Technical Specification 6.9.C.2

Boston Edison

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In accordance with the Pilgrim Nuclear Power Station Technical Specification 6.9.C.2, Boston Edison Company submits the Annual Radiological Environmental Monitoring Program Report for 1995 (Report #28).

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RLC/dmc/9449

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PILGRIM NUCLEAR POWER STATION

Radiological Environmental Monitoring Program
Report No. 28

January 1 through December 31, 1995

Boston Edison

BOSTON EDISON COMPANY

PILGRIM NUCLEAR POWER STATION

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

REPORT NO. 28

January 1 through December 31, 1995

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January 1 through December 31, 1995

INTRODUCTION

This report summarizes the results of the Boston Edison Company's Radiological Environmental Monitoring Program (REMP) conducted in the vicinity of Pilgrim Nuclear Power Station (PNPS) during the period from January 1 to December 31, 1995. This document has been prepared in accordance with the requirements of PNPS Technical Specifications section 6.9.C.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 1995, there were 1,388 samples collected from the atmospheric, aquatic and terrestrial environments. In addition, 435 exposure measurements were obtained using environmental thermoluminescent dosimeters (TLDs) and six exposure rate measurements were performed using a high pressure ion chamber. All of the various samples and TLDs were collected by Boston Edison Company and Massachusetts Division of Marine Fisheries personnel.

A few minor problems were encountered during 1995 in the collection of environmental samples in accordance with the PNPS Technical Specifications. Five out of the required 140 TLDs were missing from their posted locations during the quarterly retrieval process. Equipment failures and power outages resulted in missing one out of the required 572 airborne particulate filters, and one of the 572 charcoal filters. Due to seasonal unavailability of Group II (near-bottom distribution) fishes in the vicinity of the discharge canal, these samples were missed during the first quarter of 1995. A full description of the discrepancies encountered with the environmental monitoring program is presented in Appendix D of this report.

There were 1,562 analyses performed on the environmental media samples. All analyses were performed by the Yankee Atomic Electric Company Environmental Laboratory in Westboro, Mass. All samples were analyzed as required by the PNPS Technical Specifications.

LAND USE CENSUS

The annual land use census in the vicinity of Pilgrim Station was conducted as required by Technical Specifications between October 26 and 31, 1995. A total of 33 gardens having an area of more than 500 square feet were identified within three miles of PNPS. No new milk or meat animals were located during the census. Of the 33 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 1995, all 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 samples collected in 1995 which showed detectable activity potentially attributable to PNPS operations were blue mussels and Irish moss collected from the discharge canal outfall. Ingesting food products containing the low levels of cobalt-60 detected in these media would result in a dose of 0.0003 mrem to the maximum exposed individual. Off-site ambient radiation measurements using environmental TLDs and a high pressure ion chamber ranged between 45 and 97 mR/year. This range of ambient radiation levels is consistent with natural background radiation levels for Massachusetts as determined by the Environmental Protection Agency (EPA).

RADIOLOGICAL IMPACT TO THE GENERAL PUBLIC

During 1995, 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 man-made and naturally-occurring sources of 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 1995 was about 2.7 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. Radioactivity detected in environmental samples (mussels and Irish moss) collected during 1995 yielded 0.0003 mrem to the hypothetical maximally exposed individual.

CONCLUSIONS

The 1995 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 which are normally present due to natural and man-made background radiation.

Based on this information, there is no evidence of any 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 1995 performed by Boston Edison 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 6.9.C.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, 1995.

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 BECo'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 which 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	About 1
		Nuclear Power Plants	About 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). All these sources contribute to a total dose of about 300 mrem per year from all natural sources of radiation.

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 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) and nuclear power plants (less than 1 mrem/yr). Basically, 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 670 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 five miles east-southeast of Plymouth Center. Commercial operation began in December, 1972.

Pilgrim Station was shut down for a refueling outage March 24 - June 06, 1995. Monthly capacity factors are given in Table 1.3-1.

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.

TABLE 1.3-1

PNPS OPERATING CAPACITY FACTOR DURING 1995

OPERATING PERCENT CAPACITY

(Based on 670 MWe)

Month	Percent Capacity
January	99.1
February	96.3
March*	74.4
April*	0.0
May*	0.0
June*	65.1
July	95.7
August	97.7
September	96.7
October	94.3
November	99.5
December	98.8
Average	76.5

* PNPS entered a refueling outage on March 24, 1995.
The plant was restarted on June 06, 1995.

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.

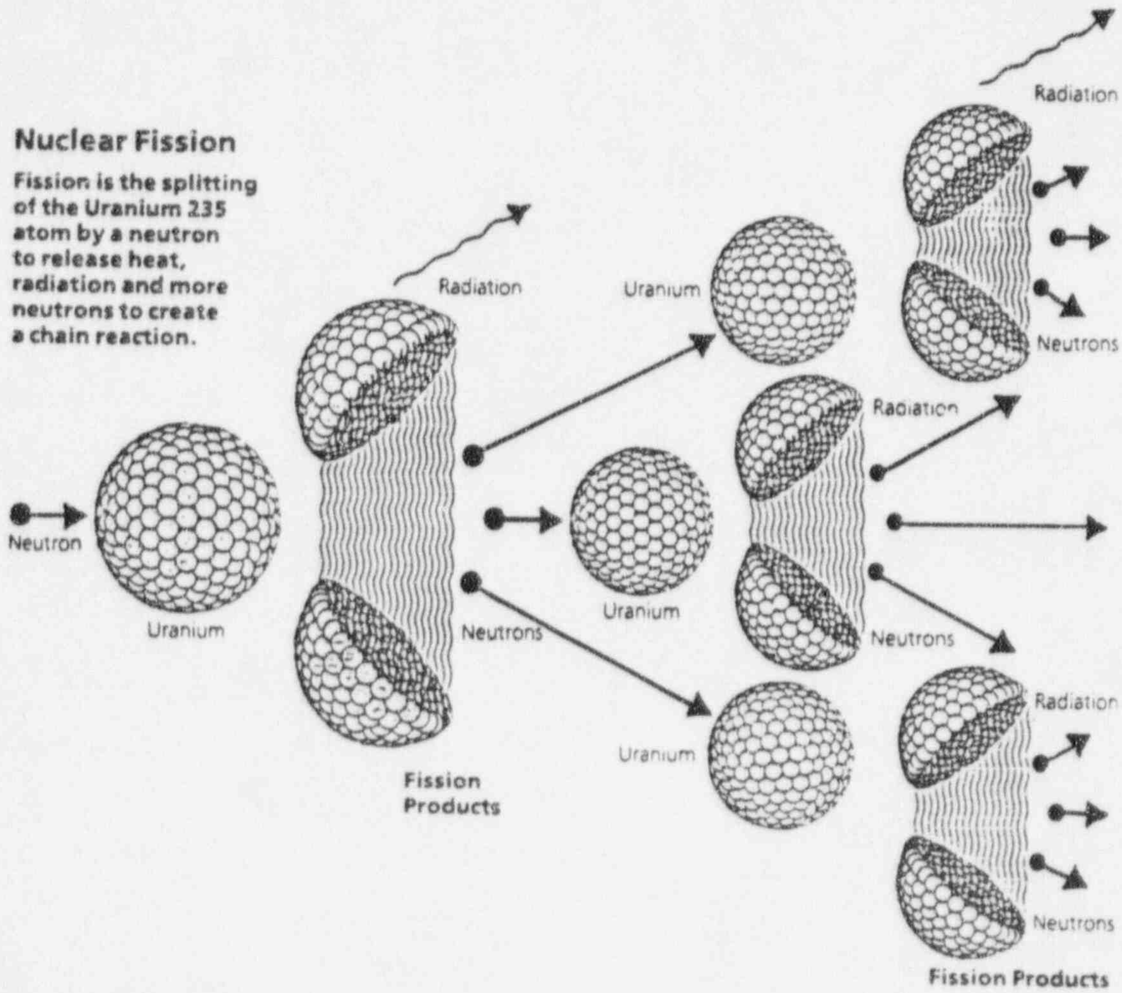


Figure 1.3-1
Radioactive Fission Product Formation

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).

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).

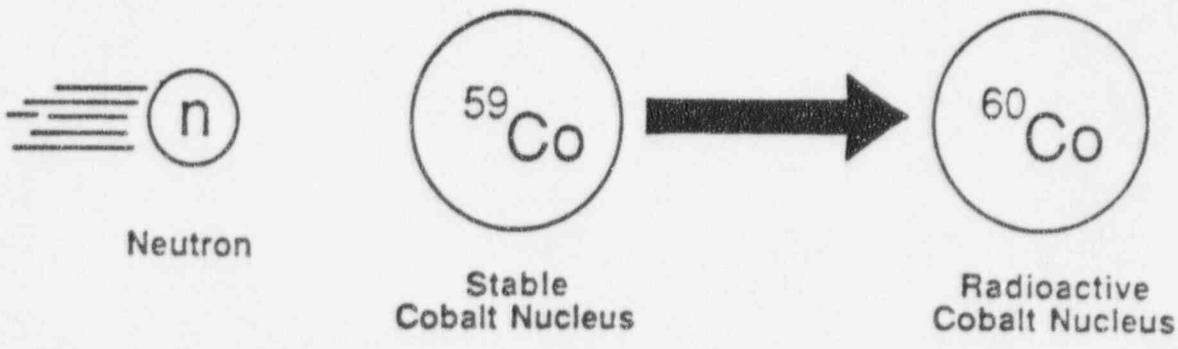


Figure 1.3-2
Radioactive Activation Product Formation

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: 1) fuel pellets; 2) fuel cladding; 3) reactor vessel and piping; 4) primary containment (drywell and torus); and 5) secondary containment (reactor building).

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 which 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 which 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 confines 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. The drywell's steel pressure vessel is enclosed by an approximately five foot thick concrete wall. 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 which 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.

SIMPLIFIED DIAGRAM OF PILGRIM NUCLEAR POWER STATION

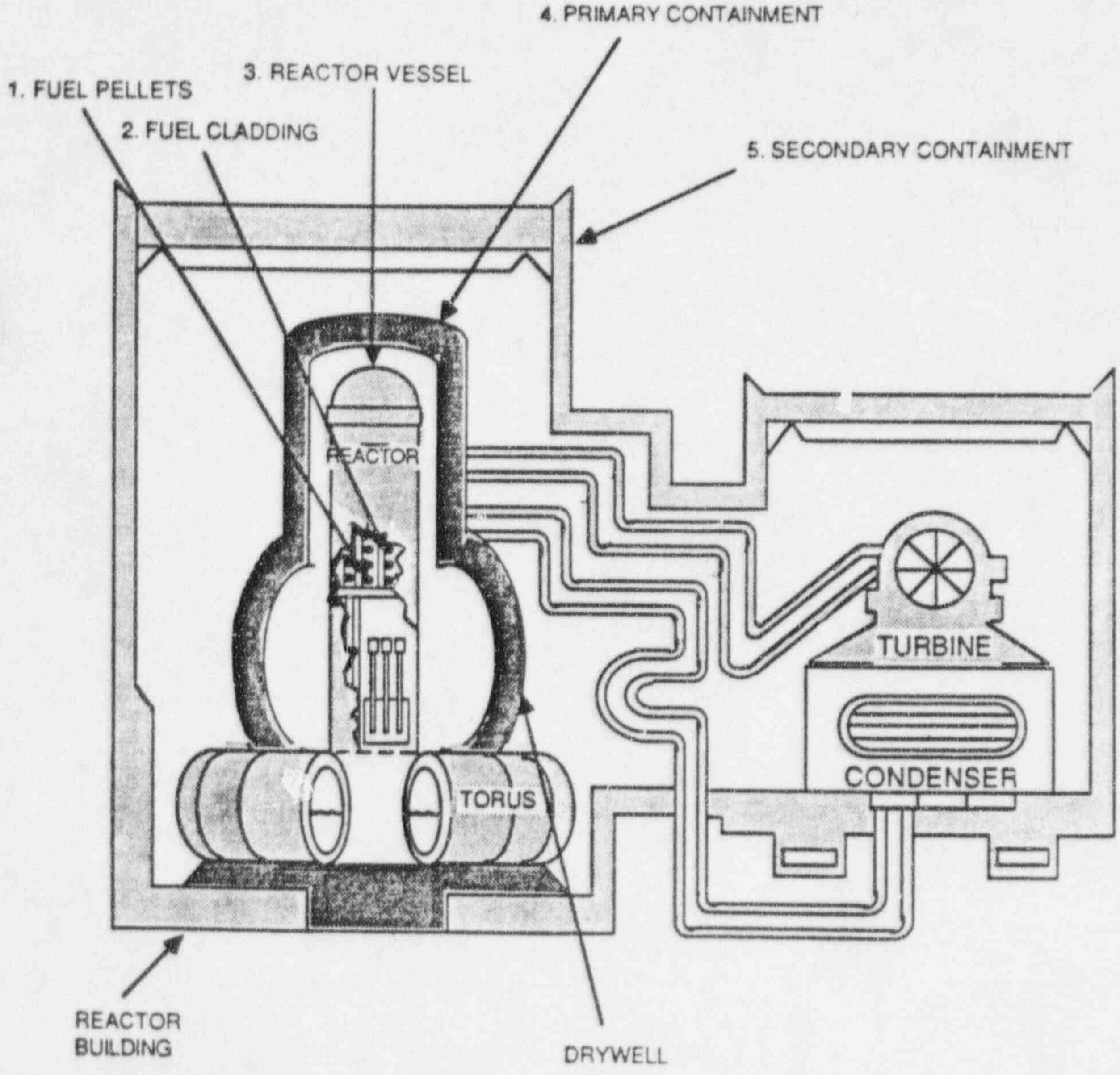


Figure 1.3-3
Barriers To Confine Radioactive Materials

Most of the radioactive fission and activation products are confined by the five barriers. 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 purified by a high efficiency filter that removes radioactive particles suspended in the water. Subsequent to that, the flow is directed through ion exchange resins where radioactive elements, diluted in the water, are removed through chemical processes. The net effect is a drastic 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 is 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 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.

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; 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 which is located on the side of the reactor building. This plenum, which vents to the atmosphere, is equipped with a shielded 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 radioactive gaseous and particulate effluent 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 which further reduces concentration levels of gaseous releases to the environment to as far below the release limits as is reasonably achievable.

The approximately 330 foot tall main stack has a special probe inside it which withdraws a portion of the air and passes it through a radioactivity monitoring system. This main stack effluent radioactivity monitoring system samples radioactive particulates, iodines, and noble gases and collects a tritium sample. 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 a 30-minute holdup line 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 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 1995 were reported to the Nuclear Regulatory Commission semiannually. The 1995 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 Technical Specifications operational objectives.

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 affect 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

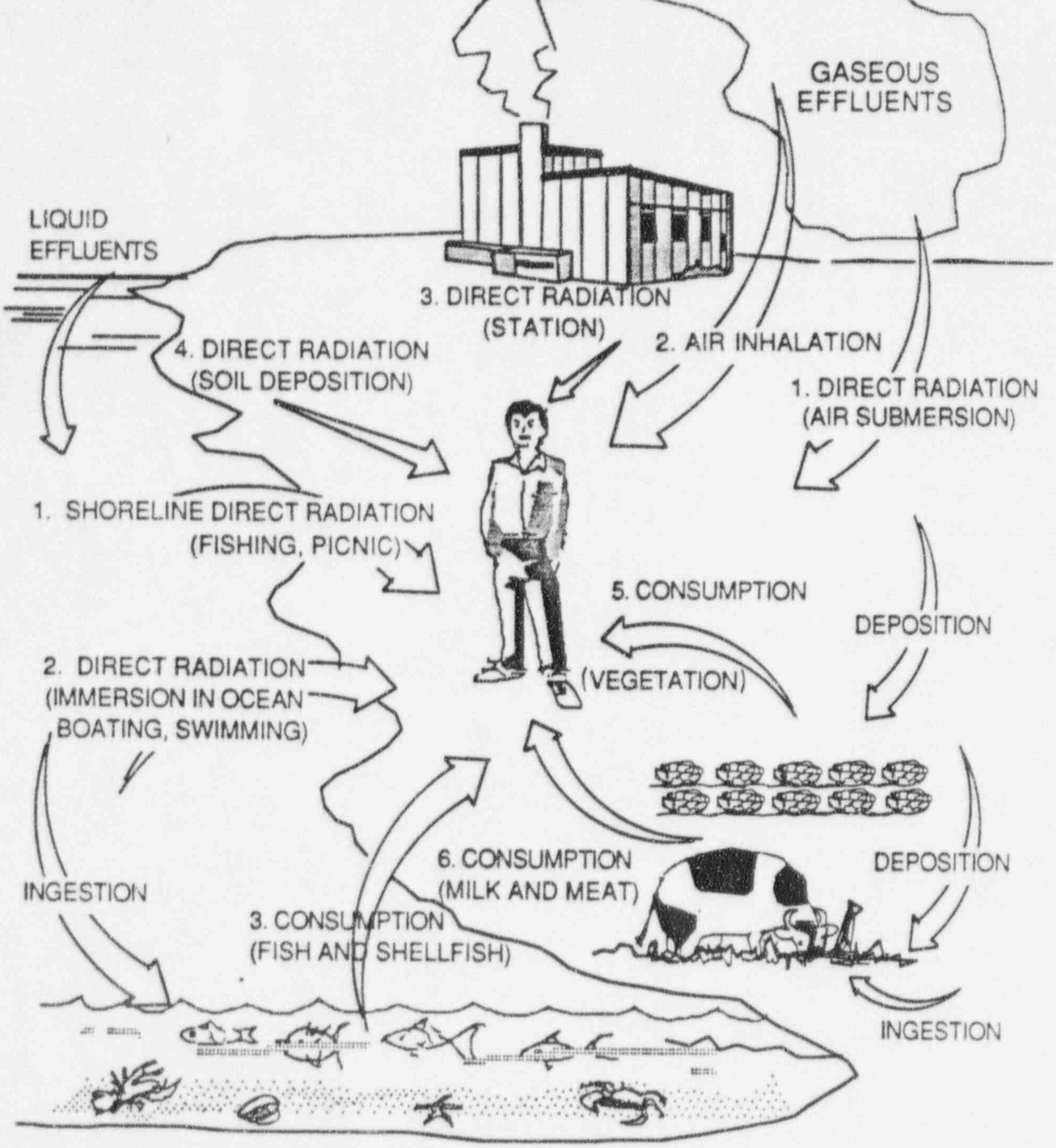


Figure 1.5-1
Radiation Exposure Pathways

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

1) external radiation from an airborne plume of radioactivity;

2) internal radiation from inhalation of airborne radioactivity;

3) ambient radiation emitted from Pilgrim Station;

4) external radiation from deposition of radioactive effluents on soil;

5) internal radiation from consumption of vegetation containing radioactivity absorbed from the soil due to ground deposition of radioactive effluents; and,

6) internal radiation from consumption of milk and meat containing radioactivity deposited on forage which is eaten by cattle and other livestock.

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

1) external radiation from liquid effluents that deposit and accumulate on the shoreline;

2) external radiation from immersion in ocean water containing radioactive liquids; and,

3) internal radiation from consumption of fish and shellfish containing radioactivity absorbed from the liquid effluents.

To the extent possible, the radiological dose impact on humans is based on direct measurements of radiation and radioactivity in the environment (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 detect these tiny amounts of radioactivity above that which is naturally present in the environment. Therefore, radiation doses are calculated using radioactivity release data and computerized dose calculations that are based on very conservative (over-estimated) NRC-recommended models. These computerized dose calculations are performed by or for Boston Edison Co. 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 Off-site Dose Calculation Manual (Reference 7) which has been reviewed by the NRC.

Monthly dose calculations are performed by Boston Edison Co. personnel. Semiannual dose calculations are performed for Boston Edison Co. by Yankee Atomic Electric Co., using their advanced "YODA" computer program. 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 1995 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 1995 will be 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 Boston Edison Company's Pilgrim Nuclear Power Station was initiated in August 1968. The purpose of the pre-operational environmental monitoring program (Reference 11) was to:

1) measure background levels and their variations in the environment in the area surrounding Pilgrim Station; and,

2) evaluate procedures, equipment, and techniques.

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 Co. 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:

1) demonstrating that doses to the general public and levels of radioactivity in the environment are within established limits and legal requirements;

2) 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;

3) 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;

4) assessing the dose equivalent to the general public and the behavior of radioactivity released during the unlikely event of an accidental release; and

5) determining whether or not the radiological impact on the environment and humans is significant.

The Nuclear Regulatory Commission requires that Boston Edison Company 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) which specify an acceptable monitoring program. The Boston Edison Company's 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 which 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 miles 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 1995 included air particulate filters, charcoal cartridges, seawater, shellfish, Irish moss, American lobster, fishes, sediment, milk, cranberries, vegetation, and forage. The medium, station number, description, 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, 2, 3, 4, and 5.

The radiation monitoring locations for the environmental TLDs are shown in Figures 2.2-1, 2, and 3. The frequency of collection and types of radioactivity analysis are described in Pilgrim Station's Technical Specifications, Sections 7.0/8.0.

The land-based (terrestrial) samples and monitoring devices are collected by Boston Edison personnel from the Electrical Engineering and Station Operation Department's Environmental Laboratory. The aquatic samples are collected by the Division of Marine Fisheries - Pilgrim Station Project personnel. The direct radiation measurements and soil radioactivity measurements are conducted by Yankee Atomic Electric Co. - Radiological Engineering Group and Environmental Laboratory personnel, respectively. The radioactivity analysis of samples and the processing of the environmental TLDs is performed by Yankee's Environmental Laboratory personnel.

The frequency, types, minimum number of samples, and maximum lower limits of detection (LLD) for the analytical measurements, are specified in the PNPS Technical Specifications.

Upon receipt of the analysis results from Yankee Atomic Electric Co., the Boston Edison staff reviews the results. If the radioactivity concentrations are above the reporting levels, the NRC must be notified within 30 days. For radioactivity which 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 1995 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 1995 Garden and Milk Animal Census are reported in Appendix C.

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

- Regular audits of the sampling and monitoring program;
- An annual audit of the analytical laboratory by the sponsor companies;
- Participation in the United States Environmental Protection Agency cross-check program;
- 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 Boston Edison Company's Quality Assurance Department.

The blind duplicates, split samples and spiked samples are analyzed by Boston Edison Company, Yankee Atomic Electric Company's Environmental Laboratory, and the other four sponsor companies. The 1995 results of this QA program are summarized in Appendix E. These results indicate that the analyses and measurements performed during 1995 exhibited acceptable precision and accuracy.

2.3 <u>Interpretation of Radioactivity Analyses Results</u>

The following pages summarize the analytical results of the environmental samples collected during 1995. Data for each environmental medium are included in a separate section. A discussion of the sampling program and results is followed by a table which summarizes the year's data for each type of medium. The tables were generated by the Yankee Atomic Electric Company's ERMAP computer program (Reference 17). 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 which 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 which have detection capability requirements specified in the PNPS Technical Specifications.

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 Yankee Atomic ERMAP computer program calculates:

- The mean value of all concentrations, including negative values and values below LLD;
- The standard error of the mean;
- 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 43). Gross beta (GR-B) analyses were performed on 571 routine samples (11 stations/wk * 52 weeks, minus 1 missing sample). None of the samples exceeded ten times the average concentration at the control location. The lower limit of detection (LLD) required by Technical Specifications is 0.01 pCi/m^3.

For samples collected from the ten indicator stations, 516 out of 519 samples indicated detectable activity at the three-sigma (standard deviation) level. The mean concentration of gross beta activity in these 519 indicator station samples was 0.015 ± 0.000 (1.5 ± 0.0 E-2) pCi/m^3. Individual values ranged from 0.0024 to 0.0340 (2.4 - 34.0 E-3) pCi/m^3.

The monitoring station which yielded the highest mean concentration was station number 21 (East Weymouth), which yielded a mean concentration of 0.017 ± 0.001 pCi/m^3, based on 51 observations. Individual values ranged from 0.0030 to 0.0347 pCi/m^3. Fifty-one out of the 52 samples showed detectable activity at the three-sigma level.

At the control location, all 52 out of 52 samples yielded detectable gross beta activity, for an average concentration of 0.017 ± 0.001 pCi/m^3. Individual samples at the control location ranged from 0.0030 to 0.0347 pCi/m^3.

Referring to the third entry in the table, analyses for potassium-40 (K-40) were performed 44 times (quarterly composites for 11 stations * 4 quarters). No samples exceeded ten times the mean control station concentration. There is no LLD value listed for K-40 in the PNPS Technical Specifications.

At the indicator stations, individual concentrations of K-40 ranged from -0.0035 to 0.0102 pCi/m^3, for a mean concentration of 0.0026 ± 0.0005 pCi/m^3. However, none of the forty samples analyzed showed detectable amounts of potassium-40 at the three-sigma level. It is important to note that the mean value presented is calculated from forty observations, all of which yielded no detectable activity.

The previous paragraph illustrates an important point about applying the three-sigma criterion to determine if radioactivity is detected. While such a screening criterion can be applied to a single measurement, it is inappropriate to apply it to a mean value calculated from mulitiple measurements. In the case of K-40 in air particulate filters, none of the 40 individual samples was "positive" at the 3-sigma level. However, the mean value of 0.0026 ± 0.0005 pCi/m^3 would initially "appear" to be "positive" if the 3-sigma criterion is applied. When the mean and its associated standard error are calculated, the uncertainties associated with each individual measurement are not propagated. If the individual results are similar, even though they are "non-positive", the resulting standard error is artificially low, and does not reflect the total uncertainty associated with all of the measurements. This makes the 3-sigma criterion inappropriate for application to a mean and standard error calculation from several measurements. A similar situation also occurs in the case of the nuclides zinc-65 (Zn-65) and zirconium-95 (Zr-95) in sediment, presented in Table 2.17-1. While none of the individual measurements were "positive" at the 3-sigma level, the mean values "appear" to be "positive" when the 3-sigma criterion is misapplied, even though there is no detectable activity for these nuclides.

The station which yielded the highest mean concentration of K-40 was station 17. Again, the mean value of 0.0048 ± 0.0021 pCi/m^3 is based on four observations, none of which yielded any detectable activity. Therefore, no potassium-40 was detected in any of the samples collected from the sampling stations.

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. Forty of these locations are listed as required monitoring locations in the PNPS Technical Specifications. In addition, 27 of the 110 TLDs are located on-site, within the PNPS protected/restricted area.

Out of the 440 TLDs (110 locations * 4 quarters) posted during 1995, 435 were retrieved and processed. Those TLDs missing from their monitoring locations were lost to storm damage and vandalism, and their absence is discussed in Appendix D. The results for environmental TLDs located off-site, beyond the PNPS protected/restricted area fence, are presented in Table 2.4-1. Results from on-site TLDs posted within the restricted area presented in Table 2.4-2. In addition to TLD results for individual locations, results from off-site 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 off-site locations ranged from 45 to 465 mR/yr. The average exposure rate at control locations greater than 15 km from Pilgrim Station (i.e., Zone 4) was 59.5 ± 7.0 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 38 and 81 mR/yr.

Inspection of on-site 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. These increases are due to the close proximity of these locations to radiation sources on-site. The radionuclide nitrogen-16 contained in steam flowing through the turbine accounts for most of the exposure on-site. 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. Such TLD locations which experienced appreciable increases since 1994 due to turbine sky shine are P03, P16, P17, and P25. Some increases in exposure also occur from the transit and temporary storage of radioactive wastes on-site. TLD locations P03, P05, P06, P07, P08, and P09 are near the radwaste trucklock and experienced exposure increases due to staging and transit of radwaste on-site. TLD location P28 is located adjacent to the low level waste storage facility, and experienced exposure increases since 1994 from accumulations in radwaste being stored there. It must be emphasized that all of the locations mentioned previously are within the protected/restricted area and are not accessible by members of the general public.

A small number of off-site TLD locations in close proximity to the protected/restricted area indicated ambient radiation exposure above expected background levels. All of these locations are on Boston Edison controlled property, and experienced exposure increases due to turbine sky shine (e.g., locations TC, OA, PB, P01, WS, and CT) and/or transit and storage of radwaste on-site (e.g., locations BLW and BLE). A hypothetical maximum exposed member of the public accessing these near-site areas on Boston Edison controlled property for limited periods of time would receive a maximum dose of 1.8 mrem/yr above their average ambient background dose of 59 mrem/yr. The exposure rates measured at areas beyond Boston Edison control did not indicate any increase in ambient exposure from Pilgrim Station operation. For example, the annual exposure rate at the nearest off-site resident (location HB, 0.6 km SE) was 63.4 ± 4.9 mR/yr, which compares quite well with the average control location exposure of 59.5 ± 7.0 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.

Annual measurements are taken with a high-pressure ion chamber at five locations on beaches in the Plymouth area, and at the control location in Duxbury. Results of these measurements (Reference 18) are listed in Table 2.4-4. These values, as well as historical measurements, are depicted graphically in Figure 2.4-1. There are 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 Boston Edison property very close to Pilgrim Station, there were no measurable increases at areas beyond Boston Edison'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 which 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. Boston Edison 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), 571 samples were collected and analyzed during 1995. 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. These discrepancies are noted in Appendix D. Despite the problems listed above, the required LLDs were met on all 571 filters collected during 1995.

The results of the analyses performed on these 571 filter samples are summarized in Table 2.5-1. Trend plots for the gross beta radioactivity levels at the near station, property line, and off-site airborne monitoring locations are shown in Figures 2.5-1, 2.5-2 and 2.5-3, respectively. Gross beta radioactivity was detected in 567 of the filter samples collected, including 51 of the 52 control location samples. This gross beta activity arises from naturally-occurring radionuclides such as radon decay daughter products. Beryllium-7 was the only gamma emitting nuclide detected, and it was observed in all 44 of the quarterly composites analyzed. No radionuclides attributable to Pilgrim Station operations were detected in any of the airborne particulate samples collected.

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), 571 samples were collected and analyzed during 1995. Although some samples had low volumes due to power loss or pump failure, all required LLDs were met. These discrepancies are noted in Appendix D.

The results of the analyses performed on these 571 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 Plymouth County Farm and from the control location in Whitman. The Annual Land Use Census conducted within three miles 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, low-level analysis for radioiodine, and strontium 89 and 90.

All 38 samples scheduled for collection during the year were obtained and analyzed. No problems were encountered in sampling milk during 1995.

The results of the analyses performed on the 38 milk samples are summarized in Table 2.7-1. Naturally-occurring potassium-40 was detected in all 38 samples. No radioactive iodine was detected in any of the samples. Strontium-90 was detected in 14 of the 19 samples from Plymouth County Farm, and in 4 of the 19 samples collected from the control location in Whitman. Cesium-137 was not detected in any of the samples collected during the year. Concentrations of Sr-90 and Cs-137 as a function of time are shown in Figures 2.7-1 and 2.7-2, respectively.

The highest concentration of Sr-90, 4.5 pCi/liter, was observed in a sample collected from the indicator location at Plymouth County Farm. The highest concentration of Sr-90 in samples collected from Whitman Farm was 3.0 pCi/liter. The Sr-90 detected in the samples resulted from radioactivity in the environment which was deposited from nuclear weapons testing conducted in the 1950s and 60s. Strontium-90 was routinely detected in the preoperational sampling program conducted prior to Pilgrim Startup in 1972, at concentrations ranging from 5 to 18 pCi/liter. When the average preoperational Sr-90 concentration of 9 pCi/liter is corrected for radioactive decay which occurred between 1972 and 1995, the expected concentration would be 5 pCi/liter. The concentrations of 3 to 5 pCi/liter observed in 1995 samples are well below the expected Sr-90 concentrations resulting from weapons testing. It is clear that the Sr-90 observed did not arise from Pilgrim Station operations.

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 of corn to be used for silage at Plymouth County Farm were also collected from the Whipple Farm (1.8 mi. SW). Samples are collected annually and analyzed by gamma spectroscopy.

All samples of forage were collected and analyzed as required during 1995. Results of the gamma analyses of forage samples are summarized in Table 2.8-1. The only radionuclides detected in any of the samples were naturally-occurring beryllium-7, and potassium-40. No radionuclides attributable to Pilgrim Station operations were detected in any of the samples.

2.9 Vegetable/Vegetation Radioactivity Analyses

Samples of vegetables are routinely collected from the Plymouth County Farm and from the control location at Bridgewater Farm. 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 were also collected from three locations corresponding to the highest atmospheric deposition factors from the two PNPS release points. Samples of vegetables are collected annually and analyzed by gamma spectroscopy.

All samples of vegetables/vegetation were collected and analyzed as required during 1995. Results of the gamma analyses of these samples are summarized in Table 2.9-1. Naturally-occurring beryllium-7, potassium-40, and thorium-232 were identified in nearly all of the samples collected. Cesium-137 was also detected in four of the samples collected.

The highest level of cesium-137 (269 pCi/kg) was detected in a sample of naturally-growing vegetation, a mixture of grass, herbaceous plants, and leaves from bushes and trees, which was collected 0.4 km (0.22 mi) southwest of the PNPS Reactor Building. As was the case for all samples of naturally-growing vegetation, these samples were collected and analyzed "as is", without processing the material to remove soil and dust on the surface of the plants. As documented in the 1994 REMP report, Cs-137 was detected in nearly all of the soil surveys conducted during 1994, indicating that Cs-137 is widespread in soil throughout New England. In addition to Cs-137, the vegetation samples in question also contained detectable thorium-232 decay-chain nuclides, indicating appreciable levels of soil and dust were incorporated with the vegetation comprising the sample. Similar samples of naturally-growing vegetation collected at control locations 21 km (13 mi) south-southeast and 50 km (31 mi) west of Pilgrim Station also showed detectable levels of both Cs-137 and Th-232. It should be noted that the three vegetable samples collected at the control location (Bridgewater Farm), which showed no detectable Cs-137 or Th-232, were relatively "clean" samples of vegetables, ready for human consumption. These samples did not contain large amounts of soil or dust which may have yielded detectable levels of both Cs-137 and Th-232.

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 corrected for radioactive decay, the expected concentration in samples of naturally-growing vegetation collected during 1995 would be between 95 and 183 pCi/kg. Clearly, the average Cs-137 concentration of 72 pCi/kg observed in the samples collected are indicative of radioactivity arising from weapons fallout, and not Pilgrim Station Operations.

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.

All three samples of cranberries were collected and analyzed as required during 1995. Results of the gamma analyses of cranberry samples are summarized in Table 2.10-1. The only radionuclide detected in any of the samples was naturally-occurring potassium-40. No radionuclides attributable to Pilgrim Station operations were detected in any of the samples.

2.11 Soil Radioactivity Analyses

A survey of radioactivity in soil is conducted once every three years at the 10 air sampling stations in the Plymouth area and the control location in East Weymouth. These locations serve as fixed survey locations at which repeated measurements can be made to determine any buildup of radioactivity from deposition of airborne radionuclides. At each of these locations, samples of topsoil are collected for gamma spectroscopy analysis in the laboratory. Soil cores are also collected if possible for gamma analyses as a function of depth. In addition, in-field measurements are made at each location with a portable gamma spectroscopy unit and a high pressure ion chamber. The portable gamma spectrometer is used to identify radionuclides present across a large area beneath the detector, whereas the high pressure ion chamber is used to detect exposure levels arising from naturally-occurring and deposited radionuclides in the soil.

The soil survey was performed as required in 1994. A total of 35 samples of topsoil and depth-divided soil cores were collected and analyzed. The results of the laboratory analyses of these soil samples are summarized in Table 2.11-1. Naturally-occurring beryllium-7, potassium-40, and thorium-232 were detected in a number of the samples. Cobalt-60 was detected in samples collected from three locations on Boston Edison property. Cesium-137 was detected in 26 of the 35 samples, including those collected from the control location. A detailed discussion of these results can be found in the 1994 REMP report.

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 sampled continuously by a composite sampler. 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 1995. Results of the analyses of water samples are summarized in Table 2.12-1. The only radionuclide detected in any of the samples was naturally-occurring potassium-40. No radionuclides attributable to Pilgrim Station operations were detected in any of the samples.

2.13 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.

Twenty-six samples of fish were collected during 1995. Group II species of fish were unavailable in the vicinity of the Discharge Canal during the first quarter of the year. This unavailability is believed to be due to low water temperatures and rough seas. These discrepancies are noted in Appendix D.

Results of the gamma analyses of fish samples collected are summarized in Table 2.13-1. The only radionuclide detected in any of the samples was naturally-occurring potassium-40. No radionuclides attributable to Pilgrim Station operations were detected in any of the samples.

2.14 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 48 samples of shellfish meat and shells scheduled for collection during 1995 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, and thorium-232 were detected in a number of the samples. Low levels of Co-60 were detected in blue mussels collected from the Discharge Canal outfall during the second and third quarters of 1995. The dose impact resulting from ingesting mussels containing the observed levels of Co-60 can be found in Appendix A.

2.15 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.

All 16 samples of Irish moss scheduled for collection during 1995 were obtained and analyzed. Results of the gamma analyses of these samples are summarized in Table 2.15-1. Naturally-occurring beryllium-7 and potassium-40 were detected in a number of the samples. Low levels of Co-60 were detected in Irish moss collected from the Discharge Canal outfall during the second and third quarters of 1995. The dose impact resulting from ingestion of foods derived from Irish moss containing Co-60 can be found in Appendix A.

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. All lobster samples are analyzed by gamma spectroscopy.

All five samples of lobsters were collected and analyzed as required during 1995. Results of the gamma analyses of lobster samples are summarized in Table 2.16-1. The only radionuclide detected in any of the samples was naturally-occurring potassium-40. No radionuclides attributable to Pilgrim Station operations were detected in any of the samples.

2.17 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 are 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.

All 56 samples of sediment were collected and analyzed as required during 1995. Results of the gamma analyses of sediment samples are summarized in Table 2.17-1. Results of the plutonium analyses are presented in Table 2.17-2. Naturally-occurring beryllium-7, potassium-40 and thorium-232 were detected in a number of the samples. No cobalt-60 was detected in any of the 39 indicator samples. Cesium-137 was detected in 11 of 39 indicator station samples and in 10 of 17 control station samples. Plutonium-239/240 was detected in all four indicator station samples and in both of the control station samples.

Cesium-137 levels in indicator samples ranged from non-detectable to a maximum concentration of 33 pCi/kg. Concentrations in samples collected from the control locations beyond the influence of Pilgrim Station also ranged from non-detectable to a maximum concentration of 42 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.

Plutonium-239/240 levels in indicator samples ranged from 2.6 pCi/kg to a maximum concentration of 7.6 pCi/kg. Concentrations in samples collected from the control locations beyond the influence of Pilgrim Station ranged from 11.5 pCi/kg to a maximum concentration of 12.0 pCi/kg. The fact that the results from indicator locations are lower than those from the 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 plutonium deposited in the environment from nuclear weapons testing.

Table 2.2-1

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

Media	No	Code	Description	Dist.	Dir.
Air Particulate Filters/ Charcoal Cartridges Soil	00	WS	Medical Building	0.1 mi	SSE
	01	ER	E. Rocky Hill Road	0.6 mi	SE
	03	WR	W. Rocky Hill Road	0.5 mi	WNW
	06	PL	Property Line	0.3 mi	NW
	07	PB	Pedestrian Bridge	0.1 mi	N
	08	OA	Overlook Area	0.1 mi	W
	09	EB	East Breakwater	0.3 mi	ESE
	10	CR	Cleft Rock	0.8 mi	SSW
	15	PC	Plymouth Center	4.2 mi	W
	17	MS	Manomet Substation	2.2 mi	SSE
	21	EW	East Weymouth Control	25 mi	NW
Milk	11	CF	Plymouth County Farm	3.5 mi	W
	21	WF	Whitman Farm Control	21 mi	WNW
Forage	11	CF	Plymouth County Farm	3.5 mi	W
	12	WF	Whitman Farm Control	21 mi	WNW
	43	WH	Whipple Farm	1.8 mi	SW
Vegetation	11	CF	Plymouth County Farm	3.5 mi	W
	27	BF	Bridgewater Farm Ctrl	19 mi	W
Cranberries	13	MR	Manomet Pt. Bog	2.4 mi	SE
	14	BR	Bartlett Rd. Bog	2.7 mi	SSE
	23	PS	Pine St. Bog Control	16 mi	WNW
Surface Water	11	DIS	Discharge Canal	0.1 mi	N
	17	BP	Bartlett Pond	1.7 mi	SE
	23	PP	Powder Point Control	8 mi	NNW
Fishes	11	DIS	Discharge Canal	0.2 mi	N
	29	PC	Priest Cove Control	30 mi	SW
	30	JR	Jones River Control	8 mi	WNW
	92	MV	Vineyard Sound Control	40 mi	SSW
	98	CC-Bay	Cape Cod Bay Control	15 mi	ESE
Shellfish	11	DIS	Discharge Canal	0.2 mi	N
	12	Ply-H	Plymouth Harbor	3 mi	W
	13	Dux-Bay	Duxbury Bay Control	8 mi	NNW
	15	MP	Manomet Point	3 mi	ESE
	24	GH	Green Harbor Control	10 mi	NNW

Table 2.2-1 (continued)

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

Media	No	Code	Description	Dist.	Dir.
Irish Moss	11	DIS	Discharge Canal	0.2 mi	N
	15	MP	Manomet Point	3 mi	ESE
	22	EL	Ellisville	8 mi	SSE
	34	BR	Brant Rock Control	10 mi	NNW
Lobster	11	DIS	Discharge Canal	0.2 mi	N
	15	Ply-H	Plymouth Harbor	4 mi	WNW
	13	Dux-Bay	Duxbury Bay Control	7 mi	NNW
Sediment	11	DIS	Discharge Canal	0.2 mi	N
	12	Ply-H	Plymouth Harbor	3 mi	W
	13	Dux-Bay	Duxbury Bay	8 mi	NNW
	14	PLB	Plymouth Beach	2 mi	W
	15	MP	Manomet Point	3 mi	ESE
	24	GH	Green Harbor Control	10 mi	NNW

Table 2.4-1

Off-Site Environmental TLD Results

TLD Station ID Description	TLD Location* Distance/Direction	Exposure Rate - mR/quarter (Value ± Std.Dev.) Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	1995 Annual** Exposure mR/year
Zone 1 TLDs: 0-3 km						
BLW BOAT LAUNCH WEST	0.11 km E	69.9 ± 3.5	40.0 ± 0.9	63.7 ± 2.6	64.0 ± 3.8	237.6 ± 53.3
TC HEALTH CLUB	0.15 km WSW	41.9 ± 1.4	19.8 ± 0.8	45.1 ± 1.4	48.0 ± 3.1	154.9 ± 51.5
OA OVERLOOK AREA	0.15 km W	126.1 ± 3.8	48.6 ± 2.2	137.2 ± 7.4	149.8 ± 6.6	461.7 ± 182.8
BLE BOAT LAUNCH EAST	0.16 km ESE	50.8 ± 3.1	32.8 ± 1.3	52.1 ± 2.7	53.5 ± 5.4	189.2 ± 39.5
PB PEDESTRIAN BRIDGE	0.21 km N	33.0 ± 1.2	25.3 ± 1.1	33.3 ± 1.7	34.6 ± 1.4	126.2 ± 17.2
P01 SHOREFRONT SECURITY	0.22 km NNW	32.5 ± 1.4	20.5 ± 0.6	32.3 ± 1.5	36.3 ± 4.7	121.6 ± 27.8
WS MEDICAL BUILDING	0.23 km SSE	32.8 ± 1.2	20.4 ± 0.6	31.[illegible] ± 1.1	35.7 ± 2.2	120.8 ± 27.1
CT PARKING LOT	0.31 km SE	25.0 ± 1.2	20.6 ± 0.7	26.1 ± 1.3	29.0 ± 2.2	100.7 ± 14.2
PMT PNPS MET TOWER	0.44 km WNW	17.0 ± 0.7	15.3 ± 1.2	16.6 ± 0.5	18.5 ± 0.7	67.4 ± 5.6
PA SHOREFRONT PARKING	0.35 km NNW	21.3 ± 0.8	17.8 ± 0.5	20.4 ± 0.8	22.6 ± 1.2	82.2 ± 8.3
A STATION A	0.37 km WSW	19.5 ± 1.0	16.7 ± 0.6	20.1 ± 0.7	17.7 ± 0.6	74.0 ± 6.5
F STATION F	0.43 km NW	18.4 ± 0.6	16.6 ± 0.6	17.3 ± 0.7	Missing	69.7 ± 3.9
B STATION B	0.44 km S	21.8 ± 0.8	18.1 ± 0.6	20.8 ± 0.6	19.2 ± 0.8	80.0 ± 6.8
EB EAST BREAKWATER	0.44 km ESE	21.5 ± 0.8	20.3 ± 0.6	22.2 ± 0.7	23.3 ± 0.8	87.3 ± 5.2
H STATION H	0.47 km SW	21.9 ± 0.8	17.8 ± 0.6	22.0 ± 0.8	19.9 ± 0.8	81.7 ± 8.1
I STATION I	0.48 km WNW	18.3 ± 0.6	16.4 ± 0.5	17.6 ± 0.6	19.5 ± 1.0	71.9 ± 5.4
L STATION L	0.50 km ESE	18.3 ± 0.7	16.2 ± 0.6	18.3 ± 0.6	19.4 ± 0.9	72.1 ± 5.4
G STATION G	0.53 km W	17.8 ± 0.7	16.0 ± 0.5	16.1 ± 0.7	16.8 ± 0.7	66.7 ± 3.6
PL PROPERTY LINE	0.54 km NW	18.2 ± 1.0	15.7 ± 0.8	17.7 ± 0.7	18.1 ± 0.7	69.7 ± 5.0
D STATION D	0.54 km NNW	22.4 ± 0.9	21.3 ± 0.9	21.7 ± 0.8	23.8 ± 1.3	89.2 ± 4.9
C STATION C	0.57 km ESE	17.7 ± 0.6	14.9 ± 0.5	17.0 ± 0.5	17.7 ± 0.9	67.2 ± 5.5
HB HALL'S BOG	0.63 km SE	16.5 ± 0.6	14.6 ± 0.6	15.2 ± 0.5	17.2 ± 0.8	63.4 ± 4.9
GH GREENWOOD HOUSE	0.65 km ESE	18.8 ± 0.7	19.2 ± 1.7	17.4 ± 0.6	17.9 ± 1.0	73.4 ± 4.0
WR W ROCKY HILL ROAD	0.83 km WNW	19.9 ± 0.6	18.5 ± 0.6	18.6 ± 1.0	19.6 ± 1.0	76.5 ± 3.3
ER E ROCKY HILL ROAD	0.89 km SE	15.1 ± 0.8	13.3 ± 0.6	14.1 ± 0.5	15.1 ± 0.8	57.6 ± 3.8
MT MICROWAVE TOWER	1.03 km SSW	17.1 ± 0.6	15.5 ± 0.5	15.7 ± 0.5	14.6 ± 0.6	63.0 ± 4.2
CR CLEFT ROCK	1.27 km SSW	16.4 ± 0.7	14.7 ± 0.5	14.1 ± 0.5	16.2 ± 0.7	61.4 ± 4.7
BD BAYSHORE/GATE RD	1.34 km WNW	17.1 ± 0.5	15.7 ± 0.4	16.4 ± 0.9	15.1 ± 0.8	64.3 ± 3.8
MR MANOMET ROAD	1.38 km S	14.9 ± 0.5	13.4 ± 0.5	13.8 ± 0.4	12.4 ± 0.6	54.6 ± 4.4
DR DIRT ROAD	1.48 km SW	14.7 ± 0.6	13.7 ± 0.7	14.0 ± 0.6	12.7 ± 0.5	55.2 ± 3.6
EM EMERSON ROAD	1.53 km SSE	15.8 ± 0.5	14.4 ± 0.5	14.5 ± 0.6	13.9 ± 0.7	58.7 ± 3.3
EP EMERSON/PRISCILLA	1.55 km SE	16.4 ± 1.1	14.0 ± 0.4	13.7 ± 0.5	14.5 ± 0.8	58.7 ± 5.1
AR EDISON ACCESS ROAD	1.59 km SSE	15.3 ± 0.7	14.0 ± 0.5	13.6 ± 0.6	13.3 ± 0.5	56.3 ± 3.8
BS BAYSHORE	1.76 km W	17.8 ± 0.9	16.7 ± 0.5	16.9 ± 0.9	15.7 ± 0.5	67.2 ± 3.9
E STATION E	1.86 km S	17.0 ± 0.6	15.6 ± 0.4	16.3 ± 0.6	14.5 ± 0.6	63.4 ± 4.4
JG JOHN GAULEY	1.99 km W	16.2 ± 0.7	14.7 ± 0.5	15.5 ± 0.6	14.7 ± 0.9	61.1 ± 3.3
J STATION J	2.04 km SSE	15.6 ± 0.6	14.8 ± 0.5	14.6 ± 0.5	Missing	60.0 ± 2.5
WH WHITEHORSE ROAD	2.09 km SSE	16.1 ± 0.6	14.3 ± 0.5	14.4 ± 0.5	15.3 ± 0.9	60.0 ± 3.7
RC PLYMOUTH YMCA	2.09 km WSW	16.8 ± 0.8	15.1 ± 0.6	15.6 ± 0.7	14.8 ± 0.6	62.2 ± 3.8
K STATION K	2.17 km S	15.8 ± 0.6	14.1 ± 0.4	14.7 ± 0.5	13.7 ± 0.9	58.3 ± 3.8
TT TAYLOR/THOMAS	2.26 km SE	17.2 ± 0.8	13.7 ± 0.8	13.9 ± 0.5	16.5 ± 1.0	61.3 ± 7.2
YV YANKEE VILLAGE	2.28 km WSW	16.9 ± 0.8	14.7 ± 0.7	15.3 ± 0.6	14.5 ± 0.9	61.4 ± 4.6
GN GOODWIN PROPERTY	2.38 km SW	12.9 ± 0.6	10.7 ± 0.4	11.4 ± 0.4	10.4 ± 1.1	45.4 ± 4.6
RW RIGHT OF WAY	2.83 km S	14.2 ± 0.6	11.1 ± 0.4	13.5 ± 0.4	12.0 ± 0.8	50.8 ± 5.7
TP TAYLOR/PEARL	2.98 km SE	15.1 ± 0.7	12.4 ± 0.4	12.4 ± 0.6	14.6 ± 1.0	54.5 ± 5.9

* 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)

Off-Site Environmental TLD Results

TLD Station ID	Description	TLD Location* Distance/Direction	Exposure Rate - mR/quarter (Value ± Std.Dev.) Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	1995 Annual** Exposure mR/year
Zone 2 TLDs: 3-8 km							
VR	VALLEY ROAD	3.26 km SSW	15.0 ± 0.7	11.9 ± 0.4	13.4 ± 0.5	12.3 ± 1.0	52.6 ± 5.8
ME	MANOMET ELEM	3.29 km SE	14.9 ± 0.5	13.2 ± 0.3	14.7 ± 0.6	13.4 ± 0.9	56.2 ± 3.6
WC	WARREN/CLIFFORD	3.31 km W	15.6 ± 0.8	13.0 ± 0.5	13.3 ± 0.8	13.4 ± 1.0	55.2 ± 5.0
BB	RT.3A/BARTLETT RD	3.33 km SSE	16.8 ± 0.6	14.0 ± 0.7	14.4 ± 0.7	14.8 ± 1.0	60.0 ± 5.1
MP	MANOMET POINT	3.57 km SE	15.4 ± 0.6	13.0 ± 0.5	13.5 ± 0.5	15.3 ± 0.9	57.3 ± 5.1
MS	MANOMET SUBSTATION	3.60 km SSE	18.7 ± 0.5	16.7 ± 0.6	17.1 ± 0.6	18.3 ± 1.0	70.8 ± 4.1
BW	BEACHWOOD ROAD	3.93 km SE	16.4 ± 0.8	14.1 ± 0.5	15.2 ± 0.7	14.1 ± 1.0	59.8 ± 4.6
PT	PINES ESTATE	4.44 km SSW	14.6 ± 0.6	12.6 ± 0.6	14.7 ± 0.7	12.5 ± 0.7	54.4 ± 5.1
EA	EARL ROAD	4.60 km SSE	13.1 ± 0.6	12.7 ± 0.5	12.7 ± 0.6	Missing	51.3 ± 1.7
SP	S PLYMOUTH SUBST	4.62 km W	16.8 ± 0.8	14.8 ± 0.4	15.8 ± 0.5	14.3 ± 0.7	61.7 ± 4.6
RP	ROUTE 3 OVERPASS	4.81 km SW	15.3 ± 0.8	13.0 ± 0.5	14.4 ± 0.7	13.0 ± 0.7	55.7 ± 4.7
RM	RUSSELL MILLS RD	4.85 km WSW	15.0 ± 0.5	12.5 ± 0.5	13.9 ± 0.6	12.6 ± 0.6	54.0 ± 4.8
HD	HILLDALE ROAD	5.18 km W	15.6 ± 0.5	14.5 ± 0.6	14.8 ± 0.4	13.9 ± 1.0	58.9 ± 3.2
MB	MANOMET BEACH	5.43 km SSE	15.1 ± 0.5	12.8 ± 0.6	14.0 ± 0.6	13.4 ± 0.8	55.3 ± 4.2
BR	BEAVERDAM ROAD	5.52 km S	13.3 ± 0.5	12.4 ± 0.6	13.6 ± 0.5	12.4 ± 0.8	51.6 ± 2.9
PC	PLYMOUTH CENTER	6.69 km W	12.4 ± 0.6	10.0 ± 0.6	9.6 ± 0.5	12.9 ± 0.9	45.0 ± 6.8
LD	LONG POND/DREW RD	6.97 km WSW	14.4 ± 0.6	12.6 ± 0.6	12.9 ± 0.5	13.2 ± 0.6	53.2 ± 3.4
HR	HYANNIS ROAD	7.33 km SSE	15.8 ± 0.8	12.7 ± 0.5	13.9 ± 0.5	13.1 ± 0.8	55.6 ± 5.7
MH	MEMORIAL HALL	7.58 km WNW	26.7 ± 1.1	22.6 ± 0.7	23.0 ± 0.6	25.1 ± 1.4	97.4 ± 7.8
SN	SAQUISH NECK	7.58 km NNW	12.6 ± 0.7	10.5 ± 0.4	11.6 ± 0.6	10.9 ± 0.7	45.6 ± 3.8
CP	COLLEGE POND	7.59 km SW	15.3 ± 0.7	13.2 ± 0.7	14.6 ± 0.7	13.2 ± 0.9	56.3 ± 4.6
Zone 3 TLDs: 8-15 km							
DW	DEEP WATER POND	8.59 km W	18.4 ± 1.0	15.7 ± 0.4	16.5 ± 1.1	16.6 ± 0.8	67.2 ± 4.8
LP	LONG POND ROAD	8.88 km SSW	13.6 ± 0.6	11.3 ± 0.4	13.1 ± 0.5	11.5 ± 0.8	49.4 ± 4.7
NP	NORTH PLYMOUTH	9.38 km WNW	Missing	15.8 ± 0.4	14.7 ± 0.5	18.5 ± 1.2	65.3 ± 8.0
SS	STANDISH SHORES	10.39 km NW	14.1 ± 0.8	11.1 ± 0.4	12.3 ± 0.7	14.0 ± 0.8	51.5 ± 5.9
EL	ELLISVILLE ROAD	11.52 km SSE	15.9 ± 0.9	13.6 ± 0.8	14.3 ± 0.5	13.2 ± 0.9	57.0 ± 5.0
UC	UP COLLEGE POND RD	11.78 km SW	14.2 ± 0.6	11.3 ± 0.4	13.2 ± 0.7	12.1 ± 0.7	50.7 ± 5.2
SH	SACRED HEART	12.92 km W	15.8 ± 1.4	13.6 ± 0.4	15.7 ± 0.5	13.4 ± 1.0	58.5 ± 5.5
KC	KING CAESAR ROAD	13.11 km NNW	15.6 ± 0.8	13.3 ± 0.7	12.6 ± 0.6	15.9 ± 1.6	57.5 ± 7.0
BE	BOURNE ROAD	13.37 km S	14.4 ± 0.9	Missing	13.7 ± 0.9	11.9 ± 0.8	53.3 ± 5.6
SA	SHERMAN AIRPORT	13.43 km WSW	14.8 ± 0.8	13.0 ± 0.6	14.1 ± 0.6	12.9 ± 0.7	54.9 ± 3.9
Zone 4 TLDs: >15 km							
CS	CEDARVILLE SUBST	15.93 km S	17.2 ± 0.9	14.3 ± 0.6	16.0 ± 0.8	13.8 ± 0.7	61.3 ± 6.3
KS	KINGSTON SUBST	16.15 km WNW	14.2 ± 0.5	12.8 ± 0.4	13.8 ± 0.8	12.7 ± 0.8	53.5 ± 3.3
LR	LANDING ROAD	16.46 km NNW	15.2 ± 0.7	13.2 ± 0.5	13.4 ± 0.6	15.7 ± 1.1	57.5 ± 5.3
CW	CHURCH/WEST	16.56 km NW	14.5 ± 0.7	12.4 ± 0.8	12.2 ± 0.5	14.2 ± 0.6	53.2 ± 4.8
MM	MAIN/MEADOW	17.02 km WSW	15.7 ± 0.7	13.0 ± 0.4	15.1 ± 0.6	13.9 ± 0.7	57.6 ± 4.9
DMF	DIV MARINE FISH	20.97 km SSE	17.4 ± 1.0	14.8 ± 0.6	16.4 ± 0.6	14.6 ± 0.8	63.3 ± 5.6
EW	E.WEYMOUTH SUBST	39.69 km NW	18.1 ± 0.6	16.8 ± 1.0	16.2 ± 0.7	18.6 ± 1.3	69.7 ± 4.8

* 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 2.4-2

On-Site Environmental TLD Results

TLD Station ID Description	TLD Location* Distance/Direction	Exposure Rate - mR/quarter (Value ± Std.Dev.) Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	1995 Annual** Exposure mR/year
Onsite TLDs						
P21 O&M/RXB. BREEZEWAY	50 m SE	51.1 ± 1.4	31.8 ± 0.9	45.5 ± 1.9	44.2 ± 3.1	172.6 ± 32.7
P24 EXEC.BUILDING	57 m W	47.8 ± 1.5	30.4 ± 0.7	45.0 ± 2.2	42.9 ± 3.1	166.1 ± 31.0
P04 FENCE-R SCREENHOUSE	66 m N	93.9 ± 4.8	72.3 ± 1.6	100.0 ± 4.8	98.1 ± 7.1	364.4 ± 52.1
P20 O&M - 2ND W WALL	67 m SE	75.9 ± 2.2	32.3 ± 1.2	90.4 ± 2.9	81.1 ± 5.3	279.7 ± 103.4
P25 EXEC.BUILDING LAWN	76 m WNW	112.4 ± 7.6	93.7 ± 3.1	114.8 ± 7.1	115.8 ± 8.3	436.8 ± 43.8
P05 FENCE-WATER TANK	81 m NNE	40.8 ± 3.3	31.7 ± 1.4	42.5 ± 3.0	42.6 ± 4.2	157.7 ± 21.7
P06 FENCE-OIL STORAGE	85 m NE	106.9 ± 4.7	55.7 ± 1.5	84.8 ± 4.8	111.3 ± 6.3	358.8 ± 102.1
P19 O&M - 2ND SW CORNER	86 m S	79.1 ± 2.4	31.8 ± 1.0	91.4 ± 3.0	91.2 ± 8.9	293.4 ± 113.6
P18 O&M - 1ST SW CORNER	90 m S	74.4 ± 5.8	30.1 ± 1.5	71.8 ± 5.5	82.4 ±10.6	258.6 ± 94.9
P08 COMPRESSED GAS STOR	92 m E	62.4 ± 6.3	46.7 ± 1.8	91.4 ± 6.9	81.6 ± 5.8	282.1 ± 80.5
P03 FENCE-L SCREENHOUSE	100 m NW	79.1 ± 3.5	43.9 ± 1.5	84.4 ± 5.2	98.4 ± 7.2	305.8 ± 93.2
P17 FENCE-EXEC.BUILDING	107 m W	152.9 ± 6.4	56.8 ± 3.3	156.2 ± 7.4	167.2 ±14.7	533.1 ± 206.1
P07 FENCE-INTAKE BAY	121 m ENE	83.7 ± 3.4	42.5 ± 1.7	76.6 ± 2.7	68.5 ± 4.7	271.2 ± 72.2
P23 O&M - 2ND S WALL	121 m SSE	50.4 ± 2.6	21.5 ± 0.6	51.2 ± 1.5	51.4 ± 2.6	174.5 ± 59.1
P26 FENCE-WAREHOUSE	134 m ESE	59.5 ± 3.4	33.3 ± 1.2	65.6 ± 4.0	58.3 ± 4.0	216.6 ± 57.4
P02 FENCE-SHOREFRONT	135 m NW	62.4 ± 4.0	29.3 ± 0.7	57.2 ± 4.4	61.0 ± 5.1	209.8 ± 62.9
P09 FENCE-W BOAT RAMP	136 m E	56.3 ± 2.6	32.0 ± 1.2	51.2 ± 3.2	50.2 ± 3.9	189.7 ± 42.8
P22 O&M - 2ND N WALL	137 m SE	46.3 ± 4.0	23.6 ± 1.0	46.1 ± 2.7	45.4 ± 3.1	161.4 ± 45.1
P16 FENCE-W SWITCHYARD	172 m SW	112.8 ± 3.6	44.5 ± 2.2	133.2 ± 5.2	131.5 ± 8.8	422.1 ± 167.2
P11 FENCE-TCF GATE	183 m ESE	54.6 ± 2.3	90.0 ± 2.2	114.4 ± 6.1	80.5 ± 4.4	339.5 ± 99.3
P27 FENCE-TCF/BOAT RAMP	185 m ESE	51.4 ± 2.3	51.4 ± 1.6	87.6 ± 3.1	95.0 ± 6.4	285.4 ± 93.1
P12 FENCE-ACCESS GATE	202 m SE	34.1 ± 1.1	21.1 ± 1.0	34.3 ± 2.2	37.3 ± 3.4	126.8 ± 29.2
P15 FENCE-E SWITCHYARD	220 m S	43.0 ± 1.4	22.2 ± 1.0	43.6 ± 2.6	45.3 ± 3.4	154.1 ± 43.9
P10 FENCE-TCF/INTAKE BAY	223 m E	35.1 ± 1.0	32.0 ± 1.2	40.2 ± 2.0	43.9 ± 2.9	151.2 ± 21.4
P13 FENCE-MEDICAL BLDG.	224 m SSE	32.8 ± 1.5	20.4 ± 0.9	34.0 ± 2.8	33.3 ± 2.5	120.5 ± 26.3
P14 FENCE-BUTLER BLDG	228 m S	34.4 ± 1.8	20.2 ± 0.6	31.1 ± 1.8	32.9 ± 2.6	118.5 ± 26.0
P28 FENCE-TCF/PRKNG LOT	259 m ESE	26.8 ± 0.9	37.7 ± 1.4	30.1 ± 1.6	97.7 ±10.1	192.3 ± 134.1

* 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 1995

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	23.5 ± 18.8	15.7 ± 2.9	15.2 ± 1.5	16.0 ± 1.6
Apr-Jun	17.8 ± 7.0	13.5 ± 2.5	13.2 ± 1.8	13.9 ± 1.6
Jul-Sep	22.8 ± 20.4	14.3 ± 2.5	14.0 ± 1.4	14.7 ± 1.6
Oct-Dec	23.9 ± 22.7	14.1 ± 3.0	14.0 ± 2.3	14.8 ± 1.9
Jan-Dec	87.8 ± 72.8	57.6 ± 11.2	56.4 ± 7.4	59.5 ± 7.0

* Zone 1 extends from the PNPS restricted/protected area boundary outward to 3 kilometers (2 miles).

Table 2.4-4

Beach Survey Exposure Rate Measurements

Ambient Radiation Survey Results

Location	Exposure Rate Micro-R/hr ± 1 std. dev.	Beach Terrain
White Horse Beach (Near Hilltop Ave)	6.7 ± 0.1	Sandy. Few granite boulders within thirty feet.
Priscilla Beach (In Back of Full Sail Bar)	9.2 ± 0.1	Sandy with small amounts of gravel.
Plymouth Beach (Outer Beach)	6.5 ± 0.1	Sandy.
Plymouth Beach (Inner Beach)	6.4 ± 0.1	Sandy.
Plymouth Beach (Behind Bert's Restaurant)	11.1 ± 0.1	Sandy with gravel. Breakwater and seawall nearby.
Duxbury Beach (Control)	7.6 ± 0.1	Sandy with coarse gravel and exposed cobble.

Table 2.5-1
Air Particulate Filter Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(January - December 1995)

MEDIUM: AIR PARTICULATE

UNITS: PCI/CU. M

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN STA. NO.	STATION WITH HIGHEST MEAN MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
GR-B (571) (0)	.01	(1.5 ± 0.0)E -2 (2.4 - 34.0)E -3 (516/519)	21	(1.7 ± 0.1)E -2 (3.0 - 34.7)E -3 (51/ 52)	(1.7 ± 0.1)E -2 (3.0 - 34.7)E -3 (51/ 52)
BE-7 (44) (0)		(8.9 ± 0.3)E -2 (5.0 - 13.0)E -2 (40/ 40)	09	(9.7 ± 1.3)E -2 (6.4 - 13.0)E -2 (4/ 4)	(8.9 ± 1.2)E -2 (5.5 - 11.0)E -2 (4/ 4)
K-40 (44) (0)		(2.6 ± 0.5)E -3 (-3.5 - 10.2)E -3 (0/ 40)	17	(4.8 ± 2.1)E -3 (1.9 - 102.0)E -4 (0/ 4)	(1.3 ± 1.5)E -3 (-2.6 - 4.5)E -3 (0/ 4)
CS-134 (44) (0)	.01	(-1.4 ± 0.5)E -4 (-1.2 - 0.4)E -3 (0/ 40)	01	(1.2 ± 1.0)E -4 (-8.1 - 34.5)E -5 (0/ 4)	(-4.9 ± 3.0)E -4 (-1.4 - -0.1)E -3 (0/ 4)
CS-137 (44) (0)	.01	(-7.6 ± 3.7)E -5 (-7.6 - 4.7)E -4 (0/ 40)	15	(1.9 ± 1.0)E -4 (5.2 - 47.1)E -5 (0/ 4)	(-4.9 ± 4.0)E -5 (-1.2 - 0.5)E -4 (0/ 4)

* Non-Routine refers to the number of separate measurements which were greater than ten (10) times the average background for the period of the report.

** The fraction of sample analyses yielding detectable measurements (i.e., > 3 Standard Deviations).

Table 2.6-1
Charcoal Cartridge Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(January - December 1995)

MEDIUM: CHARCOAL CARTRIDGE — UNITS: PCI/CU. M

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN STA. NO.	STATION WITH HIGHEST MEAN MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
I-131 (571) (0)	.07	(6.3 ± 6.8)E -4 (-7.8 - 28.0)E -2 (0/519)	17	(2.5 ± 1.0)E -3 (-1.2 - 2.0)E -2 (0/ 52)	(-5.8 ± 126.8)E -5 (-1.5 - 2.3)E -2 (0/ 52)

* Non-Routine refers to the number of separate measurements which were greater than ten (10) times the average background for the period of the report.

** The fraction of sample analyses yielding detectable measurements (i.e., > 3 Standard Deviations).

Table 2.7-1
Milk Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(January - December 1995)

MEDIUM: MILK

UNITS: PCI/LITER

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS MEAN RANGE NO. DETECTED**	STA. NO.	STATION WITH HIGHEST MEAN MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
SR-89 (38) (0)		(4.1 ± 3.1)E -1 (-2.0 - 3.7)E 0 (0/ 19)	11	(4.1 ± 3.1)E -1 (-2.0 - 3.7)E 0 (0/ 19)	(1.5 ± 4.6)E -1 (-5.0 - 3.8)E 0 (0/ 19)
SR-90 (38) (1)		(1.9 ± 0.2)E 0 (1.7 - 45.3)E -1 (14/ 19)	11	(1.9 ± 0.2)E 0 (1.7 - 45.3)E -1 (14/ 19)	(4.3 ± 2.4)E -1 (-1.3 - 3.0)E 0 (4/ 19)
K-40 (38) (0)		(1.4 ± 0.0)E 3 (1.3 - 1.6)E 3 (19/ 19)	11	(1.4 ± 0.0)E 3 (1.3 - 1.6)E 3 (19/ 19)	(1.4 ± 0.0)E 3 (1.3 - 1.5)E 3 (19/ 19)
I-131 (38) (0)	1.	(2.0 ± 1.1)E -2 (-6.4 - 14.0)E -2 (0/ 19)	11	(2.0 ± 1.1)E -2 (-6.4 - 14.0)E -2 (0/ 19)	(5.6 ± 18.0)E -3 (-1.2 - 1.8)E -1 (0/ 19)
CS-134 (38) (0)	15.	(-6.5 ± 4.0)E -1 (-3.2 - 3.7)E 0 (0/ 19)	21	(-1.0 ± 4.7)E -1 (-4.2 - 2.9)E 0 (0/ 19)	(-1.0 ± 4.7)E -1 (-4.2 - 2.9)E 0 (0/ 19)
CS-137 (38) (0)	15.	(1.3 ± 0.4)E 0 (-1.5 - 6.3)E 0 (0/ 19)	11	(1.3 ± 0.4)E 0 (-1.5 - 6.3)E 0 (0/ 19)	(5.0 ± 5.1)E -1 (-2.6 - 5.6)E 0 (0/ 19)
BA-140 (38) (0)	15.	(3.3 ± 4.7)E -1 (-3.0 - 3.5)E 0 (0/ 19)	11	(3.3 ± 4.7)E -1 (-3.0 - 3.5)E 0 (0/ 19)	(-2.2 ± 5.6)E -1 (-4.2 - 3.8)E 0 (0/ 19)

* Non-Routine refers to the number of separate measurements which were greater than ten (10) times the average background for the period of the report.

** The fraction of sample analyses yielding detectable measurements (i.e., > 3 Standard Deviations).

Table 2.8-1
Forage Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(January - December 1995)

MEDIUM: FORAGE | UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS MEAN RANGE NO. DETECTED**	STA. NO.	STATION WITH HIGHEST MEAN MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
BE-7 (3) (1)		(6.1 ± 3.3)E 2 (2.8 - 9.4)E 2 (1/ 2)	11	(9.4 ± 3.0)E 2 (1/ 1)	(2.9 ± 1.7)E 2 (0/ 1)
K-40 (3) (0)		(5.8 ± 3.7)E 3 (2.1 - 9.6)E 3 (2/ 2)	21	(1.1 ± 0.0)E 4 (1/ 1)	(1.1 ± 0.0)E 4 (1/ 1)
I-131 (3) (0)		(5.8 ± 3.4)E 1 (2.5 - 9.2)E 1 (0/ 2)	11	(9.2 ± 27.2)E 1 (0/ 1)	(7.8 ± 19.2)E 1 (0/ 1)
CS-134 (3) (0)	130.	(-1.4 ± 0.5)E 1 (-1.9 - -0.9)E 1 (0/ 2)	11	(-8.6 ± 14.9)E 0 (0/ 1)	(-2.3 ± 1.3)E 1 (0/ 1)
CS-137 (3) (0)	130.	(-7.3 ± 16.0)E -1 (-2.3 - 0.9)E 0 (0/ 2)	11	(8.7 ± 149.0)E -1 (0/ 1)	(-6.9 ± 13.0)E 0 (0/ 1)
TH-232 (3) (0)		(4.8 ± 5.5)E 1 (-6.5 - 103.0)E 0 (0/ 2)	21	(1.4 ± 0.5)E 2 (0/ 1)	(1.4 ± 0.5)E 2 (0/ 1)

* Non-Routine refers to the number of separate measurements which were greater than ten (10) times the average background for the period of the report.

** The fraction of sample analyses yielding detectable measurements (i.e., > 3 Standard Deviations).

Table 2.9-1
Vegetable/Vegetation Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(January - December 1995)

MEDIUM: VEGETABLE/VEGETATION UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN STA. NO.	STATION WITH HIGHEST MEAN MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
BE-7 (15) (0)		(1.3 ± 0.3)E 3 (5.6 - 259.0)E 1 (7/ 10)	99D	(3.0 ± 0.1)E 3 (1/ 1)	(9.7 ± 6.0)E 2 (3.7 - 300.0)E 1 (2/ 5)
K-40 (15) (0)		(3.1 ± 0.4)E 3 (8.3 - 57.6)E 2 (10/ 10)	35	(5.8 ± 0.2)E 3 (1/ 1)	(2.7 ± 0.3)E 3 (1.9 - 3.7)E 3 (5/ 5)
I-131 (15) (0)		(1.1 ± 0.4)E 1 (-5.0 - 38.2)E 0 (0/ 10)	27	(2.1 ± 1.1)E 1 (5.8 - 41.7)E 0 (0/ 3)	(1.5 ± 0.7)E 1 (3.7 - 41.7)E 0 (0/ 5)
CS-134 (15) (0)	60.	(8.9 ± 43.5)E -1 (-1.4 - 3.3)E 1 (0/ 10)	31	(3.3 ± 1.3)E 1 (0/ 1)	(-4.9 ± 2.0)E 0 (-8.5 - 3.0)E 0 (0/ 5)
CS-137 (15) (2)	60.	(7.2 ± 3.4)E 1 (-6.6 - 269.0)E 0 (4/ 10)	99B	(2.7 ± 0.1)E 2 (1/ 1)	(1.5 ± 0.6)E 1 (1.1 - 34.9)E 0 (2/ 5)
TH-232 (15) (0)		(9.3 ± 2.8)E 1 (-3.1 - 25.5)E 1 (4/ 10)	35	(2.5 ± 0.2)E 2 (1/ 1)	(3.3 ± 2.9)E 1 (-3.3 - 11.4)E 1 (2/ 5)

* Non-Routine refers to the number of separate measurements which were greater than ten (10) times the average background for the period of the report.

** The fraction of sample analyses yielding detectable measurements (i.e., > 3 Standard Deviations).

Table 2.10-1
Cranberry Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(January - December 1995)

MEDIUM: CRANBERRIES

UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN STA. NO.	STATION WITH HIGHEST MEAN MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
BE-7 (3) (0)		(8.7 ± 2.5)E 1 (6.2 - 11.2)E 1 (0/ 2)	14	(1.1 ± 0.8)E 2 (0/ 1)	(1.5 ± 82.9)E 0 (0/ 1)
K-40 (3) (0)		(8.0 ± 1.0)E 2 (7.0 - 9.0)E 2 (2/ 2)	13	(9.0 ± 1.5)E 2 (1/ 1)	(7.5 ± 1.7)E 2 (1/ 1)
I-131 (3) (0)		(5.0 ± 7.6)E 0 (-2.6 - 12.6)E 0 (0/ 2)	14	(1.3 ± 1.8)E 1 (0/ 1)	(-5.6 ± 5.3)E 1 (0/ 1)
CS-134 (3) (0)	60.	(1.6 ± 1.0)E 0 (5.4 - 26.3)E -1 (0/ 2)	14	(2.6 ± 8.5)E 0 (0/ 1)	(-1.7 ± 1.0)E 1 (0/ 1)
CS-137 (3) (0)	60.	(3.5 ± 2.4)E 0 (1.0 - 5.8)E 0 (0/ 2)	14	(5.8 ± 7.7)E 0 (0/ 1)	(-6.4 ± 7.9)E 0 (0/ 1)
TH-232 (3) (0)		(2.3 ± 2.7)E 1 (-3.6 - 49.9)E 0 (0/ 2)	14	(5.0 ± 3.7)E 1 (0/ 1)	(1.6 ± 3.4)E 1 (0/ 1)

* Non-Routine refers to the number of separate measurements which were greater than ten (10) times the average background for the period of the report.

** The fraction of sample analyses yielding detectable measurements (i.e., > 3 Standard Deviations).

Table 2.11-1
Soil Radioactivity Analyses

Analyses of radioactivity in soil are performed once every three years. The last soil survey was performed in 1994, and results of these analyses can be found in Pilgrim Station's Radiological Environmental Monitoring Program Report #27, dated April 1995. The next routine soil survey is scheduled to be performed in 1997.

Table 2.12-1
Surface Water Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(January - December 1995)

MEDIUM: SURFACE WATER

UNITS: PCI/LITER

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN STA. NO.	STATION WITH HIGHEST MEAN MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
H-3 (12) (0)		(9.8 ± 8.8)E 1 (-3.3 - 4.6)E 2 (0/ 8)	17	(1.8 ± 1.0)E 2 (6.2 - 46.3)E 1 (0/ 4)	(6.1 ± 112.8)E 0 (-2.3 - 3.1)E 2 (0/ 4)
K-40 (36) (0)		(1.6 ± 0.3)E 2 (-3.0 - 36.9)E 1 (12/ 24)	11	(3.2 ± 0.1)E 2 (2.6 - 3.7)E 2 (12/ 12)	(2.9 ± 0.1)E 2 (2.3 - 3.7)E 2 (12/ 12)
MN-54 (36) (0)		(2.3 ± 2.7)E -1 (-2.6 - 2.2)E 0 (0/ 24)	17	(5.0 ± 4.2)E -1 (-2.6 - 2.2)E 0 (0/ 12)	(-4.7 ± 3.7)E -1 (-2.8 - 1.3)E 0 (0/ 12)
CO-58 (36) (0)		(3.0 ± 24.7)E -2 (-3.0 - 2.9)E 0 (0/ 24)	23	(6.7 ± 5.8)E -1 (-2.7 - 4.6)E 0 (0/ 12)	(6.7 ± 5.8)E -1 (-2.7 - 4.6)E 0 (0/ 12)
FE-59 (36) (0)		(8.2 ± 5.8)E -1 (-4.1 - 6.2)E 0 (0/ 24)	17	(2.1 ± 0.8)E 0 (-1.6 - 6.2)E 0 (0/ 12)	(1.6 ± 0.8)E 0 (-3.2 - 5.0)E 0 (0/ 12)
CO-60 (36) (0)		(-3.6 ± 2.6)E -1 (-3.2 - 1.9)E 0 (0/ 24)	23	(1.0 ± 5.2)E -1 (-2.3 - 4.0)E 0 (0/ 12)	(1.0 ± 5.2)E -1 (-2.3 - 4.0)E 0 (0/ 12)
ZN-65 (36) (0)		(-8.6 ± 6.5)E -1 (-4.6 - 11.1)E 0 (0/ 24)	17	(-7.3 ± 12.1)E -1 (-4.6 - 11.1)E 0 (0/ 12)	(-3.1 ± 0.8)E 0 (-7.2 - 1.9)E 0 (0/ 12)
ZR-95 (36) (0)		(8.3 ± 58.1)E -2 (-5.0 - 6.1)E 0 (0/ 24)	11	(7.3 ± 7.5)E -1 (-3.9 - 6.1)E 0 (0/ 12)	(3.0 ± 6.6)E -1 (-3.0 - 4.3)E 0 (0/ 12)
I-131 (36) (0)		(2.3 ± 1.8)E -2 (-2.1 - 1.8)E -1 (0/ 24)	17	(5.6 ± 1.9)E -2 (-4.9 - 18.0)E -2 (0/ 12)	(-9.3 ± 146.6)E -4 (-9.7 - 7.7)E -2 (0/ 12)
CS-134 (36) (0)		(-9.0 ± 4.4)E -1 (-8.6 - 3.0)E 0 (0/ 24)	23	(2.4 ± 5.2)E -1 (-2.5 - 2.7)E 0 (0/ 12)	(2.4 ± 5.2)E -1 (-2.5 - 2.7)E 0 (0/ 12)
CS-137 (36) (0)		(-6.7 ± 2.6)E -1 (-2.9 - 2.0)E 0 (0/ 24)	23	(-5.3 ± 4.6)E -1 (-2.5 - 1.8)E 0 (0/ 12)	(-5.3 ± 4.6)E -1 (-2.5 - 1.8)E 0 (0/ 12)
BA-140 (36) (0)		(-4.2 ± 5.8)E -1 (-6.5 - 5.5)E 0 (0/ 24)	23	(1.7 ± 5.1)E -1 (-2.8 - 3.2)E 0 (0/ 12)	(1.7 ± 5.1)E -1 (-2.8 - 3.2)E 0 (0/ 12)

* Non-Routine refers to the number of separate measurements which were greater than ten (10) times the average background for the period of the report.

** The fraction of sample analyses yielding detectable measurements (i.e., > 3 Standard Deviations).

Table 2.13-1
Fish Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(January - December 1995)

MEDIUM: FISHES

UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS MEAN RANGE NO. DETECTED**	STA. NO.	STATION WITH HIGHEST MEAN MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
BE-7 (26) (0)		(-2.2 ± 2.4)E 1 (-2.2 - 1.8)E 2 (0/ 18)	89	(-7.7 ± 75.7)E 0 (0/ 1)	(-4.7 ± 2.7)E 1 (-1.7 - 0.9)E 2 (0/ 8)
K-40 (26) (0)		(3.0 ± 0.1)E 3 (2.2 - 4.0)E 3 (18/ 18)	89	(3.3 ± 0.3)E 3 (1/ 1)	(3.1 ± 0.1)E 3 (2.7 - 3.5)E 3 (8/ 8)
MN-54 (26) (0)	130.	(2.7 ± 2.5)E 0 (-1.7 - 2.1)E 1 (0/ 18)	89	(8.4 ± 7.9)E 0 (0/ 1)	(-2.2 ± 2.2)E 0 (-8.2 - 8.4)E 0 (0/ 8)
CO-58 (26) (0)	130.	(-4.2 ± 1.9)E 0 (-2.2 - 0.8)E 1 (0/ 18)	89	(9.3 ± 9.1)E 0 (0/ 1)	(-5.6 ± 19.0)E -1 (-7.3 - 9.3)E 0 (0/ 8)
FE-59 (26) (0)	260.	(-2.4 ± 10.0)E 0 (-7.1 - 7.3)E 1 (0/ 18)	98	(2.5 ± 1.7)E 1 (3.2 - 5.8)E 1 (0/ 5)	(1.7 ± 1.1)E 1 (-3.2 - 5.8)E 1 (0/ 8)
CO-60 (26) (0)	130.	(5.1 ± 3.5)E 0 (-2.5 - 3.6)E 1 (0/ 18)	11	(5.1 ± 3.5)E 0 (-2.5 - 3.6)E 1 (0/ 18)	(-9.1 ± 39.1)E -1 (-2.5 - 1.4)E 1 (0/ 8)
ZN-65 (26) (0)	260.	(-2.2 ± 0.7)E 1 (-7.7 - 4.1)E 1 (0/ 18)	92	(1.5 ± 1.5)E 1 (0.0 - 3.0)E 1 (0/ 2)	(-7.5 ± 8.7)E 0 (-5.7 - 3.0)E 1 (0/ 8)
CS-134 (26) (0)	130.	(4.7 ± 3.3)E 0 (-2.1 - 3.1)E 1 (0/ 18)	11	(4.7 ± 3.3)E 0 (-2.1 - 3.1)E 1 (0/ 18)	(-1.5 ± 3.7)E 0 (-1.4 - 2.2)E 1 (0/ 8)
CS-137 (26) (0)	130.	(1.5 ± 1.8)E 0 (-1.7 - 1.7)E 1 (0/ 18)	89	(1.4 ± 0.9)E 1 (0/ 1)	(1.7 ± 42.9)E -1 (-1.4 - 1.8)E 1 (0/ 8)
TH-232 (26) (0)		(1.2 ± 86.1)E -1 (-7.3 - 3.7)E 1 (0/ 18)	89	(5.5 ± 2.8)E 1 (0/ 1)	(2.0 ± 1.4)E 1 (-4.4 - 6.8)E 1 (0/ 8)

* Non-Routine refers to the number of separate measurements which were greater than ten (10) times the average background for the period of the report.

** The fraction of sample analyses yielding detectable measurements (i.e., > 3 Standard Deviations).

Table 2.14-1
Shellfish Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(January - December 1995)

MEDIUM: SHELLFISH | UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS MEAN RANGE NO. DETECTED**	STA. NO.	STATION WITH HIGHEST MEAN MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
BE-7 (48)		(2.8 ± 1.1)E 1	11	(3.2 ± 0.6)E 1	(1.1 ± 1.9)E 1
(0)		(-7.1 - 17.7)E 1		(1.4 - 5.3)E 1	(-2.2 - 2.4)E 2
		(6/ 24)		(4/ 8)	(3/ 24)
K-40 (48)		(8.1 ± 1.0)E 2	15	(9.7 ± 1.7)E 2	(8.0 ± 1.3)E 2
(0)		(5.8 - 145.0)E 1		(4.7 - 12.5)E 2	(9.7 - 226.0)E 1
		(20/ 24)		(4/ 4)	(18/ 24)
MN-54 (48)	130.	(1.5 ± 0.9)E 0	12	(3.1 ± 1.8)E 0	(3.8 ± 16.7)E -1
(0)		(-4.9 - 15.9)E 0		(-4.9 - 15.9)E 0	(-1.5 - 2.7)E 1
		(0/ 24)		(0/ 12)	(0/ 24)
CO-58 (48)	130.	(1.0 ± 1.0)E 0	12	(2.5 ± 1.8)E 0	(-2.0 ± 1.4)E 0
(0)		(-4.6 - 15.4)E 0		(-4.6 - 15.4)E 0	(-1.9 - 1.5)E 1
		(0/ 24)		(0/ 12)	(0/ 24)
FE-59 (48)	260.	(-6.1 ± 3.3)E 0	13	(6.5 ± 9.1)E 0	(3.8 ± 6.1)E 0
(0)		(-6.4 - 1.1)E 1		(-5.7 - 7.2)E 1	(-5.7 - 7.2)E 1
		(0/ 24)		(0/ 16)	(0/ 24)
CO-60 (48)	5.	(2.6 ± 1.5)E 0	13	(4.1 ± 2.9)E 0	(2.7 ± 2.0)E 0
(0)		(-9.7 - 23.4)E 0		(-1.7 - 3.3)E 1	(-1.7 - 3.3)E 1
		(4/ 24)		(0/ 16)	(0/ 24)
ZN-65 (48)	5.	(2.0 ± 268.6)E -2	11	(3.2 ± 8.7)E -1	(-7.3 ± 3.9)E 0
(0)		(-3.3 - 2.6)E 1		(-3.2 - 4.2)E 0	(-4.8 - 3.0)E 1
		(0/ 24)		(0/ 8)	(0/ 24)
CS-134 (48)	5.	(-2.7 ± 1.4)E 0	24	(2.8 ± 6.2)E -1	(-5.5 ± 1.9)E 0
(0)		(-2.3 - 1.4)E 1		(-1.5 - 3.0)E 0	(-3.3 - 0.6)E 1
		(0/ 24)		(0/ 8)	(0/ 24)
CS-137 (48)	5.	(-2.4 ± 11.4)E -1	13	(1.2 ± 1.7)E 0	(7.3 ± 11.4)E -1
(0)		(-2.0 - 1.0)E 1		(-1.0 - 1.5)E 1	(-1.0 - 1.5)E 1
		(0/ 24)		(0/ 16)	(0/ 24)
CE-144 (48)	15.	(-5.7 ± 5.7)E 0	15	(-2.3 ± 1.4)E 0	(-4.0 ± 5.8)E 0
(0)		(-8.5 - 6.5)E 1		(-5.4 - 1.5)E 0	(-8.0 - 8.6)E 1
		(0/ 24)		(0/ 4)	(0/ 24)
TH-232 (48)		(1.3 ± 0.6)E 1	13	(3.4 ± 1.7)E 1	(2.8 ± 1.1)E 1
(0)		(-2.2 - 11.4)E 1		(-7.6 - 14.2)E 1	(-7.6 - 14.2)E 1
		(5/ 24)		(5/ 16)	(10/ 24)

* Non-Routine refers to the number of separate measurements which were greater than ten (10) times the average background for the period of the report.

** The fraction of sample analyses yielding detectable measurements (i.e., > 3 Standard Deviations).

Table 2.15-1
Irish Moss Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(January - December 1995)

MEDIUM: IRISH MOSS

UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*		REQUIRED LLD	INDICATOR STATIONS MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN STA. NO.	STATION WITH HIGHEST MEAN MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
BE-7	(16) (5)		(1.9 ± 0.3)E 2 (6.0 - 41.8)E 1 (5/ 12)	22	(2.2 ± 0.6)E 2 (1.2 - 3.7)E 2 (3/ 4)	(7.5 ± 2.6)E 1 (2.3 - 14.6)E 1 (0/ 4)
K-40	(16) (0)		(6.0 ± 0.4)E 3 (3.7 - 9.1)E 3 (12/ 12)	11	(7.2 ± 0.7)E 3 (6.1 - 9.1)E 3 (4/ 4)	(6.7 ± 0.5)E 3 (5.5 - 8.1)E 3 (4/ 4)
MN-54	(16) (0)		(2.9 ± 1.4)E 0 (-6.0 - 10.2)E 0 (0/ 12)	22	(5.4 ± 2.4)E 0 (-1.3 - 10.2)E 0 (0/ 4)	(2.1 ± 0.9)E 0 (5.3 - 409.0)E -2 (0/ 4)
CO-58	(16) (0)		(-2.9 ± 1.2)E 0 (-1.4 - 0.2)E 1 (0/ 12)	34	(1.6 ± 2.4)E 0 (-3.5 - 7.4)E 0 (0/ 4)	(1.6 ± 2.4)E 0 (-3.5 - 7.4)E 0 (0/ 4)
FE-59	(16) (0)		(-2.7 ± 6.8)E 0 (-3.8 - 4.6)E 1 (0/ 12)	22	(5.7 ± 14.0)E 0 (-1.5 - 4.6)E 1 (0/ 4)	(-2.5 ± 15.4)E 0 (-2.6 - 4.2)E 1 (0/ 4)
CO-60	(16) (2)		(1.4 ± 0.5)E 1 (-6.4 - 57.4)E 0 (2/ 12)	11	(3.0 ± 1.1)E 1 (1.2 - 5.7)E 1 (2/ 4)	(-7.2 ± 32.8)E -1 (-5.7 - 8.9)E 0 (0/ 4)
ZN-65	(16) (0)		(-5.7 ± 6.1)E 0 (-4.9 - 3.1)E 1 (0/ 12)	22	(5.0 ± 134.7)E -1 (-2.3 - 3.1)E 1 (0/ 4)	(-1.7 ± 0.5)E 1 (-2.8 - -0.6)E 1 (0/ 4)
CS-134	(16) (0)		(-3.0 ± 16.9)E -1 (-5.7 - 16.4)E 0 (0/ 12)	11	(3.1 ± 4.6)E 0 (-3.9 - 16.4)E 0 (0/ 4)	(-2.2 ± 2.4)E 0 (-7.8 - 3.3)E 0 (0/ 4)
CS-137	(16) (0)		(1.0 ± 1.8)E 0 (-1.4 - 1.1)E 1 (0/ 12)	34	(7.8 ± 0.9)E 0 (5.5 - 9.6)E 0 (0/ 4)	(7.8 ± 0.9)E 0 (5.5 - 9.6)E 0 (0/ 4)
TH-232	(16) (0)		(9.9 ± 7.9)E 0 (-4.7 - 5.6)E 1 (0/ 12)	22	(2.6 ± 0.5)E 1 (1.6 - 3.5)E 1 (0/ 4)	(1.8 ± 0.2)E 1 (1.4 - 2.3)E 1 (0/ 4)

* Non-Routine refers to the number of separate measurements which were greater than ten (10) times the average background for the period of the report.

** The fraction of sample analyses yielding detectable measurements (i.e., > 3 Standard Deviations).

Table 2.16-1
Lobster Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(January - December 1995)

MEDIUM: AMERICAN LOBSTER

UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN STA. NO.	STATION WITH HIGHEST MEAN MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
BE-7 (5) (0)		(5.3 ± 7.1)E 1 (-1.5 - 1.7)E 2 (0/ 4)	11	(5.3 ± 7.1)E 1 (-1.5 - 1.7)E 2 (0/ 4)	(9.5 ± 72.8)E 0 (0/ 1)
K-40 (5) (0)		(2.2 ± 0.2)E 3 (1.6 - 2.6)E 3 (4/ 4)	13	(2.9 ± 0.3)E 3 (1/ 1)	(2.9 ± 0.3)E 3 (1/ 1)
MN-54 (5) (0)	130.	(-2.8 ± 6.6)E 0 (-1.0 - 1.7)E 1 (0/ 4)	13	(9.5 ± 7.8)E 0 (0/ 1)	(9.5 ± 7.8)E 0 (0/ 1)
CO-58 (5) (0)	130.	(4.6 ± 5.2)E 0 (-7.1 - 15.8)E 0 (0/ 4)	11	(4.6 ± 5.2)E 0 (-7.1 - 15.8)E 0 (0/ 4)	(-5.7 ± 88.4)E -1 (0/ 1)
FE-59 (5) (0)	260.	(1.5 ± 1.7)E 1 (-3.1 - 4.6)E 1 (0/ 4)	11	(1.5 ± 1.7)E 1 (-3.1 - 4.6)E 1 (0/ 4)	(2.1 ± 31.8)E 0 (0/ 1)
CO-60 (5) (0)	130.	(5.6 ± 5.5)E 0 (-4.[illegible] 18.5)E 0 ([illegible] 4)	13	(7.3 ± 10.0)E 0 (0/ 1)	(7.3 ± 10.0)E 0 (0/ 1)
ZN-65 (5) (0)	260.	(-6.1 ± 12.9)E 0 (-3.4 - 2.6)E 1 (0/ 4)	11	(-6.1 ± 12.9)E 0 (-3.4 - 2.6)E 1 (0/ 4)	(-1.8 ± 2.0)E 1 (0/ 1)
CS-134 (5) (0)	130.	(1.7 ± 5.1)E 0 (-10.0 - 14.5)E 0 (0/ 4)	11	(1.7 ± 5.1)E 0 (-10.0 - 14.5)E 0 (0/ 4)	(-1.2 ± 1.0)E 1 (0/ 1)
CS-137 (5) (0)	130.	(5.7 ± 15.3)E -1 (-3.8 - 2.7)E 0 (0/ 4)	13	(8.4 ± 8.6)E 0 (0/ 1)	(8.4 ± 8.6)E 0 (0/ 1)
TH-232 (5) (0)		(-1.1 ± 1.9)E 1 (-6.6 - 2.3)E 1 (0/ 4)	13	(3.2 ± 4.0)E 1 (0/ 1)	(3.2 ± 4.0)E 1 (0/ 1)

* Non-Routine refers to the number of separate measurements which were greater than ten (10) times the average background for the period of the report.

** The fraction of sample analyses yielding detectable measurements (i.e., > 3 Standard Deviations).

Table 2.17-1
Sediment Radioactivity Analyses

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(January - December 1995)

MEDIUM: SEDIMENT UNITS: PCI/KG DRY

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN STA. NO.	STATION WITH HIGHEST MEAN MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
BE-7 (56) (0)		(1.5 ± 0.7)E 1 (-5.8 - 14.6)E 1 (2/ 39)	13	(6.2 ± 6.2)E 1 (-3.0 - 67.3)E 1 (1/ 11)	(4.9 ± 4.0)E 1 (-3.0 - 67.3)E 1 (2/ 17)
K-40 (56) (0)		(9.2 ± 0.1)E 3 (8.2 - 11.7)E 3 (39/ 39)	13	(1.3 ± 0.0)E 4 (1.0 - 1.6)E 4 (11/ 11)	(1.1 ± 0.0)E 4 (8.8 - 15.9)E 3 (17/ 17)
CO-58 (56) (0)	50.	(-2.7 ± 0.6)E 0 (-9.5 - 6.4)E 0 (0/ 39)	14	(-1.6 ± 0.5)E 0 (-2.9 - 0.1)E 0 (0/ 6)	(-3.3 ± 0.9)E 0 (-9.9 - 3.7)E 0 (0/ 17)
CO-60 (56) (0)	50.	(1.1 ± 0.7)E 0 (-1.0 - 0.9)E 1 (0/ 39)	11	(1.3 ± 1.8)E 0 (-1.0 - 0.9)E 1 (0/ 11)	(-4.1 ± 13.7)E -1 (-1.3 - 0.8)E 1 (0/ 17)
ZN-65 (56) (0)	50.	(4.7 ± 1.7)E 0 (-2.0 - 2.4)E 1 (0/ 39)	14	(6.8 ± 4.5)E 0 (-1.0 - 2.0)E 1 (0/ 6)	(3.5 ± 4.2)E 0 (-1.9 - 4.4)E 1 (0/ 17)
ZR-95 (56) (0)	50.	(6.8 ± 1.4)E 0 (-8.7 - 27.4)E 0 (0/ 39)	13	(1.5 ± 0.3)E 1 (3.4 - 29.0)E 0 (0/ 11)	(1.1 ± 0.2)E 1 (-3.1 - 29.0)E 0 (0/ 17)
CS-134 (56) (0)	50.	(-7.7 ± 10.6)E -1 (-1.3 - 2.2)E 1 (0/ 39)	11	(1.0 ± 2.9)E 0 (-1.2 - 2.2)E 1 (0/ 11)	(-1.6 ± 2.1)E 0 (-2.1 - 1.7)E 1 (0/ 17)
CS-137 (56) (0)	50.	(5.6 ± 1.8)E 0 (-7.1 - 32.8)E 0 (11/ 39)	13	(3.0 ± 0.3)E 1 (1.6 - 4.2)E 1 (10/ 11)	(2.1 ± 0.4)E 1 (-4.8 - 41.6)E 0 (10/ 17)
CE-144 (56) (0)	150.	(5.4 ± 3716.2)E -3 (-5.2 - 4.8)E 1 (0/ 39)	15	(1.6 ± 0.5)E 1 (-2.0 - 4.8)E 1 (0/ 11)	(-4.6 ± 6.0)E 0 (-6.7 - 3.9)E 1 (0/ 17)
TH-232 (56) (0)		(3.8 ± 0.1)E 2 (2.2 - 5.2)E 2 (39/ 39)	13	(5.0 ± 0.3)E 2 (3.9 - 6.9)E 2 (11/ 11)	(4.4 ± 0.3)E 2 (3.1 - 6.9)E 2 (17/ 17)
PU-238 (6) (0)		(4.4 ± 2.5)E -2 (-1.4 - 10.0)E -2 (0/ 4)	12	(1.0 ± 0.7)E -1 (0/ 1)	(4.0 ± 28.0)E -2 (-2.4 - 3.2)E -1 (0/ 2)
PU-239 (6) (0)		(3.1 ± 0.4)E 0 (2.6 - 4.1)E 0 (4/ 4)	13	(1.2 ± 0.0)E 1 (1.1 - 1.2)E 1 (2/ 2)	(1.2 ± 0.0)E 1 (1.1 - 1.2)E 1 (2/ 2)

* Non-Routine refers to the number of separate measurements which were greater than ten (10) times the average background for the period of the report.

** The fraction of sample analyses yielding detectable measurements (i.e., > 3 Standard Deviations).

Table 2.17-2

Sediment Plutonium Analyses

Environmental Radiological Program Summary
Pilgrim Nuclear Power Station, Plymouth, MA
(January - December 1995)

Location	Core Depth (cm)	Results pCi/Kg (dry) +-1 S.D.	
		Plutonium 238	Plutonium 239, Plutonium 240
Rocky Point	0-2	NDA	2.85 ± 0.28
Rocky Point	12-14	NDA	2.76 ± 0.18
Plymouth Harbor	0-2	NDA	4.12 ± 0.25
Manomet Point	0-2	NDA	2.57 ± 0.18
Duxbury Bay - Control	0-2	NDA	12.0 ± 0.94
Duxbury Bay - Control	12-14	NDA	11.5 ± 0.86

* NDA indicates no detectable activity.

Figure 2.2-1

Air Sampling and TLD Locations Within PNPS Exclusion Area

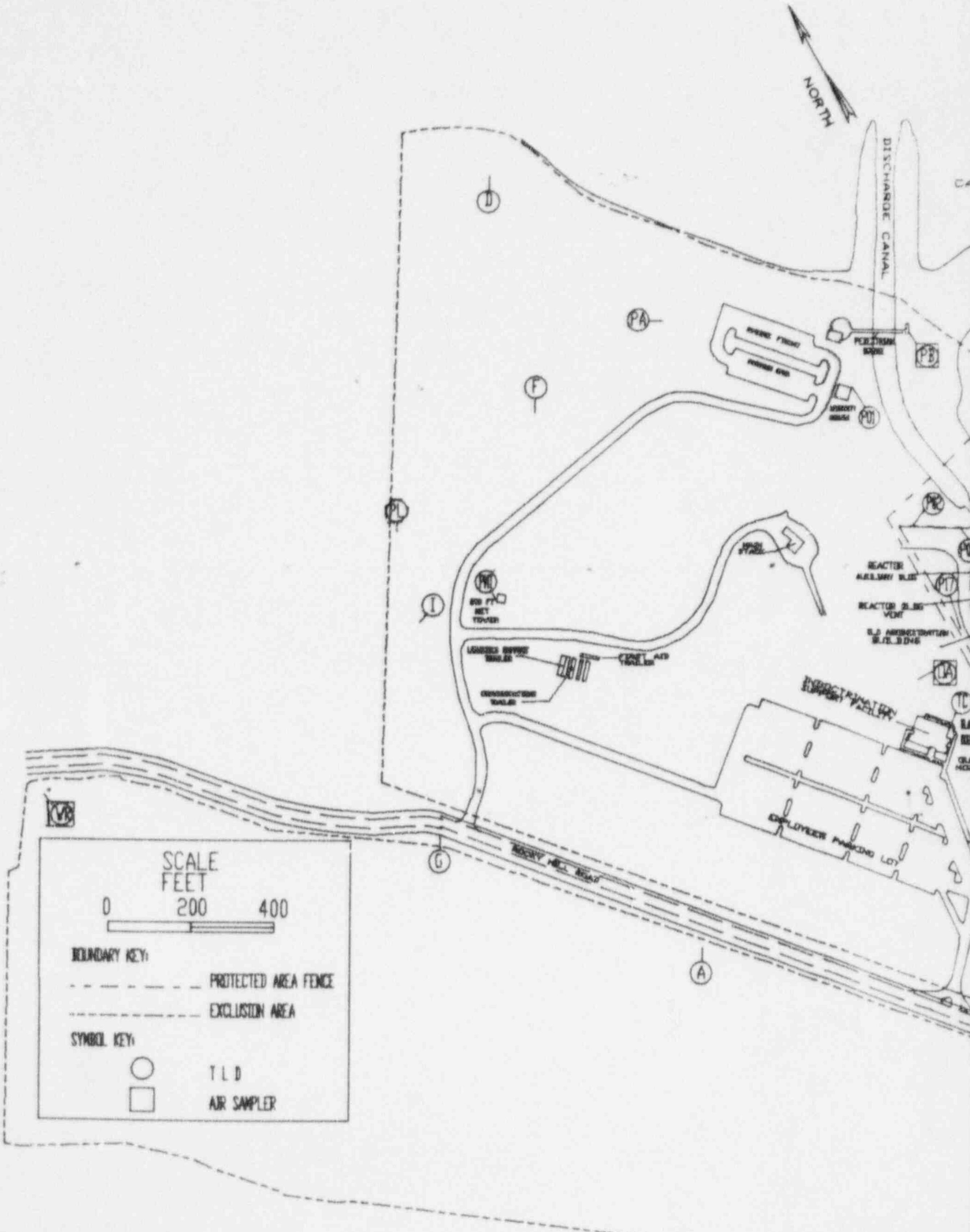
ENVIRONMENTAL TLD LOCATIONS

Code	Description	Dist.*	Dir.*
A	Station A	0.23 mi	WSW
B	Station B	0.27 mi	S
C	Station C	0.35 mi	ESE
CT	Contractor Lot	0.19 mi	SE
D	Station D	0.34 mi	NNW
EB	East Breakwater	0.27 mi	ESE
F	Station F	0.27 mi	NW
G	Station G	0.33 mi	W
HB	Hall's Bog	0.39 mi	SE
I	Station I	0.30 mi	WNW
L	Station L	0.31 mi	ESE
OA	Overlook Area	0.09 mi	W
PO1	Shorefront Security	0.14 mi	NNW
PO2	Fence - Shorefront	0.08 mi	NW
PO3	Fence - L Screenhouse	0.06 mi	NW
PO4	Fence - R Screenhouse	0.04 mi	N
PO5	Fence - Water Tank	0.05 mi	NNE
PO6	Fence - Oil Storage	0.05 mi	NE
PO7	Fence - Intake Bay	0.08 mi	ENE
PO8	Compressed Gas Stor	0.06 mi	E
PO9	Fence - W Boat Ramp	0.08 mi	E
P10	Fence - TCF/Intake Bay	0.14 mi	E
P11	Fence - TCF Gate	0.11 mi	ESE
P12	Fence - Access Gate	0.13 mi	SE
P13	Fence Medical Building	0.14 mi	SSE
P14	Fence - Butler Building	0.14 mi	S
P15	Fence - E Switchyard	0.14 mi	S
P16	Fence - W Switchyard	0.11 mi	SW
P17	Fence Exec. Building	0.07 mi	W
P18	O&M - 1st SW Corner	0.06 mi	S
P19	O&M - 2nd SW Corner	0.05 mi	S
P20	O&M - 2nd W Wall	0.04 mi	SE
P21	O&M/RXB. Breezeway	0.03 mi	SE
P22	O&M - 2nd N Wall	0.09 mi	SE
P23	O&M - 2nd S Wall	0.08 mi	SSE
P24	Exec. Building	0.04 mi	W
P25	Exec. Building Lawn	0.05 mi	WNW
P26	Fence - Warehouse	0.08 mi	ESE
P27	Fence - TCF/Boat Ramp	0.11 mi	ESE
P28	Fence - TCF/Parking Lot	0.16 mi	ESE
PA	Parking Area	0.22 mi	NNW
PB	Pedestrian Bridge	0.13 mi	N
PL	Property Line	0.34 mi	NW
PMT	PNPS Met Twr	0.27 mi	WNW
TC	Health Club	0.09 mi	WSW
WR	W. Rocky Hill Road	0.52 mi	WNW
WS	Medical Building	0.14 mi	SSE

AIR SAMPLE LOCATIONS

Code	Description	Dist.*	Dir.*
EB	East Breakwater	0.31 mi	ESE
OA	Overlook Area	0.09 mi	W
PB	Pedestrian Bridge	0.13 mi	N
PL	Property Line	0.34 mi	NW
WR	W. Rocky Hill Road	0.52 mi	WNW
WS	Medical Building	0.14 mi	SSE

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


NORTH
DISCHARGE CANAL
D
PA
PB
F
PL
I
TL
DA
REACTOR
INDOCTRINATION SUPPORT FACILITY
EMPLOYEE PARKING LOT
FIRST AID TRAILER
VR
G
A
SCALE
FEET
0
200
400
BOUNDARY KEY:
PROTECTED AREA FENCE
EXCLUSION AREA
SYMBOL KEY:
T L D
AIR SAMPLER

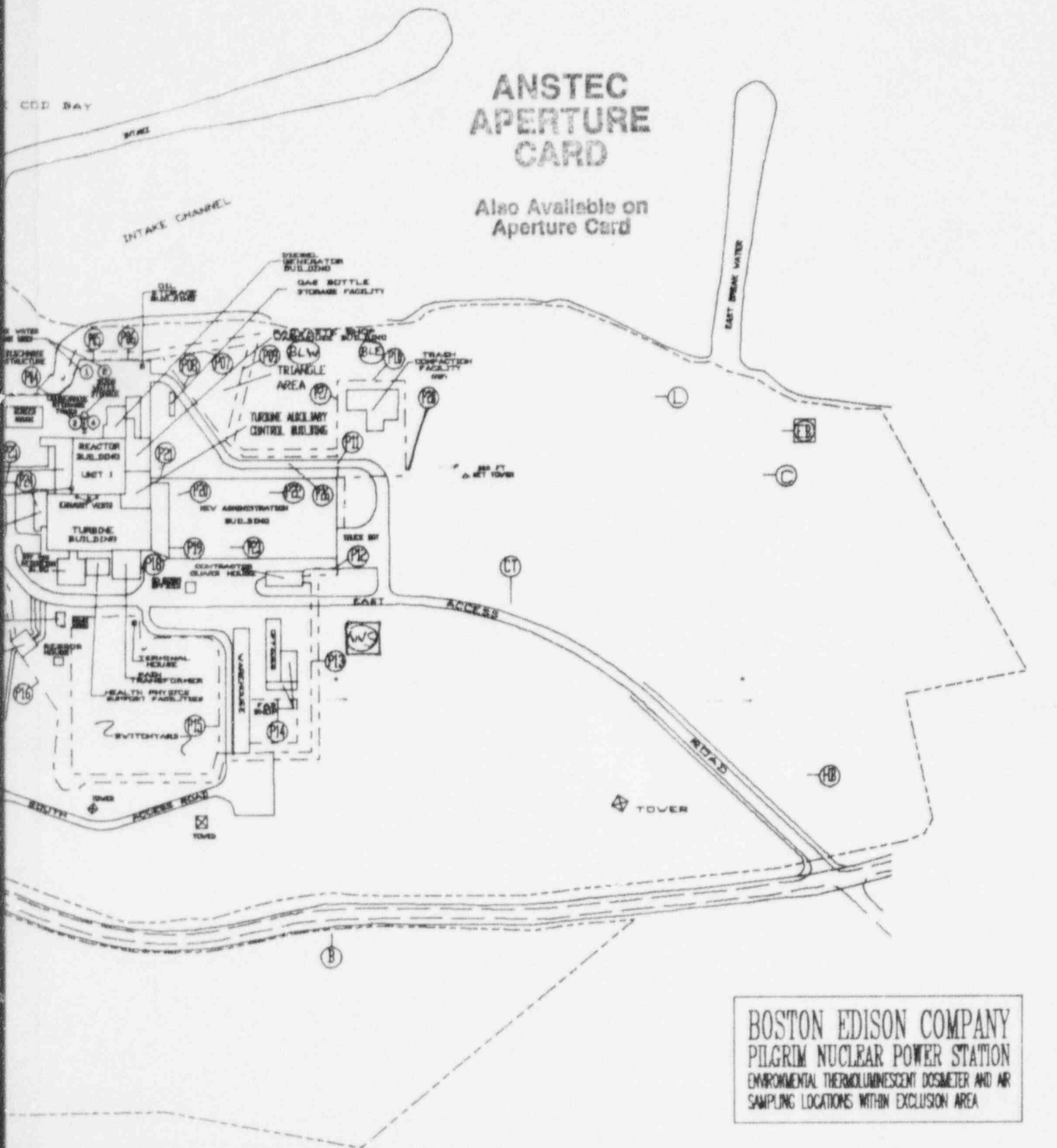


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Figure 2.2-2

Air Sampling and TLD Locations Within Two Miles of PNPS

ENVIRONMENTAL TLD LOCATIONS

Code	Description	Dist.*	Dir.*
AR	Access Road	0.99 mi	SSE
BB	3A & Bartlett Rd	2.1 mi	SSE
BD	Bayshore Drive	0.83 mi	WNW
BS	Bayshore	1.1 mi	W
BW	Beachwood Road	2.4 mi	SE
CR	Cleft Rock	0.79 mi	SSW
DR	Dirt Road	0.92 mi	SW
E	Station E	1.2 mi	S
EM	Emerson Road	0.95 mi	SSE
EP	Emer Rd & Pris	0.96 mi	SE
ER	E Rocky Hill Rd	0.55 mi	SE
GH	Greenwood House	0.40 mi	ESE
GN	Goodwin Property	1.5 mi	SW
H	Station H	0.29 mi	SW
J	Station J	1.3 mi	SSE
JG	John Gauley	1.2 mi	W
K	Station K	1.4 mi	S
ME	Manomet Elm	2.0 mi	SE
MP	Manomet Pt	2.2 mi	SE
MR	Manomet Road	0.86 mi	S
MS	Manomet Subst	2.2 mi	SSE
MT	Micro Tower	0.64 mi	SSW
PT	Pines Estate	2.8 mi	SSW
RC	Rec Pool	1.3 mi	WSW
RW	Right of Way	1.8 mi	S
SP	S Ply. Sub	2.9 mi	W
TP	Taylor & Pearl	1.9 mi	SE
TT	Taylor & Tom Ave	1.4 mi	SE
VR	Valley Road	2.0 mi	SSW
WC	Warren & Clifford	2.1 mi	W
WH	White Horse Rd	1.3 mi	SSE
YV	Yankee Village	1.4 mi	WSW

AIR SAMPLE LOCATIONS

Code	Description	Dist.*	Dir.*
CR	Cleft Rock	0.79 mi	SSW
MS	Manomet Substation	2.2 mi	SSE
ER	East Rocky Hill Rd	0.55 mi	SE

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

Figure 2.2-2 (cont.)

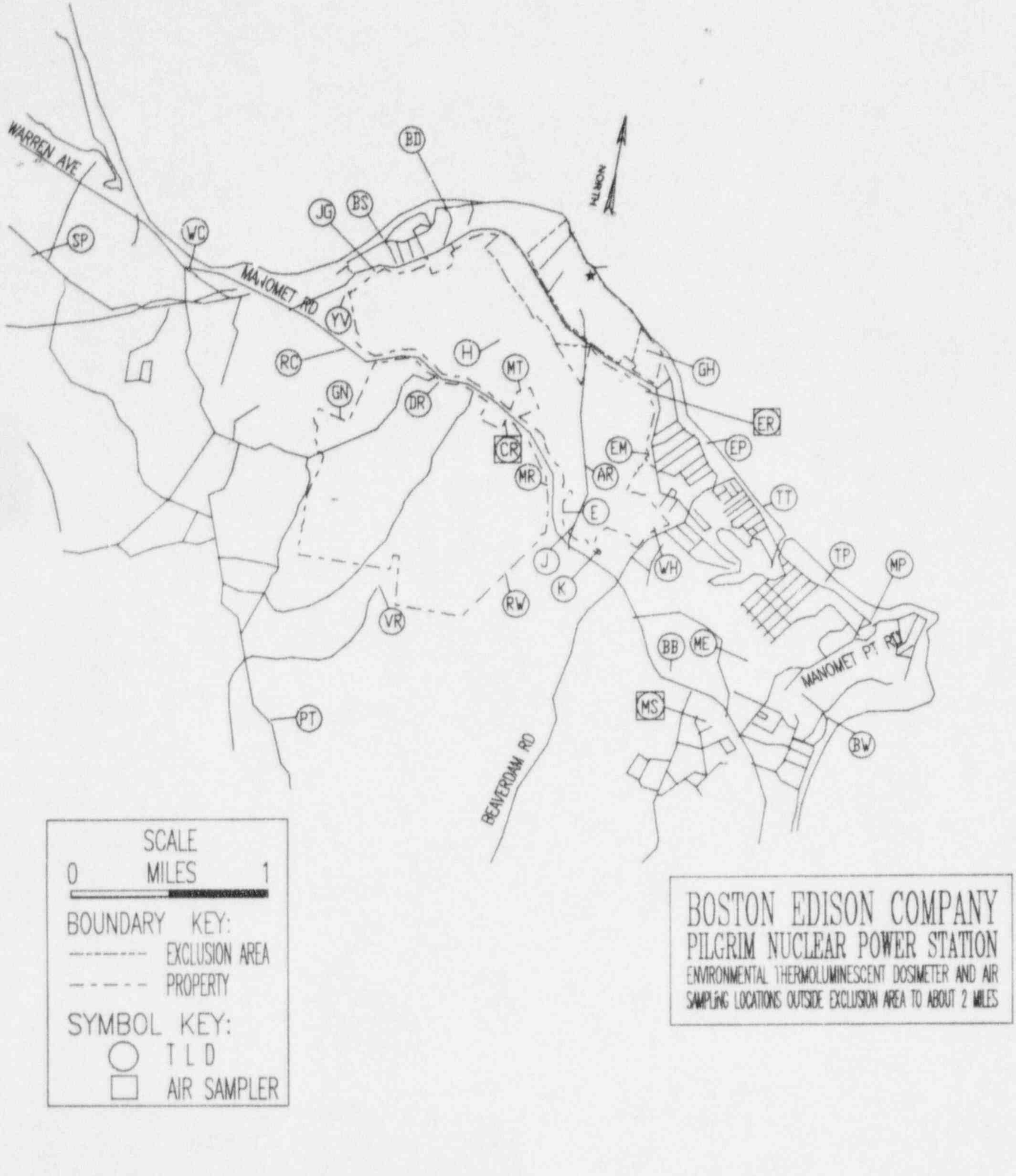


Figure 2.2-3

Air Sampling and TLD Locations Beyond Two Miles of PNPS

ENVIRONMENTAL TLD LOCATIONS

Code	Description	Dist.*	Dir.*
BB	3A & Bartlett	2.1 mi	SSE
BD	Bayshore Drive	0.83 mi	WNW
BE	Bourne Road	8.3 mi	S
BR	Beaver Dam Road	3.4 mi	S
BS	Bayshore	1.1 mi	W
BW	Beachwood Road	2.4 mi	SE
CR	Cleft Rock	0.79 mi	SSW
CS	Cedarville Sub	9.9 mi	S
CP	College Pond	4.7 mi	SW
CW	Church & West	10 mi	NW
DMF	Div. Mar. Fish.	13 mi	SSE
DW	Deep Water	5.3 mi	W
EA	Earl Road	2.9 mi	SSE
EL	Ellisville Road	7.2 mi	SSE
EP	Emer. Rd & Pris	0.96 mi	SE
EW	E. Weymouth Sub	25 mi	NW
HD	Hilldale Road	3.2 mi	W
HR	Hyannis Road	4.6 mi	SSE
JG	John Gauley	1.2 mi	W
KC	King Caesar Road	8.1 mi	NNW
KS	Kingston Subst.	10 mi	WNW
LD	Long Pond & Drew	4.3 mi	WSW
LP	Long Pond Road	5.5 mi	SSW
LR	Landing Road	10 mi	NNW
MB	Manomet Beach	3.4 mi	SSE
ME	Manomet Elem	2.0 mi	SE
MH	Memorial Hall	4.7 mi	WNW
MM	Main & Meadow	11 mi	WSW
MP	Manomet Point	2.2 mi	SE
MS	Manomet Subst	2.2 mi	SSE
NP	North Plymouth	5.8 mi	WNW
PC	Plymouth Center	4.2 mi	W
PT	Pine Estates	2.8 mi	SSW
RC	Rec Pool	1.3 mi	WSW
RM	Russell Mill	3.0 mi	WSW
RP	Rt 3 Overpass	3.0 mi	SW
SA	Sherman Airport	8.3 mi	WSW
SH	Sacred Heart	8.0 mi	W
SN	Saquish Neck	4.7 mi	NNW
SS	Standish Shores	6.5 mi	NW
SP	S. Plymouth Sub	2.9 mi	W
TP	Taylor & Pearl	1.9 mi	SE
TT	Taylor & Thomas	1.4 mi	SE
UC	Up Coll. Pnd. Rd	7.3 mi	SW
WC	Warren & Clifford	2.0 mi	W
YV	Yankee Village	1.4 mi	WSW

AIR SAMPLE LOCATIONS

Code	Description	Dist.*	Dir.*
CR	Cleft Rock	0.79 mi	SSW
EW	East Weymouth	25 mi	NW
MS	Manomet Subst	2.2 mi	SSE
PC	Plymouth Center	4.2 mi	W

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

Figure 2.2-3 (cont.)

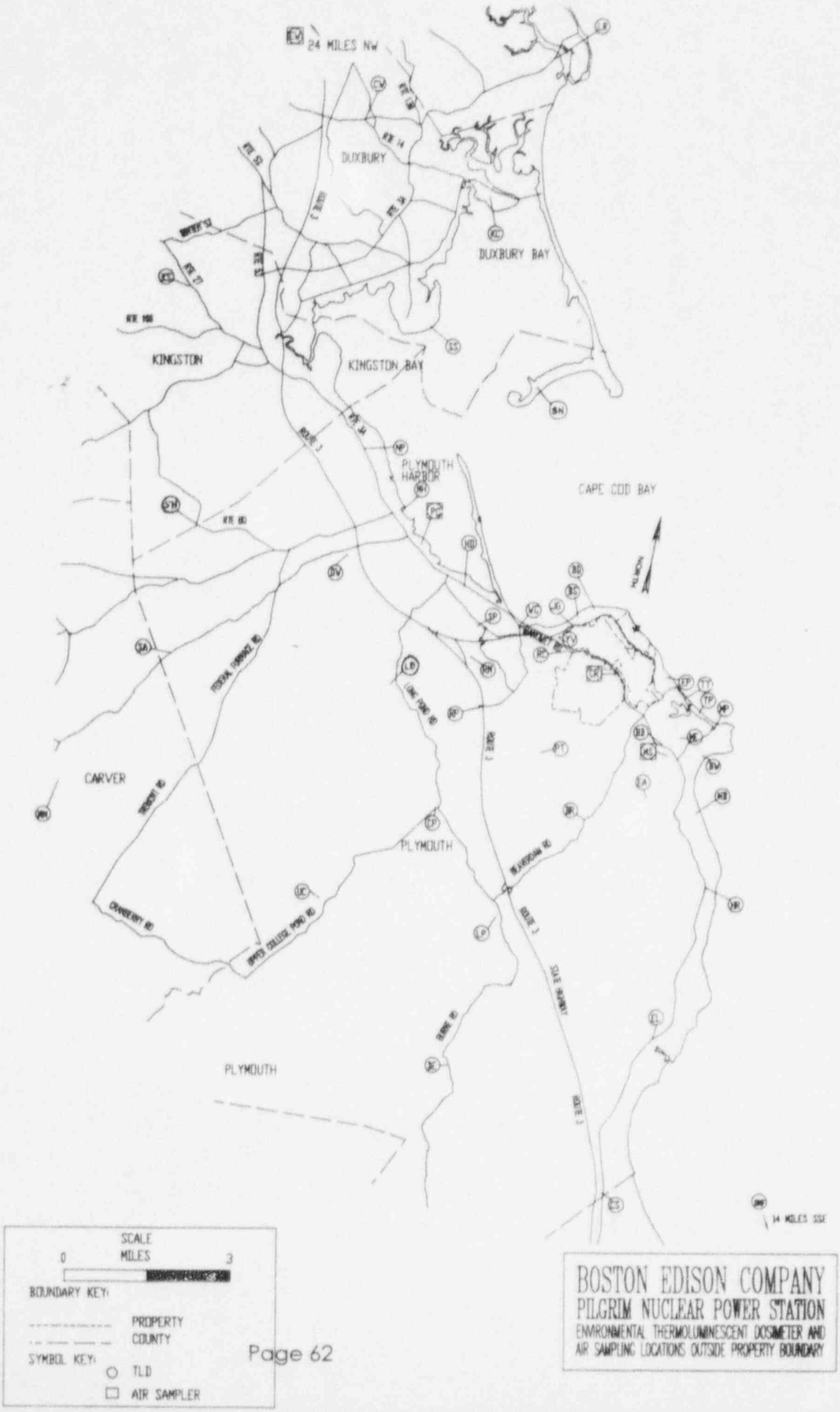


Figure 2.2-4

Terrestrial and Aquatic Sampling Locations

Code	Description	Dist.*	Dir.*
	SURFACE WATER		
DIS	Discharge Canal	0.13 mi	N
BP	Bartlett Pond	1.7 mi	SE
PP	Powder Point Control	7.9 mi	NNW
	SHELLFISH		
DIS	Discharge Canal	0.21 mi	N
PLY-H	Plymouth Harbor	2.8 mi	W
MP	Manomet Point	3.0 mi	ESE
DUX-BAY	Duxbury Bay Control	7.8 mi	NNW
PP	Powder Point Control	8.0 mi	NNW
GH	Green Harbor Control	9.9 mi	NNW
	IRISH MOSS		
DIS	Discharge Canal	0.21 mi	N
MP	Manomet Point	2.2 mi	ESE
EL	Ellisville	7.9 mi	SSE
BK	Brant Rock Control	10 mi	NNW
	AMERICAN LOBSTER		
DIS	Discharge Canal	0.21 mi	N
PLY-H	Plymouth Harbor	4.0 mi	WNW
DUX-BAY	Duxbury Bay Control	7.1 mi	NNW
PLB	Plymouth Beach	2.5 mi	W
	FISHES		
DIS	Discharge Canal	0.21 mi	N
PLB	Plymouth Beach	2.5 mi	W
JR	Jones River Control	7.8 mi	WNW
CC-BAY	Cape Cod Bay Control	15 mi	E
NR	N River-Hanover Control	15 mi	NNW
CA	Cataumet Control	20 mi	SSW
PT	Provincetown Control	20 mi	NE
BB	Buzzards Bay Control	25 mi	SSW
PC	Priest Cove Control	30 mi	SW
NS	Nantucket Sound Control	30 mi	SSE
AO	Atlantic Ocean Control	30 mi	E
MV	Vineyard Sound Control	40 mi	SSW

Code	Description	Dist.*	Dir.*
	SEDIMENT		
RP	Rocky Point	0.21 mi	N
PLY-H	Plymouth Harbor	3.0 mi	W
PLB	Plymouth Beach	2.5 mi	W
MP	Manomet Point	2.5 mi	ESE
DUX-BAY	Duxbury Bay Control	8.7 mi	NNW
GH	Green Harbor Control	10 mi	NNW
	MILK		
CF	Plymouth County Farm	3.5 mi	W
WF	Whitman Farm Control	21 mi	WNW
	CRANBERRIES		
MR	Manomet Pt. Bog	2.4 mi	SE
BT	Bartlett Rd. Bog	2.7 mi	SSE
PS	Pine St. Bog Control	16 mi	WNW
	VEGETABLES/VEGETATION		
CF	Plymouth County Farm	3.5 mi	W
BF	Bridgewater Farm Ctrl	19 mi	W
RH	Rocky Hill Road	0.5 mi	SE
BK	Brook Road	1.8 mi	SSE
BD	Beaverdam Road	2.1 mi	S
CH	Clay Hill Road	1.0 mi	W
BA	Site Boundary A	0.9 mi	SSW
BB	Site Boundary B	0.3 mi	ESE
BC	Site Boundary C	0.2 mi	SW
NC	Norton Control	31 mi	W
DMF	Div. Marine Fish.	13 mi	SSE
	FORAGE		
CF	Plymouth County Farm	3.5 mi	W
WF	Whitman Farm Control	21 mi	WNW
WH	Whipple Farm	1.8 mi	SW

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

Figure 2.2-4 (cont.)

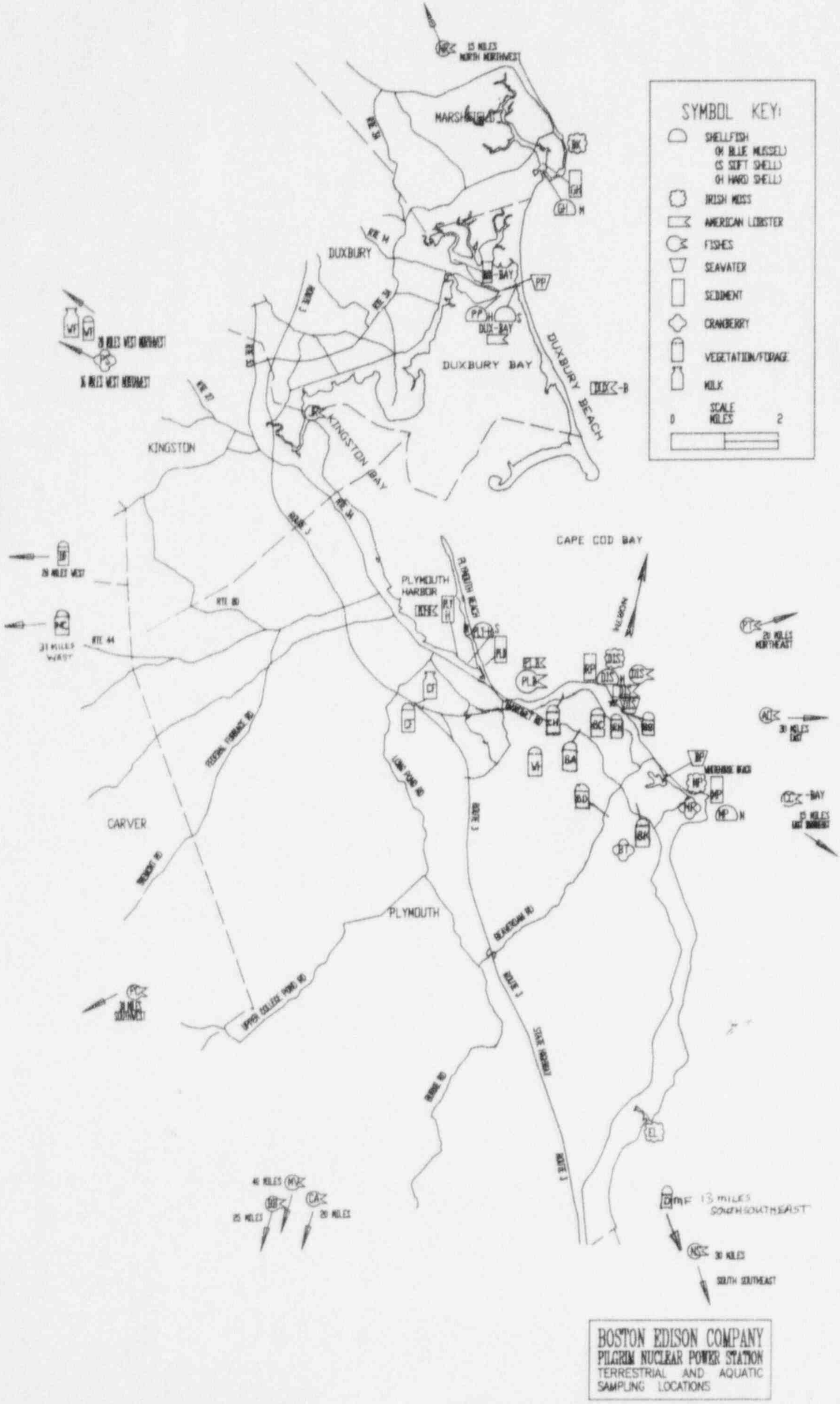


Figure 2.2-5

Environmental Sampling And Measurement Control Locations

Code	Description	Dist.*	Dir.*
	AIR SAMPLE		
EW	East Weymouth	25 mi	NW
	SEDIMENT		
GH	Green Harbor Control	10 mi	NNW
DUX-BAY	Duxbury Bay Control	8.7 mi	NNW
	SURFACE WATER		
PP	Powder Point Control	7.9 mi	NNW
	SHELLFISH		
DUX-BAY	Duxbury-Bay Control	7.8 mi	NNW
PP	Powder Point Control	8.0 mi	NNW
GH	Green Harbor Control	9.9 mi	NNW
	IRISH MOSS		
BK	Brant Rock Control	10 mi	NNW
	AMERICAN LOBSTER		
DUX-BAY	Duxbury Bay Control	7.1 mi	NNW
	FISHES		
JR	Jones River Control	7.8 mi	WNW
CC-BAY	Cape Cod Bay Control	15 mi	E
NR	N. River Hanover Control	15 mi	NNW
CA	Cataumet Control	20 mi	SSW
PT	Provincetown Control	20 mi	NE
BB	Buzzards Bay Control	25 mi	SSW
PC	Priest Cove Control	30 mi	SW
NS	Nantucket Sound Control	30 mi	SSE
AO	Atlantic Ocean Control	30 mi	E
MV	Vineyard Sound Control	40 mi	SSW

Code	Description	Dist.*	Dir.*
	TLD		
KS	Kingston Subst	10 mi	WNW
LR	Landing Road	10 mi	NNW
CS	Cedarville Sub	9.9 mi	S
CW	Church & West	10 mi	NW
MM	Main & Meadow	11 mi	WSW
DMF	Div. Mar. Fish	13 mi	SSE
EW	East Weymouth Sub	25 mi	NW
	MILK		
WF	Whitman Farm Control	21 mi	WNW
	CRANBERRIES		
PS	Pine St. Bog Control	16 mi	WNW
	VEGETABLES/VEGETATION		
BF	Bridgewater Farm	19 mi	W
NC	Norton Control	31 mi	W
DMF	Div. Marine Fish.	13 mi	SSE
	FORAGE		
WF	Whitman Farm Control	21 mi	WNW

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

Figure 2.2-5 (cont.)

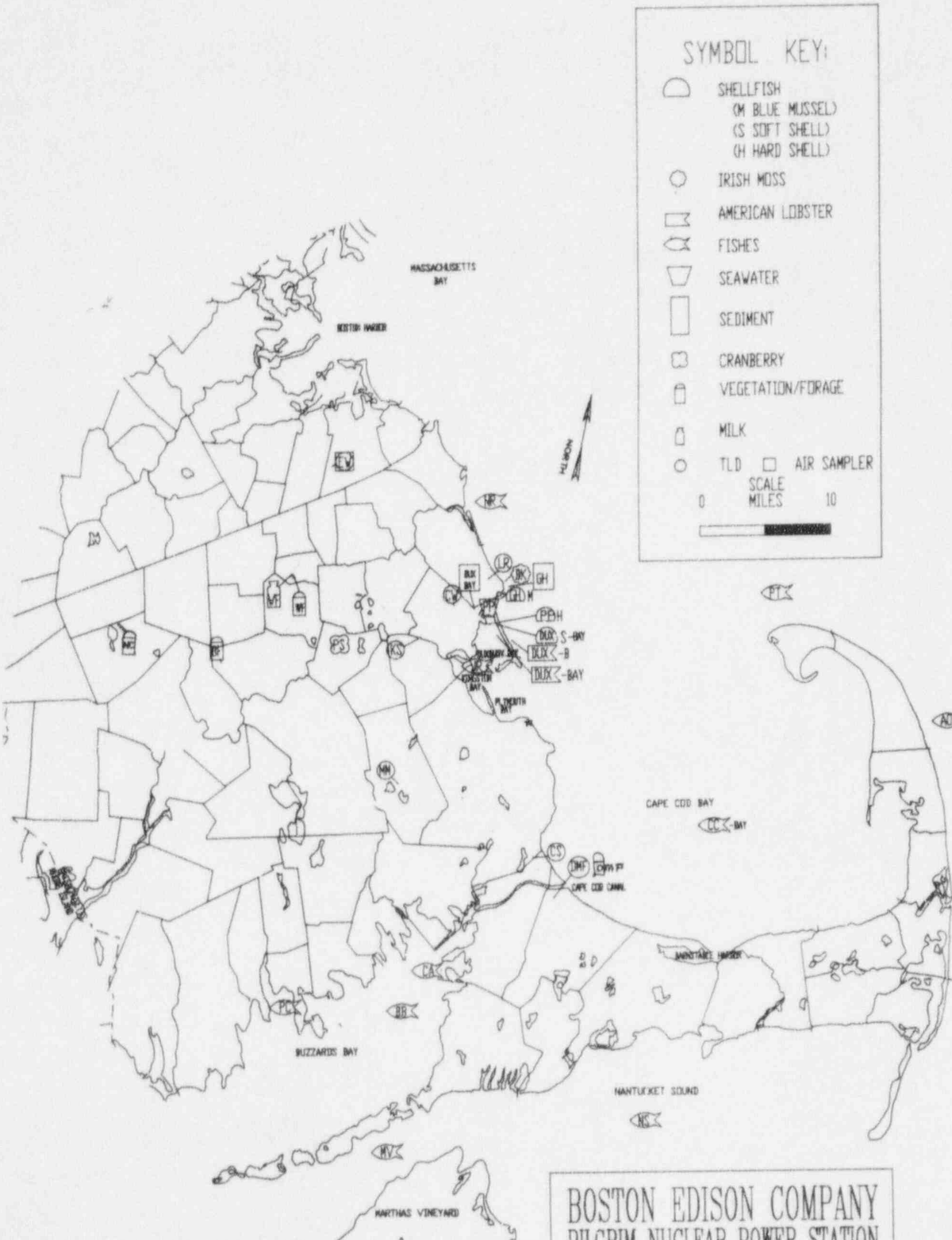


FIGURE 2.4-1

HISTORICAL BEACH SURVEY EXPOSURE RATE MEASUREMENTS

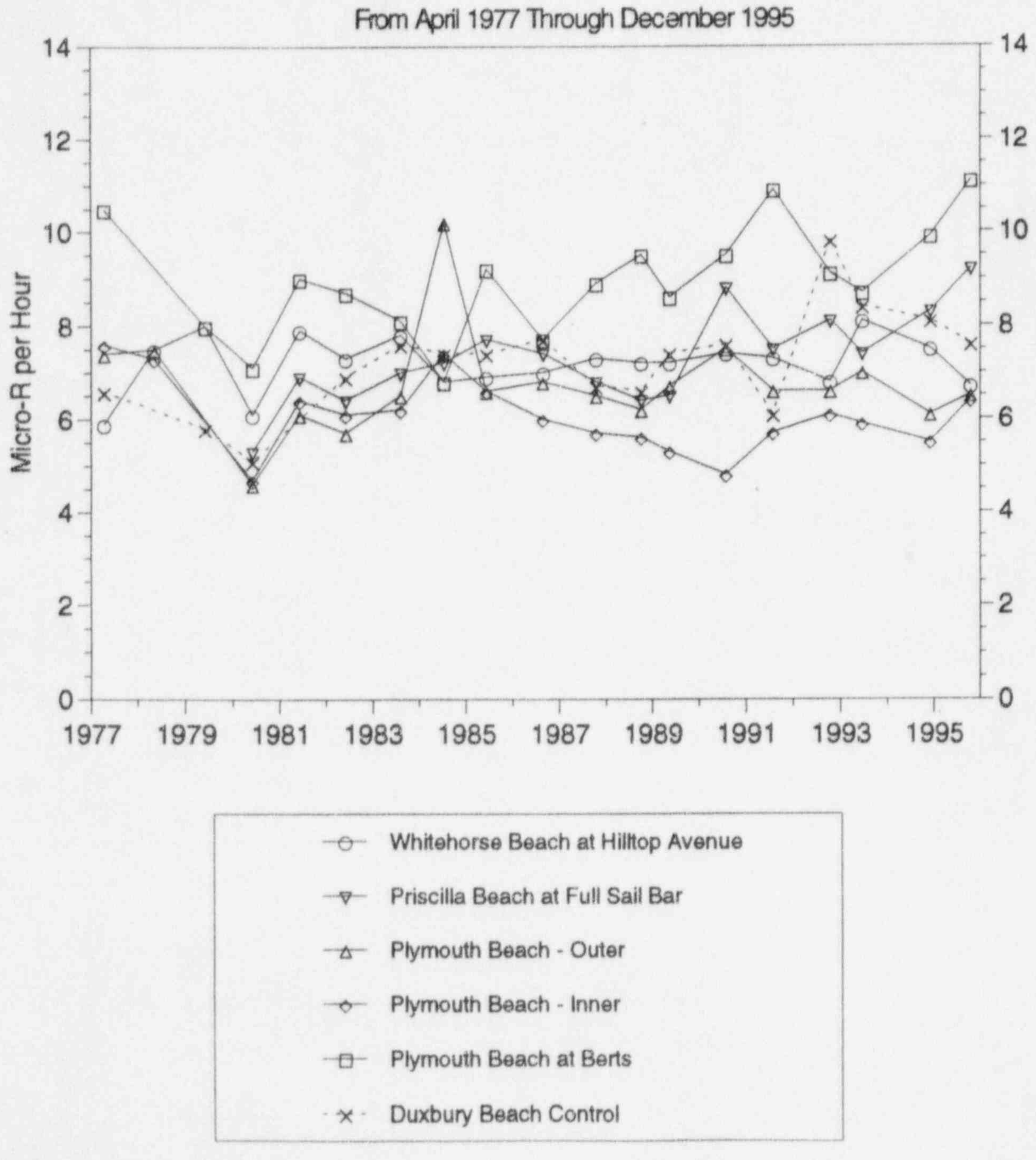


FIGURE 2.5-1

AIRBORNE GROSS-BETA RADIOACTIVITY LEVELS: NEAR STATION

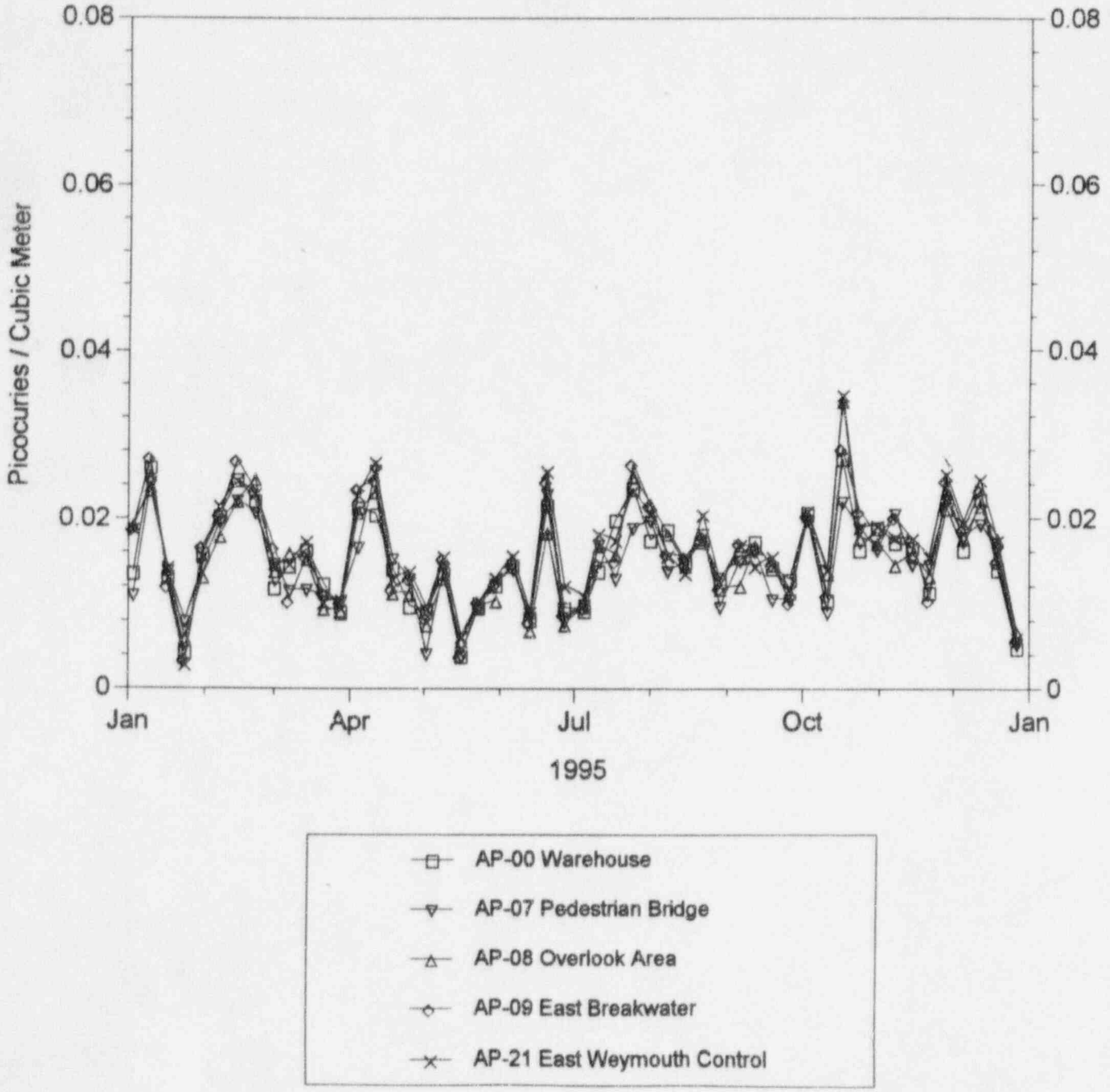


FIGURE 2.5-2

AIRBORNE GROSS-BETA RADIOACTIVITY LEVELS: PROPERTY LINE

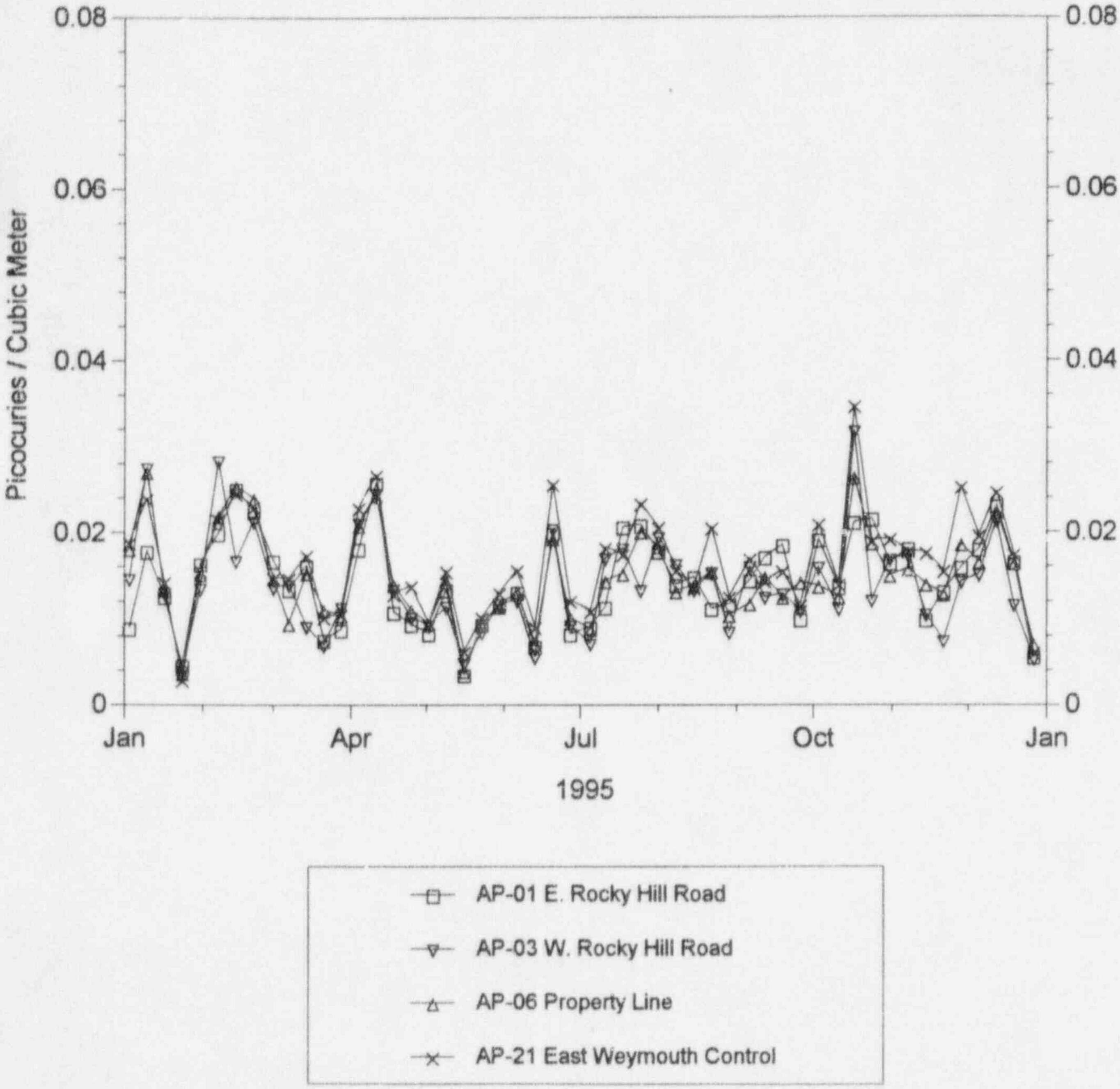


FIGURE 2.5-3

AIRBORNE GROSS-BETA RADIOACTIVITY LEVELS: OFF-SITE

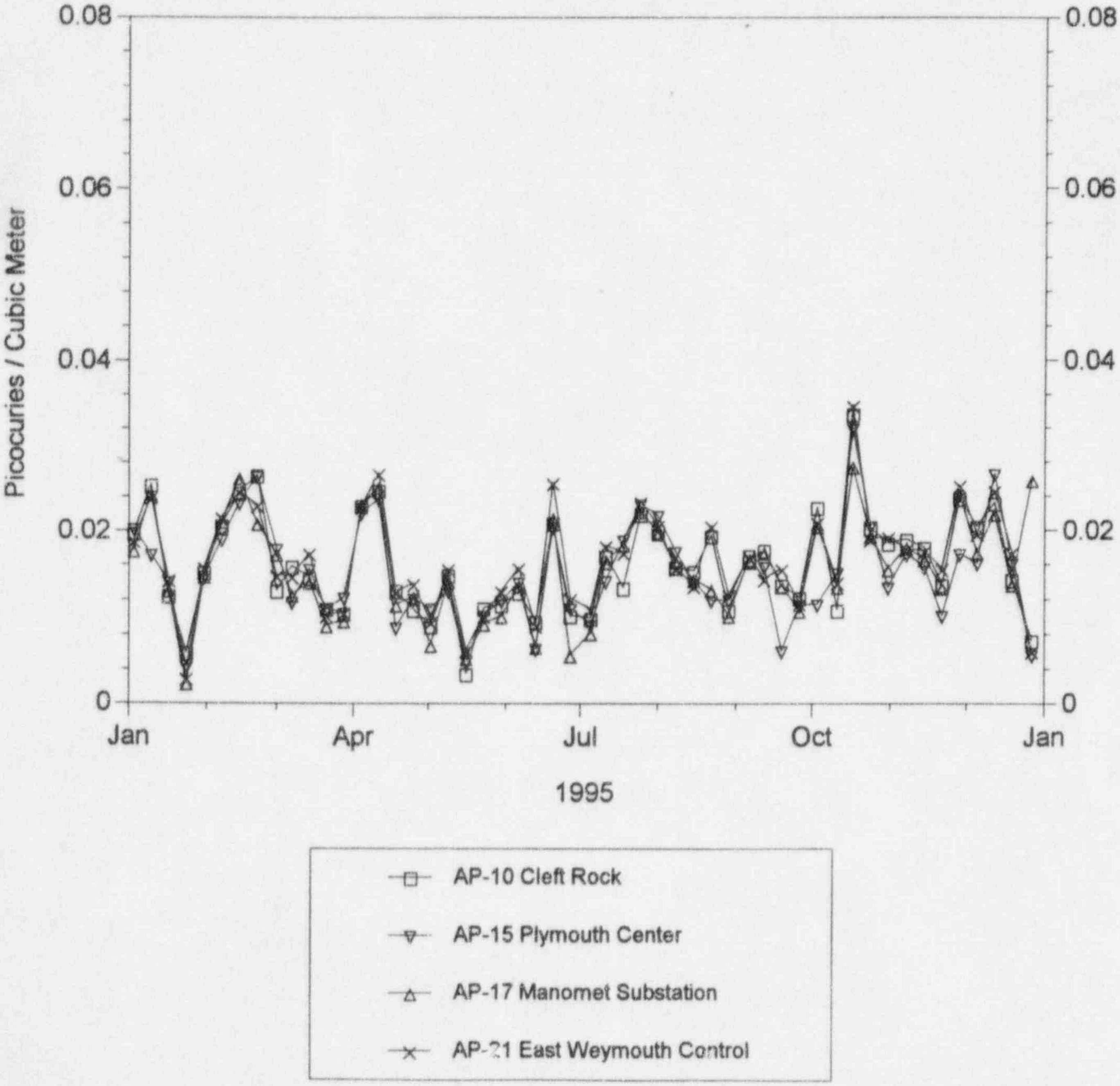


FIGURE 2.7-1

LEVELS OF STRONTIUM - 90 IN MILK SAMPLES

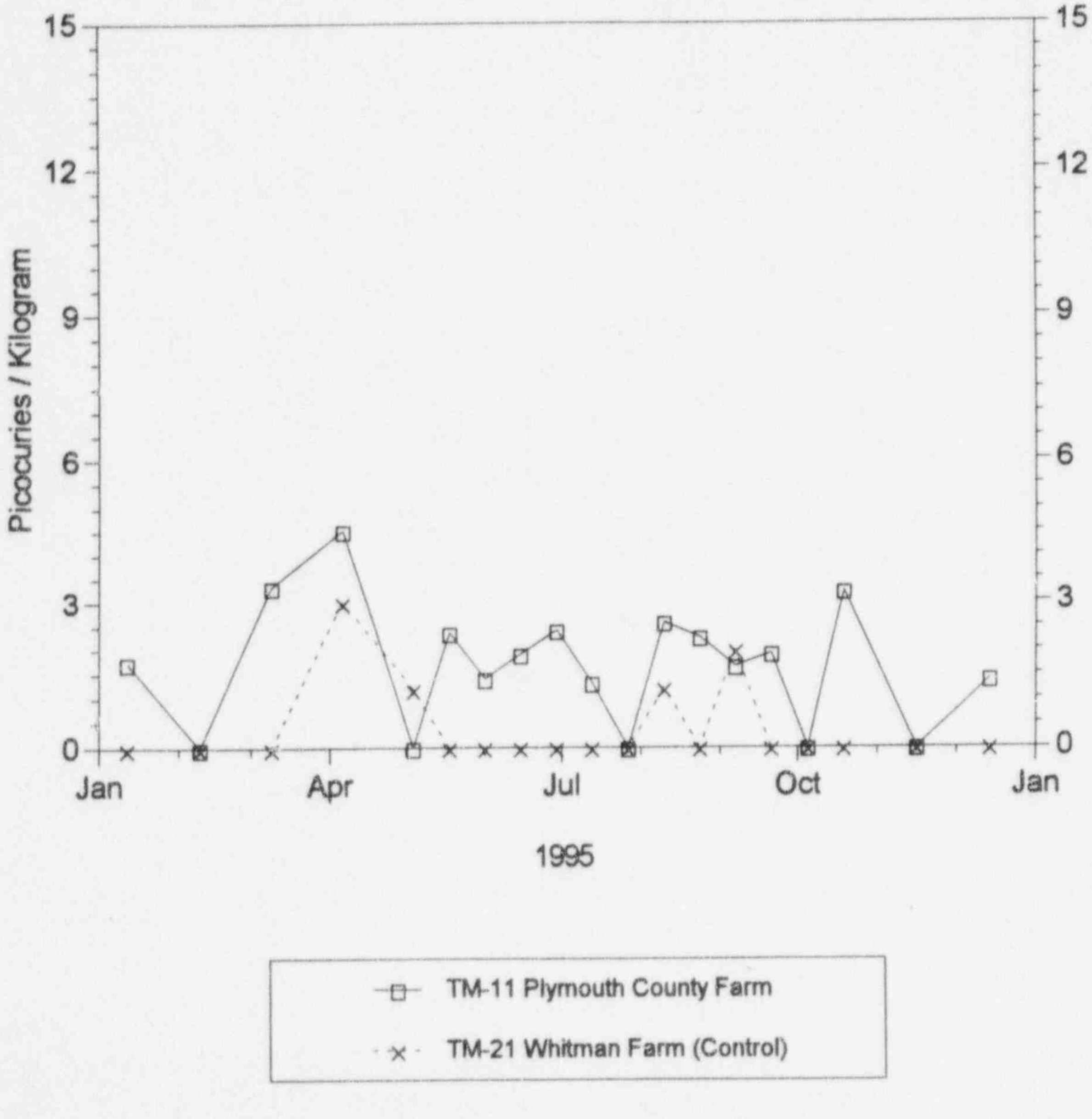
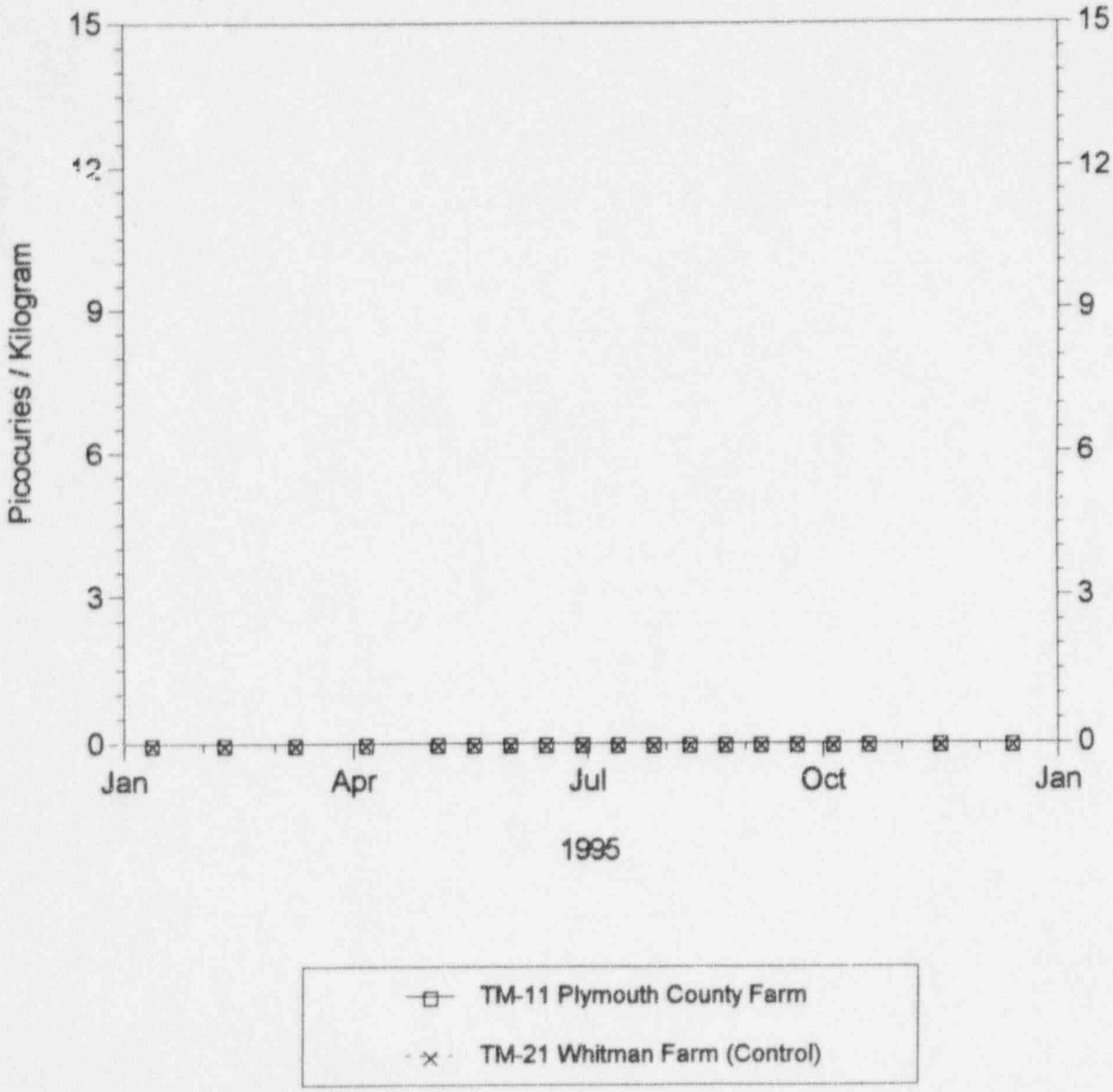


FIGURE 2.7-2

LEVELS OF CESIUM - 137 IN MILK SAMPLES



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:

1) calculations based on measurements of plant effluents; and

2) 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 1995 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:

1) shoreline external radiation during fishing and recreation at the Pilgrim Station Shorefront;

2) external radiation from the ocean during boating and swimming; and

3) ingestion of fish and shellfish.

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

1) external radiation from cloud shine and submersion in gaseous effluents;

2) inhalation of airborne radioactivity;

3) external radiation from soil deposition;

4) consumption of vegetables; and

5) 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 was taken from the "Annual Dose Assessment to the General Public from Radioactive Effluents" report for the period of January 1 through December 31, 1995.

Table 3.0-1

Radiation Doses from 1995 Pilgrim Station Operations

	Maximum Individual Dose From Exposure Pathway - mrem/yr			
Receptor	Liquid Effluents	Gaseous Effluents*	Ambient Radiation**	Total
Total Body	0.004	0.90	1.8	2.7
Thyroid	0.002	1.38	1.8	3.2
Max. Organ	0.013	1.38	1.8	3.2

* 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 Boston Edison 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 (eg. 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 1995, 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 1995, shellfish and Irish moss were the only sample media that contained detectable radioactivity potentially attributable to PNPS operations. The low levels of cobalt-60 detected in mussels and Irish moss would present a dose contribution of about 0.0003 mrem to the maximum exposed hypothetical individual.

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. Boston Edison Company, Pilgrim Nuclear Power Station Off-site Dose Calculation Manual, Revision 7, November 1995.

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-0473, "Standard Radiological Effluent Technical Specifications for Boiling Water Reactors," Revision 3, September 1982.

4.0 REFERENCES (continued)

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 Off-site Radiological Monitoring - June 9, 1977.

17. J. E. Vossahlik, Yankee Atomic Electric Company, Computer Program "ERMAP," Version 3.1 - January 9, 1979.

18. C. G. St. John, Yankee Atomic Electric Company, "1995 Annual Direct Radiation Survey at Beaches Near Pilgrim Station," EL 615/95, January 15, 1996.

SHELLFISH AND IRISH MOSS RADIOACTIVITY DOSE IMPACT

During 1995, cobalt-60 was detected in one sample of mussel meat collected from the discharge outfall during the third quarter, as well as in mussel shell samples collected from the same location during both the second and third quarters. Since only the meat of the mussels is consumed by humans, the dose assessment impact from ingesting mussel meat was calculated using the mean concentration of 2.2 pCi/kg of Co-60, based on the four samples collected from the discharge outfall during 1995. Ingestion rates of shellfish for the maximum exposed individual in each age class as listed in the PNPS ODCM were assumed (adult = 9 kg/yr, teen = 6 kg/yr, child = 3 kg/yr).

Cobalt-60 was also detected in samples of Irish moss collected from the discharge outfall during the second and third quarters of 1995. The annual average concentration of Co-60 based on the four samples of Irish moss collected during 1995 was 30.3 pCi/kg. Since Irish moss is not consumed directly, but is processed and used in small quantities as an ingredient in foods such as ice cream, it is highly unlikely that an individual could consume an appreciable amount of Co-60 via this pathway. The PNPS ODCM does not list a consumption factor for Irish moss as a potential ingestion pathway. For purposes of conservatism in this assessment, it is assumed that an individual could consume an equivalent of 0.5 kg of foodstuffs derived from Irish moss collected from the PNPS discharge outfall, containing a total of 15 pCi of Co-60.

The total body dose to the maximum exposed individual in each age class was derived by calculating the ingestion intake (pCi) of cobalt-60 from shellfish and Irish moss food derivatives and multiplying by the total body dose conversion factor (mrem/pCi ingested) as listed in Regulatory Guide 1.109. Results of those calculations are listed below.

Age Class	Shellfish pCi Co-60 Ingested	Irish Moss pCi Co-60 Ingested	Combined pCi Co-60 Ingested	Total Body DCF mrem/pCi	Total Body Dose mrem
Adult	19.8	15	34.8	4.72E-06	1.64E-04
Teen	13.2	15	28.2	6.33E-06	1.79E-04
Child	6.6	15	21.6	1.56E-05	3.37E-04

Based on the above calculations, the maximum total body dose received from the ingestion of shellfish and Irish moss food derivatives containing cobalt-60 is 3.37E-04 mrem. This additional dose of 0.0003 mrem would be considered negligible in comparison to the 300-400 mrem received by the average individual each year from other sources of radiation exposure.

APPENDIX B

EFFLUENT RELEASE INFORMATION

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 1995	Apr-Jun 1995
a. Liquid Effluents		
1. Total number of releases:	3.40E+01	6.30E+01
2. Total time period (minutes):	2.51E+03	3.37E+03
3. Maximum time period (minutes):	3.49E+02	1.80E+02
4. Average time period (minutes):	7.38E+01	5.35E+01
5. Minimum time period (minutes):	2.50E+01	1.30E+01
6. Average stream flow (Liters/min):	1.11E+06	6.95E+05
during periods of release of effluents into a flowing stream		
b. Gaseous Effluents	None	None

6. ABNORMAL RELEASES

	Jan-Mar 1995	Apr-Jun 1995
a. Liquid Effluents	None	None
b. Gaseous Effluents	None	None

Table 1A
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Gaseous Effluents - Summation of All Releases
January-June 1995

A. FISSION AND ACTIVATION GASES

	Period: Jan-Mar 1995	Period: Apr-Jun 1995	Estimated Total Error
	1.58E+03	1.67E+02	22%
Average Release Rate During Period: µCi/sec	2.00E+02	2.12E+01	
Percent of Technical Specification Limit	*	*	

B. IODINES

	Period: Jan-Mar 1995	Period: Apr-Jun 1995	Estimated Total Error
Total Iodine-131 Release: Ci	3.29E-03	5.10E-04	20%
Average Release Rate During Period: µCi/sec	4.17E-04	6.47E-05	
Percent of Technical Specification Limit	*	*	

C. PARTICULATES

	Period: Jan-Mar 1995	Period: Apr-Jun 1995	Estimated Total Error
Total Release: Ci	8.54E-04	3.82E-04	21%
Average Release Rate During Period: µCi/sec	1.08E-04	4.85E-05	
Percent of Technical Specification Limit	*	*	
Gross Alpha Radioactivity: Ci	NDA	NDA	

D. TRITIUM

	Period: Jan-Mar 1995	Period: Apr-Jun 1995	Estimated Total Error
Total Release: Ci	1.28E+01	3.46E+00	20%
Average Release Rate During Period: µCi/sec	1.62E+00	4.39E-01	
Percent of Technical Specification Limit	*	*	

Notes for Table 1A:

* Percent of Technical Specification limit values in above sections are based on dose assessments not performed as part of this report. These were provided in the annual supplemental dose assessment report issued prior to April 1, 1996.

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

Table 1B
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Gaseous Effluents - Elevated Release
January-June 1995

Nuclide Released	Continuous Mode		Batch Mode	
	Jan-Mar 1995	Apr-Jun 1995	Jan-Mar 1995	Apr-Jun 1995
1. FISSION AND ACTIVATION GASES - Ci				
N-13	NDA	NDA	N/A	N/A
Kr-85m	2.07E+02	4.33E+01	N/A	N/A
Kr-87	2.55E+02	2.45E+01	N/A	N/A
Kr-88	5.16E+02	8.77E+01	N/A	N/A
Xe-133	1.51E+02	9.77E+00	N/A	N/A
Xe-135	2.87E+02	1.67E+00	N/A	N/A
Xe-135m	NDA	NDA	N/A	N/A
Xe-138	2.10E+01	NDA	N/A	N/A
Total for period	1.44E+03	1.67E+02	N/A	N/A
2. IODINES - Ci				
I-131	1.78E-03	3.57E-04	N/A	N/A
I-133	5.92E-03	4.54E-03	N/A	N/A
Total for period	7.70E-03	4.90E-03	N/A	N/A
3. PARTICULATES - Ci				
Sr-89	3.83E-05	4.72E-05	N/A	N/A
Sr-90	NDA	NDA	N/A	N/A
Cs-134	NDA	NDA	N/A	N/A
Cs-137	4.79E-06	2.73E-06	N/A	N/A
Ba/La-140	1.31E-04	1.32E-04	N/A	N/A
Total for period	1.74E-04	1.82E-04	N/A	N/A
4. TRITIUM - Ci				
H-3	4.59E-01	3.42E-01	N/A	N/A

Notes for Table 1B:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLD 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 1C
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Gaseous Effluents - Ground Level Release
January-June 1995

Nuclide Released	Continuous Mode		Batch Mode	
	Jan-Mar 1995	Apr-Jun 1995	Jan-Mar 1995	Apr-Jun 1995
1. FISSION AND ACTIVATION GASES - Ci				
N-13	NDA	NDA	N/A	N/A
Kr-85m	NDA	NDA	N/A	N/A
Kr-87	NDA	NDA	N/A	N/A
Kr-88	NDA	NDA	N/A	N/A
Xe-133	NDA	NDA	N/A	N/A
Xe-135	1.16E+02	NDA	N/A	N/A
Xe-135m	NDA	NDA	N/A	N/A
Xe-138	1.96E+01	NDA	N/A	N/A
Total for period	1.36E+02	NDA	N/A	N/A
2. IODINES - Ci				
I-131	1.51E-03	1.53E-04	N/A	N/A
I-133	5.94E-03	8.10E-05	N/A	N/A
Total for period	7.45E-03	2.34E-04	N/A	N/A
3. PARTICULATES - Ci				
Co-60	NDA	8.67E-05	N/A	N/A
Sr-89	3.58E-04	7.99E-05	N/A	N/A
Sr-90	NDA	NDA	N/A	N/A
Cs-134	NDA	NDA	N/A	N/A
Cs-137	NDA	7.26E-06	N/A	N/A
Ba/La-140	3.22E-04	2.64E-05	N/A	N/A
Total for period	6.80E-04	2.00E-04	N/A	N/A
4. TRITIUM - Ci				
H-3	1.23E+01	3.12E+00	N/A	N/A

Notes for Table 1C:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLD 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 2A
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Liquid Effluents - Summation of All Releases
January-June 1995

	Period: Jan-Mar 1995	Period: Apr-Jun 1995	Estimated Total Error
A. FISSION AND ACTIVATION PRODUCTS			
Total Release (not including H-3, noble gas, or alpha): Ci	2.71E-04	6.89E-02	12%
Average Diluted Concentration During Period: μCi/mL	9.71E-11	2.94E-08	
Percent of Effluent Concentration Limit*	4.08E-03	1.18E+00	
B. TRITIUM			
Total Release: Ci	5.99E-02	7.65E+00	9.4%
Average Diluted Concentration During Period: μCi/mL	2.15E-08	3.26E-06	
Percent of Effluent Concentration Limit*	2.15E-03	3.26E-01	
C. DISSOLVED AND ENTRAINED GASES			
Total Release: Ci	NDA	NDA	16%
Average Diluted Concentration During Period: μCi/mL	NDA	NDA	
Percent of Effluent Concentration Limit*	NDA	NDA	
D. GROSS ALPHA RADIOACTIVITY			
Total Release: Ci	NDA	NDA	34%
E. VOLUME OF WASTE RELEASED PRIOR TO DILUTION			
Waste Volume: Liters	3.56E+05	1.22E+06	5.7%
F. VOLUME OF DILUTION WATER USED DURING PERIOD			
Dilution Volume: Liters	2.79E+09	2.34E+09	10%

Notes for Table 2A:

* Additional percent of Technical Specification limit values based on dose assessments were provided in the annual supplemental dose assessment report issued prior to April 1, 1996.

1. NDA stands for No Detectable Activity.
2. LLD for dissolved and entrained gases listed as NDA is 1E-05 μCi/mL.
2. LLD for liquid gross alpha activity listed as NDA is 1E-07 μCi/mL.

Table 2B
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Liquid Effluents
January- June 1995

Nuclide Released	Continuous Mode		Batch Mode	
	Jan-Mar 1995	Apr-Jun 1995	Jan-Mar 1995	Apr-Jun 1995
1. FISSION AND ACTIVATION PRODUCTS - Ci				
Cr-51	N/A	N/A	NDA	7.97E-04
Mn-54	N/A	N/A	1.58E-05	9.64E-03
Fe-55	N/A	N/A	6.66E-05	4.93E-04
Fe-59	N/A	N/A	NDA	6.71E-04
Co-58	N/A	N/A	NDA	3.02E-03
Co-60	N/A	N/A	1.09E-04	4.02E-02
Zn-65	N/A	N/A	NDA	5.19E-04
Sr-89	N/A	N/A	7.11E-06	7.80E-06
Sr-90	N/A	N/A	2.81E-06	4.91E-06
Zr/Nb-95	N/A	N/A	NDA	NDA
Mo-99/Tc-99m	N/A	N/A	NDA	NDA
Ag-110m	N/A	N/A	NDA	6.40E-05
Sb-124	N/A	N/A	NDA	9.78E-07
I-131	N/A	N/A	NDA	2.17E-07
I-133	N/A	N/A	NDA	NDA
Cs-134	N/A	N/A	NDA	3.15E-04
Cs-137	N/A	N/A	6.97E-05	1.32E-02
Ba/La-140	N/A	N/A	NDA	NDA
Ce-141	N/A	N/A	NDA	1.37E-05
Total for period	N/A	N/A	2.71E-04	6.89E-02
2. DISSOLVED AND ENTRAINED GASES - Ci				
Xe-133	N/A	N/A	NDA	NDA
Xe-135	N/A	N/A	NDA	NDA
Total for period	N/A	N/A	NDA	NDA

Notes for Table 2B:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLD 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

Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Supplemental Information
July-December 1995

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

	Jul-Sep 1995	Oct-Dec 1995
5. BATCH RELEASES		
a. Liquid Effluents		
1. Total number of releases:	3.30E+01	1.60E+01
2. Total time period (minutes):	2.70E+03	8.00E+02
3. Maximum time period (minutes):	2.35E+02	1.50E+02
4. Average time period (minutes):	8.17E+01	5.00E+01
5. Minimum time period (minutes):	2.00E+01	5.00E+00
6. Average stream flow (Liters/min): during periods of release of effluents into a flowing stream	1.17E+06	1.17E+06
b. Gaseous Effluents	None	None
6. ABNORMAL RELEASES		
a. Liquid Effluents	None	None
b. Gaseous Effluents	None	None

Table 1A
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Gaseous Effluents - Summation of All Releases
July-December 1995

	Period: Jul-Sep 1995	Period: Oct-Dec 1995	Estimated Total Error
A. FISSION AND ACTIVATION GASES			
Total Release: Ci	3.85E+02	2.09E+02	22%
Average Release Rate During Period: µCi/sec	4.88E+01	2.65E+01	
Percent of Technical Specification Limit	*	*	
B. IODINES			
Total Iodine-131 Release: Ci	9.11E-04	1.42E-03	20%
Average Release Rate During Period: µCi/sec	1.16E-04	1.80E-04	
Percent of Technical Specification Limit	*	*	
C. PARTICULATES			
Total Release: Ci	5.77E-04	5.44E-04	21%
Average Release Rate During Period: µCi/sec	7.32E-05	6.90E-05	
Percent of Technical Specification Limit	*	*	
Gross Alpha Radioactivity: Ci	NDA	NDA	
D. TRITIUM			
Total Release: Ci	8.51E+00	2.32E+01	20%
Average Release Rate During Period: µCi/sec	1.08E+00	2.94E+00	
Percent of Technical Specification Limit	*	*	

Notes for Table 1A:

* Percent of Technical Specification limit values in above sections are based on dose assessments not performed as part of this report. These were provided in the annual supplemental dose assessment report issued prior to April 1, 1996.

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

Table 1B
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Gaseous Effluents - Elevated Release
July-December 1995

Nuclide Released	Continuous Mode		Batch Mode	
	Jul-Sep 1995	Oct-Dec 1995	Jul-Sep 1995	Oct-Dec 1995
1. FISSION AND ACTIVATION GASES - Ci				
N-13	NDA	NDA	N/A	N/A
Ar-41	NDA	9.40E-01	N/A	N/A
Kr-85m	1.01E+02	1.80E+01	N/A	N/A
Kr-87	2.94E+01	1.69E+00	N/A	N/A
Kr-88	1.71E+02	1.79E+01	N/A	N/A
Xe-133	7.00E+01	3.34E+01	N/A	N/A
Xe-135	2.57E+00	2.70E+00	N/A	N/A
Xe-135m	NDA	NDA	N/A	N/A
Xe-138	1.09E+01	1.78E+01	N/A	N/A
Total for period	3.85E+02	9.24E+01	N/A	N/A
2. IODINES - Ci				
I-131	7.57E-04	7.44E-04	N/A	N/A
I-133	3.32E-03	2.58E-03	N/A	N/A
Total for period	4.08E-03	3.33E-03	N/A	N/A
3. PARTICULATES - Ci				
Sr-89	3.40E-05	2.00E-05	N/A	N/A
Sr-90	NDA	NDA	N/A	N/A
Cs-134	NDA	NDA	N/A	N/A
Cs-137	NDA	NDA	N/A	N/A
Ba/La-140	1.58E-04	3.53E-05	N/A	N/A
Total for period	1.92E-04	5.53E-05	N/A	N/A
4. TRITIUM - Ci				
H-3	7.04E-01	5.38E-01	N/A	N/A

Notes for Table 1B:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLD 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 1C
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Gaseous Effluents - Ground Level Release
July-December 1995

	Continuous Mode		Batch Mode	
Nuclide Released	Jul-Sep 1995	Oct-Dec 1995	Jul-Sep 1995	Oct-Dec 1995
1. FISSION AND ACTIVATION GASES - Ci				
N-13	NDA	6.20E-01	N/A	N/A
Ar-41	NDA	NDA	N/A	N/A
Kr-85m	NDA	2.50E-01	N/A	N/A
Kr-87	NDA	1.12E+00	N/A	N/A
Kr-88	NDA	7.40E-01	N/A	N/A
Xe-133	NDA	1.20E-01	N/A	N/A
Xe-135	NDA	1.06E+02	N/A	N/A
Xe-135m	NDA	2.11E+00	N/A	N/A
Xe-138	NDA	5.58E+00	N/A	N/A
Total for period	NDA	1.17E+02	N/A	N/A
2. IODINES - Ci				
I-131	1.54E-04	6.80E-04	N/A	N/A
I-133	1.87E-03	6.23E-03	N/A	N/A
Total for period	2.02E-03	6.91E-03	N/A	N/A
3. PARTICULATES - Ci				
Co-60	NDA	NDA	N/A	N/A
Sr-89	3.29E-04	2.34E-04	N/A	N/A
Sr-90	NDA	NDA	N/A	N/A
Cs-134	NDA	NDA	N/A	N/A
Cs-137	NDA	NDA	N/A	N/A
Ba/La-140	5.55E-05	2.55E-04	N/A	N/A
Total for period	3.85E-04	4.89E-04	N/A	N/A
4. TRITIUM - Ci				
H-3	7.81E+00	2.27E+01	N/A	N/A

Notes for Table 1C:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLD 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 2A
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Liquid Effluents - Summation of All Releases
July-December 1995

	Period: Jul-Sep 1995	Period: Oct-Dec 1995	Estimated Total Error
A. FISSION AND ACTIVATION PRODUCTS			
Total Release (not including H-3, noble gas, or alpha): Ci	6.78E-03	4.12E-04	12%
Average Diluted Concentration During Period: µCi/mL	2.13E-09	4.39E-10	
Percent of Effluent Concentration Limit*	3.69E-02	7.55E-03	
B. TRITIUM			
Total Release: Ci	9.84E+00	1.69E-02	9.4%
Average Diluted Concentration During Period: µCi/mL	3.09E-06	1.80E-08	
Percent of Effluent Concentration Limit*	3.09E-01	1.80E-03	
C. DISSOLVED AND ENTRAINED GASES			
Total Release: Ci	8.92E-06	NDA	16%
Average Diluted Concentration During Period: µCi/mL	2.81E-12	NDA	
Percent of Effluent Concentration Limit*	1.40E-06	--	
D. GROSS ALPHA RADIOACTIVITY			
Total Release: Ci	NDA	NDA	34%
E. VOLUME OF WASTE RELEASED PRIOR TO DILUTION			
Waste Volume: Liters	1.08E+06	1.34E+05	5.7%
F. VOLUME OF DILUTION WATER USED DURING PERIOD			
Dilution Volume: Liters	3.18E+09	9.39E+08	10%

Notes for Table 2A:

* Additional percent of Technical Specification limit values based on dose assessments were provided in the annual supplemental dose assessment report issued prior to April 1, 1996.

1. NDA stands for No Detectable Activity.
2. LLD for dissolved and entrained gases listed as NDA is 1E-05 µCi/mL.
2. LLD for liquid gross alpha activity listed as NDA is 1E-07 µCi/mL.

Table 2B
Pilgrim Nuclear Power Station
Effluent and Waste Disposal Report
Liquid Effluents
July-December 1995

Nuclide Released	Continuous Mode		Batch Mode	
	Jul-Sep 1995	Oct-Dec 1995	Jul-Sep 1995	Oct-Dec 1995

1. FISSION AND ACTIVATION PRODUCTS - Ci

Cr-51	N/A	N/A	1.72E-04	NDA
Mn-54	N/A	N/A	5.26E-04	3.09E-05
Fe-55	N/A	N/A	1.97E-03	2.62E-04
Fe-59	N/A	N/A	3.59E-05	NDA
Co-58	N/A	N/A	9.38E-06	NDA
Co-60	N/A	N/A	2.71E-03	7.98E-05
Zn-65	N/A	N/A	1.64E-06	NDA
Sr-89	N/A	N/A	4.71E-04	NDA
Sr-90	N/A	N/A	1.41E-06	1.24E-06
Zr/Nb-95	N/A	N/A	7.42E-07	NDA
Mo-99/Tc-99m	N/A	N/A	NDA	NDA
Ag-110m	N/A	N/A	5.15E-05	NDA
Sb-124	N/A	N/A	8.75E-07	NDA
I-131	N/A	N/A	2.99E-06	NDA
I-133	N/A	N/A	NDA	NDA
Cs-134	N/A	N/A	NDA	NDA
Cs-137	N/A	N/A	5.93E-05	3.82E-05
Ba/La-140	N/A	N/A	7.72E-04	NDA
Ce-141	N/A	N/A	NDA	NDA
Total for period	N/A	N/A	6.78E-03	4.12E-04

2. DISSOLVED AND ENTRAINED GASES - Ci

Xe-133	N/A	N/A	NDA	NDA
Xe-135	N/A	N/A	8.92E-06	NDA
Total for period	N/A	N/A	8.92E-06	NDA

Notes for Table 2B:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLD 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 October 26 and 31, 1995. The census was conducted by driving along each improved road/street in the Plymouth area within three 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 three miles (SSW and NNW sectors), the survey was extended to five miles. A total of 33 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 Boston Edison Company 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 1995 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	0.54 mi SE
Brook Road	1.76 mi SSE
Beaverdam Road	2.14 mi S
Clay Hill Road	1.02 mi W

In addition to these special sampling locations identified and sampled in conjunction with the 1995 land use census, samples were also collected at or near the Plymouth County Farm (3.5 mi W), Whipple Farm (1.8 mi SW), and from the control location at Bridgewater Farm (19 mi W).

Samples of naturally-growing vegetation were also collected from 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 were:

Highest Main Stack D/Q:	0.91 mi SSW
Highest Reactor Building Vent D/Q:	0.31 mi ESE
2nd highest D/Q, both release points:	0.22 mi SW

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 1995 sampling program.

APPENDIX D

ENVIRONMENTAL MONITORING PROGRAM DISCREPANCIES

There were a number of instances during 1995 in which problems were encountered in the collection of environmental samples. Most of these problems were minor in nature and did not have an adverse affect on the results or integrity of the monitoring program. Details of these various problems are given below.

In 1995, four thermoluminescent dosimeters (TLDs) were not recovered from their assigned locations during the quarterly retrieval process, and one TLD was damaged during processing. During the first quarter, the TLD was not recovered at North Plymouth (NP). In this case, the plastic strap holding the TLD enclosure to the utility pole had broken and the TLD was lost. During the second quarter the TLD was collected from the site on Bourne Avenue (BE), but was damaged by the automatic reader during processing. Therefore, no data were available from this TLD during this period. During the fourth quarter, TLDs were not recovered at Station F (F), Station J (J), and along Earl Road (EA). In the cases of Stations F and J, the plastic strap holding the TLD enclosure had broken and the TLDs were lost. The utility pole to which TLD EA had been attached had been replaced and the TLD enclosure removed. In all cases of TLD losses, the TLDs were re-located in the immediate vicinity, but steps were taken whenever possible to post the TLD cages in a less conspicuous manner.

Within the air sampling program, there were a few instances in which continuous sampling was interrupted at the eleven airborne sampling locations during 1995. 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 affect 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.

In addition to the short-term interruptions, there were several instances where equipment malfunctions or power outages affected more than one sampling station or resulted in missing more than 24 hours of sampling capability out of the weekly (168 hour) period. In those cases involving equipment failure, the sampling rack was changed out and replaced with an operational unit. Pump malfunction was attributed to two such sampling losses at Pedestrian Bridge (11.7 hour run time) between 28-Mar-95 and 04-Apr-95, and also at the Overlook Area (18.7 hour run time) between 30-May-95 and 06-Jun-95.

When sampling interruptions resulted from power losses, steps were taken to restore power as soon as possible. Equipment and power modifications in the Screenhouse resulted in interruptions to the power bus supplying the Pedestrian Bridge air sampler. Such power interruptions were attributed to a sampling loss during the week of 25-Apr-95 to 02-May-95 (8.5 hour run time). Additional Screenhouse modifications later in the year resulted in power interruptions to the Pedestrian Bridge during the periods of 24-Oct-95 to 31-Oct-95 (100 hour run time), 31-Oct-95 to 07-Nov-95 (115 hour run time), 07-Nov-95 to 14-Nov-95 (148 hour run time), and 14-Nov-95 to 21-Nov-95 (100 hour run time).

Power was also interrupted at the Pedestrian Bridge when the ground fault interrupt circuit tripped during the periods of 12-Dec-95 to 19-Dec-95 (142 hour run time), and 19-Dec-95 to 27-Dec-95 (164 hour run time). These breaker trips were due to salt spray and snow entering the sampler enclosure during high winds accompanying large storms.

Repair and remodeling activities at the Plymouth Town Hall (PC) resulted in a power interruption during the week of 28-Nov-95 to 05-Dec-95. The sampler ran 120 hours during this period.

Despite the lower-than-normal sampling volumes in the various instances involving power interruptions and equipment failures, required LLDs were met on 569 of the 571 particulate filters and 569 of the 571 iodine cartridges collected during 1995. The required LLDs were not achieved only on those samples when the sampler run time was very short (<24 hours) out of the weekly period due to equipment failure or power losses described above. Despite the low sample volumes in these cases, the samples were still counted for screening purposes. None of the 1186 sample analyses performed indicated any questionable or anomalous results. When viewed collectively during the entire year of 1995, the following sampling recoveries were achieved in the airborne sampling program:

Location	Recovery	Location	Recovery	Location	Recovery
WS	100.0%	PB	92.9%	PC	99.2%
ER	100.0%	OA	98.3%	MS	100.0%
WR	100.0%	EB	100.0%	EW	100.0%
PL	100.0%	CR	99.9%		

Samples of naturally-growing vegetation (grass, leaves from trees and bushes, etc.) were 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. In addition to these substitute samples, samples of naturally-growing vegetation were also collected in the three locations yielding the highest calculated deposition coefficients (D/Q) for airborne releases from PNPS. Such samples represent "worst case" samples for comparison, as the deposition and resulting ground-level concentrations of radionuclides at these locations would be 2 to 10 times higher than at the gardens identified during the land use census. 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 E of this report.

Samples of Group II (near-bottom distribution) fishes were not collected in the vicinity of the Discharge Outfall during the first quarter of 1995. Fish species in this category tend to move to deeper water during the colder months and were not available in the area for collection. Although concerted and repeated efforts were made by personnel from the Massachusetts Division of Marine Fisheries to collect the fish, they were not able to obtain the required samples. Also, samples of Group III (Anadromous) and Group IV (Coastal migratory) fishes are normally collected from the vicinity of the Discharge Outfall by mid-August of each year. Due to low fish populations, the collection of species in these categories was delayed until mid-September, fulfilling the annual sampling requirement.

In summary, the various problems encountered in collecting environmental samples during 1995 were relatively minor when viewed in the context of the entire monitoring program. All required LLDs were achieved on all samples collected, and no anomalous or questionable results were obtained. None of the discrepancies resulted in an adverse affect on the overall monitoring program.

APPENDIX E

QUALITY ASSURANCE PROGRAM RESULTS

A. Introduction

The accuracy of the data obtained through Boston Edison Company's 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 Boston Edison from the Yankee Atomic Electric Company's Environmental Laboratory (YAEL). Much of the information contained herein has been summarized from the YAEL "Semi-Annual Quality Assurance Status Report: January - June 1995," and the YAEL "Semi-Annual Quality Assurance Status Report: July - December 1995."

B. Laboratory Analyses

The quality control programs that were performed during 1995 to demonstrate the validity of laboratory analyses by YAEL include the following:

1. YAEL participation in the Environmental Protection Agency (EPA) Interlaboratory Comparison (cross-check) program for those types of samples routinely analyzed by the laboratory. This provides an independent check of accuracy and precision of the laboratory analyses. When the results of the cross-check analysis fall outside of the control limit, an investigation is made to determine the cause of the problem, and corrective measures are taken, as appropriate.

2. YAEL intralaboratory quality control program to assure the validity and reliability of the data. This program includes quality control of laboratory equipment, use of reference standards for calibration, and analysis of blank and spiked samples. The records of the quality control program are reviewed by the responsible cognizant individual, and corrective measures are taken, as appropriate.

3. A blind duplicate program is maintained in which paired samples from the five sponsor companies, including Boston Edison, are prepared from homogeneous media and sent to the laboratory for analysis. The results from this blind duplicate program are used to check for precision in laboratory analyses.

The results of these studies are discussed below.

a. YAEL Intralaboratory and EPA Interlaboratory Results

Results of the Quality Assurance Program are reported in two separate categories based upon YAEL acceptance criteria. The first criterion concerns accuracy, which is defined as the deviation of any one result from the assumed known value. The second criterion concerns precision, which deals with the ability of the measurement to be faithfully replicated by a comparison of an individual result to the mean of all results for a given sample set. In addition to evaluating all individual samples against the YAEL acceptance criteria, if the mean result of an EPA cross-check analysis exceeds the 3-sigma control limit (as defined by the EPA in their known value summary report) an investigation is conducted by YAEL personnel to determine the reason for the deviation.

The Quality Assurance Program implemented at the analytical laboratory indicated good precision and accuracy in reported values. Table 1 shows the cumulative results of accuracy and precision for laboratory analyses in 1995 for YAEL intralaboratory analyses and EPA interlaboratory cross-check analyses. For accuracy, 70 and 89 percent of the results were within 5 and 10 percent of the known values, respectively, with 97 percent of all results falling within the laboratory criterion of 15 percent. For precision, 75 and 91 percent of the results were within 5 and 10 percent of the mean, respectively, with 100 percent of all results meeting the laboratory criterion of 15 percent.

The results of the EPA Interlaboratory Comparison program, when considered apart from the remainder of the Quality Assurance program, were satisfactory with respect to accuracy and precision in 1995. A total of 126 analyses were performed on air particulate filters, milk, and water. Based upon this sample analysis total, 119 analyses (i.e., 92 percent) met the EPA's definition of "control limit" acceptance criteria for accuracy.

TABLE 1

INTRALABORATORY AND EPA INTERLABORATORY RESULTS - 1995

Category	Total Number of Measurements	Fraction of Measurements within deviation range		
		0-5%	0-10%	0-15%*
	YAEL INTRALABORATORY ANALYSES			
Accuracy	301	79.1%	93.7%	99.3%
Precision	153	75.8%	89.5%	100.0%
	EPA INTERLABORATORY ANALYSES			
Accuracy	126	48.4%	76.2%	92.1%
Precision	126	74.6%	93.7%	100.0%
	TOTAL COMBINED ANALYSES			
Accuracy	427	70.0%	88.5%	97.2%
Precision	279	75.3%	91.4%	100.0%

* This category also contains those samples having a verified zero concentration which were analyzed and found not to contain detectable levels of the nuclide of interest.

b. Blind Duplicate Program

A total of 49 paired samples were submitted by the five sponsor companies for analysis during 1995. The database used for the duplicate analysis consisted of paired measurements of 26 gamma-emitting nuclides, H-3, Sr-89, Sr-90, low-level I-131, and gross beta. The sample media included milk, groundwater, sea/river water, food crops, marine algae, and mussel meat.

A dual-level criteria for agreement has been established. If the paired measurements fall within ± 15 percent of their average value, then agreement between the measurements has been met. If the value falls outside of the ± 15 percent criteria, then a two standard deviation range (95 percent confidence level) is established for each of the analyses. If the confidence intervals for the two analyses overlap, agreement is obtained.

From the 49 paired samples, 1260 paired duplicate measurements were analyzed during 1995. Out of these measurements, 1249 (99.1%) fell within the established criteria discussed above. No trend was evident with respect to repeated failings of measurements for the listed radionuclides and media.

C. Environmental TLD Measurements

Quality control testing was performed during 1995 to demonstrate the performance of the routine environmental TLD processing by YAEL. 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 YAEL. In all of these tests, dosimeters were irradiated to known doses and submitted to YAEL 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.

YAEL 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 percent 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)." Acceptance criteria for accuracy and precision to be used in 1995 was adopted by the Laboratory Quality Control Audit Committee (LQCAC) on November 13, 1987. Recognizing the inherent variability associated with each dosimeter type, control limits for both accuracy and precision of ± 3 sigma plus 5 percent (for bias) were set by the LQCAC. The actual magnitude of the 3 sigma plus 5 percent 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 1995, there were 96 quality control tests. All 48 environmental TLDs tested during January - June 1995 were within the control limits for both accuracy and precision. The comparisons yielded a mean accuracy of -0.60 percent. The comparisons exhibited a precision value with an overall standard deviation of 1.5 percent. The 48 TLDs tested in July - December 1995 showed a mean accuracy of +0.7 percent. TLDs measured during the second semiannual period exhibited a precision value with a standard deviation of 1.1 percent, well within the acceptance criteria. In total, all 84 environmental TLDs tested during 1995 were within the control limits for accuracy (± 20.1%) and precision (± 12.8%).

D. Conclusions

Laboratory analysis results for the EPA Interlaboratory Comparison program, the YAEL intralaboratory quality control program, and the sponsor companies blind duplicate program met the laboratory criterion of less than 15% deviation in more than 94% of all cases.

The environmental TLD measurements for intralaboratory and independent third party comparisons resulted in both mean accuracy and precision within 5 percent deviation.

Therefore, the quality assurance programs for the Boston Edison Company's Radiological Environmental Monitoring Program indicated that the analyses and measurements performed by Yankee Atomic Environmental Laboratory during 1995 exhibited acceptable accuracy and precision.