities. This was historically the only dairy facility near Pilgrim Station, and had been sampled continuously since Pilgrim Station began operation in 1972. Although attempts were made to obtain milk samples from an alternate indicator location, a suitable substitute could not be found. Thus, milk collection Plymouth County Farm was discontinued in July, but control samples of milk continued to be collected and analyzed in the event an indicator milk location could be secured. When the ODCM was revised to standardize to industry standards during the latter half of 2003, the milk sampling program was dropped.

An alternate location had to be found for sampling control vegetable samples in the Bridgewater area. In past years, samples had been collected at the Bridgewater County Farm, associated with the Bridgewater Correctional Facility. Due to loss of state funding for garden projects during 2003, no garden was grown. An alternate location was found at the Hanson Farm in Bridgewater, located in the same compass sector, and at approximately the same distance as the Bridgewater County Farm. As expected for control samples, vegetables collected at this location only contained naturally-occurring radioactivity (K-40).

Some problems were encountered in collection of crop samples during 2003. Crops which had normally been sampled in the past (lettuce, tomatoes, potatoes, and onions) were not grown at the Plymouth County Farm (CF) during 2003. Pumpkins and squash were substituted for the edible 'hard' vegetables, whereas samples of naturally-growing leafy vegetation (grass, leaves from trees and bushes, etc.) were substituted for the lettuce. No radionuclides attributed to PNPS operations were detected in any of the samples.

Naturally-growing leafy vegetation (grass, leaves from trees and bushes, etc.) was collected near some gardens identified during the annual land use census. Due to the unavailability of crops grown in these

gardens, these substitute samples were collected as near as practicable to the gardens of interest. No radionuclides attributed to PNPS operations were detected in any of the samples. Additional details regarding the land use census can be found in Appendix C of this report.

The cranberry bog at Manomet Point (MP) was not in production during 2003, so a sample could not be obtained from this location. Samples were collected as required from the other indicator bog located along Bartlett Road (BT), and an additional sample was collected from a bog located along Beaverdam Road. Again, the extensive sampling of leafy vegetation would provide a better indication of deposition radionuclides, so the loss of the Manomet Point sample does not adversely affect overall monitoring efforts.

During the first week of January 2003, storm surge washed the intake line from the discharge canal composite sampler onto the rocks. Due to the hazards associated with replacing the line, a regimen of collecting weekly grab samples from the discharge canal was instituted. Such grab sampling occurred throughout the remainder of the year while efforts continued to establish a more reliable alternate method and equipment to obtain composite samples.

Due to inclement weather and unavailability of contractor personnel during July, the collection of a lobster sample from the discharge canal outfall was not completed by the end of the month. Although sampling is normally performed on a monthly basis from June through September, the ODCM requirement does not specify a rigid one-month sampling interval. A sample was procured on 11-Aug, which met the ODCM requirement to sample lobster four times between May and October.

Samples of Group I (bottom-distribution) and Group II (near-bottom distribution) fishes were not collected in the vicinity of the discharge outfall during the first and fourth calendar quarters of 2003. Such fish species move to deeper water during colder months, and were not available. Repeated and concerted efforts were made, but failed to produce fish samples during the first and fourth quarters. In addition, only a single subsample of Group IV fish (bluefish) was collected from the control location during the year.

In summary, the various problems encountered in collecting and analyzing environmental samples during 2003 were relatively minor when viewed in the context of the entire monitoring program. None of the discrepancies resulted in an adverse impact on the overall monitoring program.

APPENDIX E

FRAMATOME ANP QUALITY ASSURANCE PROGRAM RESULTS

E.1 Introduction

The accuracy of the data obtained through the PNPS Radiological Environmental Monitoring Program (REMP) is ensured through a comprehensive Quality Assurance Program. This appendix addresses those aspects of quality assurance that deal with the accuracy and precision of the analytical sample results and the environmental TLD measurement results that are obtained by PNPS from the Framatome ANP Environmental Laboratory. Much of the information contained herein has been summarized from the Framatome ANP "Semi-Annual Quality Assurance Status Report: January - June 2003," and "Semi-Annual Quality Assurance Status Report: July - December 2003."

As stated earlier in the report, Pilgrim Station began using Entergy's J.A. Fitzpatrick Environmental Laboratory beginning in July 2003 for sample analysis of REMP samples. Since this laboratory also has an intercomparison program, details of those results are also summarized in Appendix F.

E.2 Framatome ANP Environmental TLD Measurements

Quality control testing was performed during 2003 to demonstrate the performance of the routine environmental TLD processing by Framatome ANP. The quality of the dosimetric results is evaluated relative to independent third party testing and internal performance testing. These tests were performed independent of the processing of environmental TLDs at Framatome ANP. In all of these tests, dosimeters were irradiated to known doses and submitted to Framatome ANP for processing as unknowns. The quality control programs provide a statistical measure of accuracy, precision and consistency of the processing against a reliable standard, which in turn points out any trends or changes in performance.

Framatome ANP began performance testing of the Panasonic environmental TLDs in July 1987. The testing included internal performance testing and testing by an independent third party.

A ± 30% accuracy acceptance standard under field conditions is recommended by ANSI 545-1975, "American National Standard Performance, Testing and Procedural Specifications for Thermoluminescent Dosimetry (Environmental Applications)." The Laboratory Quality Control Audit Committee (LQCAC) adopted acceptance criteria for accuracy and precision to be used in 2003 on November 13, 1987. Recognizing the inherent variability associated with each dosimeter type, control limits for accuracy and precision of ± 3 sigma plus 5% (for bias) were set by the LQCAC. The actual magnitude of the 3 sigma plus 5% control limits depends on the historical performance of each type of dosimeter, with each response being indicative of random and systematic uncertainties, combined with any deviation attributable to TLD operation.

The results of the TLD quality control programs are reported in the categories of accuracy and precision. Accuracy was calculated by comparing each discrete reported dose to the known or delivered dose. The deviation of individual results relative to the mean reported dose is used as a measure of precision.

The quality control program implemented for dosimetry processing indicated good precision and accuracy in the reported values. In 2003, there were 96 quality control tests. All 48 environmental TLDs tested during January - June 2003 were within the control limits for both accuracy and precision. The comparisons yielded a mean accuracy of +1.71%. The comparisons exhibited a precision value with an overall standard deviation of 2.88%. The 48 TLDs tested in July - December 2003 showed a mean accuracy of –0.71%. TLDs measured during the second semiannual period exhibited a precision value with a standard deviation of 1.46%, well within the acceptance criteria. In total, all 96 environmental TLDs tested during 2003 were within the control limits for both accuracy (± 20.1%) and precision (± 12.8%).

E.3 Conclusions

Laboratory analysis results for the independent Interlaboratory Comparison programs (i.e., EPA, Analytics, DOE, and NIST), the Framatome ANP intralaboratory quality control program, and the sponsor companies blind duplicate program met the laboratory criterion of less than 15% deviation in more than 96% of all cases.

The environmental TLD measurements for intralaboratory and independent third party comparisons resulted in both mean accuracy and precision within 2% deviation.

Therefore, the quality assurance programs for the PNPS Radiological Environmental Monitoring Program indicated that the analyses and measurements performed by the Framatome ANP Environmental Laboratory during 2003 exhibited acceptable accuracy and precision.

APPENDIX F

J.A. FITZPATRICK INTERLABORATORY COMPARISON PROGRAM

F.1 Program Description

An important factor in assuring the quality of radiological environmental monitoring results is the analytical laboratory's participation in an Interlaboratory Comparison Program. The Interlaboratory Comparison Program shall include sample media for which samples are routinely collected and for which Comparison samples are commercially available. Participation in an Interlaboratory Comparison Program ensures that independent checks on the precision and accuracy of the measurement of radioactive material in the environmental samples are performed as part of the Quality Assurance Program for environmental monitoring. To fulfill the requirement for an Interlaboratory Comparison Program, the JAF Environmental Laboratory has engaged the services of two independent laboratories to provide quality assurance comparison samples. The two laboratories are Analytics, Incorporated in Atlanta, Georgia and the U.S. Department of Energy's Environmental Measurements Laboratory (EML) in New York City.

Analytics supplies sample media as blind sample spikes, which contain certified levels of radioactivity unknown to the analysis laboratory. These samples are prepared and analyzed using standard laboratory procedures. The results are submitted to Analytics, which issues a statistical summary report. The JAFNPP Environmental Laboratory uses predetermined acceptance criteria methodology for evaluating the laboratory's performance for Analytic's sample results.

In addition to the Analytics Program, the JAF Environmental Laboratory participated in the Environmental Measurements Laboratory (EML) Quality Assessment Program (QAP). EML supplies sample media as blind sample spikes to approximately 127 laboratories worldwide. These samples, containing a spiked amount of low level activity, are analyzed using standard laboratory procedures. The results are submitted to the Environmental Measurements Laboratory for statistical evaluation. Reports are provided to each participating laboratory, which provide an evaluation of the laboratory's performance.

F.2 Program Schedule

SAMPLE MEDIA	LABORATORY ANALYSIS	SAMPLE PROVIDER ANALYTICS	EML	YEARLY TOTAL
Water	Gross Beta	0	2	2
Water	Tritium	1	2	3
Water	I-131	2	0	2
Water	Mixed Gamma	2	2	4
Air	Gross Beta	2	2	4
Air	I-131	2	0	2
Air	Mixed Gamma	2	2	4
Milk	I-131	2	0	2
Milk	Mixed Gamma	2	0	2
Soil	Mixed Gamma	1	0	1
Vegetation	Mixed Gamma	1	0	1
TOTAL SAMPLE INVENTORY		17	10	27

F.3 Acceptance Criteria

Each sample result is evaluated to determine the accuracy and precision of the laboratory's analysis result. The evaluation method for the QA sample results is dependent on the supplier of the sample. The sample evaluation methods are discussed below.

F.3.1 Analytics Sample Results

Samples provided by Analytics are evaluated using what is specified as the NRC method. This method is based on the calculation of the ratio of results reported by the participating laboratory (QC result) to the Vendor Laboratory Known value (reference result).

An Environmental Laboratory analytical result is evaluated using the following calculation:

The value for the error resolution is calculated.

$$\text{The error resolution} = \frac{\text{Reference Result}}{\text{Reference Results Error}}$$

Using the appropriate row under the Error Resolution column in Table F.3-1 below, a corresponding Ratio of Agreement interval is given.

The value for the ratio is then calculated.

$$\text{Ratio of Agreement} = \frac{\text{QC Result}}{\text{Reference Result}}$$

If the value falls within the agreement interval, the result is acceptable.

TABLE F.3-1

ERROR RESOLUTION	RATIO OF AGREEMENT
≤ 3	0.4-2.5
3.1 to 7.5	0.5-2.0
7.6 to 15.5	0.6-1.66
15.6 to 50.5	0.75-1.33
50.6 to 200	0.8-1.25
>200	0.85-1.18

Again, this acceptance test is generally referred to as the "NRC" method. The acceptance criteria is contained in Procedure DVP-04.01 and was taken from the Criteria of Comparing Analytical Results (USNRC) and Bevington, P.R., Data Reduction and Error Analysis for the Physical Sciences, McGraw-Hill, New York, (1969). The NRC method generally results in an acceptance range of approximately ± 25% of the Known value when applied to sample results from the Analytics Inc. Interlaboratory Comparison Program. This method is used as the procedurally required assessment method and requires the generation of a nonconformity report when results are unacceptable.

F.3.2 Environmental Measurements Laboratory (EML)

The laboratory's analytical performance is evaluated by EML based on the historical analytical capabilities for individual analyte/matrix pairs. The statistical criteria for Acceptable Performance, "A", has been chosen by EML to be between the 15th and 85th percentile of the cumulative normalized distribution, which can be viewed as the middle 70% of all historic measurements. The Acceptable With Warning criteria, "W", is between the 5th and 15th percentile and between the 85th and 95th percentile. In other words, the middle 70% of all reported values are acceptable, while the other 5th-15th (10%) and 85th-95th percentiles (10%) are in the warning area. The Not Acceptable criteria, "N", is established at less than the 5th percentile and greater than the 95th percentile, that is, the outer 10% of the historical data. Using five years of historical analytical data, the EML, determined performance results using the percentile criteria summarized below:

Result	Cumulative Normalized Distribution
Acceptable ("A")	15% - 85%
Acceptable with Warning ("W")	5% - 15% or 85% - 95%
Not Acceptable ("N")	<5% or >95%

F.4 Program Results Summary

The Interlaboratory Comparison Program numerical results are provided on Table F.4-1.

F.4.1 Analytics QA Samples Results

Seventeen QA blind spike samples were analyzed as part of Analytics 2003 Interlaboratory Comparison Program. The following sample media were evaluated as part of the comparison program.

- Air Charcoal Cartridge: I-131
- Air Particulate Filter: Mixed Gamma Emitters, Gross Beta
- Water: I-131, Mixed Gamma Emitters, Tritium
- Soil: Mixed Gamma Emitters
- Milk: I-131, Mixed Gamma Emitters
- Vegetation: Mixed Gamma Emitters

The JAF Environmental Laboratory performed 81 individual analyses on the seventeen QA samples. Of the 81 analyses performed, 79 were in agreement using the NRC acceptance criteria for a 97.5% agreement ratio.

Sample non-conformities are discussed in Section F.4.1.1.

F.4.1.1 Analytics Sample Nonconformities

A. Analytics Sample E-3687-05, Co-58 in Soil -- Nonconformity No. 2003-02

A spiked mixed gamma in soil sample supplied by Analytics, Inc., was analyzed in accordance with standard laboratory procedures. The sample contained a total of nine radionuclides for analysis. Nine of the nine radionuclides present were quantified. Eight of the nine radionuclides were quantified within the acceptable range. The mean result for Co-58 was determined to be outside the QA Acceptance Criteria resulting in a sample nonconformity. The soil sample was analyzed five times using three different detectors with the mean Co-58 result reported as 81 pCi/kg. The known result for the sample was 102 pCi/kg as determined by the supplier. One of the five reported results was 92 pCi/kg and resulted in an agreement when compared to the known of 102 pCi/kg with a ratio of 0.90. The remaining 4 individual results were outside the acceptance criteria and had ratios to the known that ranged from 0.75 to 0.79. All of the analysis had relatively high associated counting errors, which ranged from 9.8% to 22%.

An evaluation of the Co-58 result was performed. The spectrum and peak search results were examined with no abnormalities identified. Co-58 decays by electron capture with a 70.9 day half-life and a gamma ray energy of 810 keV with a yield of 99.5%. No significant secondary gamma energies are produced in the Co-58 decay scheme. The average net count rates of the five analyses were very low and ranged from a high of 0.94 counts per minute to a low of 0.66 counts per minute. The low activity in the sample resulted in high associated counting errors as noted above.

The combination of low sample activity, very low count rate and high background level in the spectrum, resulted in an inaccurate sample result. The wide range of the associated counting errors demonstrates the low confidence level in the reported results. The nonconforming analytical result for this sample is not routine and does not indicate a programmatic deficiency in the analysis of Co-58 in soil samples or other environmental media. Confidence in the accurate analysis of Co-58 can be demonstrated by other Co-58 analytical results, both in the overall results for the 2003 QA program and historical Co-58 QA program results. The Co-58 results for the other Quality Assurance samples analyzed as part of the 2003 Interlaboratory Comparison Program were all acceptable and are summarized below:

2003 Co-58 Results

Sample ID	Medium	JAF	Reference	Ratio
E-3610-05	WATER pCi/liter	43±2	42±1	1.02
E-3855-05	WATER pCi/liter	94±3	94±3	1.00
E-3611-05	FILTER pCi/filter	53±2	52±2	1.02
E-3856-05	FILTER pCi/filter	70±3	69±2	1.01
E-3686-05	SOIL pCi/kg	89±5	93±3	0.96
E-3857-05	MILK pCi/liter	99±3	98±3	1.00
E-3689-05	VEGETATION pCi/kg	149±8	138±5	1.08
			Mean Ratio =	1.01

A review of historical QA data for the period of 2002 through 1999 was performed. There were no nonconformities related to the analysis of Co-58 during this period. In 2002, six QA samples were analyzed which contained Co-58. The mean ratio for these samples relative to the known (reference) value was 1.02. The 2003 nonconformity is considered to be an isolated instance. The low concentration of Co-58 present in the sample is considered to be the major contributor to the nonconformity. This low activity resulted in a very low count rate and a low net count rate to background ratio as indicated by the high associated counting error. The historical Co-58 results and the 2003 program result demonstrate that there is no systematic error or persistent bias present in the analysis of samples for Co-58 in soil of other environmental sample media. No corrective actions were implemented as a result of this nonconformity.

F.4.1.1 Analytics Sample Nonconformities

B. Analytics Sample E-3689-05, Co-60 in Vegetation -- Nonconformity No. 2003-01

A spiked mixed gamma in Vegetation sample supplied by Analytics, Inc., was analyzed in accordance with standard laboratory procedures. The sample contained a total of nine radionuclides for analysis. Nine of the nine radionuclides present were quantified. Eight of the nine radionuclides were quantified within the acceptable range. The results for Co-60 were determined to be outside the QA Acceptance Criteria resulting a sample nonconformity. The Vegetation sample was analyzed three times using three different detectors with the mean Co-60 result reported as 0.253 ± 0.007 pCi/gram. The known result for the sample was 0.197 ± 0.007 pCi/gram as determined by the supplier. The calculated ratio to the known was 1.28 or 28% greater than the known.

An evaluation of the Co-60 result was performed. The spectrum and peak search results were examined with no abnormalities identified. The precise cause of the nonconformity could not be explicitly determined. The difference in the sample density and the density of vegetation geometry calibration source is considered to be a significant contributing cause. The vegetation calibration source is constructed using 720 grams of homogeneous organic material in a 1 liter Marinelli beaker. The Analytics cross check sample contained 600 grams of the same material that was analyzed using the same counting geometry as the calibration source. In addition to the difference in sample density, the results were biased by settling of the sample in the Marinelli beaker, which because of the geometry, would place the material closer to the detector. With the material in the counting beaker being closer to the detector along with the overall difference in density, a positive bias would be introduced into the analysis. The presence of the high bias is confirmed by the results for the other radionuclides present in the sample. With the exception of Cr-51, the results for the other seven radionuclides resulted in high ratios (bias) relative to the known value and ranged from 1.05 to 1.22 (5% to 22% higher) when compared to the reference results.

The nonconforming analytical result for this sample media is not routine and does not indicate a programmatic deficiency in the analysis of Co-60 in Vegetation samples or other environmental media. Confidence in the accurate analysis of Co-60 can be demonstrated by other Co-60 analytical results, both in the sample results for the 2003 QA program and historical Co-60 QA results. The Co-60 results for the other Quality Assurance samples analyzed as part of the 2003 Interlaboratory Comparison Program were all acceptable and are summarized below:

2003 Co-60 Results

Sample ID	Medium	JAF	Reference	Ratio
E-3610-05	WATER pCi/liter	156±2	157±5	0.99
E-3855-05	WATER pCi/liter	122±2	117±4	1.04
E-3611-05	FILTER pCi/filter	175±2	179±6	0.98
E-3856-05	FILTER pCi/filter	90±2	87±3	1.03
E-3686-05	MILK pCi/liter	132±4	132±4	1.00
E-3857-05	MILK pCi/liter	133±2	123±4	1.08
E-3687-05	SOIL pCi/kg	155±5	145±5	1.07
			Mean Ratio =	1.03

A review of historical QA data for the period of 2002 through 1999 was performed. There were no nonconformities related to the analysis of Co-60 during this period. In 2002, eight QA samples were analyzed which contained Co-60. The mean ratio for these samples relative to the known (reference) value was 0.99. The 2003 nonconformity is considered to be an isolated instance. The lower sample volume/density produced a high bias in the analytical results which is considered to be the major cause of the nonconformity. The historical Co-60 results and the 2003 program result demonstrate that there is no systematic error or persistent bias present in the analysis of samples for Co-60 in Vegetation or other

environmental sample media. As a corrective action, the interlaboratory comparison program supplier was requested to provide sufficient sample media to duplicate the counting geometry.

F.4.2 Environmental Measurements Laboratory (EML)

In 2003, JAF Environmental Laboratory participated in both the EML Quality Assessment Programs, QAP-58 and QAP-59. Sample sets consisted of the following sample media:

- Water: Gross Beta, Mixed Gamma Emitters
- Water: Tritium
- Air Particulate Filter: Mixed Gamma Emitters/Gross Beta

A total of 10 samples containing 18 individual radionuclides were evaluated for the samples included in QAP-58 and QAP-59. Using the EML acceptance criteria, 18 of 18 radionuclides analyses (100%) were evaluated to be acceptable. Results for the EML cross Check Program are contained in Table F.4-1 and results for all participants can be viewed on-line at www.eml.doe.gov. A summary of the JAF Environmental Laboratory results is as follows:

Matrix	Total Analyses	Acceptable	Not Acceptable
Air	10	10	0
Water	8	8	0
Total	18	18	0
Percentage		100%	0.0%

There were no sample nonconformities with samples analyzed for the Environmental Measurements Laboratory program.

TABLE F.4-1
INTERLABORATORY INTERCOMPARISON PROGRAM
Gross Beta Analysis of Air Particulate Filters -- (pCi/filter)

DATE	JAF ENV ID NUMBER	MEDIUM	ANALYSIS	JAF RESULT (1)	REFERENCE LABORATORY* (2)	RATIO (3)
6/12/03	E-3685-05	AIR pCi/filter	GROSS BETA	76.8±1.2 73.7±1.2 76.6±1.2 Mean = 75.7±0.7	81±3	0.94, A
12/11/03	E-3930-05	AIR pCi/filter	GROSS BETA	56.6±0.85 58.6±0.87 54.9±0.84 Mean = 56.7±0.49	57±2	1.00, A

(1) Results reported as activity ± 1 sigma.
(2) Results reported as activity ± 2 sigma.
(3) Ratio = Reported/Analytics (See Section F.3).
(*) Sample provided by Analytics, Inc.
(A) Evaluation Results, Acceptable.

TABLE F.4-1 (Continued)
INTERLABORATORY INTERCOMPARISON PROGRAM
Tritium Analysis of Water -- (pCi/liter)

DATE	JAF ENV ID NUMBER	MEDIUM	ANALYSIS	JAF RESULT (1)	REFERENCE LABORATORY* (2)	RATIO (3)
3/20/03	E-3609-05	WATER pCi/liter	H-3	4538±183 4547±183 4729±185 Mean = 4605±106	4463±149	1.03, A

(1) Results reported as activity ± 1 sigma. Sample Analyzed by JAF Environmental Laboratory.
(2) Results reported as activity ± 2 sigma.
(3) Ratio = Reported/Analytics (See Section F.3).
(*) Samples provided by Analytics, Inc.
(A) Evaluation Results, Acceptable.

TABLE F.4-1 (Continued)
INTERLABORATORY INTERCOMPARISON PROGRAM
Iodine Analysis of Water, Air and Milk

DATE	JAF ENV ID NUMBER	MEDIUM	ANALYSIS	JAF RESULT (1)	REFERENCE LABORATORY* (2)	RATIO (3)
3/20/03	E-3610-05	WATER pCi/liter	I-131**	72.6±2.9 70.2±4.3 68.7±2.6 Mean = 70.5±1.9	70±2	1.01, A
6/12/03	E-3688-05	AIR pCi/cc	I-131	73.8±9.3 73.2±9.7 72.2±10.1 Mean = 73.1±5.6	62±2	1.18, A
6/12/03	E-3686-05	MILK pCi/liter	I-131**	91.8±2.5 94.7±2.5 91.6±2.0 Mean = 92.7±1.3	103±3	0.90, A
9/18/03	E-3858-05	AIR pCi/cc	I-131	79.3±9.2 76.9±9.1 95.0±9.0 Mean = 83.7±5.3	82±3	1.02, A
9/18/03	E-3855-05	WATER pCi/liter	I-131**	77.0±1.7 76.4±1.5 74.0±2.4 Mean = 75.8±1.1	76±3	1.00, A
9/18/03	E-3857-05	MILK pCi/liter	I-131**	68.2±2.9 70.7±1.7 68.9±1.9 Mean = 69.3±1.3	74±2	0.95, A

(1) Results reported as activity ± 1 sigma.
(2) Results reported as activity ± 2 sigma.
(3) Ratio = Reported/Analytics (See Section F.3).
(*) Samples provided by Analytics, Inc.
(**) Result determined by Resin Extraction/Gamma Spectral Analysis.
(A) Evaluation Results, Acceptable.

TABLE F.4-1 (Continued)
INTERLABORATORY INTERCOMPARISON PROGRAM
Gamma Analysis Water -- (pCi/liter)

DATE	JAF ENV ID NUMBER	MEDIUM	ANALYSIS	JAF RESULT (1)	REFERENCE LABORATORY* (2)	RATIO (3)
3/20/03	E-3610-05	WATER pCi/liter	Ce-141	167±9.9 165±8.3 160±10.4 177±3.8 166±6.3 Mean = 167±3.6	168±6	0.99, A
			Cr-51	339±44.8 192±41.7 241±55.0 244±18.7 270±33.6 Mean = 257.2±18.2	238±8	1.08, A
			Cs-134	76.7±5.2 76.9±4.7 75.4±5.7 83.9±1.7 78.1±3.0 Mean = 78.2±1.9	88±3	0.89, A
			Cs-137	180±6.5 184±6.3 182±7.8 185±2.4 185±4.4 Mean = 183.2±2.6	195±7	0.94, A
			Mn-54	68.0±4.7 68.1±4.4 67.0±5.7 65.9±1.7 66.0±3.1 Mean = 67.0±1.9	63±2	1.06, A
			Fe-59	49.9±6.2 53.4±6.8 47.5±7.7 45.1±2.4 53.8±4.5 Mean = 49.9±2.6	46±2	1.09, A
			Zn-65	92.8±9.2 77.2±8.4 87.1±10.7 95.1±3.4 85.5±6.3 Mean = 87.5±3.6	90±3	0.98, A
			Co-60	156±4.9 151±4.8 156±6.0 160±1.8 156±3.3 Mean = 155.8 ±2.0	157±5	0.99, A

TABLE F.4-1 (Continued)
INTERLABORATORY INTERCOMPARISON PROGRAM
Gamma Analysis Water -- (pCi/liter)

DATE	JAF ENV.ID NUMBER	MEDIUM	ANALYSIS	JAF RESULT (1)	REFERENCE LABORATORY* (2)	RATIO (3)
			Co-58	44.9±4.7 35.1±4.2 39.8±5.5 47.4±1.6 45.6±3.2 Mean = 42.6±1.8	42±1	1.02, A

(1) Results reported as activity ± 1 sigma.
(2) Results reported as activity ± 2 sigma.
(3) Ratio = Reported/Analytics (See Section F.3).
(*) Sample provided by Analytics, Inc.
(A) Evaluation Results, Acceptable.

TABLE F.4-1 (Continued)
INTERLABORATORY INTERCOMPARISON PROGRAM
Gamma Analysis Water -- (pCi/liter)

DATE	JAF ENV ID NUMBER	MEDIUM	ANALYSIS	JAF RESULT (1)	REFERENCE LABORATORY* (2)	RATIO (3)
9/18/03	E-3855-05	WATER pCi/liter	Ce-141	77.0±7.1 81.5±6.3 73.1±6.7 Mean = 77.2±3.9	81±3	0.95, A
			Cr-51	174.0±31.2 239.0±31.1 162.0±30.9 Mean = 191.7±17.9	221±7	0.87, A
			Cs-134	102±4.5 108±3.8 104±8.6 Mean = 104.7±3.5	113±4	0.93, A
			Cs-137	76.5±3.8 81.8±3.6 77.1±4.5 Mean = 78.5±2.3	84±3	0.94, A
			Mn-54	84.3±4.4 102±3.9 98.4±5.0 Mean = 94.9±2.6	88±3	1.08, A
			Fe-59	83.9±5.9 73.4±4.8 73.6±5.9 Mean = 77.0±3.2	75±3	1.03, A
			Zn-65	158±9.4 178±8.2 184±10.5 Mean = 173.3±5.4	166±6	1.04, A
			Co-60	125±3.7 120±3.2 121±4.2 Mean =122.0 ± 2.1	117±4	1.04, A
			Co-58	94.8±4.5 96.8±3.9 89.7±5.2 Mean = 93.8±2.6	94±3	1.00, A

(1) Results reported as activity ± 1 sigma.
(2) Results reported as activity ± 2 sigma.
(3) Ratio = Reported/Analytics (See Section F.3).
(*) Sample provided by Analytics, Inc.
(A) Evaluation Results, Acceptable.

TABLE F.4-1 (Continued)
INTERLABORATORY INTERCOMPARISON PROGRAM
Gamma Analysis of Air Particulate Filters -- (pCi/filter)

DATE	JAF ENV ID NUMBER	MEDIUM	ANALYSIS	JAF RESULT (1)	REFERENCE LABORATORY* (2)	RATIO (3)
3/20/03	E-3611-05	FILTER pCi/filter	Ce-141	191±6.5 191±2.7 191±6.7 Mean = 191±3.2	191±6	1.00, A
			Cr-51	271±32.0 247±30.8 264±14.6 270±32.2 Mean = 263±14.2	272±9	0.97, A
			Cs-134	90.6±5.1 91.3±1.6 93.0±4.9 Mean = 91.6±2.4	100±3	0.92, A
			Cs-137	212±6.7 216±6.7 211±2.2 214±6.1 Mean = 213.3±2.9	221±7	0.96, A
			Mn-54	81.9±5.0 79.8±1.6 80.8±4.4 Mean = 80.9±2.4	71±2	1.14, A
			Fe-59	62.1±7.0 57.1±6.7 58.8±2.6 54.4±6.3 Mean = 58.1±3.0	52±2	1.12, A
			Zn-65	120±10.4 98±10.5 115±3.4 102±9.5 Mean = 108.8±4.5	103±3	1.06, A
			Co-60	176±5.6 176±5.7 174±1.7 176±5.0 Mean = 175.5±2.4	179±6	0.98, A
			Co-58	53.8±4.7 59.0±4.6 49.6±1.5 48.5±4.1 Mean = 52.7±2.0	52±2	1.02, A

(1) Results reported as activity ± 1 sigma.
(2) Results reported as activity ± 2 sigma.
(3) Ratio = Reported/Analytics (See Section F.3).
(*) Sample provided by Analytics, Inc.
(A) Evaluation Results, Acceptable.

TABLE F.4-1 (Continued)
INTERLABORATORY INTERCOMPARISON PROGRAM
Gamma Analysis of Air Particulate Filters -- (pCi/filter)

DATE	JAF ENV ID NUMBER	MEDIUM	ANALYSIS	JAF RESULT (1)	REFERENCE LABORATORY* (2)	RATIO (3)
9/18/03	E-3856-05	FILTER pCi/filter	Ce-141	62.8±4.9 64.6±5.1 58.8±8.7 66.9±1.6 Mean = 63.3±2.8	61±2	1.03, A
			Cr-51	210±36.4 141±42.0 173±83.8 176±35.2 Mean = 175±27	165±6	1.06, A
			Cs-134	85.5±4.9 81.2±4.8 83.7±4.7 84.6±4.7 Mean = 83.8±2.4	85±3	0.99, A
			Cs-137	59.7±4.0 59.9±3.6 61.1±3.7 66.1±4.0 Mean = 61.7±1.9	63±2	0.98, A
			Mn-54	83.2±4.9 79.2±4.4 70.2±4.8 76.7±4.9 Mean = 77.3±2.4	66±2	1.17, A
			Fe-59	78.5±7.6 45.1±6.6 76.7±11.8 58.6±7.9 Mean = 64.7±4.4	56±2	1.16, A
			Zn-65	148±11.1 128±9.6 136±10.7 148±10.4 Mean = 140.0±5.2	124±4	1.13, A
			Co-60	82.8±4.0 86.9±3.6 93.5±4.0 95.1±4.1 Mean = 89.6±2.0	87±3	1.03, A
			Co-58	69.3±5.4 67.7±5.1 69.9±6.7 73.2±5.4 Mean = 70.0±2.8	69±2	1.01, A

(1) Results reported as activity ± 1 sigma.
(2) Results reported as activity ± 2 sigma.
(3) Ratio = Reported/Analytics (See Section F.3).
(*) Sample provided by Analytics, Inc.
(A) Evaluation Results, Acceptable..

TABLE F.4-1 (Continued)
INTERLABORATORY INTERCOMPARISON PROGRAM
Gamma Analysis Milk -- (pCi/liter)

DATE	JAF ENV ID NUMBER	MEDIUM	ANALYSIS	JAF RESULT (1)	REFERENCE LABORATORY* (2)	RATIO (3)
6/12/03	E-3686-05	MILK pCi/liter	Ce-141	282±7.7 280±8.8 292±8.3 290±9.2 Mean = 286±8.5	283±9	1.01, A
			Cr-51	248±34.7 203±34.5 247±31.2 291±34.8 Mean = 247.3±33.8	239±8	1.03, A
			Cs-134	94.3±3.8 94.4±5.3 85.0±4.0 94.7±5.1 Mean = 92.1±4.6	103±3	0.89, A
			Cs-137	226±5.1 206±6.7 229±5.4 221±6.8 Mean = 220.5±6.0	230±8	0.96, A
			Mn-54	192±5.0 182±6.4 191±5.1 195±6.5 Mean = 190±5.8	186±6	1.02, A
			Fe-59	101±5.6 94.5±7.3 100±5.3 106±7.0 Mean = 100.4±6.3	99±3	1.01, A
			Zn-65	182±8.2 196±11.5 195±8.6 202±11.2 Mean = 193.8±10.0	181±6	1.07, A
			Co-60	137±3.3 132±4.5 132±3.4 128±4.3 Mean 132.3=3.9	132±4	1.00, A
			Co-58	83.5±3.9 89.6±5.2 88.4±4.2 95.8±5.3 Mean = 89.3±4.7	93±3	0.96, A

(1) Results reported as activity ± 1 sigma.
(2) Results reported as activity ± 2 sigma.
(3) Ratio = Reported/Analytics (See Section F.3).
(*) Sample provided by Analytics, Inc.
(A) Evaluation Results, Acceptable.

TABLE F.4-1 (Continued)
INTERLABORATORY INTERCOMPARISON PROGRAM
Gamma Analysis Milk -- (pCi/liter)

DATE	JAF ENV ID NUMBER	MEDIUM	ANALYSIS	JAF RESULT (1)	REFERENCE LABORATORY* (2)	RATIO (3)
9/18/03	E-3857-05	MILK pCi/liter	Ce-141	81.9±8.4 87.1±7.0 88.2±5.9 Mean = 85.7±4.2	86±3	1.00, A
			Cr-51	218±39.1 245±34.8 208±32.7 Mean = 223.7±20.6	233±8	0.96, A
			Cs-134	112±5.8 122±5.4 120±4.0 Mean = 118±3.0	119±4	0.99, A
			Cs-137	81.9±5.1 82.0±4.8 89.2±3.9 Mean = 84.4±2.7	88±3	0.95, A
			Mn-54	98.8±5.6 103±5.3 102±4.3 Mean = 101.3±2.9	93±3	1.09, A
			Fe-59	70.6±7.6 79.2±6.7 86.0±6.0 Mean = 78.6±3.9	79±3	1.00, A
			Zn-65	172±12.1 184±11.0 191±6.5 Mean = 182.3±5.9	176±6	1.03, A
			Co-60	132±4.8 132±4.5 134±3.7 Mean = 132.7±2.5	123±4	1.08, A
			Co-58	93.2±5.9 103±5.7 99.5±4.7 Mean = 98.6±3.1	99±3	1.00, A

(1) Results reported as activity ± 1 sigma.
(2) Results reported as activity ± 2 sigma.
(3) Ratio = Reported/Analytics (See Section F.3).
(*) Sample provided by Analytics, Inc.
(A) Evaluation Results, Acceptable.

TABLE F.4-1 (Continued)
INTERLABORATORY INTERCOMPARISON PROGRAM
Gamma Analysis Soil -- (pCi/gram)

DATE	JAF ENV ID NUMBER	MEDIUM	ANALYSIS	JAF RESULT (1)	REFERENCE LABORATORY* (2)	RATIO (3)
6/12/03	E-3687-05	SOIL pCi/gram	Ce-141	0.375 ± 0.035 0.315±0.0310 0.356±0.0318 0.299±0.0146 0.312 ± 0.020 Mean = 0.331±0.012	0.310±0.010	1.07, A
			Cr-51	0.370±0.137 0.311±0.094 0.228±0.082 Mean = 0.303±0.062	0.262±0.009	1.16, A
			Cs-134	0.119±0.019 0.134±0.018 0.160±0.018 0.131±0.012 0.131±0.008 Mean = 0.135±0.007	0.113±0.004	1.19, A
			Cs-137	0.355±0.024 0.372±0.024 0.362±0.022 0.377±0.010 0.367±0.014 Mean = 0.367±0.009	0.359±0.012	1.02, A
			Mn-54	0.221±0.022 0.235±0.021 0.213±0.019 0.222±0.009 0.212±0.012 Mean = 0.220±0.008	0.204±0.007	1.08, A
			Fe-59	0.094±0.033 0.068±0.029 0.141±0.017 0.102±0.017 Mean = 0.101±0.010	0.108±0.004	0.94, A
			Zn-65	0.220±0.030 0.156±0.032 0.249±0.029 0.208±0.014 0.234±0.019 Mean = 0.213±0.012	0.199±0.007	1.07, A
			Co-60	0.169±0.014 0.144±0.014 0.155±0.013 0.159±0.006 0.150±0.008 Mean = 0.155±0.005	0.145±0.005	1.07, A

TABLE F.4-1 (Continued)
INTERLABORATORY INTERCOMPARISON PROGRAM
Gamma Analysis Soil -- (pCi/gram)

DATE	JAF ENV ID NUMBER	MEDIUM	ANALYSIS	JAF RESULT (1)	REFERENCE LABORATORY* (2)	RATIO (3)
			Co-58	0.077±0.017 0.092±0.018 0.077±0.017 0.081±0.008 0.079±0.011 Mean = 0.081±0.007	0.102±0.003	0.79, D NC # 2003-2

(1) Results reported as activity ± 1 sigma.
(2) Results reported as activity ± 2 sigma.
(3) Ratio = Reported/Analytics (See Section F.3).
(*) Sample provided by Analytics, Inc.
(A) Evaluation Results, Acceptable.
(D) Evaluation Results, Not Acceptable
(NC) Non Conformity Number

TABLE F.4-1 (Continued)
INTERLABORATORY INTERCOMPARISON PROGRAM
Gamma Analysis Vegetation -- (pCi/gram)

DATE	JAF ENV ID NUMBER	MEDIUM	ANALYSIS	JAF RESULT (1)	REFERENCE LABORATORY* (2)	RATIO (3)
6/12/03	E-3689-05	VEGETATION pCi/gram	Ce-141	0.434±0.021 0.449±0.024 0.470±0.011 Mean = 0.442±0.011	0.422±0.014	1.05, A
			Cr-51	0.205±0.074 0.269±0.102 0.410±0.057 Mean = 0.295±0.046	0.356±0.012	0.83, A
			Cs-134	0.188±0.013 0.188±0.016 0.188±0.005 Mean = 0.188±0.007	0.154±0.005	1.22, A
			Cs-137	0.378±0.018 0.373±0.021 0.414±0.007 Mean = 0.388±0.009	0.343±0.011	1.13, A
			Mn-54	0.326±0.017 0.308±0.021 0.323±0.007 Mean = 0.319±0.009	0.277±0.009	1.15, A
			Fe-59	0.173±0.021 0.144±0.026 0.160±0.010 Mean = 0.159±0.012	0.148±0.005	1.07, A
			Zn-65	0.281±0.030 0.253±0.037 0.332±0.012 Mean = 0.289±0.016	0.270±0.009	1.07, A
			Co-60	0.261±0.012 0.254±0.015 0.244±0.005 Mean = 0.255±0.008	0.197±0.007	1.28, D NC # 2003-1
			Co-58	0.130±0.014 0.152±0.017 0.166±0.006 Mean = 0.149±0.008	0.138±0.005	1.08, A

(1) Results reported as activity ± 1 sigma.
(2) Results reported as activity ± 2 sigma.
(3) Ratio = Reported/Analytics (See Section F.3).
(*) Sample provided by Analytics, Inc.
(A) Evaluation Results, Acceptable.
(D) Evaluation Results, Not Acceptable
(NC) Non Conformity Number

TABLE F.4-1 (Continued)
INTERLABORATORY INTERCOMPARISON PROGRAM
Gamma Analysis Water -- (Bq/liter)

DATE	JAF ENV ID NUMBER	MEDIUM	ANALYSIS	JAF RESULT (1)	REFERENCE LABORATORY* (1)	RATIO (2)
3/1/03	QAP-58	WATER Bq/liter	Cs-134	29.2±1.8 29.8±1.8 29.9±1.0 26.4±1.3 27.4±1.6 Mean = 28.5±0.7	30.5±1.09	0.934, A
			Cs-137	60.3±2.3 61.8±1.3 62.2±1.7 61.8±2.1 Mean = 61.5±0.9	63.8±3.4	0.964, A
			Co-60	230.5±3.4 225.7±3.4 228.7±1.9 231.6±2.6 236.8±3.3 Mean = 230.7±1.3	234.0±8.4	0.986, A

(1) Results reported as activity ± 1 sigma.
(2) Ratio = Reported/EML (See Section F.3).
(*) Sample provided by Environmental Measurements Lab., Dept. of Energy.
(A) Evaluation Results, Acceptable.

TABLE F.4-1 (Continued)
INTERLABORATORY INTERCOMPARISON PROGRAM
Gamma Analysis Water -- (Bq/liter)

DATE	JAF ENV ID NUMBER	MEDIUM	ANALYSIS	JAF RESULT (1)	REFERENCE LABORATORY* (1)	RATIO (2)
09/01/03	QAP-59	WATER Bq/liter	Cs-134	63.6±2.5 65.1±2.5 67.7±3.3 69.2±2.3 Mean = 66.4±1.3	63.0±2.0	1.054, A
			Cs-137	82.1±2.7 84.7±2.7 83.6±4.0 81.0±2.6 Mean = 82.9±1.5	80.3±4.1	1.032, A
			Co-60	525.4±4.8 525.4±4.8 518.0±6.9 536.5±4.7 Mean = 526.3±2.7	513.0±18.0	1.026, A

(1) Results reported as activity ± 1 sigma.
(2) Ratio = Reported/EML (See Section F.3).
(*) Sample provided by Environmental Measurements Lab., Dept. of Energy.
(A) Evaluation Results, Acceptable.

TABLE F.4-1 (Continued)
INTERLABORATORY INTERCOMPARISON PROGRAM
Gamma Analysis Air Particulate Filters -- (Bq/filter)

DATE	JAF ENV ID NUMBER	MEDIUM	ANALYSIS	JAF RESULT (1)	REFERENCE LABORATORY* (1)	RATIO (2)
3/1/03	QAP-58	FILTER Bq/filter	Co-60	33.9±0.5 32.5±0.5 33.7±0.4 33.3±0.2 Mean = 33.3±0.2	33.5±0.87	0.994, A
			Mn-54	47.7±0.7 45.9±0.6 49.6±0.7 48.1±0.2 Mean = 47.8±0.3	43.8±1.13	1.091, A
			Cs-137	104.3±0.9 98.3±0.9 103.6±0.9 104.0±0.3 Mean = 102.7±0.4	99.7±2.3	1.023, A
9/1/03	QAP-59	FILTER Bq/filter	Mn-54	65.1±0.9 65.9±0.9 62.9±0.9 64.0±0.8 Mean = 64.5±0.4	58.0±1.3	1.112, A
			Co-60	57.0±0.7 55.1±0.7 55.5±0.7 54.8±0.6 Mean = 55.6±0.3	55.1±1.1	1.009, A
			Cs-137	58.8±0.8 59.6±0.8 56.6±0.8 56.6±0.7 Mean = 57.9±0.4	54.8±1.1	1.057, A

(1) Results reported as activity ± 1 sigma.
(2) Ratio = Reported/EML (See Section F.3).
(*) Sample provided by Environmental Measurements Lab., Dept. of Energy.
(A) Evaluation Results, Acceptable.

TABLE F.4-1 (Continued)
INTERLABORATORY INTERCOMPARISON PROGRAM
Gross Beta Analysis of Water -- (Bq/liter)

DATE	JAF ENV ID NUMBER	MEDIUM	ANALYSIS	JAF RESULT (1)	REFERENCE LABORATORY* (1)	RATIO (2)
3/1/03	QAP-58	WATER Bq/liter	GROSS BETA	583±13 595±13 587±13 Mean = 588±7	627.5±10.0	0.937, A
9/1/03	QAP-59	WATER Bq/liter	GROSS BETA	1760±29 1776±29 1853±30 Mean = 1796±17	1948.0±195.0	0.922, A

(1) Results reported as activity ± 1 sigma.
(2) Ratio = Reported/EML (See Section F.3).
(*) Sample provided by Environmental Measurements Lab., Dept. of Energy.
(A) Evaluation Results, Acceptable.

TABLE F.4-1 (Continued)
INTERLABORATORY INTERCOMPARISON PROGRAM
Tritium Analysis of Water -- (Bq/liter)

DATE	JAF ENV ID NUMBER	MEDIUM	ANALYSIS	JAF RESULT	REFERENCE LABORATORY* (1)	RATIO (2)
3/1/03	QAP-58	WATER Bq/liter	H-3	419.3±8.8 415.8±8.8 413.0±8.8 Mean = 416±5.1	390.0±3.4	1.067, A
9/1/03	QAP-59	WATER Bq/liter	H-3	470±10 469±10 477±10 Mean = 472±6	446.3±2.2	1.058, A

(1) Results reported as activity ± 1 sigma.
(2) Ratio = Reported/EML (See Section F.3).
(*) Sample provided by Environmental Measurements Lab., Dept. of Energy.
(A) Evaluation Results, Acceptable.

TABLE F.4-1 (Continued)
INTERLABORATORY INTERCOMPARISON PROGRAM
Gross Beta Analysis of Air -- (Bq/filter)

DATE	JAF ENV ID NUMBER	MEDIUM	ANALYSIS	JAF RESULT (1)	REFERENCE LABORATORY* (1)	RATIO (2)
3/1/03	QAP-58	AIR Bq/filter	GROSS BETA	1.52±0.03 1.47±0.03 1.44±0.03 Mean = 1.48±0.02	1.5±0.15	0.987, A
9/1/03	QAP-59	AIR Bq/filter	GROSS BETA	3.82±0.04 3.83±0.04 3.79±0.04 Mean = 3.81±0.02	3.89±0.39	0.979, A

(1) Results reported as activity ± 1 sigma.
(2) Ratio = Reported/EML (See Section F.3).
(*) Sample provided by Environmental Measurements Lab., Dept. of Energy.
(A) Evaluation Results, Acceptable.

F.5 References

F.5.1 Semi-Annual Report of the Department of Energy, Office of Environmental Management, Quality Assessment Program, EML 621, June 2003.

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F.5.3 Radioactivity and Radiochemistry, The Counting Room: Special Edition, 1994 Caretaker Publications, Atlanta, Georgia.

F.5.4 Data Reduction and Error Analysis for the Physical Sciences, Bevington P.R., McGraw Hill, New York (1969).

F.5.5 Table of Radioactive Isotopes, Browne; Wiley Press– Interscience Publications, 1986