PNPS Technical Specifications
Section 6.9.C.2

BOSTON EDISON
Pilgrim Nuclear Power Station
Rocky Hill Road
Plymouth, Massachusetts 02360

R. A. Anderson
Vice President &
Station Director
Nuclear Operations

April 30, 1991
BECo Ltr. 91-62

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

Docket No. 50-293
License No. DPR-35

Dear Sir:

In accordance with the Pilgrim Nuclear Power Station Technical Specification Section 6.9.C.2, the Boston Edison Company submits the Annual Environmental Radiation Monitoring Program Report for 1990 (Report #23).

R. A. Anderson

WM/bal

Attachment

cc: Mr. Thomas T. Martin
Regional Administrator, Region I
U.S. Nuclear Regulatory Commission
475 Allendale Rd.
King of Prussia, PA 19406

Sr. NRC Resident Inspector - Pilgrim Station

IE25
1/1

PILGRIM NUCLEAR POWER STATION

Radiological Environmental Monitoring Program Report No. 23

January 1 through December 31, 1990

BOSTON EDISON

BOSTON EDISON COMPANY

PILGRIM NUCLEAR POWER STATION

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

REPORT NO. 23

January 01 through December 31, 1990

Prepared by: _____
M. L. Most
Environmental Engineer

_____
K. J. Sejkora
Environmental Program Manager

Reviewed by: _____
C. S. Goddard
Chemistry and Radwaste Section Manager

Approved by: _____
N. J. DiMascio
Radiological Section Manager

TABLE OF CONTENTS

TABLE OF CONTENTS (cont.)

LIST OF TABLES

LIST OF TABLES (cont.)

LIST OF FIGURES

LIST OF FIGURES (cont.)

EXECUTIVE SUMMARY

Boston Edison Company
Pilgrim Nuclear Power Station
Radiological Environmental Monitoring Program
Report
January 1 through December 31, 1990

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, 1990. 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 1990, there were 1,418 samples collected from the atmospheric, aquatic and terrestrial environments. In addition, 420 exposure measurements were obtained using environmental thermoluminescent dosimeters (TLDs) and six exposure rate measurements were performed using a high pressure ion chamber. These 1,418 samples and 420 monitoring devices were collected by Boston Edison Company and Massachusetts Division of Marine Fisheries personnel.

All samples were collected as required by the PNPS Technical Specifications with the following exceptions: 2 out of 160 of the TLD measurements were missed, and samples of Group II fishes were not collected during the first quarter. Of the TLDs required by PNPS Technical Specifications, there were two TLDs which were found missing from their posted locations during the quarterly retrievals. The missing TLDs and cages were relocated to be inconspicuous and less accessible, where possible. In addition, Group II (near-bottom distribution) fishes were not available in the vicinity of the discharge canal between January and March. Therefore, samples of fish from this category were not collected for the first quarter of the year.

There were 1,600 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 September 11 and 29, 1990. A total of 31 gardens with 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 31 garden locations identified, eight were sampled as part of the environmental monitoring program.

RADIOLOGICAL IMPACT TO THE ENVIRONMENT

During 1990, 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. Shellfish (mussels) was the only sampling medium which showed radioactivity which could be attributable to Pilgrim Station's operation.

None of the radioactivity analysis results exceeded the reporting levels specified in the PNPS Technical Specifications. Furthermore, the detectable radioactivity which could be attributable to Pilgrim Station's operation was only a small percentage of the naturally-occurring and other man-made amounts of radioactivity. In addition, off-site direct radiation measurements using environmental TLDs and a high pressure ion chamber ranged between 42 and 150 mR/year. This range of 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 1990, 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 maximum estimated total body dose to the general public from radioactive effluents due to PNPS operations for 1990 was about 0.2 mrem for the year. This conservative estimate is well below the EPA's annual dose limit to any member of the general public and is a fraction of a percent of the typical dose received from natural and man-made radiation.

In addition to dose calculations based on radioactive effluents, a special study was initiated to determine the dose contribution from radioactivity that was detected in mussels. Results of this study showed that the radioactivity in shellfish would result in a maximum dose to a member of the general public of much less than one mrem, using extremely conservative assumptions.

CONCLUSIONS

The 1989 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 1990 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.[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, 1990.

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.[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

Sources and Doses of Radiation[3]

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	Less than 1
		Nuclear Power Plants	Less than 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.

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.

Radon and thoron levels vary greatly with location. Many newspaper articles have recently appeared concerning elevated levels of radon/thoron at some locations in Colorado, New York, Pennsylvania and New Jersey. Residents of these areas 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 fully operational from January 1 to December 31, 1990. 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-1 CAPACITY FACTOR

199C

OPERATING PERCENT CAPACITY

(Based on 670 MWe)

Month	Percent Capacity
January	99.4
February	97.4
March	30.0
April	5.4
May	77.9
June	96.3
July	55.1
August	94.5
September	21.6
October	98.7
November	96.8
December	94.5
Average	72.3

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.

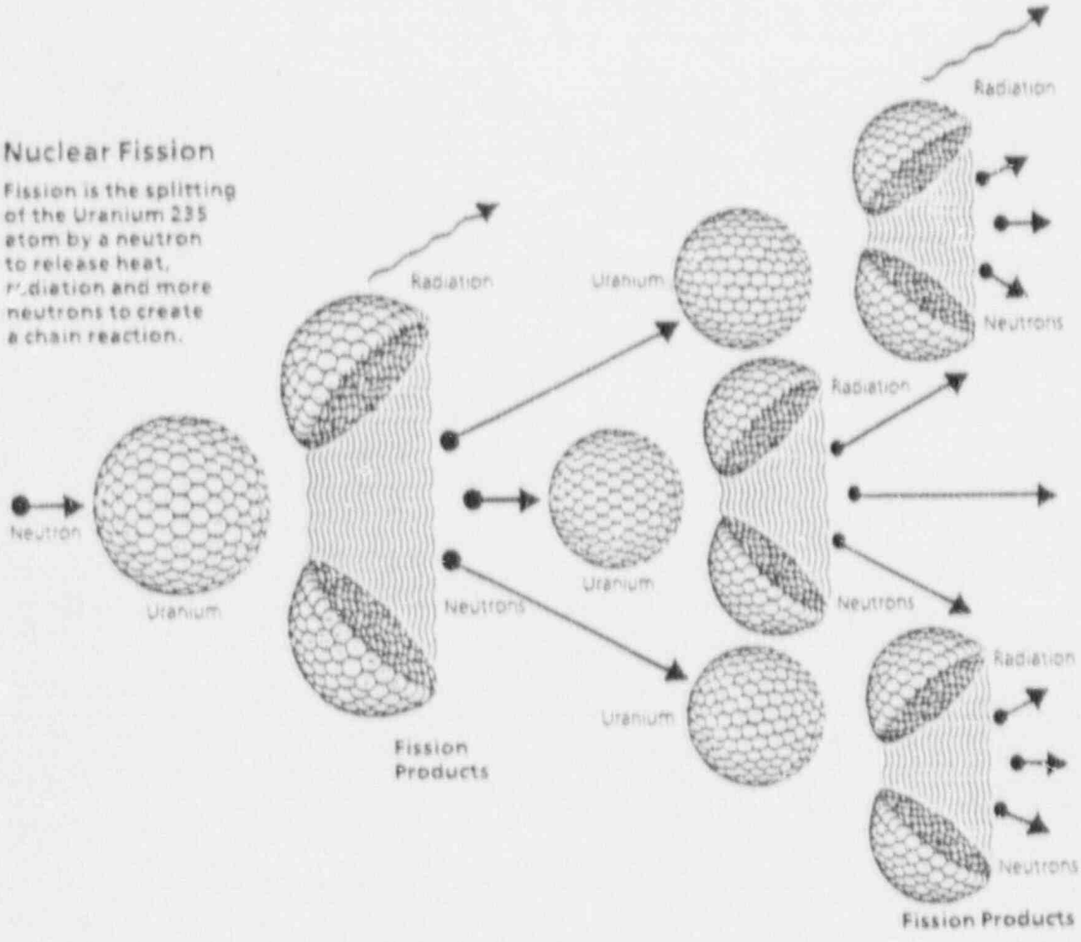


Figure 1.3-1
Radioactive Fission Products

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, (see Figure 1.3-1)[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 cesium-137, iodine-131, strontium-90, xenon-133, and krypton-85.

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 cobalt-60, cobalt-58, iron-59, manganese-54, and zinc-65.

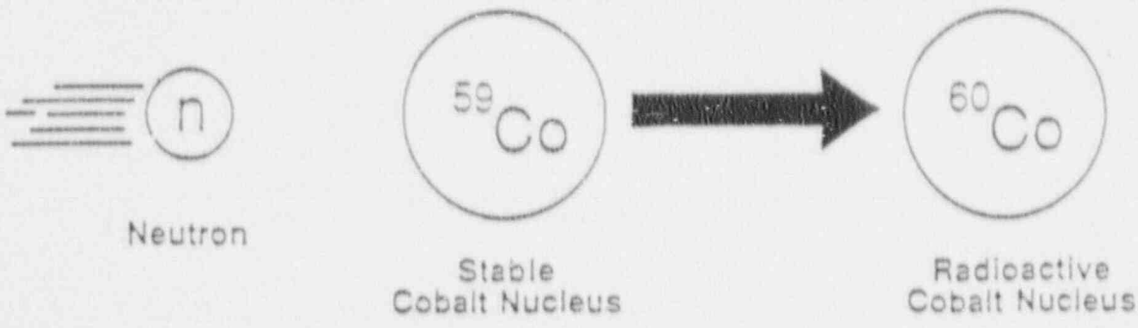


Figure 1.3-2
Radioactive Activation Product

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,[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.

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

SIMPLIFIED DIAGRAM OF PILGRIM NUCLEAR POWER STATION

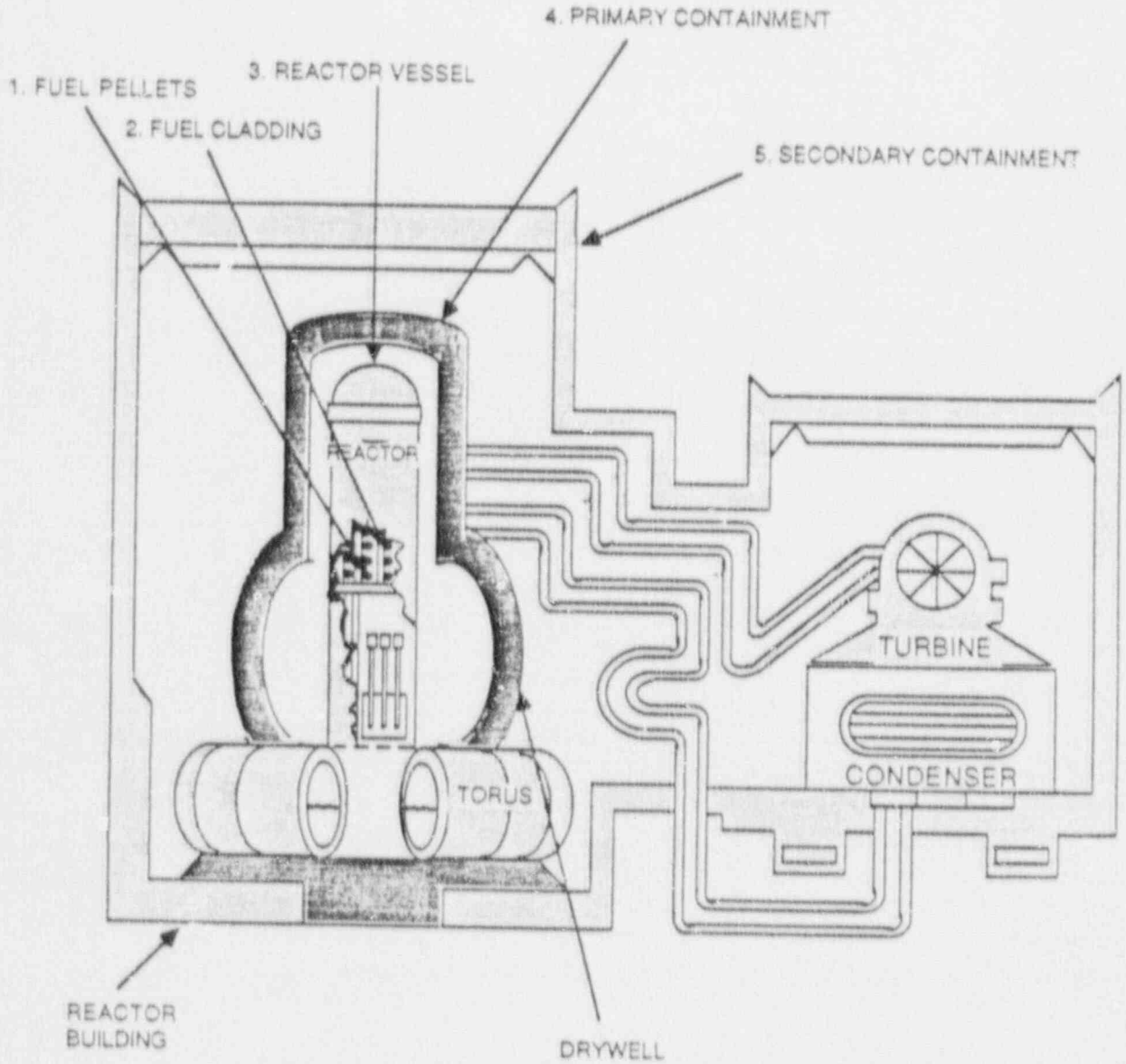


Figure 1.3-3
Five Barriers That Confine Radioactive Materials

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;
- 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 has a shielded radioactivity monitor located on it. 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 be 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;
- 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, has a shielded radiation detector located on it. 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 draws a portion of the air out 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, a pre-filter to remove radioactive particulates, and several charcoal adsorbers to remove radioactive iodines and further retard the short half-life gases.

The radioactive off-gas from the condenser is then directed into a ventilation pipe to which the off-gas radiation monitor is attached. The radiation level meter and strip chart recorder for this detector are also located in the Control Room. If the 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 charcoal adsorbers fail to return the radioactivity levels 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 effluent control 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 the continuous radiation monitoring and the periodic sampling and analysis is to measure the quantities of radioactivity being released to determine if the radioactivity release limits are complied with. 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 1990 were reported to the Nuclear Regulatory Commission semiannually. The 1990 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 impact 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

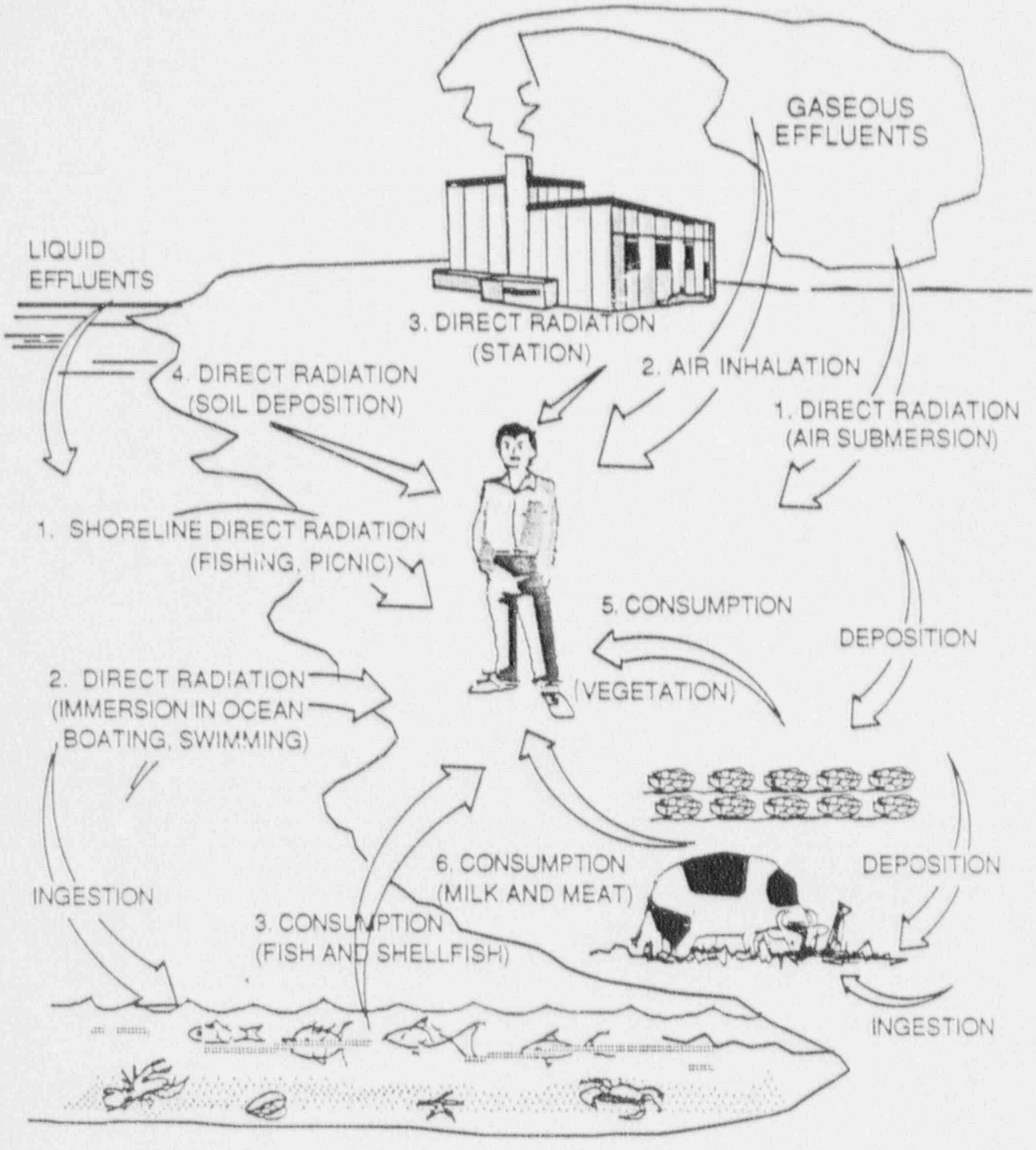


Figure 1.5-1
Generalized Radiation Exposure Pathways to Humans

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

1) external radiation from an airborne plume of radioactivity;

2) internal radiation from inhalation of airborne radioactivity;

3) direct 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 impact 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 measurements 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.[6] The dose calculations are documented and described in detail in the Pilgrim Nuclear Power Station's Off-site Dose Calculation Manual[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 20.105,[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 500 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,[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,[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 1990 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 1990 will be discussed in Section 2 of this report.

2.0 Description and Results of the Radiological Environmental Monitoring Program

The Radiological Environmental Monitoring Program (REMP) at Boston Edison Company's Pilgrim Nuclear Power Station was initiated in August of 1968. The purpose of the pre-operational environmental monitoring program was to:[11]

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 continued for approximately three and a half years, from August 1968 to June 1972.[12] 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;
- Direct 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 provides information on radioactivity and radiation levels in the environment for the purpose of:[13]

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 which specify an acceptable monitoring program.[14] 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[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.[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.

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 1990 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 2.0-1. These sampling locations are also displayed on the maps shown in Figures 2.0-1, 2, 3, 4, and 5.

The radiation monitoring locations for the environmental TLDs are shown in Figures 2.0-1, 2 and 3. The frequency of collection and types of radioactivity analysis are described in Appendix C, Table 8.1-1.

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.

Table 2.0-1

Pilgrim Nuclear Power Station's Radiological Environmental
1990 Routine Sampling Locations

Media	No	Code	Description	Dist.		Dir.
Air Particulate	00	WS	Warehouse	0.1	Mi	ESE
Filters/	01	ER	E. Rocky Hill Road	0.3	Mi	SE
Charcoal Cartridges	03	WR	W. Rocky Hill Road	0.2	Mi	WSW
	06	PL	Property Line	0.3	Mi	W
	07	PB	Pedestrian Bridge	0.1	Mi	NNW
	08	OA	Overlook Area	0.1	Mi	SW
	09	EB	East Breakwater	0.3	Mi	SE
	10	CR	Cleft Rock	0.9	Mi	SW
	15	PC	Plymouth Center	4.1	Mi	W
	17	MS	Manomet Substation	2.3	Mi	SSE
	21	EW	East Weymouth Control	24	Mi	NW
Surface Water	11	DIS	Discharge Canal	0.1	Mi	NNW
	17	BP	Barlett Pond	3	Mi	SE
	23	PP	Powder Point Control	8	Mi	NNW
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	SE
	23	PP	Powder Point Control	8	Mi	NNW
	24	GH	Green Harbor Control	9	Mi	NNW
Irish Moss	11	DIS	Discharge Canal	0.2	Mi	N
	15	MP	Manomet Point	3	Mi	SE
	22	EL	Ellisville	8	Mi	SE
	34	BR	Brant Rock Control	10	Mi	NNW
American Lobster	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
Fishes	11	DIS	Discharge Canal	0.2	Mi	N
	29	PC	Priest Cove Control	30	Mi	SW
	30	JR	Jones River Control	8	Mi	NNW
	92	MV	Vineyard Sound Control	50	Mi	SSW
	98	CC-Bay	Cape Cod Bay Control	15	Mi	ESE
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	SE
	24	GH	Green Harbor Control	9	Mi	NNW
Milk	11	CF	Plymouth County Farm	3.4	Mi	W
	21	WF	Whitman Farm Control	20	Mi	WNW

Table 2.0-1 (continued)

Pilgrim Nuclear Power Station's Radiological Environmental
1990 Sampling Locations

Media	No	Code	Description	Dist.		Dir.
Cranberries	13	MR	Manomet Pt. Bog	2.5	Mi	SE
	14	BR	Bartlett Rd. Bog	2.7	Mi	SSE
	23	PS	Pine St. Bog Control	17	Mi	WNW
Vegetation	11	CF	Plymouth County Farm	3.4	Mi	W
	27	BF	Bridgewater Farm Ctrl	20	Mi	W
	43	WH	Whipple Farm	1.8	Mi	SW
	60	AF	Work Residence	0.8	Mi	SE
	77	MG	Moon Residence	2.1	Mi	WSW
Beef Forage	11	CF	Plymouth County Farm	3.4	Mi	W
	12	WF	Whitman Farm Control	20	Mi	WNW

Figure 2.0-1

Environmental Thermoluminescent
Dosimeter and Air Sampling Locations Within Exclusion Area

ENVIRONMENTAL TLD LOCATIONS

Code	Description	Dist.*	Dir.*
A	Station A	1300 ft	W
B	Station B	1300 ft	SSW
C	Station C	1700 ft	SE
D	Station D	1700 ft	NNW
EB	East Breakwater	1800 ft	SE
F	Station F	1400 ft	NW
G	Station G	1700 ft	WNW
I	Station I	1600 ft	NW
L	Station L	1400 ft	ESE
OA	Overlook Area	500 ft	W
P01	Sec H Shore	720 ft	NNW
P02	Fence Shore	440 ft	NW
P03	Fen L Screenh	330 ft	NW
P04	Fen R Screenh	220 ft	N
P05	Fen Water Tank	260 ft	NE
P06	Fen Culvert	280 ft	ENE
P07	Fen Intake	400 ft	E
P08	Fen New Admin	300 ft	E
P09	Fen TCF Side	450 ft	E
P10	Fen Intake TCF	740 ft	ESE
P11	Gate Wh to TCF	620 ft	SE
P12	Fen Wh Con Gate	660 ft	SSE
P13	Fen Con & RHR	740 ft	S
P14	Fen Butler B	750 ft	S
P15	Fen Unit #9	740 ft	SSW
P16	Fen Swy M Gate	560 ft	SW
P17	Fen Shf M Gate	350 ft	WNW
P18	I&C N Admin	290 ft	S
P19	Compliance Area	280 ft	S
P20	Dosimetry Window	220 ft	SSE
P21	WW Admin & Turb	170 ft	SE
P22	QA/QC Area	450 ft	SE
P23	CMG Area	400 ft	SSE
P24	Old Admin Bld 2nd	190 ft	W
P25	First Aid Trailer	250 ft	WNW
P26	Fence Warehouse	490 ft	SE
P27	TCF Boat Launch	640 ft	ESE
P28	TCF Cont. Lot	800 ft	ESE
PA	Parking Area	1200 ft	NNW
PB	Pedestrian Bridge	700 ft	N
PL	Property Line	1700 ft	NW
TC	Training Center	520 ft	W
WR	W. Rocky Hill Road	2600 ft	WNW
WS	Warehouse	600 ft	SSE
PMT	Plymouth Met Twr	1400 ft	NW
HB	Halls Bog	2000 ft	SSE
CT	Contractor Lot	1100 ft	SSE

AIR SAMPLE LOCATIONS

Code	Description	Dist.*	Dir.*
EB	East Breakwater	0.33 mi	ESE
OA	Overlook Area	0.09 mi	W
PB	Pedestrian Bridge	0.13 mi	N
PL	Property Line	0.32 mi	NW
WR	W. Rocky Hill Road	0.48 mi	WNW
WS	Warehouse	0.11 mi	SSE

* Distance and direction are measured from the centerline of the reactor to the sampling/monitoring location. Values listed are approximate and are being evaluated in conjunction with revision of sampling location maps.

Figure 2.0-1 (cont.)

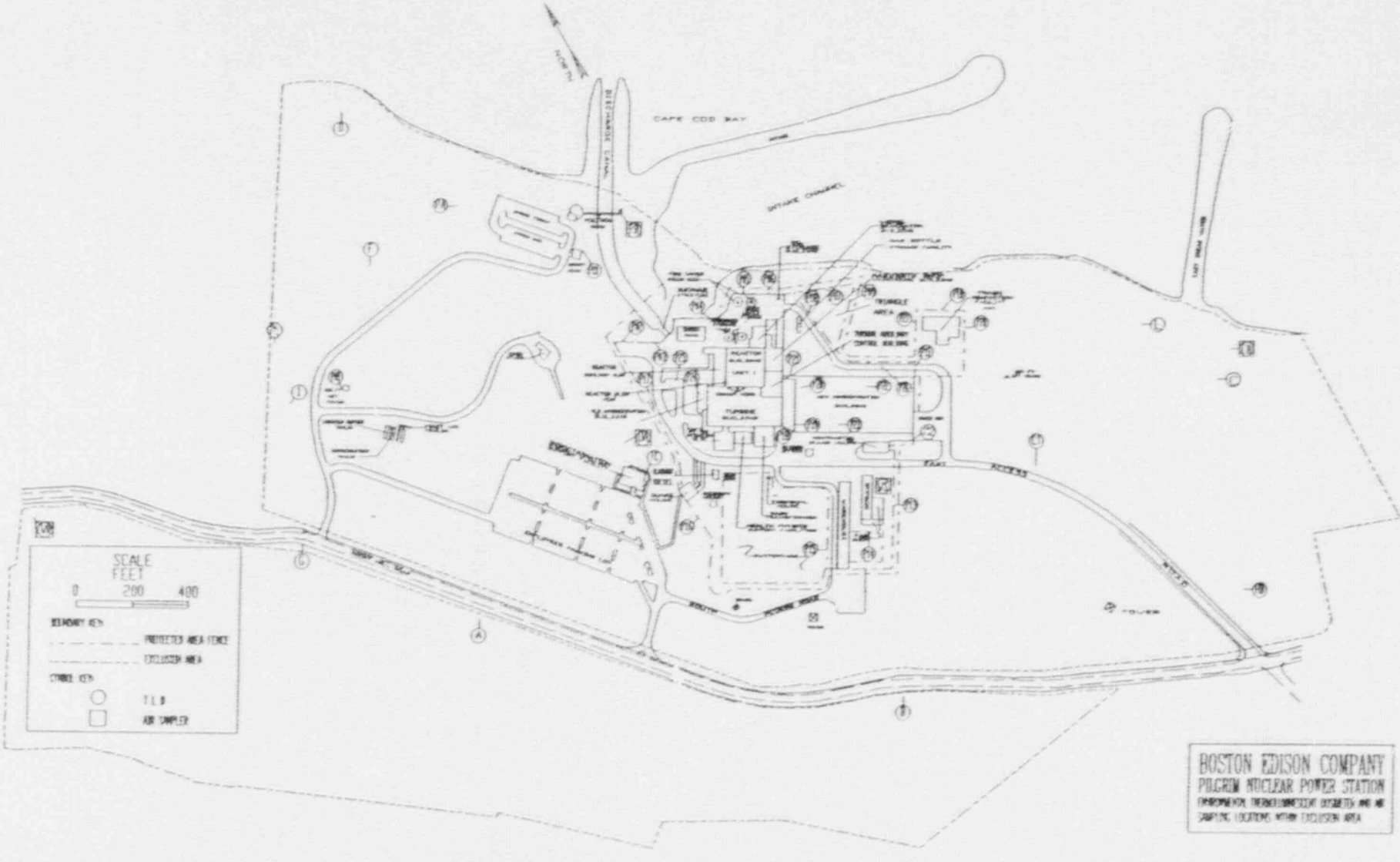


Figure 2.0-2

Environmental Thermoluminescent Dosimeter and
Air Sampling Locations Outside Exclusion Area to About Two Miles

ENVIRONMENTAL TLD LOCATIONS

Code	Description	Dist.*	Dir.*
AR	Access Road	0.92 mi	S
BB	3A & Bartlett Rd	2.1 mi	SSE
BD	Bayshore Drive	0.81 mi	WNW
BS	Bayshore	1.3 mi	W
BW	Beachwood Road	2.5 mi	SE
CR	Cleft Rock	0.86 mi	S
DR	Dirt Road	0.94 mi	SW
E	Station E	1.2 mi	S
EM	Emerson Road	1.1 mi	SSE
EP	Emer Rd & Pris	1.1 mi	SE
ER	E Rocky Hill Rd	0.65 mi	SE
GH	Greenwood House	0.57 mi	SE
GN	Goodwin Property	1.4 mi	SW
H	Station H	0.57 mi	SW
J	Station J	1.3 mi	S
JG	John Gauley	1.1 mi	W

ENVIRONMENTAL TLD LOCATIONS

Code	Description	Dist.*	Dir.*
K	Station K	1.4 mi	SSE
ME	Manomet Elm	2.1 mi	SE
MP	Manomet Pt	2.3 mi	SE
MR	Manomet Road	0.98 mi	S
MS	Manomet Subst	2.3 mi	SSE
MT	Micro Tower	0.58 mi	SSW
PT	Pines Estate	2.7 mi	SSW
RC	Rec Pool	1.3 mi	WSW
RW	Right of Way	1.7 mi	S
SP	S Ply. Sub	2.8 mi	W
TP	Taylor & Pearl	1.9 mi	SE
TT	Taylor & Tom Ave	1.5 mi	SE
VR	Valley Road	1.8 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	0.86 mi	SSW
MS	Manomet Substation	2.3 mi	SSE
ER	East Rocky Hill Rd	0.65 mi	SE

* Distance and direction are measured from the centerline of the reactor to the sampling/monitoring location. Values listed are approximate and are being evaluated in conjunction with revision of sampling location maps.

Figure 2.0-2 (cont.)

Figure 2.0-3

Environmental Thermoluminescent Dosimeter and
Air Sampling Locations Outside Property Boundary

ENVIRONMENTAL TLD LOCATIONS

Code	Description	Dist.*	Dir.*
BB	3A & Bartlett	2.1 mi	SSE
BD	Bayshore Drive	0.81 mi	WNW
BE	Bourne Road	8.4 mi	SSW
BR	Beaver Dam Road	3.5 mi	S
BS	Bayshore	1.3 mi	W
BW	Beachwood Road	2.5 mi	SE
CR	Cleft Rock	0.86 mi	S
CS	Cedarville Sub	10 mi	S
CP	College Pond	4.8 mi	SW
CW	Church & West	10 mi	NW
DMF	Div. Mar. Fish.	14 mi	SSE
DW	Deep Water	5.3 mi	W
EA	Earl Road	3.0 mi	SSE
EL	Ellisville Road	7.2 mi	SSE
EP	Emer. Rd & Pris	1.1 mi	SE
EW	E. Weymouth Sub	24 mi	NW
HD	Hilldale Road	3.1 mi	W
HR	Hyannis Road	4.8 mi	SSE
JG	John Gauley	1.1 mi	W
KC	King Caesar Road	8.1 mi	NNW
KS	Kingston Subst.	10 mi	WNW
SH	Snake Hill Road	4.5 mi	WSW
LP	Long Pond Road	5.7 mi	SSW
LR	Landing Road	10 mi	NNW

ENVIRONMENTAL TLD LOCATIONS

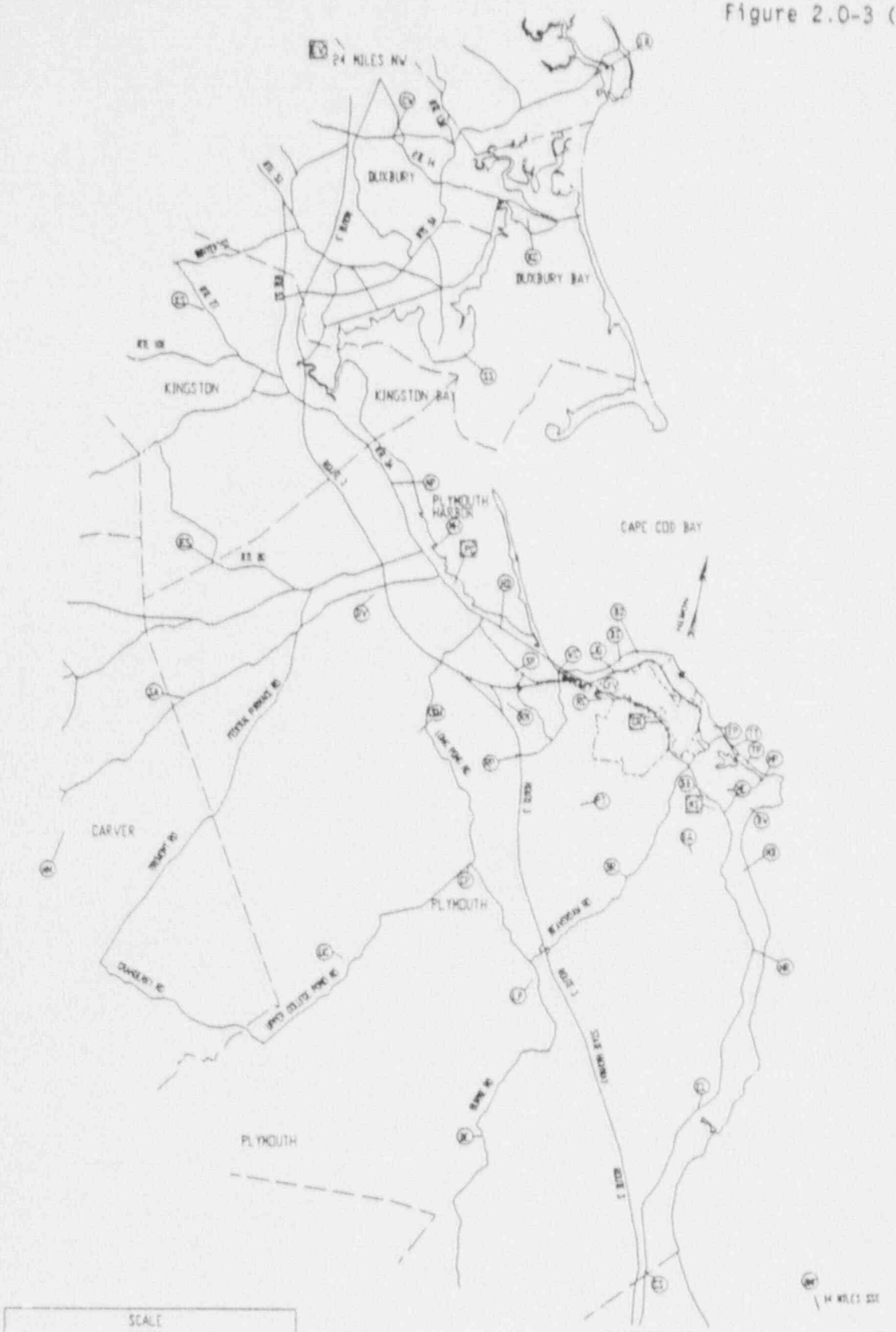
Code	Description	Dist.*	Dir.*
MB	Manomet Beach	3.4 mi	SSE
ME	Manomet Elem	2.1 mi	SE
MH	Memorial Hall	4.7 mi	WNW
MM	Main & Meadow	11 mi	WSW
MP	Manomet Point	2.3 mi	SE
MS	Manomet Subst	2.3 mi	SSE
NP	North Plymouth	5.8 mi	WNW
PC	Plymouth Center	4.1 mi	W
PT	Pine Estates	2.7 mi	SSW
RC	Rec Pool	1.3 mi	WSW
RM	Russell Mill	3.0 mi	WSW
RP	Rt 3 Overpass	3.0 mi	SW
SA	Sherman Airport	8.4 mi	WSW
ES	Elm Street	8.1 mi	W
SS	Standish Shores	6.5 mi	NW
SP	S. Plymouth Sub	2.8 mi	W
TP	Taylor & Pearl	1.9 mi	SE
TT	Taylor & Thomas	1.5 mi	SE
UC	Up Coll. Pnd. Rd	7.4 mi	SW
WC	Warren & Clifford	2.1 mi	W
YV	Yankee Village	3.4 mi	WSW

AIR SAMPLE LOCATIONS

Code	Description	Dist.*	Dir.*
CR	Cleft Rock	0.86 mi	SSW
EW	East Weymouth	24 mi	NW
MS	Manomet Subst	2.3 mi	SSE
PC	Plymouth Center	4.1 mi	W

* Distance and direction are measured from the centerline of the reactor to the sampling/monitoring location. Values listed are approximate and are being evaluated in conjunction with revision of sampling location maps.

Figure 2.0-3 (cont.)



BOSTON EDISON COMPANY
PILGRIM NUCLEAR POWER STATION
ENVIRONMENTAL THERMOLUMINESCENT DOSIMETER AND AIR SAMPLING LOCATIONS OUTSIDE PROPERTY BOUNDARY

Figure 2.0-4

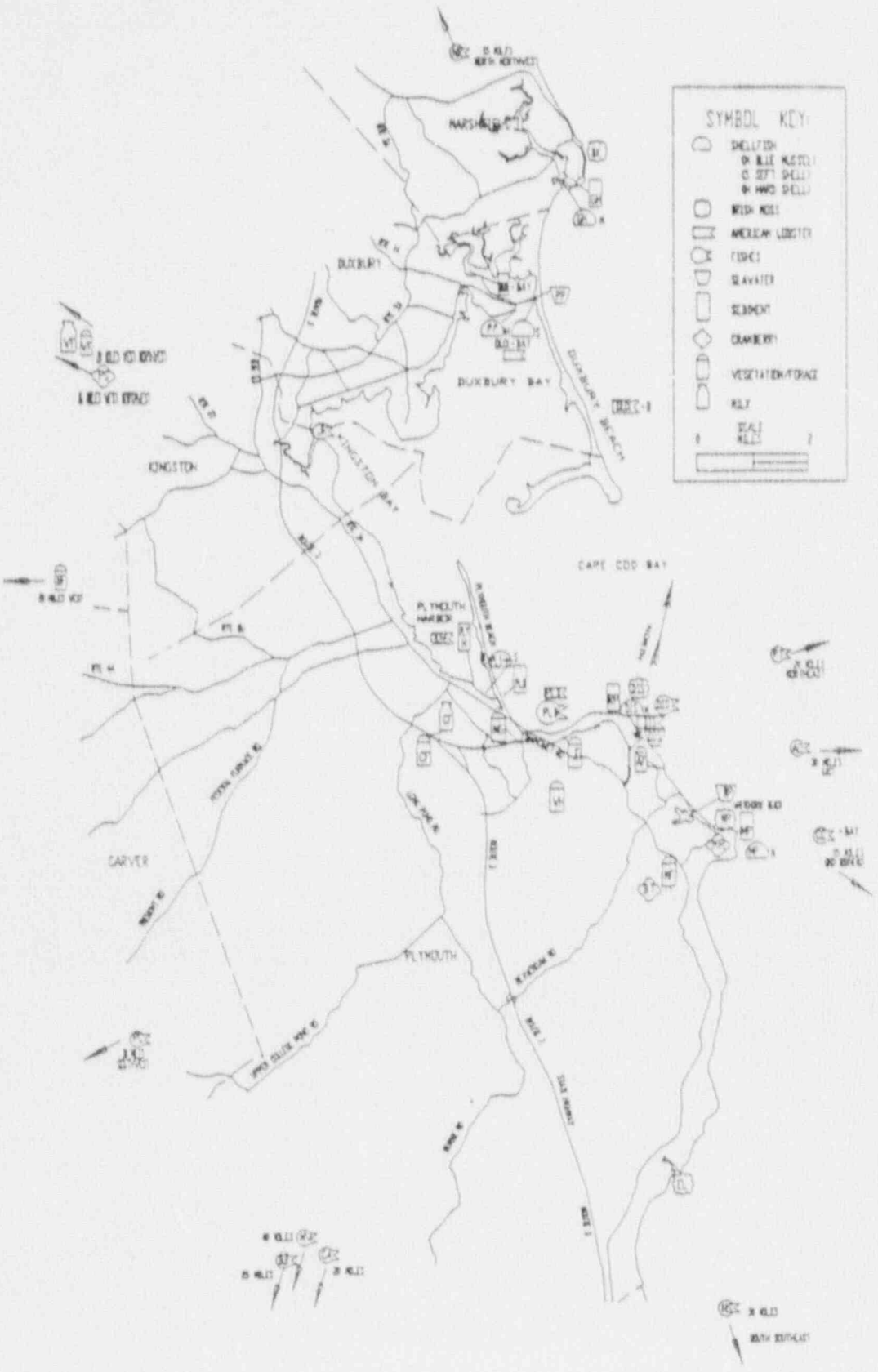
Terrestrial and Aquatic Sampling Locations

Code	Description	Dist.*	Dir.*
	SEAWATER		
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-B	Duxbury Beach Control	5.8 mi	NNW
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	W
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	20 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		
CF	Plymouth County Farm	3.4 mi	W
BF	Bridgewater Farm Ctrl	20 mi	W
WH	Wh[illegible]pple Farm	1.8 mi	SW
AF	Work Residence	0.8 mi	SE
ML			
JG			
MG	Moon Residence	2.1 mi	WSW
	FORAGE		
CF	Plymouth County Farm	3.5 mi	W
WF	Whitman Farm Control	20 mi	WNW

* Distance and direction are measured from the centerline of the reactor to the sampling/monitoring location. Values listed are approximate and are being evaluated in conjunction with revision of sampling location maps.

Figure 2.0-4 (cont.)



BOSTON EDISON COMPANY
PILGRIM NUCLEAR POWER STATION
TERRESTRIAL AND AQUATIC
SAMPLING LOCATIONS

Figure 2.0-5

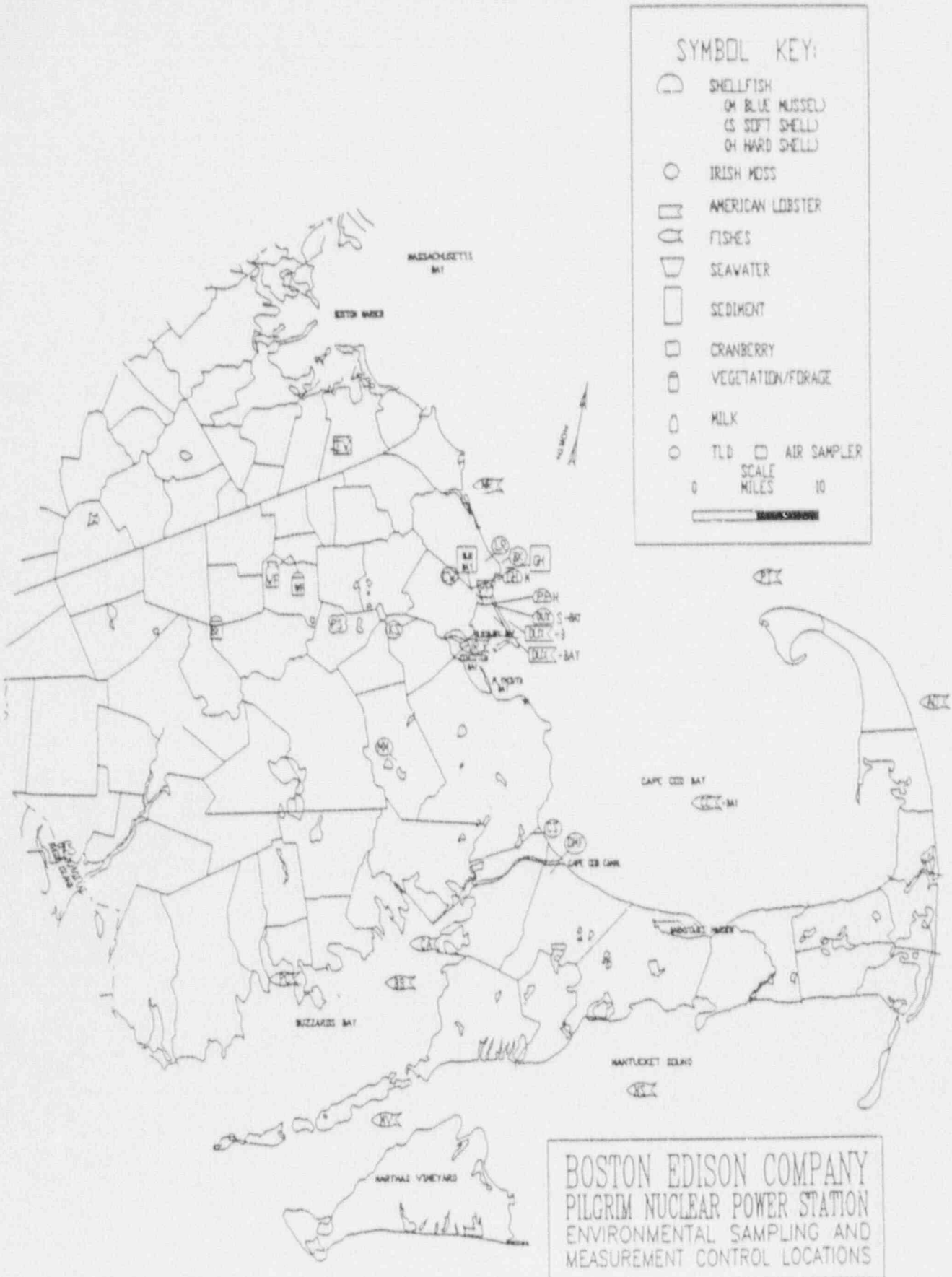
Environmental Sampling And Measurement Control Locations

Code	Description	Dist.*	Dir.*
	AIR SAMPLE		
EW	East Weymouth	24 mi	NW
	SEDIMENT		
GH	Green Harbor Control	10 mi	NNW
DUX-BAY	Duxbury Bay Control	8.7 mi	NNW
	SEAWATER		
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	ESE
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	10 mi	S
CW	Church & West	10 mi	NW
MM	Main & Meadow	11 mi	WSW
DMF	Div. Mar. Fish	14 mi	SSE
EW	East Weymouth Sub	24 mi	NW
	MILK		
WF	Whitman Farm Control	20 mi	WNW
	CRANBERRIES		
PS	Pine St. Bog Control	16 mi	WNW
	VEGETABLES		
BF	Bridgewater Farm Control	20 mi	W
WF	Whitman Farm Control	20 mi	WNW
	FORAGE		
WF	Whitman Farm Control	20 mi	WNW

* Distance and direction are measured from the centerline of the reactor to the sampling/monitoring location. Values listed are approximate and are being evaluated in conjunction with revision of sampling location maps.

Figure 2.0-5 (cont.)



BOSTON EDISON COMPANY
PILGRIM NUCLEAR POWER STATION
ENVIRONMENTAL SAMPLING AND
MEASUREMENT CONTROL LOCATIONS

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 (see Appendix C, Table 8.1-1 and Table 8.1-4).

Upon receipt of the analysis results from Yankee Atomic Electric Co., the Boston Edison staff reviews the results. Reporting levels for radioactivity concentrations in environmental samples are listed in Table 7.1-2 of Appendix C. 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 1990 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 1990 Garden and Milk Animal Census are reported in Appendix D.

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;

- Spiked sample analyses by the analytical laboratory;

- Boston Edison Company's TLD QA Program and YAEL's TLD QA Program.

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 1990 results of this QA program are summarized in Appendix F. These results indicate that the analyses and measurements which were performed during 1990 exhibited acceptable precision and accuracy.

Results of Radiometric Analyses and Measurements

The following pages summarize the analytical results of the environmental samples which were collected during 1990. 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.[17] The unit of measurement for each medium is listed at the top of each table. The left hand column contains the radionuclides which are 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 as specified in the PNPS Technical Specifications (see Table 8.1-4 of Appendix C).

Those sampling stations which are 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 Direct 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;
- The number of positive measurements (activity which is three times greater than the standard deviation) divided by 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. The strontium-90 may be detectable at lower levels if the sample were counted for a longer period of time or analyzed in a different manner.

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 35). Gross beta (GR-B) analyses were performed on 572 routine samples (11 stations/wk * 52 weeks). 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, 517 out of 520 samples indicated detectable activity at the three-sigma (standard deviation) level. The mean concentration of gross beta activity in these 520 indicator station samples was 0.021 ± 0.000 (2.1 ± 0.0 E-2) pCi/m^3. Individual values ranged from 0.0023 to 0.049 (2.3 - 48.5 E-3) pCi/m^3.

The indicator station which yielded the highest mean concentration was station number 10 (Cleft Rock), which yielded a mean concentration of 0.022 ± 0.001 pCi/m^3, based on 52 observations. Individual values ranged from 0.0056 to 0.0448 pCi/m^3. All 52 out of 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 0.022 ± 0.001 pCi/m^3. Individual samples at the control location ranged from 0.0052 to 0.047 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 -0.0053 to 0.0084 pCi/m , for a mean concentration of 0.0027 ± 0.0006 pCi/m^3. However, <u>none</u> of the forty samples analyzed showed <u>detectable</u> 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 <u>no</u> detectable activity. Although the mean value appears to indicate some potassium-40 present in the samples, neither the individual observations nor the collective mean were significantly different from background levels.

The station which yielded the highest mean concentration of K-40 was station 00. Again, the mean value of 0.0049 ± 0.0012 pCi/m^3 is based on four observations, <u>none</u> of which yielded any detectable activity. Therefore, <u>no</u> potassium-40 was detected in any of the samples collected from the sampling stations.

2.1 Air Particulate Filters

A type A/E glass fiber particulate filter, a charcoal cartridge, and an air sampling vacuum pump were used to collect radioactive airborne particulates and iodines. Results of the charcoal cartridge sampling are presented in Section 2.2. The eleven locations sampled during 1990 are listed in Table 2.0-1. Analyses of the air particulate filters for gross beta radiation are performed weekly. In addition, quarterly composites of the particulate samples for each sampling location were analyzed for gamma-emitting nuclides. Although there were several instances of low sample volume due to power failures, pump failures, and crimped sample lines during the year, all particulate sample analyses met the maximum value for the lower limit of detection (LLD) during 1990.

The summary of the radioactivity analysis results for air particulates for 1990 is presented in Table 2.1-1. The station identification numbers correspond to the locations identified in Table 2.0-1. Naturally-occurring beryllium-7 was observed in several indicator and control station air particulate filters. No radionuclides attributable to PNPS operations were detected in any of the samples collected during 1990.

Trend plots of the gross beta activity vs. time for the on-site, property boundary and off-site indicator stations are provided in Figure 2.1-1, Figure 2.1-2, and Figure 2.1-3, respectively.

There were two instances when gross beta activity at Cleft Rock (AP-10) showed what appeared to be somewhat higher activity relative to other monitoring stations during the same time period. In both instances, the sample activity was less than 5 times the activity of the control sample and was well below the activity in pre-operational samples collected between 1968 - 1972.

Analysis of air particulate samples collected during 1990 showed no evidence of any significant radiological impact on the environment or on the general public due to Pilgrim Station.

Table 2.1-1
Summary of Radioactivity Analysis Results
For Air Particulate Filters - 1990

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1990)

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.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS ********** MEAN RANGE NO. DETECTED**
GR-B (572)	.01	(2.1 ± 0.0)E -2	10	(2.2 ± 0.1)E -2	(2.2 ± 0.1)E -2
(0)		(2.3 - 48.5)E -3		(5.6 - 44.8)E -3	(5.2 - 47.2)E -3
		(517/520)		*(52/ 52)*	*(52/ 52)*
BE-7 (44)		(4.6 ± 0.2)E -2	10	(5.3 ± 0.7)E -2	(4.2 ± 1.0)E -2
(0)		(2.8 - 7.7)E -2		(4.0 - 7.1)E -2	(2.8 - 7.2)E -2
		(40/ 40)		*(4/ 4)*	*(4/ 4)*
K-40 (44)		(2.7 ± 0.6)E -3	00	(4.9 ± 1.2)E -3	(-5.4 ± 18.9)E -4
(0)		(-5.3 - 8.4)E -3		(2.4 - 7.6)E -3	(-5.3 - 3.1)E -3
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
MN-54 (44)		(1.1 ± 3.8)E -5	06	(1.1 ± 0.3)E -4	(2.1 ± 8.4)E -5
(0)		(-1.4 - 5.3)E -4		(4.2 - 19.1)E -5	(-1.2 - 2.6)E -4
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
CO-58 (44)		(-3.9 ± 4.1)E -5	03	(1.4 ± 1.2)E -4	(-6.3 ± 21.1)E -5
(0)		(-7.0 - 4.9)E -4		(-7.6 - 48.6)E -5	(-6.2 - 3.5)E -4
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
FE-59 (44)		(-1.2 ± 1.4)E -4	15	(5.7 ± 3.2)E -4	(3.0 ± 11.3)E -5
(0)		(-2.5 - 1.6)E -3		(-1.4 - 13.7)E -4	(-1.1 - 3.7)E -4
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
CO-60 (44)		(-1.7 ± 5.2)E -5	01	(4.0 ± 1.8)E -4	(-1.6 ± 2.3)E -4
(0)		(-7.4 - 7.3)E -4		(6.4 - 73.3)E -5	(-7.2 - 2.5)E -4
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
ZN-65 (44)		(-1.2 ± 1.0)E -4	10	(5.5 ± 2.6)E -4	(1.0 ± 2.2)E -4
(0)		(-1.6 - 1.1)E -3		(-1.5 - 11.2)E -4	(-3.7 - 6.2)E -4
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
ZR-95 (44)		(2.5 ± 1.1)E -4	00	(6.5 ± 1.9)E -4	(2.7 ± 3.2)E -4
(0)		(-1.7 - 2.4)E -3		(2.3 - 11.4)E -4	(-2.0 - 12.2)E -4
		(0/ 40)		*(0/ 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 STD DEVIATIONS) IS INDICATED WITH *( )*.

Table 2.1-1 (continued)
Summary of Radioactivity Analysis Results
For Air Particulate Filters - 1990

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1990)

MEDIUM: AIR PARTICULATE

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**
RU-103 (44)		(3.8 ± 7.0)E -5	09	(2.3 ± 3.5)E -4	(-4.0 ± 228.9)E -6
(0)		(-7.6 - 10.8)E -4		(-6.1 - 10.8)E -4	(-5.6 - 5.5)E -4
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
RU-106 (44)		(6.0 ± 3.5)E -4	15	(3.7 ± 0.8)E -3	(-1.2 ± 11.2)E -4
(0)		(-5.3 - 5.4)E -3		(1.9 - 5.4)E -3	(-2.3 - 2.8)E -3
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
CS-134 (44)	.01	(-2.1 ± 0.4)E -4	10	(1.1 ± 2.2)E -4	(-1.3 ± 0.5)E -4
(0)		(-8.7 - 6.8)E -4		(-2.7 - 6.8)E -4	(-2.6 - -0.3)E -4
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
CS-137 (44)	.01	(1.2 ± 0.4)E -4	03	(3.9 ± 1.2)E -4	(5.3 ± 8.4)E -5
(0)		(-3.5 - 5.9)E -4		(9.1 - 59.4)E -5	(-1.1 - 2.5)E -4
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
BA-140 (44)		(-1.5 ± 2.2)E -4	10	(5.4 ± 5.8)E -4	(-7.6 ± 3.0)E -4
(0)		(-3.4 - 3.0)E -3		(-3.9 - 20.1)E -4	(-1.9 - 0.5)E -3
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
CE-141 (44)		(9.9 ± 7.2)E -5	00	(4.2 ± 1.6)E -4	(-2.2 ± 2.7)E -4
(0)		(-1.0 - 1.3)E -3		(-3.0 - 73.1)E -5	(-9.0 - 3.4)E -4
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
CE-144 (44)		(3.3 ± 1.8)E -4	10	(9.6 ± 12.0)E -4	(-6.0 ± 4.9)E -4
(0)		(-1.9 - 3.8)E -3		(-1.9 - 3.8)E -3	(-2.0 - 0.1)E -3
		(0/ 40)		*(0/ 4)*	*(0/ 4)*
TH-232 (44)		(3.6 ± 1.6)E -4	17	(1.1 ± 0.3)E -3	(-4.0 ± 8.1)E -4
(0)		(-1.7 - 2.3)E -3		(6.8 - 20.2)E -4	(-2.3 - 1.2)E -3
		(0/ 40)		*(0/ 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 STD DEVIATIONS) IS INDICATED WITH *( )*.

Figure 2.1-1

Radioactivity Measurements of Air Sample Filters
Taken from On-Site Locations and Control Location

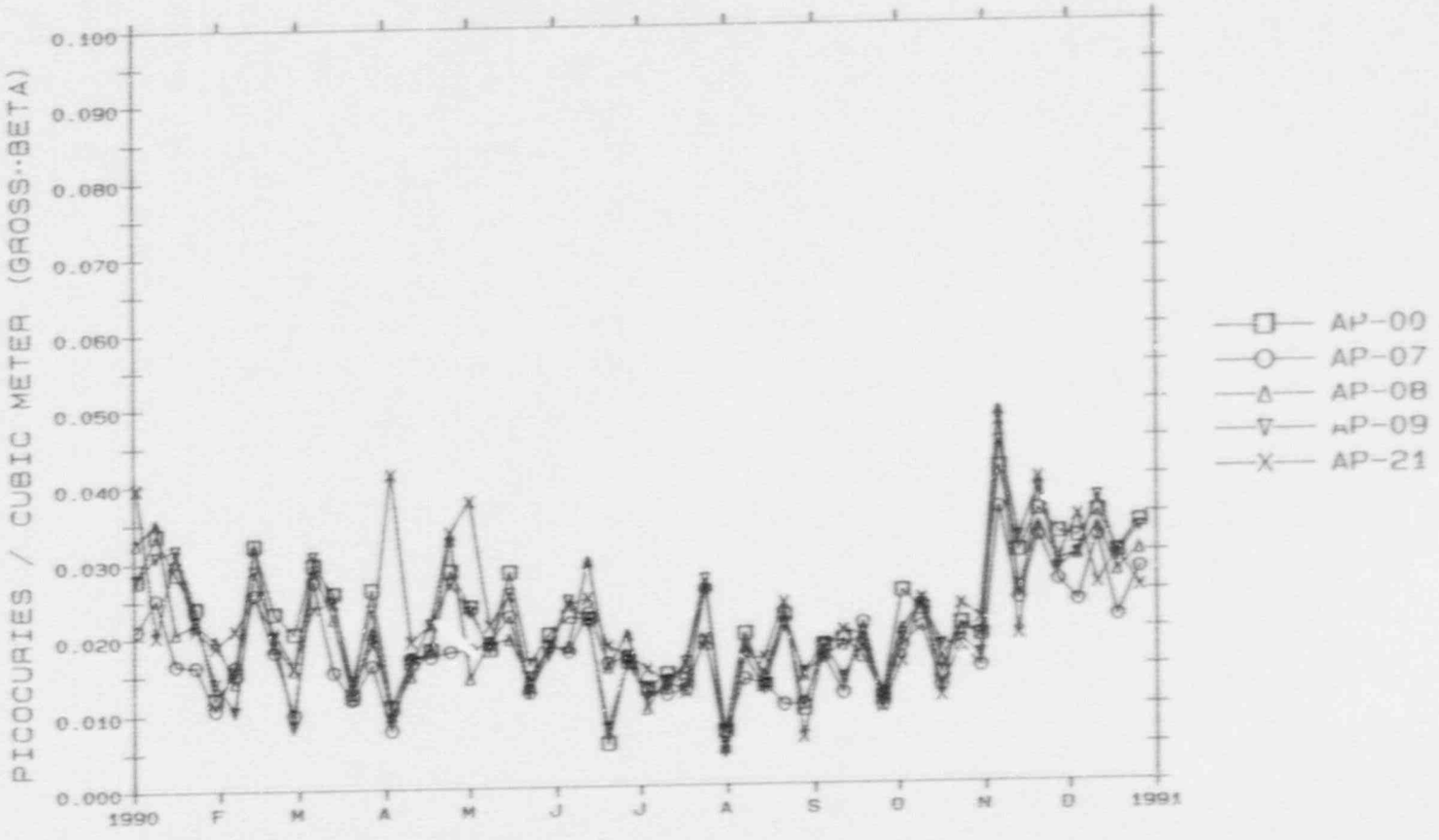


Figure 2.1-2

Radioactivity Measurements of Air Sample Filters
Taken from Property Boundary Locations and Control Location

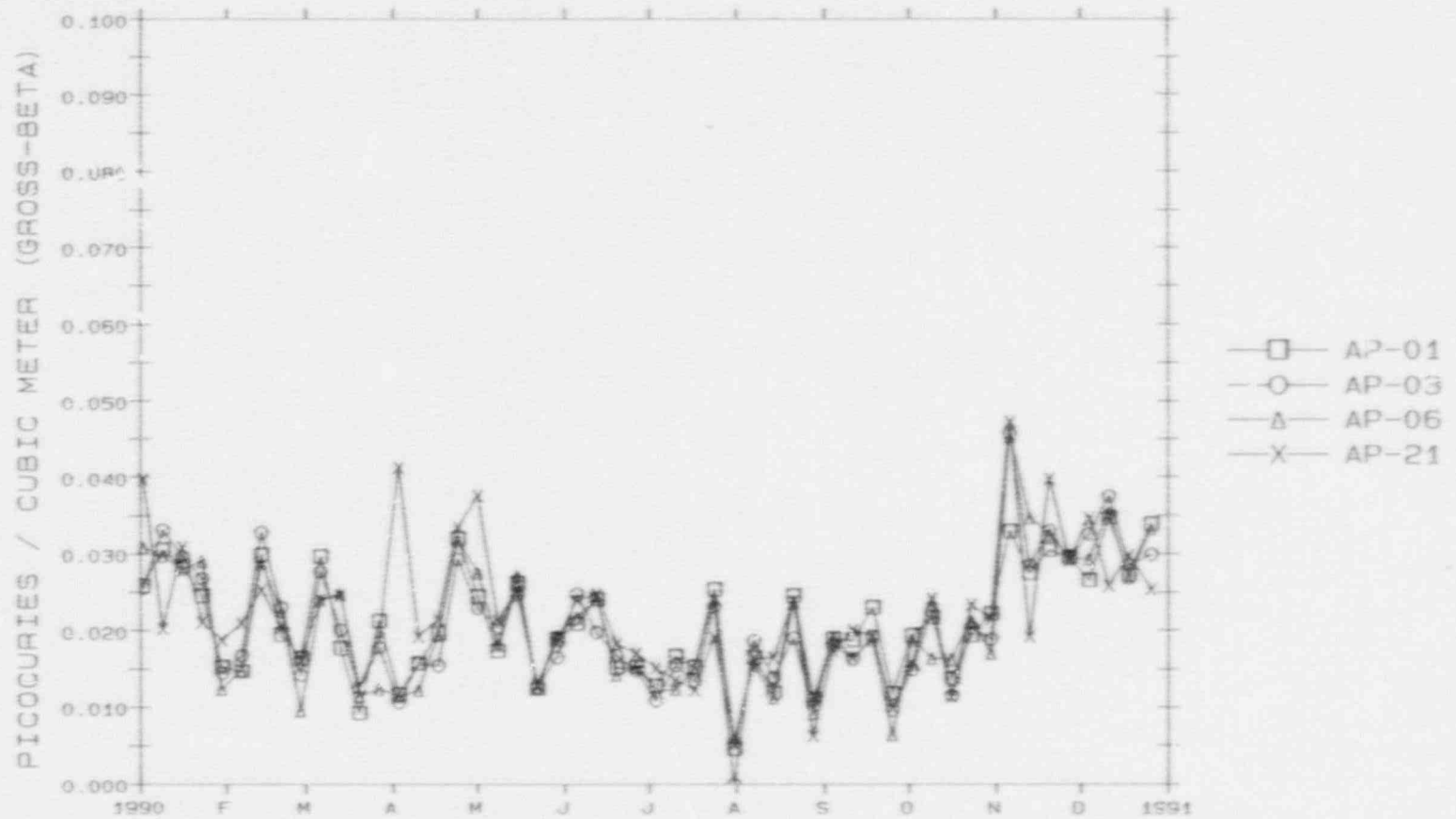
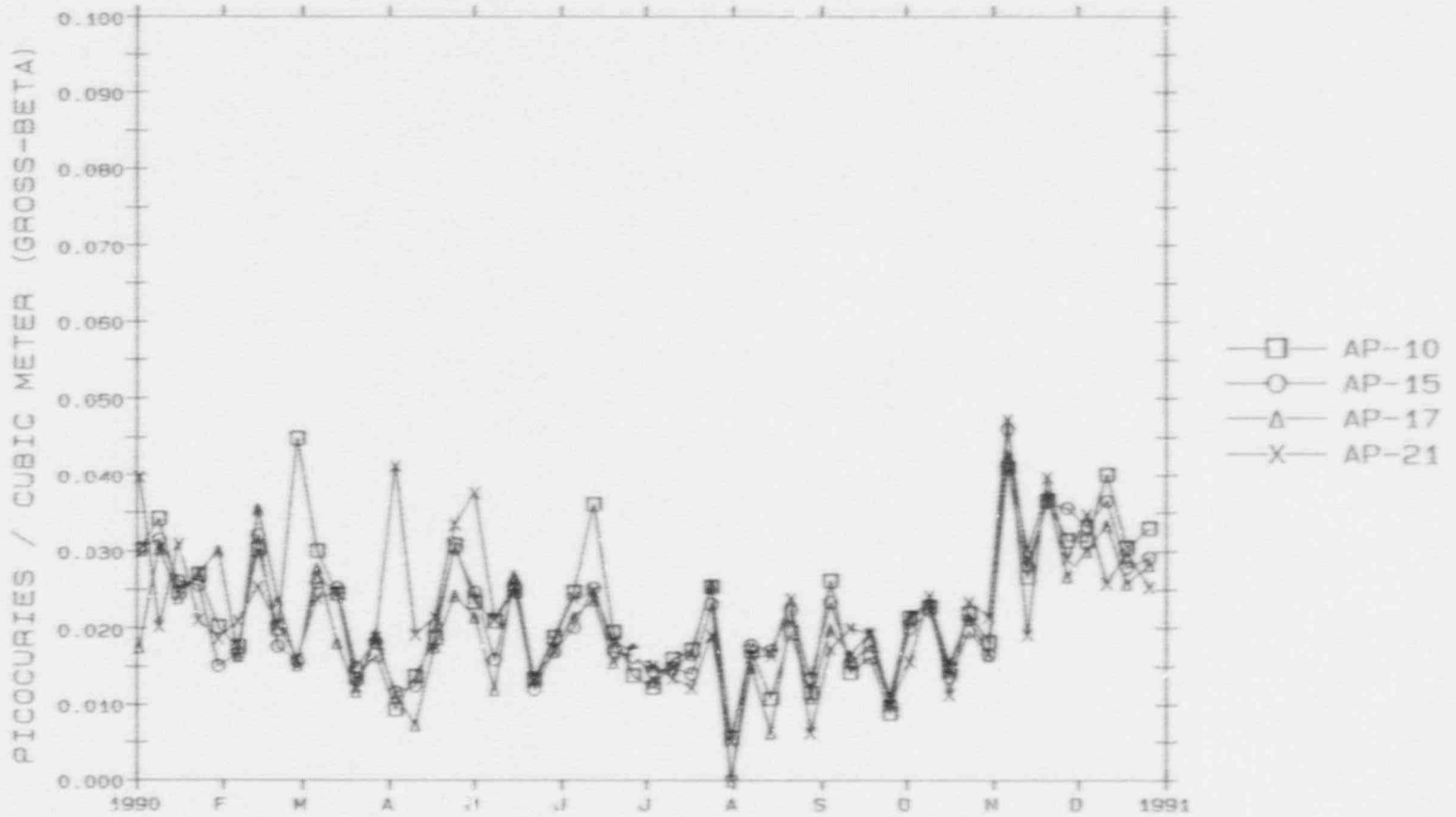


Figure 2.1-3

Radioactivity Measurements of Air Sample Filters
Taken from Off-Site Locations and Control Location



2.2 Charcoal Cartridges

The same sample collection systems which were used to collect airborne particulates were also used to collect gaseous iodine on charcoal cartridges. The Nucon Level A charcoal cartridges were analyzed weekly for gaseous iodine-131. The eleven locations sampled during 1990 are indicated in Table 2.0-1.

A total of 572 charcoal cartridges were collected during 1990. Despite several instances of low sample flow resulting from power failures, pump failures, and crimped sample lines, the lower level of detection (LLD) was met for all 572 samples collected.

The summary of the radioactivity analysis results for charcoal cartridges collected during 1990 is provided in Table 2.2-1. The results indicate that the mean value of the gaseous iodine-131 concentrations for the indicator stations is statistically no different than the mean value for the control station; that is, none of the results showed detectable levels of iodine-131.

Therefore, analysis of charcoal cartridges collected during 1990 showed no evidence of any significant radiological impact on the environment due to Pilgrim Station.

Table 2.2-1
Summary of Radioactivity Analysis Results
For Charcoal Cartridges - 1990

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1990)

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.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
I-131 (572)	.07	(1.5 ± 5.4)E -4	00	(2.0 ± 2.0)E -3	(1.6 ± 1.7)E -3
(0)		(-4.9 - 4.7)E -2		(-2.9 - 3.0)E -2	(-2.6 - 3.3)E -2
		(0/520)		*(0/ 52)*	*(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 STD DEVIATIONS) IS INDICATED WITH *( )*.

2.3 Soil

Soil surveys at eleven locations are performed once every three years. Since the surveys were conducted during 1988 at the required eleven locations, plus several additional locations, no soil surveys were performed during 1990. The results of the most recent soil survey were reported in the 1988 Annual Environmental Radiation Monitoring Program Report, issued in May 1989.

2.4 Direct Radiation

Exposure rates from external radiation sources were measured during 1990 in the vicinity of Pilgrim Station using two methods. Measurements were obtained at 107 locations, only 40 of which are required by PNPS Technical Specifications, using environmental thermoluminescent dosimeters (TLDs) which were posted and retrieved each quarter. In addition, annual measurements were made at six local beaches using a high pressure ion chamber. Indicator TLDs were placed in the vicinity of Pilgrim Station as shown in Figures 2.0-1 through 2.0-3. Control TLDs were placed at locations so as to be outside the influence of Pilgrim Station and are shown in Figure 2.0-5.

Only two out of the 160 TLDs (40 stations * 4 quarters) required by Technical Specifications were not collected during 1990. The TLDs located at Station J (1st Qtr.) and at Sherman Airport (4th Qtr.) were found missing from their posted locations during the quarterly retrievals. In addition, six other TLDs were missed during the course of the year. TLDs which were not retrieved are noted in Table 2.4.1-1. In all cases, the missing TLD and cage were relocated to be inconspicuous and less accessible.

2.4.1 Environmental Thermoluminescent Dosimeters

A state-of-the-art thermoluminescent dosimeter program was implemented in 1987 using the Panasonic UD-801 and UD-814 combination TLD packet. Thermoluminescence is a process in which ionizing radiation, upon interacting with the sensitive material of the TLD (the phosphor or 'element'), causes some of the energy deposited in the phosphor to be stored in stable electron 'traps' in the TLD material. The energy stored in the TLDs as a result of interactions with radiation is removed and measured by a controlled heating process in a calibrated light reading system. As the TLD is heated, the phosphor releases the stored energy as light. The amount of light given off is directly proportional to the radiation dose the TLD received. These highly sensitive TLDs are capable of accurately measuring exposures between 1 mR (well below normal environmental levels for the quarterly monitoring periods) and 200,000 mR.

Table 2.4.1-1 shows quarterly average exposure rates and annual exposure from direct gamma radiation at the off-site TLD stations. The off-site exposure rates ranged from approximately 5 micro-R/hr to 12 micro-R/hr, yielding annual exposures ranging from 43 mR to 100 mR.

Two TLD locations beyond the PNPS protected area fence yielded annual exposure rates of greater than 100 mR/yr. These were Pedestrian Bridge (112 mR/yr) and Overlook Area (150 mR/yr). These locations are within the PNPS exclusion area in close proximity to the reactor building and indicate increased exposure as a result of reactor operation. In addition, the TLD at Pedestrian Bridge is located over granite material used to construct the breakwaters, which can contribute to increased exposure due to its high content of naturally-occurring radionuclides.

In addition to average doses for each TLD for each readout period, average doses were calculated for four geographic zones. Table 2.4.1-2 lists environmental radiation levels that are consistent with past trends.

Results from the 28 on-site TLDs are presented in Table 2.4.1-3. Quarterly and annual average exposure rates are listed for each location. A number of these results are considerably higher than off-site locations, due to the close proximity of some on-site TLDs to radiation sources within Pilgrim Station.

2.4.2 Beach Surveys

Sensitive radiation detection surveys using a high pressure ion chamber were performed at Plymouth Beach, White Horse Beach, and Duxbury Beach during July of 1990.[18] These measurements were performed by Yankee Atomic Electric Company's Radiological Engineering Group personnel.

The purpose of this survey is to detect differences in the external exposure rate encountered at beaches near the plant (Plymouth and White Horse) and at a control location (Duxbury). The detector's calibration was checked before each measurement. The data in Table 2.4.2-1 indicate that the exposure rates at Plymouth Beach and White Horse Beach are not significantly different from the exposure rates measured at the distant control station in Duxbury.

The results of the 1990 beach surveys are in agreement with the previous beach surveys conducted annually from 1977 through 1989. The graphical trend of the radiation levels at these beaches depicted in Figure 2.4.2-1 shows little change in the exposure rate over the thirteen year period.

Granite beach stones and gravel are present at three locations. It has been demonstrated that proximity to beach stones results in higher exposure rates than in sandy areas (see Annual Report No. 10).

2.4.3 Summary

The direct radiation (TLD) measurements and beach survey results for 1990 are comparable to previous years' background radiation levels and are within the expected natural background exposure rates in the northeastern part of the United States. The low levels of radiation measured at all monitoring locations were the result of naturally-occurring sources, as well as fallout from nuclear weapons testing. Therefore, analysis of direct radiation data collected during 1990 showed no evidence of any significant radiological impact on the environment or the general public due to Pilgrim Station.

TABLE 2.4.1-1

OFF-SITE ENVIRONMENTAL THERMOLUMINESCENT DOSIMETER RESULTS - 1990

TLD STATION		LOCATION*		EXPOSURE RATE - mR/quarter (VALUE ± STD.DEV)				ANNUAL MEAN** ± STD.DEV. mR/yr
ID	DESCRIPTION	DIST	DIR	FIRST	SECOND	THIRD	FOURTH	
OA	OVERLOOK AREA	0.09 mi.	W	35.6 ± 2.1	33.5 ± 1.8	36.6 ± 2.1	44.3 ± 2.2	150.1 ± 21.0
TC	TRAINING CTR	0.10 mi.	WSW	19.8 ± 1.2	19.0 ± 0.8	18.7 ± 0.7	19.2 ± 1.6	76.6 ± 5.7
PB	PEDESTRIAN BRIDGE	0.13 mi.	NNW	28.4 ± 1.9	27.2 ± 1.3	28.2 ± 0.7	28.2 ± 1.7	112.0 ± 7.3
P01	SHOREFRNT SECURITY	0.14 mi.	NNW	19.2 ± 1.2	19.2 ± 1.1	19.3 ± 0.8	17.8 ± 0.8	75.5 ± 5.3
CT	CONTR. PARK. LOT	0.21 mi.	SE	17.8 ± 1.3	18.7 ± 0.6	18.0 ± 0.7	16.2 ± 1.0	70.7 ± 6.1
PA	PARKING AREA	0.23 mi.	NNW	16.5 ± 1.0	17.6 ± 0.7	18.6 ± 0.8	17.7 ± 1.1	7. 4 ± 5.4
B	STATION B	0.25 mi.	S	16.8 ± 1.0	17.9 ± 0.6	16.8 ± 0.6	16.8 ± 0.8	68.3 ± 4.0
A	STATION A	0.25 mi.	WSW	15.9 ± 1.1	16.3 ± 0.6	17.3 ± 1.2	16.2 ± 0.7	65.7 ± 5.0
L	STATION L	0.27 mi.	ESE	15.0 ± 1.0	15.5 ± 0.9	15.2 ± 0.5	14.8 ± 0.7	60.4 ± 3.8
PMT	PNPS MET TOWER	0.27 mi.	WNW	15.2 ± 1.0	15.9 ± 0.8	16.6 ± 1.0	15.5 ± 0.9	63.2 ± 5.0
F	STATION F	0.27 mi.	NW	15.2 ± 0.8	17.2 ± 0.6	17.8 ± 0.7	17.2 ± 0.9	67.4 ± 5.9
I	STATION I	0.30 mi.	WNW	15.9 ± 1.1	16.7 ± 0.6	17.7 ± 1.2	16.5 ± 1.0	66.9 ± 5.5
C	STATION C	0.32 mi.	ESE	14.7 ± 0.9	15.8 ± 1.0	15.7 ± 0.7	14.9 ± 1.0	61.1 ± 4.8
G	STATION G	0.32 mi.	W	15.8 ± 1.0	16.3 ± 0.7	15.9 ± 0.6	15.4 ± 0.9	63.4 ± 4.1
PL	PROPERTY LINE	0.32 mi.	NW	16.0 ± 1.0	16.1 ± 0.7	17.9 ± 1.1	16.5 ± 0.9	66.5 ± 5.5
D	STATION D	0.32 mi.	NNW	20.4 ± 1.1	22.4 ± 1.1	23.5 ± 1.4	22.3 ± 1.1	88.5 ± 7.6
EB	EAST BREAKWATER	0.34 mi.	ESE	19.3 ± 2.4	18.0 ± 0.7	17.7 ± 0.7	16.2 ± 1.1	71.2 ± 8.3
HB	HALL'S BOG	0.38 mi.	SE	13.2 ± 0.8	14.1 ± 0.4	14.8 ± 0.8	14.0 ± 0.7	56.0 ± 4.2
WR	W ROCKY HILL RD	0.45 mi.	WNW	18.6 ± 1.1	19.7 ± 0.8	20.2 ± 1.1	18.9 ± 0.8	77.4 ± 5.4
GH	GREENWOOD HOUSE	0.50 mi.	SE	15.4 ± 1.0	16.5 ± 0.9	18.2 ± 0.7	15.9 ± 1.0	65.9 ± 5.4
H	STATION H	0.57 mi.	SW	17.8 ± 1.0	19.1 ± 0.8	18.0 ± 0.6	18.3 ± 0.9	73.1 ± 4.5
MT	MICROWAVE TOWER	0.58 mi.	SSW	15.7 ± 0.9	17.0 ± 0.7	16.9 ± 0.9	15.8 ± 0.9	65.5 ± 4.7
ER	E ROCKY HILL RD	0.65 mi.	SE	14.0 ± 0.9	14.5 ± 0.5	14.9 ± 0.5	13.9 ± 0.8	57.2 ± 3.7
BD	BAYSHORE DR	0.81 mi.	WNW	16.8 ± 0.9	17.1 ± 0.7	17.1 ± 0.7	17.0 ± 0.7	67.9 ± 3.0
CR	CLEFT ROCK	0.86 mi.	S	15.1 ± 1.0	15.7 ± 0.8	15.2 ± 0.7	14.9 ± 0.8	60.9 ± 4.0
AR	ACCESS ROAD	0.92 mi.	S	14.2 ± 0.9	15.2 ± 0.7	14.3 ± 0.4	13.7 ± 0.8	57.4 ± 4.2
DR	DIRT ROAD	0.94 mi.	SW	14.3 ± 1.0	15.4 ± 0.8	14.4 ± 0.8	14.3 ± 0.7	58.5 ± 4.4

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

** Annual average value is based on arithmetic mean of observed quarterly values multiplied by 4.0 quarters/yr. Standard deviation of annual average includes arithmetic standard deviation calculated from quarterly values plus contribution from individual quarterly uncertainties (standard deviations).

TABLE 2.4.1-1 (CONTINUED)

OFF-SITE ENVIRONMENTAL THERMOLUMINESCENT DOSIMETER RESULTS - 1990

TLD STATION		LOCATION*		EXPOSURE RATE - mR/quarter (VALUE ± STD.DEV)				ANNUAL MEAN** ± STD.DEV. mR/yr
ID	DESCRIPTION	DIST	DIR	FIRST	SECOND	THIRD	FOURTH	
MR	MANOMET ROAD	0.98 mi.	S	15.4 ± 1.4	16.0 ± 0.6	15.1 ± 0.5	Missing	62.1 ± 4.9
EP	EMERSON & PRISCILL	1.10 mi.	SE	14.6 ± 0.9	16.1 ± 0.6	15.1 ± 0.6	13.2 ± 0.7	58.9 ± 5.8
EM	EMERSON RD	1.10 mi.	SSE	14.4 ± 0.8	15.4 ± 0.8	15.1 ± 0.5	14.4 ± 0.9	59.3 ± 4.1
JG	JOHN GAULEY	1.10 mi.	W	14.9 ± 1.0	15.5 ± 1.2	15.5 ± 0.4	13.5 ± 0.8	59.4 ± 5.6
E	STATION E	1.20 mi.	S	15.1 ± 0.9	15.1 ± 0.7	15.0 ± 0.5	14.2 ± 0.8	59.5 ± 3.8
BS	BAYSHORE	1.26 mi.	W	17.4 ± 1.2	18.4 ± 0.8	16.8 ± 0.5	16.4 ± 0.7	69.1 ± 5.3
J	STATION J	1.30 mi.	S	Missing	14.8 ± 0.8	13.7 ± 0.9	13.6 ± 0.6	56.3 ± 4.7
RC	PLYMOUTH YMCA	1.30 mi.	WSW	15.5 ± 1.0	15.9 ± 0.7	15.6 ± 0.8	17.5 ± 3.7	64.6 ± 9.9
WH	WHITEHORSE RD	1.32 mi.	SSE	14.3 ± 0.9	14.3 ± 0.6	14.6 ± 0.5	13.6 ± 1.0	56.8 ± 3.9
K	STATION K	1.38 mi.	SSE	14.1 ± 0.9	15.3 ± 1.0	14.9 ± 0.7	14.3 ± 0.8	58.6 ± 4.7
GN	GOODWIN PROPERTY	1.40 mi.	SW	10.7 ± 0.8	11.5 ± 0.8	11.6 ± 0.4	9.8 ± 0.6	43.5 ± 4.7
YV	YANKEE VILLAGE	1.40 mi.	WSW	15.1 ± 1.0	15.6 ± 0.5	15.7 ± 0.4	13.6 ± 0.8	59.9 ± 5.1
TT	TAYLOR & THOMAS	1.50 mi.	SE	14.5 ± 0.9	13.9 ± 0.6	14.9 ± 1.0	13.5 ± 1.1	56.9 ± 4.8
RW	RIGHT OF WAY	1.70 mi.	S	12.1 ± 0.8	12.8 ± 0.5	13.2 ± 0.5	11.2 ± 0.9	49.3 ± 4.7
VR	VALLEY ROAD	1.80 mi.	SSW	12.5 ± 0.8	13.4 ± 0.7	13.4 ± 0.6	11.5 ± 0.6	50.9 ± 4.8
TP	TAYLOR & PEARL	1.90 mi.	SE	13.4 ± 0.9	14.8 ± 0.6	14.0 ± 0.5	12.5 ± 0.8	54.7 ± 5.2
BB	3A & BARTLETT RD	2.10 mi.	SSE	14.5 ± 0.9	15.8 ± 0.9	14.9 ± 0.6	13.4 ± 0.7	58.6 ± 5.4
WC	WARREN & CLIFFORD	2.10 mi.	W	14.0 ± 0.9	14.3 ± 0.9	13.8 ± 0.7	12.3 ± 0.7	54.4 ± 5.2
ME	MANOMET ELEM	2.12 mi.	SE	12.7 ± 0.8	13.3 ± 0.4	13.3 ± 1.1	12.1 ± 0.8	51.3 ± 4.3
MP	MANOMET PT	2.27 mi.	SE	14.4 ± 0.9	14.7 ± 0.6	14.9 ± 0.5	13.5 ± 1.5	57.5 ± 5.1
MS	MANOMET SUBSTA	2.34 mi.	SSE	17.5 ± 1.0	17.7 ± 0.9	18.4 ± 0.8	16.2 ± 1.3	69.9 ± 6.0
BW	BEECHWOOD RD	2.50 mi.	SE	14.2 ± 0.8	14.7 ± 0.9	15.5 ± 0.7	13.4 ± 1.3	57.8 ± 5.6
PT	PINES ESTATE	2.70 mi.	SSW	12.4 ± 0.8	13.1 ± 0.6	13.5 ± 0.6	Missing	52.0 ± 4.0
SP	S PLYMOUTH SUBSTA	2.80 mi.	W	14.4 ± 1.0	15.0 ± 0.6	15.5 ± 0.7	13.5 ± 1.4	58.4 ± 5.6
EA	EARL RD	2.98 mi.	SSE	12.0 ± 0.8	13.1 ± 0.9	12.8 ± 0.4	11.6 ± 1.0	49.5 ± 4.7
RP	RT. 3 OVERPASS	3.00 mi.	SW	14.4 ± 0.8	14.7 ± 0.5	14.7 ± 0.8	12.8 ± 0.5	56.7 ± 4.8

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

** Annual average value is based on arithmetic mean of observed quarterly values multiplied by 4.0 quarters/yr. Standard deviation of annual average includes arithmetic standard deviation calculated from quarterly values plus contribution from individual quarterly uncertainties (standard deviations).

TABLE 2.4.1-1 (CONTINUED)

OFF-SITE ENVIRONMENTAL THERMOLUMINESCENT DOSIMETER RESULTS - 1990

TLD STATION		LOCATION*		EXPOSURE RATE - mR/quarter (VALUE ± STD.DEV)				ANNUAL MEAN** ± STD.DEV. mR/yr
ID	DESCRIPTION	DIST	DIR	FIRST	SECOND	THIRD	FOURTH	
RM	RUSSELL MILLS RD	3.00 mi.	WSW	12.9 ± 0.8	13.2 ± 0.8	13.9 ± 0.6	11.3 ± 0.6	51.2 ± 5.5
HD	HILLDALE RD	3.10 mi.	W	14.5 ± 0.9	15.2 ± 0.8	15.1 ± 0.5	Missing	59.6 ± 4.0
MB	MANOMET BEACH	3.40 mi.	SSE	13.3 ± 0.8	14.5 ± 0.9	14.9 ± 0.4	13.6 ± 1.0	56.3 ± 4.8
BR	BEAVERDAM RD	3.51 mi.	S	11.4 ± 0.7	12.8 ± 0.5	12.6 ± 0.5	11.1 ± 0.7	47.9 ± 4.4
PC	PLYMOUTH CENTER	4.12 mi.	W	11.2 ± 0.8	10.8 ± 0.5	11.1 ± 0.5	9.6 ± 0.5	42.7 ± 4.1
LD	LONG POND & DREW	4.50 mi.	WSW	13.6 ± 1.0	14.1 ± 0.7	13.5 ± 0.5	12.4 ± 0.5	53.6 ± 4.5
MH	MEMORIAL HALL	4.70 mi.	WNW	23.3 ± 1.6	22.6 ± 1.2	23.4 ± 0.9	21.1 ± 1.1	90.5 ± 7.1
CP	COLLEGE POND	4.76 mi.	SW	13.8 ± 0.9	14.1 ± 0.7	14.8 ± 0.7	12.9 ± 1.4	55.6 ± 5.4
HR	HYANNIS ROAD	4.80 mi.	SSE	12.6 ± 0.9	12.7 ± 0.6	12.9 ± 0.6	11.6 ± 0.6	49.8 ± 3.9
DW	DEEP WATER POND	5.30 mi.	W	Missing	17.2 ± 0.5	17.5 ± 0.6	Missing	69.5 ± 3.2
LP	LONG POND RD	5.70 mi.	SSW	12.3 ± 0.9	13.1 ± 0.9	13.2 ± 0.5	11.5 ± 0.6	50.1 ± 4.7
NP	NORTH PLYMOUTH	5.82 mi.	WNW	17.0 ± 1.1	16.9 ± 0.6	16.8 ± 0.5	14.7 ± 0.6	65.4 ± 5.5
SS	STANDISH SHORES	6.49 mi.	NW	13.2 ± 0.8	13.1 ± 0.7	13.3 ± 0.6	11.0 ± 0.5	50.6 ± 5.4
EL	ELLISVILLE RD	7.20 mi.	SSE	13.4 ± 0.8	13.7 ± 0.6	13.9 ± 0.7	12.1 ± 0.6	53.1 ± 4.4
UC	UP COLL. PND. RD	7.40 mi.	SW	12.0 ± 0.8	12.8 ± 0.8	13.2 ± 0.9	Missing	50.7 ± 4.8
SH	SACRED HEART	8.10 mi.	W	13.8 ± 0.8	14.5 ± 0.6	14.8 ± 0.6	13.7 ± 1.1	56.8 ± 4.3
KC	KING CAESAR RD	8.10 mi.	NNW	13.5 ± 0.9	14.4 ± 0.5	14.3 ± 0.8	13.3 ± 1.0	55.6 ± 4.3
BE	BOURNE ROAD	8.40 mi.	SSW	11.4 ± 0.9	12.4 ± 0.8	12.5 ± 0.5	11.0 ± 0.7	47.3 ± 4.6
SA	SHERMAN AIRPORT	8.40 mi.	WSW	13.3 ± 0.8	13.4 ± 0.6	13.8 ± 0.6	Missing	54.0 ± 3.5
CS	CEDARVILLE SUBSTA	10.00 mi.	S	14.9 ± 1.0	15.1 ± 0.7	15.8 ± 0.7	13.9 ± 1.3	59.8 ± 5.4
KS	KINGSTON SUBSTA	10.00 mi.	WNW	14.1 ± 0.9	13.7 ± 0.6	14.1 ± 0.6	12.3 ± 0.8	54.9 ± 5.3
CW	CHURCH & WEST ST	10.00 mi.	NW	13.6 ± 1.2	12.9 ± 0.5	13.3 ± 0.6	12.2 ± 1.0	52.0 ± 4.7
LR	LANDING RD	10.00 mi.	NNW	13.4 ± 0.9	14.1 ± 0.5	14.0 ± 0.4	13.2 ± 1.1	54.7 ± 4.1
MM	MAIN & MEADOW ST	11.00 mi.	WSW	13.9 ± 0.9	14.5 ± 0.7	14.8 ± 1.0	13.6 ± 1.3	56.8 ± 5.1
DMF	DIV. MAR. FISH	14.00 mi.	SSE	19.0 ± 1.1	19.3 ± 0.9	19.9 ± 0.8	18.0 ± 1.0	76.2 ± 5.4
EW	E WEYMOUTH SUBSTA	24.00 mi.	NW	16.2 ± 1.1	16.1 ± 0.9	16.3 ± 0.6	14.2 ± 0.8	62.9 ± 5.6

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

** Annual average value is based on arithmetic mean of observed quarterly values multiplied by 4.0 quarters/yr. Standard deviation of annual average includes arithmetic standard deviation calculated from quarterly values plus contribution from individual quarterly uncertainties (standard deviations).

Table 2.4.1-2

Off-site Environmental Thermoluminescent Dosimeter
Averages by Geographic Zone - 1990

Period	Average Exposure ± S.D. (mR/Period)			
	Environmental TLD Zones			
	Zone 1 < 2 mi	Zone 2 2 mi - 5 mi	Zone 3 5 mi - 10 mi	Zone 4 > 10 mi
1st Quarter 1990	16.3 ± 4.1	13.9 ± 2.8	13.5 ± 1.7	15.0 ± 2.0
2nd Quarter 1990	16.8 ± 3.6	14.6 ± 2.5	13.9 ± 1.4	15.1 ± 2.1
3rd Quarter 1990	16.9 ± 4.1	14.8 ± 2.7	14.1 ± 1.3	15.6 ± 2.2
4th Quarter 1990	16.2 ± 5.3	13.0 ± 2.6	12.6 ± 1.5	13.9 ± 2.0
1990 Annual Exposure	66.1 ± 17.1	56.5 ± 10.7	54.3 ± 6.0	59.6 ± 8.1

TABLE 2.4.1-3

ON-SITE ENVIRONMENTAL THERMOLUMINESCENT DOSIMETER RESULTS - 1990

TLD STATION		LOCATION*		EXPOSURE RATE - mR/quarter (VALUE ± STD.DEV)				ANNUAL MEAN** ± STD.DEV. mR/yr
ID	DESCRIPTION	DIST	DIR	FIRST	SECOND	THIRD	FOURTH	
WS	WAREHOUSE	600 ft.	SSE	20.5 ± 1.4	20.4 ± 1.3	21.0 ± 0.7	21.7 ± 1.3	83.7 ± 6.1
P02	FENCE SHORE	440 ft.	NNW	29.2 ± 2.2	26.1 ± 1.7	25.4 ± 0.9	26.6 ± 1.0	107.3 ± 9.8
P03	FEN L SCREENH	330 ft.	NW	31.0 ± 1.7	31.1 ± 1.8	32.2 ± 3.4	32.7 ± 1.7	126.9 ± 10.9
P04	FEN R SCREENH	220 ft.	N	99.3 ± 5.6	100.9 ± 5.8	73.1 ± 2.0	73.8 ± 3.6	347.1 ± 65.1
P05	FEN WATER TANK	260 ft.	NE	35.[illegible] ± 2.4	36.1 ± 1.3	34.6 ± 1.3	30.2 ± 1.7	136.4 ± 13.4
P06	FEN CULVERT	280 ft.	ENE	41.1 ± 2.2	53.0 ± 2.0	47.3 ± 2.0	52.8 ± 2.9	194.3 ± 25.0
P07	FEN INTAKE	400 ft.	E	8[illegible].4 ± 4.3	88.7 ± 5.2	80.3 ± 4.0	77.0 ± 5.7	335.5 ± 33.3
P08	FEN NEW ADMIN	300 ft.	E	6[illegible].3 ± 4.0	67.3 ± 3.0	64.6 ± 3.1	56.2 ± 2.7	256.4 ± 26.6
P09	FEN TCF SIDE	450 ft.	E	81.7 ± 4.2	83.2 ± 3.6	76.5 ± 3.9	77.2 ± 4.0	318.7 ± 22.4
P10	FEN INTAKE TCF	740 ft.	ESE	35.3 ± 1.9	37.9 ± 1.1	34.0 ± 1.2	26.4 ± 1.1	134.6 ± 21.2
P11	GATE WH TO TCF	620 ft.	SE	45.8 ± 2.4	50.2 ± 1.6	33.6 ± 1.7	31.8 ± 1.6	161.4 ± 37.1
P12	FEN WH CON GATE	660 ft.	SSE	21.7 ± 1.3	21.0 ± 1.4	20.4 ± 0.7	20.2 ± 1.8	83.2 ± 6.7
P13	FEN CON & RHR	740 ft.	S	19.3 ± 1.3	19.3 ± 0.8	18.7 ± 0.6	18.2 ± 0.9	75.5 ± 4.8
P14	FEN BUTLER BLDG	750 ft.	S	16.4 ± 1.1	18.1 ± 0.7	17.0 ± 0.6	16.2 ± 0.9	67.6 ± 5.0
P15	FEN UNIT #9	720 ft.	SSW	20.3 ± 1.1	20.2 ± 1.2	19.6 ± 0.8	20.6 ± 1.2	80.7 ± 5.3
P16	FEN SWY M GATE	560 ft.	SW	34.9 ± 2.0	30.8 ± 1.3	32.0 ± 1.5	36.4 ± 1.8	134.1 ± 12.9
P17	FEN SHF M GATE	350 ft.	WNW	43.0 ± 3.1	38.7 ± 1.2	36.8 ± 1.7	47.1 ± 2.4	165.7 ± 21.0
P18	I&C NEW ADMIN	290 ft.	S	27.2 ± 2.2	26.4 ± 1.8	23.7 ± 1.3	27.0 ± 1.2	104.3 ± 10.2
P19	COMPLIANCE AREA	280 ft.	S	25.4 ± 1.7	24.8 ± 0.9	24.7 ± 1.4	27.9 ± 1.6	102.7 ± 8.9
P20	RP WINDOW	220 ft.	SSE	27.4 ± 1.6	27.4 ± 1.1	26.7 ± 1.3	28.1 ± 1.5	109.7 ± 6.7
P21	WW ADMIN & PROC	170 ft.	SE	24.5 ± 1.4	25.0 ± 1.0	25.3 ± 1.1	24.3 ± 1.3	99.1 ± 5.9
P22	QA/QC CORNER	450 ft.	SE	22.6 ± 1.5	23.1 ± 0.8	21.6 ± 0.6	22.3 ± 1.0	89.6 ± 5.4
P23	OMG CORNER	400 ft.	SSE	19.2 ± 1.3	19.5 ± 1.2	17.6 ± 1.0	19.2 ± 1.0	75.6 ± 6.0
P24	ADMIN OFF O AD	190 ft.	W	26.2 ± 1.6	27.9 ± 0.9	26.8 ± 1.3	26.0 ± 1.1	108.9 ± 7.0
P25	FIRST AID TRAIL	250 ft.	WNW	33.1 ± 3.2	31.5 ± 1.9	29.6 ± 1.2	37.4 ± 2.4	131.6 ± 17.1
P26	FENCE WAREHOUSE	490 ft.	SE	44.5 ± 2.6	44.3 ± 2.0	38.1 ± 1.6	35.9 ± 1.5	162.9 ± 19.7
P27	TCF BOAT RAMP	640 ft.	ESE	67.6 ± 3.6	49.1 ± 1.9	28.4 ± 0.9	28.0 ± 1.9	173.1 ± 76.6
P28	TCF CONTR. LOT	800 ft.	ESE	25.6 ± 1.8	24.1 ± 1.3	21.2 ± 0.9	18.8 ± 1.3	89.8 ± 13.6

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

** Annual average value is based on arithmetic mean of observed quarterly values multiplied by 4.0 quarters/yr. Standard deviation of annual average includes arithmetic standard deviation calculated from quarterly values

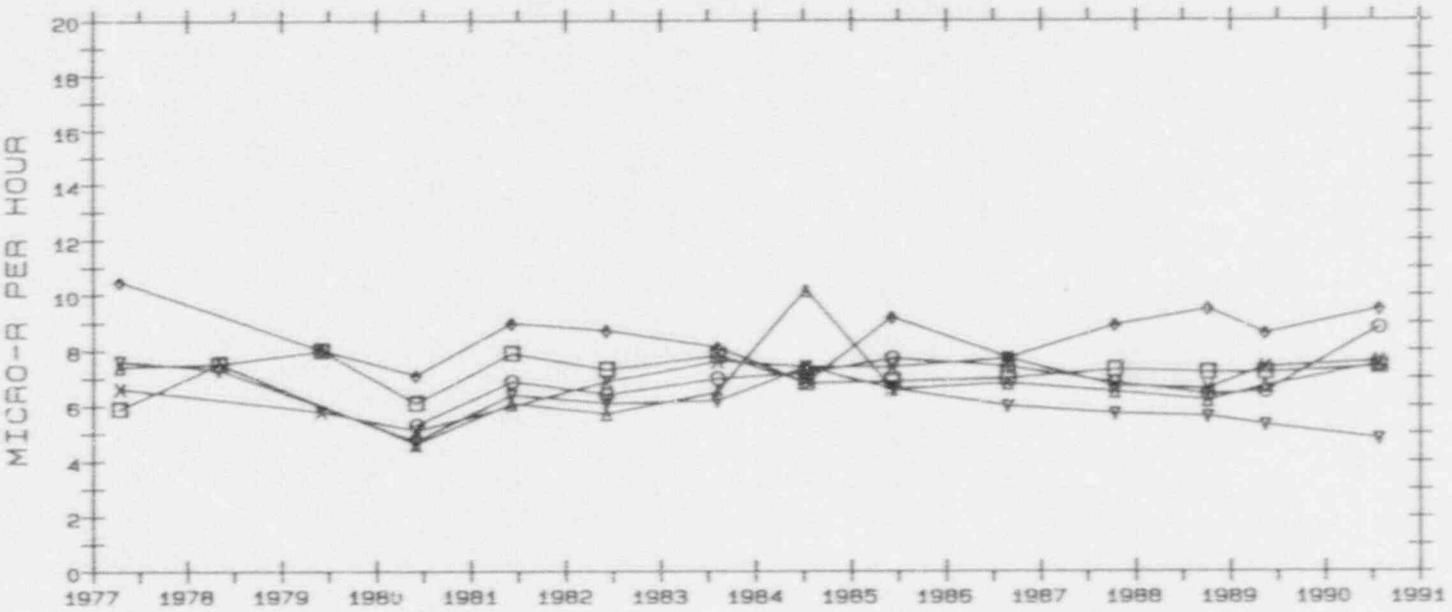
Table 2.4.2-1
Beach Survey Exposure Rates - 1990

1990 Direct Radiation Survey Results
July 26, 1990

Location	Exposure Rate Micro-R/hr ± 1 std. dev.	Beach Terrain
White Horse Beach (Near Hilltop Ave)	7.4 ± 0.4	Sandy. Few granite boulders within thirty feet.
White Horse Beach (In Back of Full Sail Bar)	8.8 ± 0.6	Sandy with small amounts of gravel.
Plymouth Beach (Outer Beach)	7.5 ± 0.5	Sandy.
Plymouth Beach (Inner Beach)	4.8 ± 0.7	Sandy.
Plymouth Beach (Behind Bert's Restaurant)	9.5 ± 0.4	Sandy with gravel. Breakwater and seawall nearby.
Duxbury Beach (Control)	7.6 ± 0.3	Sandy with coarse gravel.

Figure 2.4.2-1

Environmental Radiation Levels
At Beaches Near Pilgrim Station



—□— Whitehorse Beach at Hilltop Ave.
—○— Whitehorse Beach at Full Sail Bar
—△— Plymouth Beach - Outer
—▽— Plymouth Beach - Inner
—◇— Plymouth Beach at Berts
—X— Duxbury Beach Control

2.5 Surface Water

Samples of surface water were collected at three locations: the Discharge Canal, Bartlett Pond, and Powder Point (control). The Discharge Canal sample was collected by a continuously compositing sampler which extracts a sample of about 20 ml of water from the Discharge Canal every twenty minutes. Grab samples were collected weekly from each of the other two locations. Surface water samples were analyzed monthly for gamma isotopes with a quarterly composite analyzed for tritium. All seawater samples were collected and analyzed as required during 1990.

The summary of radioactivity analysis results for surface water samples collected during 1990 is presented in Table 2.5-1. There were no positive measurements of nuclides characteristic of Pilgrim Station's operation observed at any of the three sampling locations. The only positive radioactivity measurements observed were due to naturally-occurring potassium-40.

Therefore, analysis of surface water samples collected during 1990 showed no evidence of any significant radiological impact on the environment due to Pilgrim Station.

Table 2.5-1
Summary of Radioactivity Analysis Results For Seawater - 1990

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1990)

MEDIUM: SEAWATER

UNITS: PCI/KG

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 (42)		(3.7 ± 1.5)E 0	17	(6.9 ± 2.0)E 0	(1.2 ± 2.3)E 0
(0)		(-1.1 - 1.9)E 1		(-6.0 - 19.0)E 0	(-1.3 - 1.7)E 1
		(0/ 28)		*(0/ 14)*	*(0/ 14)*
K-40 (42)		(1.5 ± 0.3)E 2	23	(2.9 ± 0.1)E 2	(2.9 ± 0.1)E 2
(0)		(-1.0 - 36.6)E 1		(2.5 - 3.4)E 2	(2.5 - 3.4)E 2
		(14/ 28)		*(14/ 14)*	*(14/ 14)*
MN-54 (42)	15.	(6.8 ± 17.9)E -2	17	(1.6 ± 2.4)E -1	(-2.7 ± 1.7)E -1
(0)		(-1.4 - 1.8)E 0		(-1.3 - 1.7)E 0	(-1.5 - 0.8)E 0
		(0/ 28)		*(0/ 14)*	*(0/ 14)*
CO-58 (42)	15.	(1.7 ± 1.8)E -1	17	(3.6 ± 3.0)E -1	(-4.5 ± 2.6)E -1
(0)		(-2.0 - 1.9)E 0		(-2.0 - 1.9)E 0	(-2.2 - 1.7)E 0
		(0/ 28)		*(0/ 14)*	*(0/ 14)*
FE-59 (42)	30.	(-7.3 ± 4.9)E -1	23	(6.1 ± 5.4)E -1	(6.1 ± 5.4)E -1
(0)		(-6.3 - 5.3)E 0		(-2.3 - 4.1)E 0	(-2.3 - 4.1)E 0
		(0/ 28)		*(0/ 14)*	*(0/ 14)*
CO-60 (42)	15.	(-5.6 ± 2.1)E -1	23	(-3.3 ± 2.3)E -1	(-3.3 ± 2.3)E -1
(0)		(-4.2 - 1.6)E 0		(-1.6 - 1.5)E 0	(-1.6 - 1.5)E 0
		(0/ 28)		*(0/ 14)*	*(0/ 14)*
ZN-65 (42)	30.	(4.2 ± 3.[illegible] -1	11	(6.0 ± 6.2)E -1	(-1.2 ± 61.8)E -2
(0)		(-3.0 - 4.3)E 0		(-2.7 - 4.3)E 0	(-3.2 - 4.5)E 0
		(0/ 28)		*(0/ 14)*	*(0/ 14)*
ZR-95 (42)	15.	(3.5 ± 3.1)E -1	17	(4.3 ± 4.8)E -1	(-2.4 ± 4.3)E -1
(0)		(-3.3 - 4.6)E 0		(-3.3 - 4.6)E 0	(-3.0 - 2.8)E 0
		(0/ 28)		*(0/ 14)*	*(0/ 14)*
RU-103 (42)		(-3.8 ± 2.0)E -1	17	(-2.9 ± 2.7)E -1	(-4.8 ± 2.6)E -1
(0)		(-2.5 - 1.7)E 0		(-1.9 - 1.7)E 0	(-2.0 - 0.9)E 0
		(0/ 28)		*(0/ 14)*	*(0/ 14)*

* 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 STD DEVIATIONS) IS INDICATED WITH *( )*.

Table 2.5-1 (continued)
Summary of Radioactivity Analysis Results
For Seawater - 1990

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1990)

MEDIUM: SEAWATER

UNITS: PCI/KG

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**
RU-106 (42)		(2.0 ± 17.8)E -1	17	(3.4 ± 2.5)E 0	(-2.3 ± 14.6)E -1
(0)		(-2.2 - 1.6)E 1		(-1.2 - 1.6)E 1	(-9.6 - 10.2)E 0
		(0/ 28)		*(0/ 14)*	*(0/ 14)*
I-131 (42)	1.	(9.1 ± 3293.7)E -5	11	(4.7 ± 4.5)E -2	(1.2 ± 3.4)E -2
(0)		(-3.9 - 3.0)E -1		(-3.0 - 3.0)E -1	(-1.3 - 3.6)E -1
		(0/ 28)		*(0/ 14)*	*(0/ 14)*
CS-134 (42)	15.	(-7.0 ± 1.7)E -1	17	(-3.8 ± 2.6)E -1	(-1.1 ± 0.3)E 0
(0)		(-2.4 - 1.2)E 0		(-2.4 - 1.2)E 0	(-2.6 - 0.5)E 0
		(0/ 28)		*(0/ 14)*	*(0/ 14)*
CS-137 (42)	18.	(-3.3 ± 1.9)E -1	23	(-1.0 ± 2.9)E -1	(-1.0 ± 2.9)E -1
(0)		(-1.9 - 1.9)E 0		(-2.5 - 1.7)E 0	(-2.5 - 1.7)E 0
		(0/ 28)		*(0/ 14)*	*(0/ 14)*
BA-140 (42)	15.	(-5.9 ± 42.7)E -2	17	(-1.6 ± 65.1)E -2	(-5.7 ± 6.9)E -1
(0)		(-4.0 - 3.4)E 0		(-4.0 - 3.4)E 0	(-5.7 - 3.8)E 0
		(0/ 28)		*(0/ 14)*	*(0/ 14)*
CE-141 (42)		(3.6 ± 3.7)E -1	17	(4.8 ± 5.6)E -1	(2.2 ± 63.6)E -2
(0)		(-3.7 - 4.7)E 0		(-2.5 - 4.7)E 0	(-5.1 - 3.7)E 0
		(0/ 28)		*(0/ 14)*	*(0/ 14)*
CE-144 (42)		(-1.2 ± 1.2)E 0	23	(1.1 ± 1.1)E 0	(1.1 ± 1.1)E 0
(0)		(-1.1 - 1.7)E 1		(-5.5 - 9.1)E 0	(-5.5 - 9.1)E 0
		(0/ 28)		*(0/ 14)*	*(0/ 14)*
TH-232 (42)		(2.2 ± 0.6)E 0	11	(2.5 ± 0.8)E 0	(1.1 ± 0.8)E 0
(0)		(-4.8 - 8.5)E 0		(-2.5 - 8.5)E 0	(-2.9 - 7.8)E 0
		(0/ 28)		*(0/ 14)*	*(0/ 14)*
H-3 (12)	3000.	(-4.8 ± 6.0)E 1	23	(4.1 ± 12.2)E 1	(4.1 ± 12.2)E 1
(0)		(-2.3 - 1.9)E 2		(-2.3 - 3.6)E 2	(-2.3 - 3.6)E 2
		(0/ 8)		*(0/ 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 STD DEVIATIONS) IS INDICATED WITH *( )*.

2.6 Shellfish

Shellfish samples, which include soft shell clams, quahogs, and blue mussels, were collected quarterly from five locations: the Discharge Canal, Manomet Point, Plymouth Harbor, Duxbury Bay (control), and Marshfield (control). Shells and bodies were analyzed quarterly for gamma-emitting isotopes. All shellfish samples were collected and analyzed as required during 1990.

The summary of radioactivity analysis results for shellfish collected during 1990 is presented in Table 2.6-1. This table shows positive measurements of beryllium-7, potassium-40, cobalt-60, silver-110m and thorium-232 in samples from the Discharge Canal. In addition, there were positive measurements of beryllium-7, potassium-40, and thorium-232 at Manomet Point, Plymouth Harbor, Duxbury Bay, and at the Marshfield control station. The observed concentrations of beryllium-7, potassium-40, and thorium-232 are due to the natural occurrence of these radionuclides, whereas the observed concentrations of cobalt-60 and silver-110m were the result of Pilgrim Station radioactive liquid releases. It should be noted that no soft shell clams or quahogs showed any detectable radioactivity that could be attributed to Pilgrim Station's operation.

A special study was conducted to evaluate the impact of the cobalt-60 and silver-110m detected in the blue mussels. Appendix A presents the findings and results of this special study. It was shown that if a person were to consume the maximum annual quantity of seafood (9 kilograms/year) with the concentrations of the above radionuclides (as found in the mussels in the discharge canal outfall), he would receive a dose of less than 0.001 mrem to the total body and about 0.01 mrem to the most restrictive organ (adult, gastrointestinal tract/lower large intestine). This study noted that blue mussels, due to their filtration effect, concentrate the radioactivity in the water thereby making them a sensitive biological indicator.

Therefore, analysis of shellfish samples collected during 1990 showed no evidence of any significant radiological impact on the environment or on the general public due to Pilgrim Station.

Table 2.6-1
Summary of Radioactivity Analysis Results
For Shellfish - 1990

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1990)

MEDIUM: SHELLFISH

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 (58)		(2.8 ± 0.9)E 1	12	(3.7 ± 1.6)E 1	(1.4 ± 1.2)E 1
(0)		(-7.2 - 21.5)E 1		(-7.2 - 21.5)E 1	(-1.4 - 1.7)E 2
		(2/ 28)		*(1/ 15)*	*(3/ 30)*
K-40 (58)		(8.2 ± 0.7)E 2	15	(1.0 ± 0.1)E 3	(7.6 ± 1.2)E 2
(0)		(2.1 - 13.1)E 2		(8.5 - 13.1)E 2	(1.6 - 215.0)E 1
		(27/ 28)		*(5/ 5)*	*(23/ 30)*
MN-54 (58)	130.	(4.6 ± 8.0)E -1	11	(9.1 ± 3.7)E -1	(7.0 ± 94.8)E -2
(0)		(-1.5 - 0.9)E 1		(-8.6 - 20.3)E -1	(-1.3 - 1.3)E 1
		(0/ 28)		*(0/ 8)*	*(0/ 30)*
CO-58 (58)	130.	(-4.3 ± 8.3)E -1	24	(2.6 ± 4.1)E -1	(-7.3 ± 8.8)E -1
(0)		(-1.2 - 0.9)E 1		(-1.8 - 1.9)E 0	(-1.4 - 0.8)E 1
		(0/ 28)		*(0/ 10)*	*(0/ 30)*
FE-59 (58)	260.	(-3.2 ± 1.9)E 0	11	(5.6 ± 7.1)E -1	(-1.4 ± 2.4)E 0
(0)		(-3.3 - 2.1)E 1		(-2.8 - 2.7)E 0	(-3.5 - 3.1)E 1
		(0/ 28)		*(0/ 8)*	*(0/ 30)*
CO-60 (58)	5.	(4.7 ± 14.2)E -1	11	(6.7 ± 2.5)E 0	(-3.2 ± 1.5)E 0
(0)		(-2.1 - 1.9)E 1		(-1.0 - 18.5)E 0	(-3.2 - 1.7)E 1
		(5/ 28)		*(5/ 8)*	*(0/ 30)*
ZN-65 (58)	5.	(1.5 ± 1.4)E 0	12	(1.9 ± 2.6)E 0	(-1.0 ± 1.7)E 0
(0)		(-1.9 - 2.1)E 1		(-1.9 - 2.1)E 1	(-2.4 - 1.6)E 1
		(0/ 28)		*(0/ 15)*	*(0/ 30)*
ZR-95 (58)	5.	(1.4 ± 1.2)E 0	13	(2.3 ± 3.7)E 0	(2.0 ± 2.4)E 0
(0)		(-2.3 - 1.4)E 1		(-3.4 - 4.4)E 1	(-3.4 - 4.4)E 1
		(0/ 28)		*(0/ 20)*	*(0/ 30)*
AG-110M(58)		(-9.9 ± 8.3)E -1	11	(1.2 ± 1.4)E 0	(-9.8 ± 12.4)E -1
(0)		(-1.0 - 1.1)E 1		(-1.3 - 10.9)E 0	(-2.2 - 1.4)E 1
		(1/ 28)		*(1/ 8)*	*(0/ 30)*

* 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 STD DEVIATIONS) IS INDICATED WITH *( )*.

Table 2.6-1 (continued)
Summary of Radioactivity Analysis Results
For Shellfish - 1990

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1990)

MEDIUM: SHELLFISH

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**
RU-103 (58)		(-3.8 ± 6.3)E -1	13	(2.9 ± 12.0)E -1	(5.6 ± 80.5)E -2
(0)		(-1.1 - 1.0)E 1		(-1.0 - 1.4)E 1	(-1.0 - 1.4)E 1
		(0/ 28)		*(0/ 20)*	*(0/ 30)*
RU-106 (58)		(-4.5 ± 7.1)E 0	15	(8.2 ± 339.7)E -2	(-1.6 ± 0.8)E 1
(0)		(-1.2 - 0.8)E 2		(-6.3 - 12.3)E 0	(-1.0 - 1.1)E 2
		(0/ 28)		*(0/ 5)*	*(0/ 30)*
I-131 (58)		(1.1 ± 0.8)E 1	12	(1.9 ± 1.4)E 1	(-1.7 ± 1.0)E 1
(0)		(-3.8 - 17.2)E 1		(-3.8 - 17.2)E 1	(-2.3 - 0.5)E 2
		(0/ 28)		*(0/ 15)*	*(0/ 30)*
CS-134 (58)	5.	(-1.0 ± 0.9)E 0	24	(-4.6 ± 4.5)E -1	(-2.8 ± 1.3)E 0
(0)		(-1.7 - 0.9)E 1		(-2.3 - 2.2)E 0	(-2.0 - 1.2)E 1
		(0/ 28)		*(0/ 10)*	*(0/ 30)*
CS-137 (58)	5.	(7.1 ± 4.8)E -1	13	(1.7 ± 1.5)E 0	(1.3 ± 1.0)E 0
(0)		(-2.5 - 10.4)E 0		(-1.1 - 1.6)E 1	(-1.1 - 1.6)E 1
		(0/ 28)		*(0/ 20)*	*(0/ 30)*
BA-140 (58)		(-3.4 ± 2.8)E 0	11	(2.4 ± 2.2)E 0	(1.3 ± 2.9)E 0
(0)		(-6.3 - 1.3)E 1		(-1.0 - 1.1)E 1	(-2.9 - 3.5)E 1
		(0/ 28)		*(0/ 8)*	*(0/ 30)*
CE-141 (58)		(5.1 ± 1.3)E 0	12	(8.1 ± 2.1)E 0	(1.1 ± 1.9)E 0
(0)		(-1.3 - 22.6)E 0		(-1.3 - 22.6)E 0	(-1.6 - 3.4)E 1
		(0/ 28)		*(0/ 15)*	*(0/ 30)*
CE-144 (58)	15.	(9.5 ± 45.7)E -1	12	(2.1 ± 8.6)E 0	(-8.2 ± 5.3)E 0
(0)		(-6.5 - 6.2)E 1		(-6.5 - 6.2)E 1	(-8.4 - 8.1)E 1
		(0/ 28)		*(0/ 15)*	*(0/ 30)*
TH-232 (58)		(2.4 ± 0.6)E 1	13	(6.2 ± 0.9)E 1	(4.7 ± 0.7)E 1
(0)		(-4.6 - 1140.0)E -1		(-6.9 - 166.0)E 0	(-6.9 - 166.0)E 0
		(8/ 28)		*(7/ 20)*	*(12/ 30)*

* 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 STD DEVIATIONS) IS INDICATED WITH *( )*.

2.7 Irish Moss

Irish moss (Chondrus crispus) samples were collected quarterly at four locations: the Discharge Canal, Manomet Point, Ellisville (control), and Brant Rock (control). Irish moss samples were analyzed quarterly for gamma-emitting isotopes. All Irish moss samples were collected and analyzed as required during 1990.

The summary of radioactivity analysis results for Irish moss collected during 1990 is presented in Table 2.7-1. This table shows positive measurements of beryllium-7 and potassium-40 at the Discharge Canal. In addition, there was detectable beryllium-7, potassium-40, and thorium-232 in samples collected from Manomet Point and the control stations in Ellisville and Brant Rock. The positive measurements of beryllium-7, potassium-40, and thorium-232 in Irish moss are a result of naturally-occurring radioactivity. There were no positive measurements of Pilgrim Station related nuclides at any sampling locations during 1990.

Therefore, analysis of Irish moss samples collected during 1990 showed no evidence of any significant radiological impact on the environment or on the general public due to Pilgrim Station.

Table 2.7-1
Summary of Radioactivity Analysis Results
For Irish Moss - 1990

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1990)

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.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
BE-7 (16)		(2.1 ± 0.4)E 2	11	(2.6 ± 0.5)E 2	(1.8 ± 0.4)E 2
(0)		(6.3 - 34.2)E 1		(1.2 - 3.4)E 2	(6.9 - 38.5)E 1
		(7/ 8)		*(4/ 4)*	*(2/ 8)*
K-40 (16)		(6.4 ± 0.6)E 3	11	(7.7 ± 0.7)E 3	(6.8 ± 1.1)E 3
(0)		(4.6 - 9.6)E 3		(6.6 - 9.6)E 3	(4.7 - 13.9)E 3
		(8/ 8)		*(4/ 4)*	*(8/ 8)*
MN-54 (16)		(-1.3 ± 1.9)E 0	22	(2.7 ± 2.0)E 0	(1.7 ± 1.4)E 0
(0)		(-7.0 - 6.2)E 0		(-1.8 - 7.5)E 0	(-3.2 - 7.5)E 0
		(0/ 8)		*(0/ 4)*	*(0/ 8)*
CO-58 (16)		(-3.2 ± 1.7)E 0	22	(1.2 ± 27.7)E -1	(-5.1 ± 16.5)E -1
(0)		(-8.7 - 3.5)E 0		(-4.7 - 5.6)E 0	(-7.0 - 5.6)E 0
		(0/ 8)		*(0/ 4)*	*(0/ 8)*
FE-59 (16)		(-1.1 ± 0.6)E 1	34	(-2.8 ± 2.1)E 0	(-2.9 ± 5.8)E 0
(0)		(-4.4 - 1.2)E 1		(-7.1 - 2.8)E 0	(-3.5 - 2.3)E 1
		(0/ 8)		*(0/ 4)*	*(0/ 8)*
CO-60 (16)		(2.4 ± 3.2)E 0	34	(4.4 ± 8.0)E 0	(3.1 ± 3.8)E 0
(0)		(-1.6 - 1.6)E 1		(-5.3 - 28.3)E 0	(-5.3 - 28.3)E 0
		(0/ 8)		*(0/ 4)*	*(0/ 8)*
ZN-65 (16)		(6.5 ± 3.6)E 0	11	(7.3 ± 7.3)E 0	(-4.9 ± 6.9)E 0
(0)		(-1.1 - 2.4)E 1		(-1.1 - 2.4)E 1	(-4.9 - 1.4)E 1
		(0/ 8)		*(0/ 4)*	*(0/ 8)*
ZR-95 (16)		(2.1 ± 3.1)E 0	11	(3.8 ± 6.4)E 0	(-3.6 ± 5.2)E 0
(0)		(-7.7 - 19.3)E 0		(-7.7 - 19.3)E 0	(-2.9 - 1.7)E 1
		(0/ 8)		*(0/ 4)*	*(0/ 8)*
RU-103 (16)		(-1.0 ± 1.8)E 0	34	(3.6 ± 2.3)E 0	(2.0 ± 1.6)E 0
(0)		(-1.1 - 0.6)E 1		(-2.3 - 8.4)E 0	(-4.6 - 8.4)E 0
		(0/ 8)		*(0/ 4)*	*(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 STD DEVIATIONS) IS INDICATED WITH *( )*.

Table 2.7-1 (continued)
Summary of Radioactivity Analysis Results
For Irish Moss - 1990

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1990)

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**
RU-106 (16)		(-2.3 ± 0.9)E 1	22	(1.3 ± 2.1)E 1	(3.3 ± 18.7)E 0
(0)		(-6.3 - 1.7)E 1		(-2.0 - 7.3)E 1	(-9.0 - 7.3)E 1
		(0/ 8)		*(0/ 4)*	*(0/ 8)*
I-131 (16)		(2.7 ± 1.4)E 1	15	(3.4 ± 2.0)E 1	(-7.6 ± 97.7)E -1
(0)		(-3.8 - 7.0)E 1		(-9.9 - 69.8)E 0	(-3.0 - 5.9)E 1
		(0/ 8)		*(0/ 4)*	*(0/ 8)*
CS-134 (16)		(-1.4 ± 1.1)E 0	15	(-1.7 ± 172.6)E -2	(-3.6 ± 2.4)E 0
(0)		(-4.4 - 3.9)E 0		(-4.4 - 3.9)E 0	(-1.5 - 0.7)E 1
		(0/ 8)		*(0/ 4)*	*(0/ 8)*
CS-137 (16)		(2.9 ± 2.1)E 0	11	(5.2 ± 2.9)E 0	(1.8 ± 2.1)E 0
(0)		(-5.3 - 10.6)E 0		(-2.5 - 10.6)E 0	(-9.1 - 8.7)E 0
		(0/ 8)		*(0/ 4)*	*(0/ 8)*
BA-140 (16)		(-1.0 ± 0.2)E 1	22	(-4.5 ± 15.9)E 0	(-1.1 ± 0.9)E 1
(0)		(-1.6 - -0.1)E 1		(-4.2 - 2.2)E 1	(-4.4 - 2.2)E 1
		(0/ 8)		*(0/ 4)*	*(0/ 8)*
CE-141 (16)		(3.2 ± 3.0)E 0	11	(3.3 ± 4.9)E 0	(-2.0 ± 457.0)E -2
(0)		(-7.5 - 14.0)E 0		(-7.5 - 12.9)E 0	(-2.1 - 1.9)E 1
		(0/ 8)		*(0/ 4)*	*(0/ 8)*
CE-144 (16)		(-1.8 ± 6.0)E 0	11	(4.0 ± 8.4)E 0	(-6.8 ± 8.6)E 0
(0)		(-3.3 - 2.9)E 1		(-8.6 - 28.6)E 0	(-3.3 - 3.7)E 1
		(0/ 8)		*(0/ 4)*	*(0/ 8)*
TH-232 (16)		(1.9 ± 1.0)E 1	34	(4.3 ± 0.7)E 1	(3.0 ± 0.9)E 1
(0)		(-2.2 - 7.4)E 1		(3.1 - 6.1)E 1	(-4.9 - 61.4)E 0
		(1/ 8)		*(0/ 4)*	*(1/ 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 STD DEVIATIONS) IS INDICATED WITH *( )*.

2.8 American Lobster

Lobster samples were collected four times per season in the vicinity of the Discharge Canal and annually at a control location. Lobsters collected were analyzed for gamma-emitting isotopes. All lobster samples were collected and analyzed as required during 1990.

The summary of the radioactivity analysis results for American lobsters collected during 1990 is presented in Table 2.8-1. These results indicate that there were no positive measurements of any radioactivity other than naturally-occurring potassium-40 in either the indicator or the control samples.

Therefore, analysis of lobster samples collected during 1990 showed no evidence of any significant radiological impact on the environment due to Pilgrim Station.

Table 2.8-1
Summary of Radioactivity Analysis Results
For American Lobster - 1990

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1990)

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)		(-8.8 ± 4.0)E 1	89	(-3.0 ± 7.2)E 1	(-3.0 ± 7.2)E 1
(0)		(-1.9 - 0.0)E 2			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
K-40 (5)		(1.8 ± 0.3)E 3	89	(2.3 ± 0.2)E 3	(2.3 ± 0.2)E 3
(0)		(1.2 - 2.4)E 3			
		(4/ 4)		*(1/ 1)*	*(1/ 1)*
MN-54 (5)	130.	(4.3 ± 29.0)E -1	11	(4.3 ± 29.0)E -1	(-9.6 ± 9.5)E 0
(0)		(-7.6 - 5.7)E 0		(-7.6 - 5.7)E 0	
		(0/ 4)		*(0/ 4)*	*(0/ 1)*
CO-58 (5)	130.	(-2.4 ± 3.0)E 0	89	(-2.5 ± 99.4)E -1	(-2.5 ± 99.4)E -1
(0)		(-1.1 - 0.3)E 1			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
FE-59 (5)	260.	(-5.7 ± 8.4)E 0	89	(9.2 ± 24.4)E 0	(9.2 ± 24.4)E 0
(0)		(-1.8 - 1.9)E 1			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
CO-60 (5)	130.	(-5.1 ± 6.8)E 0	89	(1.5 ± 12.7)E 0	(1.5 ± 12.7)E 0
(0)		(-1.8 - 0.8)E 1			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
ZN-65 (5)	260.	(1.4 ± 1.8)E 1	11	(1.4 ± 1.8)E 1	(-3.5 ± 2.1)E 1
(0)		(-3.9 - 4.2)E 1		(-3.9 - 4.2)E 1	
		(0/ 4)		*(0/ 4)*	*(0/ 1)*
ZR-95 (5)		(8.4 ± 13.3)E 0	89	(5.0 ± 2.0)E 1	(5.0 ± 2.0)E 1
(0)		(-1.7 - 4.2)E 1			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
AG-110M(5)		(-3.2 ± 7.8)E 0	11	(-3.2 ± 7.8)E 0	(-1.9 ± 1.0)E 1
(0)		(-2.0 - 1.7)E 1		(-2.0 - 1.7)E 1	
		(0/ 4)		*(0/ 4)*	*(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 STD DEVIATIONS) IS INDICATED WITH *( )*.

Table 2.8-1 (continued)
Summary of Radioactivity Analysis Results
For American Lobster - 1990

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1990)

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**
RU-103 (5)		(6.7 ± 7.9)E 0	11	(6.7 ± 7.9)E 0	(4.3 ± 9.8)E 0
(0)		(-6.8 - 24.9)E 0		(-6.8 - 24.9)E 0	
		(0/ 4)		*(0/ 4)*	*(0/ 1)*
RU-106 (5)		(-6.1 ± 3.0)E 1	89	(2.9 ± 7.0)E 1	(2.9 ± 7.0)E 1
(0)		(-1.0 - 0.3)E 2			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
I-131 (5)		(-8.4 ± 5.3)E 1	89	(1.3 ± 2.7)E 1	(1.3 ± 2.7)E 1
(0)		(-2.4 - -0.1)E 2			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
CS-134 (5)	130.	(-2.0 ± 0.7)E 1	89	(-1.4 ± 0.8)E 1	(-1.4 ± 0.8)E 1
(0)		(-3.5 - -0.4)E 1			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
CS-137 (5)	130.	(-1.1 ± 6.4)E 0	89	(2.0 ± 1.1)E 1	(2.0 ± 1.1)E 1
(0)		(-1.5 - 1.2)E 1			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
BA-140 (5)		(-7.6 ± 8.8)E 1	89	(-1.8 ± 2.0)E 1	(-1.8 ± 2.0)E 1
(0)		(-3.3 - 0.7)E 2			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
CE-141 (5)		(1.6 ± 0.7)E 1	89	(2.7 ± 1.6)E 1	(2.7 ± 1.6)E 1
(0)		(-3.8 - 25.5)E 0			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
CE-144 (5)		(-6.8 ± 2.0)E 1	89	(3.9 ± 5.4)E 1	(3.9 ± 5.4)E 1
(0)		(-1.1 - -0.3)E 2			
		(0/ 4)		*(0/ 1)*	*(0/ 1)*
TH-232 (5)		(9.0 ± 274.4)E -1	11	(9.0 ± 274.4)E -1	(-3.8 ± 4.4)E 1
(0)		(-6.4 - 5.3)E 1		(-6.4 - 5.3)E 1	
		(0/ 4)		*(0/ 4)*	*(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 STD DEVIATIONS) IS INDICATED WITH *( )*.

2.9 Fishes

Fish samples of bottom-oriented (Group I)[a] and near-bottom (Group II)[b] species were collected quarterly (when available) in the vicinity of the Discharge Canal. In addition, samples of anadromous (Group III)[c] and coastal migratory (Group IV)[d] species were collected (when in season) in this same area. Lastly, a sample from each group was collected at a distant control location. Fish samples collected from the vicinity of the discharge canal were analyzed quarterly for gamma-emitting isotopes and fish samples collected at control locations were analyzed annually. During 1990, Group II fishes were unavailable in the first quarter due to rough seas and the species not being found in the general area of the Discharge Canal. Only one of two subsamples of Group I fishes were collected during the first quarter for the same reasons Group II fish were not collected. Fish samples from all other groups of fishes were collected and analyzed as required during 1990.

The summary of the radioactivity analysis results for fishes collected during 1990 is presented in Table 2.9-1. Naturally-occurring potassium-40 was detected in all 32 fish samples collected during 1990. No radionuclides attributable to PNPS operations were observed in any indicator station samples.

Therefore, analysis of fish samples collected during 1990 showed no evidence of any significant radiological impact on the environment due to Pilgrim Station.

[a]Group I - Bottom Oriented: Winter Flounder, Yellowtail Flounder.

[b]Group II - Near-bottom Distribution: Tautog, Cunner, Atlantic Cod, Pollock, Hake.

[c]Group III - Anadromous: Alewife, Rainbow Smelt, Striped Bass.

[d]Group IV - Coastal Migratory: Bluefish, Atlantic Herring, Atlantic Menhaden, Atlantic Mackerel.

Table 2.9-1
Summary of Radioactivity Analysis Results
For Fishes - 1990

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1990)

MEDIUM: FISHES

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 (32)		(3.1 ± 1.3)E 1	90	(6.3 ± 7.7)E 1	(-1.8 ± 1.4)E 1
(0)		(-9.2 - 14.6)E 1		*(0/ 1)*	(-6.7 - 6.3)E 1
		(0/ 23)			*(0/ 9)*
K-40 (32)		(3.1 ± 0.1)E 3	90	(3.2 ± 0.2)E 3	(2.9 ± 0.1)E 3
(0)		(2.3 - 4.0)E 3			(2.5 - 3.3)E 3
		(23/ 23)		*(1/ 1)*	*(9/ 9)*
MN-54 (32)	130.	(-3.9 ± 1.9)E 0	98	(6.4 ± 2.1)E 0	(3.0 ± 3.0)E 0
(0)		(-2.7 - 1.2)E 1		(-1.6 - 12.3)E 0	(-1.5 - 1.2)E 1
		(0/ 23)		*(0/ 7)*	*(0/ 9)*
CO-58 (32)	130.	(-2.0 ± 2.3)E 0	90	(1.0 ± 1.0)E 1	(1.0 ± 2.9)E 0
(0)		(-2.5 - 2.2)E 1			(-1.4 - 1.0)E 1
		(0/ 23)		*(0/ 1)*	*(0/ 9)*
FE-59 (32)	260.	(-3.5 ± 4042.5)E -3	92	(5.[illegible] ± 29 - 0	(1.8 ± 4.4)E 0
(0)		(-4.1 - 4.2)E 1		*(0/ [illegible]	(-2.1 - 1.8)E 1
		(0/ 23)			*(0/ 9)*
CO-60 (32)	130.	(-3.9 ± 2.3)E 0	92	(1.3 ± 15.2)E 0	(-3.2 ± 23.4)E -1
(0)		(-3.1 - 1.0)E 1			(-1.4 - 1.2)E 1
		(0/ 23)		*(0/ 1)*	*(0/ 9)*
ZN-65 (32)	260.	(-4.7 ± 3.5)E 0	98	(2.6 ± 75.0)E -1	(-3.2 ± 6.3)E 0
(0)		(-3.2 - 4.6)E 1		(-3.5 - 2.5)E 1	(-3.5 - 2.5)E 1
		(0/ 23)		*(0/ 7)*	*(0/ 9)*
ZR-95 (32)		(3.8 ± 3.0)E 0	92	(8.6 ± 21.1)E 0	(-6.1 ± 4.5)E 0
(0)		(-2.2 - 2.9)E 1			(-2.7 - 0.9)E 1
		(0/ 23)		*(0/ 1)*	*(0/ 9)*
AG-110M(32)		(-4.8 ± 2.3)E 0	92	(3.8 ± 14.9)E 0	(3.1 ± 24.5)E -1
(0)		(-2.8 - 1.2)E 1			(-1.4 - 1.0)E 1
		(0/ 23)		*(0/ 1)*	*(0/ 9)*

* 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 STD DEVIATIONS) IS INDICATED WITH *( )*.

Table 2.9-1 (continued)
Summary of Radioactivity Analysis Results
For Fishes - 1990

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1990)

MEDIUM: FISHES

UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN LOC. NO. MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
RU-103 (32)		(3.2 ± 18.9)E -1	90 (6.5 ± 12.4)E 0	(-2.4 ± 2.3)E 0
(0)		(-1.5 - 2.0)E 1		(-1.1 - 0.7)E 1
		(0/ 23)	*(0/ 1)*	*(0/ 9)*
RU-106 (32)		(-1.4 ± 15.4)E 0	90 (1.5 ± 0.7)E 2	(1.4 ± 2.5)E 1
(0)		(-1.6 - 1.6)E 2		(-1.3 - 1.5)E 2
		(0/ 23)	*(0/ 1)*	*(0/ 9)*
I-131 (32)		(-1.8 ± 1.5)E 1	98 (5.0 ± 5.6)E 0	(-2.1 ± 2.4)E 1
(0)		(1.8 - 0.9)E 2	(-1.8 - 3.1)E 1	(-2.1 - 0.3)E 2
		(0/ 23)	*(0/ 7)*	*(0/ 9)*
CS-134 (32)	130.	(-5.2 ± 2.5)E 0	11 (-5.2 ± 2.5)E 0	(-6.8 ± 1.8)E 0
(0)		(-2.8 - 3.2)E 1	(-2.8 - 3.2)E 1	(-1.5 - 0.1)E 1
		(0/ 23)	*(0/ 23)*	*(0/ 9)*
CS-137 (32)	130.	(5.7 ± 1.8)E 0	92 (1.5 ± 1.2)E 1	(8.1 ± 2.0)E 0
(0)		(-1.4 - 1.9)E 1		(1.6 - 168.0)E -1
		(0/ 23)	*(0/ 1)*	*(0/ 9)*
BA-140 (32)		(-7.2 ± 8.1)E 0	92 (2.0 ± 4.0)E 1	(-1.0 ± 3.2)E 0
(0)		(-7.7 - 8.2)E 1		(-1.1 - 2.0)E 1
		(0/ 23)	*(0/ 1)*	*(0/ 9)*
CE-141 (32)		(2.7 ± 3.1)E 0	98 (7.9 ± 4.7)E 0	(3.5 ± 5.0)E 0
(0)		(-3.2 - 2.6)E 1	(-1.9 - 1.8)E 1	(-2.4 - 1.8)E 1
		(0/ 23)	*(0/ 7)*	*(0/ 9)*
CE-1 32)		(-6.1 ± 9.4)E 0	92 (-3.0 ± 58.6)E 0	(-1.9 ± 1.1)E 1
0)		(-1.1 - 0.7)E 2		(-5.4 - 5.2)E 1
		(0/ 23)	*(0/ 1)*	*(0/ 9)*
TH-232 (32)		(1.2 ± 0.7)E 1	11 (1.2 ± 0.7)E 1	(2.1 ± 13.0)E 0
(0)		(-5.0 - 10.7)E 1	(-5.0 - 10.7)E 1	(-6.3 - 7.7)E 1
		(0/ 23)	*(0/ 23)*	*(0/ 9)*

* 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 STD DEVIATIONS) IS INDICATED WITH *( )*.

2.10 Sediment

Sediment samples were collected semiannually at five indicator stations including: the Discharge Canal, Plymouth Harbor, Duxbury Bay, Plymouth Beach, and Manomet Point, and at a control station in Marshfield. There is a detailed procedure for sub-dividing individual sediment cores in which samples are sectioned into 2-cm increments during the first half of the year (this applies to all locations except Plymouth Beach), and samples are sectioned into 5-cm increments during the second half of the year. The surface and alternate sections were analyzed for gamma-emitting nuclides semiannually. In addition, the surface section from each core and a mid-depth section from Rocky Point and Plymouth Harbor were analyzed for plutonium-238, 239, and 240 annually. All sediment samples were collected and analyzed as required during 1990.

The summary of radioactivity analysis results for sediment collected during 1990 is presented in Table 2.10-1. This table shows that positive measurements of potassium-40 and thorium-232 were observed at all indicator and control stations. Positive measurements of beryllium-7 were detected on sediment samples from three indicator station samples. The beryllium-7, potassium-40, and thorium-232 are all naturally-occurring radionuclides. Cobalt-60 was not detected in any samples during 1990. Positive measurements of cesium-137 were detected in 32 sediment samples taken from indicator and control stations. Unfortunately, Cs-137 was not directly analyzed for in pre-operational samples collected between 1968 and 1972. However, the presence of detectable levels of cesium-137 in samples collected at control locations beyond the influence of Pilgrim Station indicates that the levels observed are indicative of fallout from nuclear weapons testing. The maximum concentration of Cs-137 in any of the indicator station samples was 93 pCi/kg, essentially the same as the maximum concentration of 92.7 pCi/kg observed in control station samples.

The results of plutonium analyses for the 1990 samples are presented in Table 2.10-2. When the 1990 analysis results were compared to results from previous years' analyses, there was no apparent trend to indicate that Pilgrim Station is contributing measurable levels of plutonium-238, 239, or 240 in the environment.

Therefore, analysis of sediment samples collected during 1990 showed no evidence of any significant radiological impact on the environment due to Pilgrim Station.

Table 2.10-1
Summary of Radioactivity Analysis Results
For Sediment - 1990

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1990)

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.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS ********** MEAN RANGE NO. DETECTED**
BE-7 (61)		(2.1 ± 0.9)E 1	13	(7.6 ± 4.6)E 1	(3.7 ± 2.5)E 1
(0)		(-8.7 - 22.1)E 1		(-5.4 - 48.1)E 1	(-8.6 - 18.1)E 1
		(1/ 39)		*(2/ 11)*	*(2/ 22)*
K-40 (61)		(9.5 ± 0.2)E 3	13	(1.5 ± 0.1)E 4	(1.2 ± 0.1)E 4
(0)		(8.1 - 13.2)E 3		(1.0 - 1.9)E 4	(8.3 - 18.6)E 3
		(39/ 39)		*(11/ 11)*	*(22/ 22)*
MN-54 (61)		(-1.7 ± 0.7)E 0	24	(7.7 ± 17.0)E -1	(-2.0 ± 1.4)E 0
(0)		(-8.2 - 9.0)E 0		(-8.4 - 10.1)E 0	(-1.5 - 1.0)E 1
		(0/ 39)		*(0/ 11)*	*(0/ 22)*
CO-58 (61)	50.	(-3.2 ± 0.6)E 0	14	(-2.1 ± 1.3)E 0	(-4.0 ± 1.4)E 0
(0)		(-1.0 - 0.7)E 1		(-5.0 - 2.0)E 0	(-1.5 - 0.9)E 1
		(0/ 39)		*(0/ 6)*	*(0/ 22)*
FE-59 (61)		(-1.1 ± 1.6)E 0	24	(3.3 ± 4.5)E 0	(-4.9 ± 30.3)E -1
(0)		(-2.5 - 2.0)E 1		(-1.5 - 3.0)E 1	(-2.0 - 3.0)E 1
		(0/ 39)		*(0/ 11)*	*(0/ 22)*
CO-60 (61)	50.	(-3.2 ± 8.5)E -1	11	(2.7 ± 1.2)E 0	(-2.3 ± 1.2)E 0
(0)		(-1.4 - 1.0)E 1		(-3.9 - 10.4)E 0	(-1.1 - 1.0)E 1
		(0/ 39)		*(0/ 11)*	*(0/ 22)*
ZN-65 (61)	50.	(1.1 ± 2.0)E 0	12	(5.2 ± 3.7)E 0	(1.9 ± 2.4)E 0
(0)		(-3.3 - 2.9)E 1		(-1.7 - 2.5)E 1	(-1.8 - 2.9)E 1
		(0/ 39)		*(0/ 11)*	*(0/ 22)*
ZR-95 (61)	50.	(4.2 ± 1.7)E 0	14	(1.2 ± 0.3)E 1	(7.7 ± 2.6)E 0
(0)		(-1.8 - 2.1)E 1		(1.9 - 20.8)E 0	(-2.2 - 3.1)E 1
		(0/ 39)		*(0/ 6)*	*(0/ 22)*
RU-103 (61)		(-1.6 ± 0.7)E 0	24	(1.6 ± 1.1)E 0	(4.9 ± 11.1)E -1
(0)		(-1.1 - 0.5)E 1		(-5.1 - 7.6)E 0	(-1.2 - 0.8)E 1
		(0/ 39)		*(0/ 11)*	*(0/ 22)*

* 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 STD DEVIATIONS) IS INDICATED WITH *( )*.

Table 2.10-1 (continued)
Summary of Radioactivity Analysis Results
For Sediment - 1990

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1990)

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.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS ********** MEAN RANGE NO. DETECTED**
RU-106 (61)		(-3.0 ± 4.7)E 0	12	(1.4 ± 0.7)E 1	(-3.0 ± 8.5)E 0
(0)		(-7.8 - 5.0)E 1		(-3.4 - 5.0)E 1	(-9.7 - 8.7)E 1
		(0/ 39)		*(0/ 11)*	*(0/ 22)*
I-131 (61)		(3.7 ± 5.3)E 0	12	(2.2 ± 0.9)E 1	(-2.3 ± 10.0)E 0
(0)		(-7.0 - 8.7)E 1		(-9.2 - 87.4)E 0	(-1.4 - 0.7)E 2
		(0/ 39)		*(0/ 11)*	*(0/ 22)*
CS-134 (61)	50.	(-8.1 ± 6.9)E -1	13	(6.2 ± 19.2)E -1	(3.8 ± 10.6)E -1
(0)		(-8.7 - 10.4)E 0		(-1.1 - 1.2)E 1	(-1.1 - 1.2)E 1
		(0/ 39)		*(0/ 11)*	*(0/ 22)*
CS-137 (61)	50.	(1.3 ± 0.3)E 1	13	(7.4 ± 0.4)E 1	(4.0 ± 0.8)E 1
(0)		(-9.4 - 66.8)E 0		(4.8 - 9.3)E 1	(3.1 - 92.7)E 0
		(11/ 39)		*(11/ 11)*	*(11/ 22)*
CE-141 (61)		(7.2 ± 1.5)E 0	13	(1.7 ± 0.3)E 1	(1.5 ± 0.2)E 1
(0)		(-1.5 - 2.3)E 1		(4.4 - 31.1)E 0	(2.7 - 31.1)E 0
		(0/ 39)		*(0/ 11)*	*(0/ 22)*
CE-144 (61)	150.	(1.0 ± 0.3)E 1	13	(2.4 ± 0.8)E 1	(1.5 ± 0.6)E 1
(0)		(-5.7 - 5.3)E 1		(-2.0 - 6.9)E 1	(-4.0 - 6.9)E 1
		(0/ 39)		*(0/ 11)*	*(0/ 22)*
TH-232 (61)		(3.5 ± 0.2)E 2	13	(7.0 ± 0.4)E 2	(5.3 ± 0.4)E 2
(0)		(1.7 - 6.2)E 2		(5.2 - 9.1)E 2	(3.1 - 9.1)E 2
		(39/ 39)		*(11/ 11)*	*(22/ 22)*

* NON-ROUTINE REFERS TO THE NUMBER OF SEPARATE MEASURMENTS 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 STD DEVIATIONS) IS INDICATED WITH *( )*.

TABLE 2.10-2

Radioactivity Analysis Results for Plutonium in Sediment - 1990

Location	Core Depth (cm)	Results pCi/Kg (dry) +-1 S.D.	
		Plutonium 238	Plutonium 239, Plutonium 240
Rocky Point	0-2	NDA	2.97 ± 0.51
Rocky Point	12-14	NDA	1.81 ± 0.40
Plymouth Harbor	0-2	NDA	8.9 ± 1.6
Plymouth Harbor	12-14	NDA	8.2 ± 1.3
Plymouth Beach	0-5	NDA	NDA
Manomet Point	0-2	NDA	2.11 ± 0.58
Duxbury Bay - Control	0-2	NDA	27.5 ± 3.0
Marshfield - Control	0-2	NDA	2.43 ± 0.33

*NDA indicates no detectable activity.

2.11-1 Milk

Milk samples were collected at two locations during 1990: the Plymouth County Farm and the Whitman Farm control station. When available, samples were collected semi-monthly when animals were on pasture (generally May through October) and monthly at other times. Milk samples were analyzed for iodine-131, strontium-89, 90 and gamma-emitting isotopes. All milk samples were collected and analyzed as required during 1990.

The summary of the radioactivity analysis results for the milk collected during 1990 is presented in Table 2.11-1. The results of radioactivity analyses for cesium-137 and strontium-90 are presented graphically in Figures 2.11-1 and 2.11-2 respectively.

Positive measurements of cesium-137 were detected at Plymouth County Farm. Positive measurements of potassium-40 and strontium-90 were detected at both sampling locations. No iodine-131 was detected in milk during 1990. The presence of potassium-40 is due to naturally-occurring radioactivity. The cesium-137 and strontium-90 is considered to be attributable to fallout from previous atmospheric nuclear weapons testing, since cesium-134 and strontium-89 were not present, as would be expected if the source were PNPS. In addition, the pre-operational environmental monitoring program indicated the presence of cesium-137 and strontium-90 in milk at average levels of 18 pCi/liter and 9 pCi/liter, respectively. If the pre-operational results are corrected for radioactive decay which would have occurred between 1972 and 1990, the expected levels would be 4 pCi/liter for cesium-137 and 6 pCi/liter for strontium-90. As can be seen in Figures 2.11-1 and 2.11-2, the maximum levels of cesium-137 (4.6 pCi/liter) and strontium-90 (3.3 pCi/liter) detected in 1990 milk samples are below the decay-corrected pre-operational levels.

Therefore, analysis of milk samples collected during 1990 showed no evidence of any significant radiological impact on the environment or due to Pilgrim Station.

Table 2.11-1
Summary of Radioactivity Analysis Results
For Milk - 1990

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1990)

MEDIUM: MILK

UNITS: PCI/KG

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**
SR-89 (38)		(-4.4 ± 18.3)E -2	11	(-4.4 ± 18.3)E -2	(-2.8 ± 1.6)E -1
(0)		(-1.3 - 2.0)E 0		(-1.3 - 2.0)E 0	(-1.5 - 1.2)E 0
		(0/ 19)		*(0/ 19)*	*(0/ 19)*
SR-90 (38)		(2.3 ± 0.1)E 0	11	(2.3 ± 0.1)E 0	(1.8 ± 0.2)E 0
(0)		(1.0 - 3.3)E 0		(1.0 - 3.3)E 0	(6.1 - 359.0)E -2
		(17/ 19)		*(17/ 19)*	*(12/ 19)*
BE-7 (38)		(-2.7 ± 1.6)E 0	21	(-7.2 ± 206.6)E -2	(-7.2 ± 206.6)E -2
(0)		(-1.6 - 0.9)E 1		(-1.7 - 1.6)E 1	(-1.7 - 1.6)E 1
		(0/ 19)		*(0/ 19)*	*(0/ 19)*
K-40 (38)		(1.3 ± 0.0)E 3	21	(1.4 ± 0.0)E 3	(1.4 ± 0.0)E 3
(0)		(1.2 - 1.4)E 3		(1.2 - 1.5)E 3	(1.2 - 1.5)E 3
		(19/ 19)		*(19/ 19)*	*(19/ 19)*
MN-54 (38)		(1.8 ± 2.5)E -1	11	(1.8 ± 2.5)E -1	(1.1 ± 2.3)E -1
(0)		(-2.2 - 1.8)E 0		(-2.2 - 1.8)E 0	(-1.7 - 1.7)E 0
		(0/ 19)		*(0/ 19)*	*(0/ 19)*
CO-58 (38)		(-1.2 ± 2.4)E -1	11	(-1.2 ± 2.4)E -1	(-4.6 ± 2.6)E -1
(0)		(-2.4 - 1.7)E 0		(-2.4 - 1.7)E 0	(-2.7 - 1.5)E 0
		(0/ 19)		*(0/ 19)*	*(0/ 19)*
FE-59 (38)		(-8.4 ± 5.4)E -1	21	(3.3 ± 5.6)E -1	(3.3 ± 5.6)E -1
(0)		(-4.2 - 3.3)E 0		(-6.2 - 5.8)E 0	(-6.2 - 5.8)E 0
		(0/ 19)		*(0/ 19)*	*(0/ 19)*
CO-60 (38)		(-7.4 ± 3.7)E -1	21	(-7.1 ± 3.5)E -1	(-7.1 ± 3.5)E -1
(0)		(-3.7 - 2.3)E 0		(-4.9 - 1.0)E 0	(-4.9 - 1.0)E 0
		(0/ 19)		*(0/ 19)*	*(0/ 19)*
ZN-65 (38)		(-3.8 ± 6.0)E -1	11	(-3.8 ± 6.0)E -1	(-5.3 ± 6.2)E -1
(0)		(-4.1 - 5.9)E 0		(-4.1 - 5.9)E 0	(-5.8 - 3.7)E 0
		(0/ 19)		*(0/ 19)*	*(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 STD DEVIATIONS) IS INDICATED WITH *( )*.

Table 2.11-1 (continued)
Summary of Radioactivity Analysis Results
For Milk - 1990

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1990)

MEDIUM: MILK

UNITS: PCI/KG

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**
ZR-95 (38)		(5.1 ± 4.4)E -1	11	(5.1 ± 4.4)E -1	(1.6 ± 4.3)E -1
(0)		(-3.6 - 4.0)E 0		(-3.6 - 4.0)E 0	(-3.2 - 4.3)E 0
		(0/ 19)		*(0/ 19)*	*(0/ 19)*
RU-103 (38)		(-6.2 ± 2.4)E -1	21	(3.2 ± 31.6)E -2	(3.2 ± 31.6)E -2
(0)		(-2.8 - 1.4)E 0		(-1.7 - 3.1)E 0	(-1.7 - 3.1)E 0
		(0/ 19)		*(0/ 19)*	*(0/ 19)*
RU-106 (38)		(2.6 ± 1.6)E 0	21	(2.8 ± 1.8)E 0	(2.8 ± 1.8)E 0
(0)		(-1.1 - 1.5)E 1		(-1.0 - 1.7)E 1	(-1.0 - 1.7)E 1
		(0/ 19)		*(0/ 19)*	*(0/ 19)*
I-131 (38)	1.	(1.9 ± 2.5)E -2	21	(4.7 ± 3.1)E -2	(4.7 ± 3.1)E -2
(0)		(-2.2 - 2.5)E -1		(-1.5 - 4.1)E -1	(-1.5 - 4.1)E -1
		(0/ 19)		*(0/ 19)*	*(0/ 19)*
CS-134 (38)	15.	(-7.6 ± 2.3)E -1	11	(-7.6 ± 2.3)E -1	(-9.8 ± 1.8)E -1
(0)		(-2.5 - 1.6)E 0		(-2.5 - 1.6)E 0	(-2.3 - 0.6)E 0
		(0/ 19)		*(0/ 19)*	*(0/ 19)*
CS-137 (38)	15.	(2.3 ± 0.3)E 0	11	(2.3 ± 0.3)E 0	(9.3 ± 2.4)E -1
(0)		(1.5 - 46.1)E -1		(1.5 - 46.1)E -1	(-1.3 - 2.5)E 0
		(5/ 19)		*(5/ 19)*	*(0/ 19)*
BA-140 (38)	15.	(-8.4 ± 4.3)E -1	11	(-8.4 ± 4.3)E -1	(-9.1 ± 5.8)E -1
(0)		(-7.0 - 1.4)E 0		(-7.0 - 1.4)E 0	(-6.5 - 4.6)E 0
		(0/ 19)		*(0/ 19)*	*(0/ 19)*
CE-141 (38)		(-1.4 ± 4.8)E -1	11	(-1.4 ± 4.8)E -1	(-3.2 ± 4.6)E -1
(0)		(-3.9 - 2.4)E 0		(-3.9 - 2.4)E 0	(-3.3 - 3.5)E 0
		(0/ 19)		*(0/ 19)*	*(0/ 19)*
CE-144 (38)		(6.6 ± 173.8)E -2	21	(1.5 ± 1.9)E 0	(1.5 ± 1.9)E 0
(0)		(-9.8 - 15.4)E 0		(-1.4 - 1.7)E 1	(-1.4 - 1.7)E 1
		(0/ 19)		*(0/ 19)*	*(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 STD DEVIATIONS) IS INDICATED WITH *( )*.

Figure 2.11-1

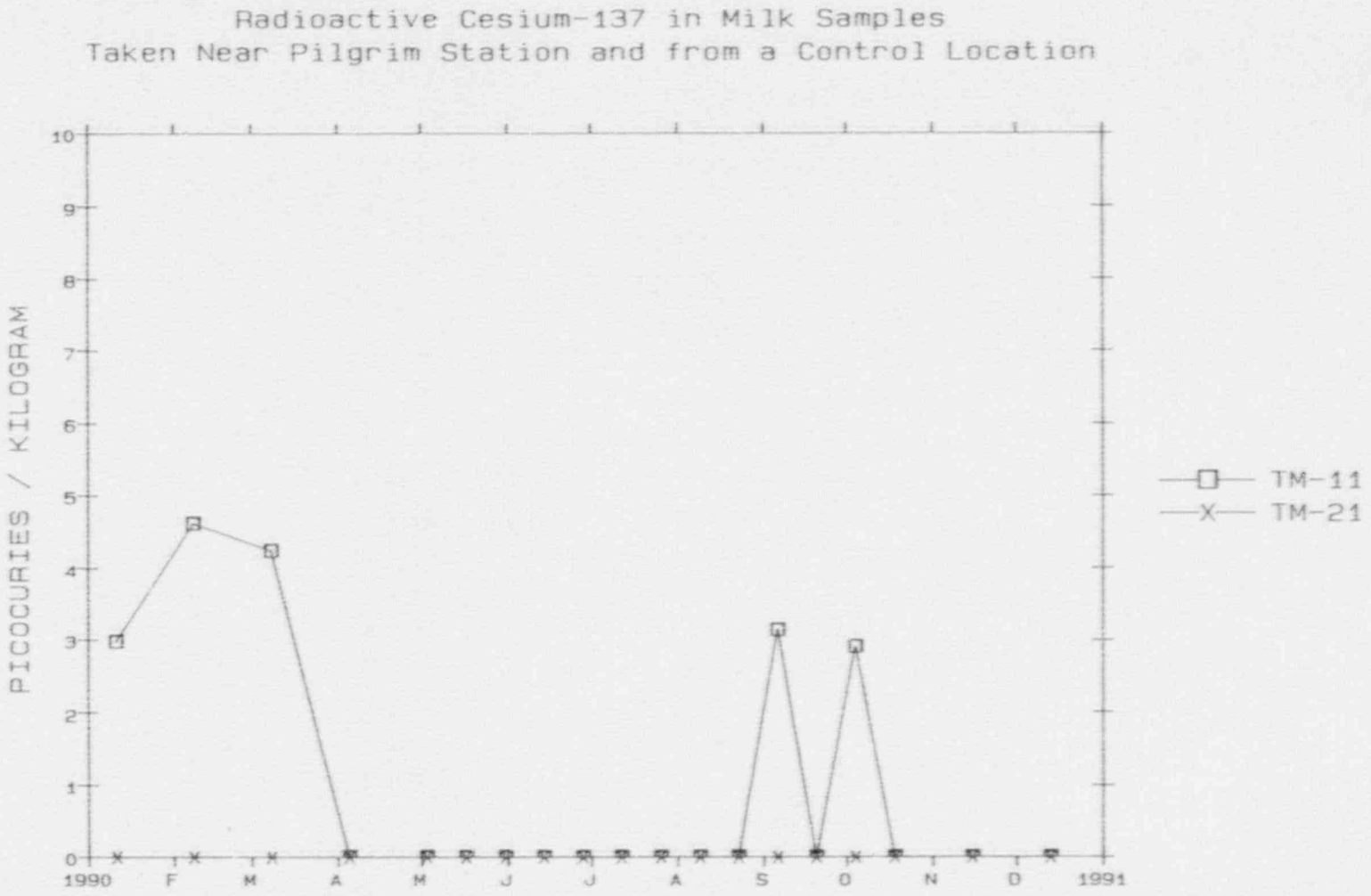
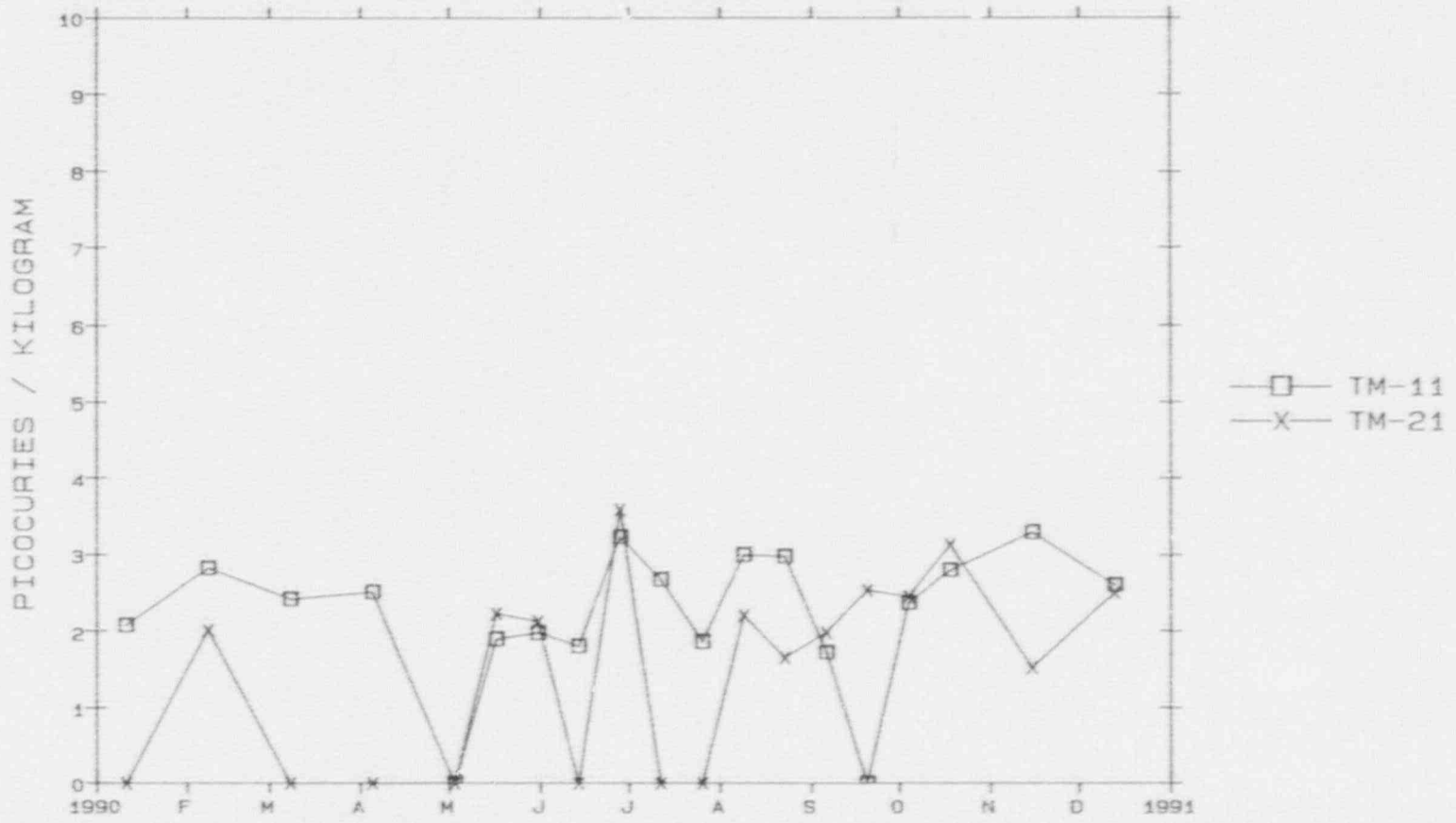

Radioactive Cesium-137 in Milk Samples
Taken Near Pilgrim Station and from a Control Location
PICOCURIES / KILOGRAM
10
9
8
7
6
5
4
3
2
1
0
1990
F
M
A
M
J
J
A
S
O
N
D
1991
TM-11
TM-21

Figure 2.11-2

Radioactive Strontium-90 in Milk Samples
Taken Near Pilgrim Station and from a Control Location



2.12 Cranberries

Cranberries were collected from three locations at the time of harvest: the Manomet Point Bog, the Bartlett Road Bog, and the Pine Street Bog (control station). Cranberries were analyzed at harvest time for gamma-emitting isotopes in edible portions. All cranberry samples were collected and analyzed as required during 1990.

The summary of the radioactivity analysis results for cranberries collected during 1990 is presented in Table 2.12-1. Naturally-occurring potassium-40 was observed in all three cranberry samples. Cesium-137 was detected at a concentration of 41 pCi/kg in a sample of cranberries collected near Pilgrim Station in September 1990. Cesium-137 was seen at concentrations of 140 - 450 pCi/kg in pre-operational samples collected between 1968 and 1972. Such levels were due to fallout resulting from nuclear weapons testing. When corrected for radioactive decay, which would have occurred between 1972 and 1990, the expected levels would be between 90 and 300 pCi/kg. The observed concentration of 41 pCi/kg is well below that expected for decay-corrected fallout cesium-137. No other radionuclides attributable to Pilgrim Station operations were detected in any of the samples.

Therefore, analysis of cranberry samples collected during 1990 showed no evidence of any significant radiological impact on the environment due to Pilgrim Station.

Table 2.12-1
Summary of Radioactivity Analysis Results
For Cranberries - 1990

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1990)

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 (4)		(7.2 ± 9.3)E 1	13	(2.4 ± 1.5)E 2	(5.4 ± 6.7)E 1
(0)		(-8.4 - 23.7)E 1			
		(0/ 3)		*(0/ 1)*	*(0/ 1)*
K-40 (4)		(7.2 ± 1.2)E 2	14	(9.7 ± 2.1)E 2	(8.5 ± 1.6)E 2
(0)		(6.0 - 9.7)E 2			
		(2/ 3)		*(1/ 1)*	*(1/ 1)*
MN-54 (4)		(8.3 ± 306.6)E -2	99	(6.1 ± 8.0)E 0	(-6.5 ± 8.1)E 0
(0)		(-3.9 - 6.1)E 0			
		(0/ 3)		*(0/ 1)*	*(0/ 1)*
CO-58 (4)		(-1.2 ± 0.7)E 1	23	(4.9 ± 7.8)E 0	(4.9 ± 7.8)E 0
(0)		(-2.6 - -0.1)E 1			
		(0/ 3)		*(0/ 1)*	*(0/ 1)*
FE-59 (4)		(1.6 ± 1.7)E 1	99	(3.7 ± 2.1)E 1	(1.7 ± 1.6)E 1
(0)		(-1.7 - 3.7)E 1			
		(0/ 3)		*(0/ 1)*	*(0/ 1)*
CO-60 (4)		(5.2 ± 2.6)E 0	14	(1.0 ± 1.4)E 1	(-8.3 ± 11.1)E 0
(0)		(2.1 - 10.4)E 0			
		(0/ 3)		*(0/ 1)*	*(0/ 1)*
ZN-65 (4)		(-8.2 ± 150.3)E -1	13	(2.2 ± 3.7)E 1	(1.4 ± 1.7)E 1
(0)		(-2.9 - 2.2)E 1			
		(0/ 3)		*(0/ 1)*	*(0/ 1)*
ZR-95 (4)		(-2.4 ± 1.1)E 1	23	(1.4 ± 1.6)E 1	(1.4 ± 1.6)E 1
(0)		(-4.2 - -0.3)E 1			
		(0/ 3)		*(0/ 1)*	*(0/ 1)*
AG-110M(4)		(4.9 ± 4.8)E 0	14	(1.4 ± 1.3)E 1	(8.1 ± 9.2)E 0
(0)		(-3.0 - 13.6)E 0			
		(0/ 3)		*(0/ 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 STD DEVIATIONS) IS INDICATED WITH *( )*.

Table 2.12-1 (continued)
Summary of Radioactivity Analysis Results
For Cranberries - 1990

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1990)

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.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
RU-103 (4)		(-6.5 ± 7.7)E 0	99	(5.1 ± 10.8)E 0	(-2.1 ± 8.5)E 0
(0)		(-2.1 - 0.5)E 1			
		(0/ 3)		*(0/ 1)*	*(0/ 1)*
RU-106 (4)		(5.3 ± 2.7)E 0	23	(5.4 ± 6.5)E 1	(5.4 ± 6.5)E 1
(0)		(0.0 - 8.4)E 0			
		(0/ 3)		*(0/ 1)*	*(0/ 1)*
I-131 (4)		(2.9 ± 25.6)E 0	14	(4.7 ± 4.7)E 1	(-2.2 ± 2.1)E 1
(0)		(-4.2 - 4.7)E 1			
		(0/ 3)		*(0/ 1)*	*(0/ 1)*
CS-134 (4)	60.	(-1.4 ± 0.2)E 1	23	(6.3 ± 7.9)E 0	(6.3 ± 7.9)E 0
(0)		(-1.7 - -1.1)E 1			
		(0/ 3)		*(0/ 1)*	*(0/ 1)*
CS-137 (4)	60.	(8.8 ± 16.3)E 0	99	(4.1 ± 1.1)E 1	(-8.8 ± 8.3)E 0
(0)		(-1.1 - 4.1)E 1			
		(1/ 3)		*(1/ 1)*	*(0/ 1)*
BA-140 (4)		(4.5 ± 3.4)E 1	13	(1.1 ± 0.7)E 2	(-3.6 ± 16.8)E 0
(0)		(8.8 - 112.0)E 0			
		(0/ 3)		*(0/ 1)*	*(0/ 1)*
CE-141 (4)		(-1.0 ± 7.5)E 0	99	(7.4 ± 14.3)E 0	(-6.4 ± 13.3)E 0
(0)		(-1.6 - 0.7)E 1			
		(0/ 3)		*(0/ 1)*	*(0/ 1)*
CE-144 (4)		(1.7 ± 2.0)E 1	99	(4.7 ± 4.8)E 1	(-2.9 ± 4.8)E 1
(0)		(-2.0 - 4.7)E 1			
		(0/ 3)		*(0/ 1)*	*(0/ 1)*
TH-232 (4)		(4.9 ± 1.1)E 1	23	(1.1 ± 0.4)E 2	(1.1 ± 0.4)E 2
(0)		(3.4 - 7.1)E 1			
		(0/ 3)		*(0/ 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 STD DEVIATIONS) IS INDICATED WITH *( )*.

2.13 Vegetation

Samples of produce (tuberous and green leafy vegetables) were collected at the time of harvest from the required locations at Plymouth County Farm and Bridgewater Farm (control station). In addition, samples of produce or naturally-growing leafy vegetation were also collected at or near gardens identified during the 1990 Land Use Census. These locations and the corresponding sample codes were:

Location	Dist.	Dir.	Sample ID
Hall residence	0.5 mi.	SE	99
Fry residence	2.7 mi.	SW	99C, 99D
Cotti residence	1.9 mi.	WSW	99E
Moon residence	2.1 mi.	WSW	99F, 99G
Brook Road	1.7 mi.	SSE	99H
Beaverdam Road	2.1 mi.	S	99I
Clay Hill Road	1.0 mi.	W	99J
Whipple residence	2.0 mi.	SW	99K

Each sample of produce/vegetation was analyzed for gamma-emitting isotopes. All samples were collected and analyzed as required during 1990.

The summary of the radioactivity analysis results for vegetation collected in 1990 is presented in Table 2.13-1. Positive measurements of beryllium-7, potassium-40, cesium-137 and thorium-232 were observed in the samples. Of these isotopes, the Be-7, K-40 and Th-232 are naturally-occurring, whereas the Cs-137 is a result of fallout from previous atmospheric nuclear weapons testing.

The highest observed concentration of Cs-137 of 152 pCi/kg was found in naturally-growing vegetation (leaves from trees and shrubs) collected from Beaverdam Road in the vicinity of an identified garden. This is comparable to the concentration of 210 pCi/kg observed in forage samples collected from the control location during 1990 (see section 2.14). These concentrations are also comparable to the pre-operational levels of 150 - 290 pCi/kg observed in samples collected between 1968 and 1972. Such concentrations are considered indicative of Cs-137 from nuclear weapons testing, and not a result of Pilgrim Station operations. No other nuclides associated with generation of nuclear power were observed in any of the samples.

Therefore, analysis of vegetation samples collected during 1990 showed no evidence of any significant radiological impact on the environment due to Pilgrim Station.

Table 2.13-1
Summary of Radioactivity Analysis Results
For Vegetation - 1990

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1990)

MEDIUM: VEGETATION

UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN STA. NO.	 MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
BE-7 (16) (6)		(5.6 ± 2.0)E 2 (-7.6 - 211.0)E 1 *(6/ 13)*	99J	(2.1 ± 0.1)E 3 *(1/ 1)*	(6.0 ± 4.7)E 1 (-3.2 - 12.4)E 1 *(0/ 3)*
K-40 (16) (0)		(3.1 ± 0.2)E 3 (1.4 - 4.5)E 3 *(13/ 13)*	99K	(4.4 ± 0.1)E 3 *(1/ 1)*	(2.1 ± 0.6)E 3 (9.2 - 30.1)E 2 *(3/ 3)*
MN-54 (16) (0)		(2.4 ± 1.6)E 0 (-4.7 - 12.1)E 0 *(0/ 13)*	99E	(9.4 ± 4.5)E 0 *(0/ 1)*	(3.0 ± 4.4)E 0 (-5.1 - 9.9)E 0 *(0/ 3)*
CO-58 (16) (0)		(-3.0 ± 1.5)E 0 (-1.5 - 0.5)E 1 *(0/ 13)*	99E	(4.9 ± 4.8)E 0 *(0/ 1)*	(-1.2 ± 9.4)E 0 (-1.9 - 1.3)E 1 *(0/ 3)*
FE-59 (16) (0)		(3.7 ± 4.6)E 0 (-1.6 - 4.1)E 1 *(0/ 13)*	99	(4.1 ± 1.6)E 1 *(0/ 1)*	(1.2 ± 0.7)E 1 (-8.3 - 214.0)E -1 *(0/ 3)*
CO-60 (16) (0)		(5.1 ± 24.3)E -1 (-1.9 - 1.3)E 1 *(0/ 13)*	99	(1.3 ± 1.1)E 1 *(0/ 1)*	(-1.2 ± 0.6)E 1 (-2.5 - -0.3)E 1 *(0/ 3)*
ZN-65 (16) (0)		(-4.8 ± 2.7)E 0 (-2.2 - 1.3)E 1 *(0/ 13)*	99E	(1.3 ± 1.1)E 1 *(0/ 1)*	(-7.1 ± 7.2)E 0 (-1.6 - 0.7)E 1 *(0/ 3)*
ZR-95 (16) (0)		(-2.0 ± 2.2)E 0 (-2.2 - 0.8)E 1 *(0/ 13)*	99D	(7.9 ± 17.8)E 0 *(0/ 1)*	(8.7 ± 151.1)E -1 (-1.7 - 3.1)E 1 *(0/ 3)*
AG-110M(16) (0)		(-3.1 ± 2.3)E 0 (-2.2 - 1.0)E 1 *(0/ 13)*	99D	(1.0 ± 1.3)E 1 *(0/ 1)*	(7.5 ± 2.0)E 0 (3.5 - 9.9)E 0 *(0/ 3)*

* 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 STD DEVIATIONS) IS INDICATED WITH *( )*.

Table 2.13-1 (continued)
Summary of Radioactivity Analysis Results
For Vegetation - 1990

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1990)

MEDIUM: VEGETATION

UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS ********** MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN ********** STA. NO.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS ********** MEAN RANGE NO. DETECTED**
RU-103 (16)		(-1.0 ± 2.5)E 0	99D	(1.6 ± 1.1)E 1	(-1.4 ± 9.3)E 0
(0)		(-1.8 - 1.6)E 1			(-2.0 - 0.8)E 1
		(0/ 13)		*(0/ 1)*	*(0/ 3)*
RU-106 (16)		(-6.0 ± 16.0)E 0	99D	(7.2 ± 8.6)E 1	(-4.5 ± 50.9)E 0
(0)		(-9.4 - 8.9)E 1			(-8.1 - 9.2)E 1
		(0/ 13)		*(0/ 1)*	*(0/ 3)*
I-131 (16)		(5.1 ± 5.0)E 0	99C	(4.4 ± 4.5)E 1	(-1.6 ± 2.4)E 1
(0)		(-2.0 - 4.4)E 1			(-5.9 - 2.4)E 1
		(0/ 13)		*(0/ 1)*	*(0/ 3)*
CS-134 (16)	60.	(-8.5 ± 2.3)E 0	99I	(-2.1 ± 9.9)E -1	(-1.5 ± 0.4)E 1
(0)		(-2.2 - 0.0)E 1			(-2.3 - -0.8)E 1
		(0/ 13)		*(0/ 1)*	*(0/ 3)*
CS-137 (16)	60.	(2.2 ± 1.2)E 1	99I	(1.5 ± 0.0)E 2	(-7.4 ± 5.5)E 0
(5)		(-1.1 - 15.1)E 1			(-1.3 - 0.4)E 1
		(5/ 13)		*(1/ 1)*	*(0/ 3)*
BA-140 (16)		(1.3 ± 2.8)E 0	99J	(1.9 ± 0.9)E 1	(6.8 ± 9.1)E 0
(0)		(-1.8 - 1.9)E 1			(-1.1 - 1.7)E 1
		(0/ 13)		*(0/ 1)*	*(0/ 3)*
CE-141 (16)		(5.0 ± 2.2)E 0	99C	(2.1 ± 1.6)E 1	(-8.6 ± 60.7)E -1
(0)		(-6.4 - 21.4)E 0			(-1.0 - 1.0)E 1
		(0/ 13)		*(0/ 1)*	*(0/ 3)*
CE-144 (16)		(2.8 ± 9.9)E 0	99D	(8.2 ± 4.9)E 1	(-5.0 ± 8.1)E 1
(0)		(-5.8 - 8.2)E 1			(-2.0 - 0.7)E 2
		(0/ 13)		*(0/ 1)*	*(0/ 3)*
TH-232 (16)		(5.3 ± 2.0)E 1	99K	(2.1 ± 0.1)E 2	(1.3 ± 2.7)E 1
(4)		(-6.1 - 20.7)E 1			(-4.1 - 4.1)E 1
		(4/ 13)		*(1/ 1)*	*(0/ 3)*

* 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 STD DEVIATIONS) IS INDICATED WITH *( )*.

2.14 Forage

Cattle forage is collected from two locations annually: the Plymouth County Farm and the Whitman Farm (control station). Forage samples were analyzed annually for gamma-emitting isotopes. All forage samples were collected and analyzed as required during 1990.

The summary of radioactivity analysis results for the forage collected during 1990 is presented in Table 2.14-1. Positive measurements of beryllium-7 and potassium-40 were detected at both stations. These radionuclides are both naturally-occurring. Cesium-137 was also detected at both stations at levels of 43 pCi/kg in the sample from Plymouth County Farm and at 210 pCi/kg in the sample from the control location at Whitman Farm.

The observed concentrations of Cs-137 in forage at levels of 43 and 210 pCi/kg are comparable to pre-operational levels of 150-290 pCi/kg observed in samples collected from 1968 through 1972. The levels observed in the 1990 sample would be considered indicative of Cs-137 from nuclear weapons testing. No other radionuclides attributable to Pilgrim Station Operations were observed in forage samples.

Therefore, analysis of forage samples collected during 1990 showed no evidence of any significant radiological impact on the environment due to Pilgrim Station.

Table 2.14-1
Summary of Radioactivity Analysis Results
For Forage - 1990

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1990)

MEDIUM: FORAGE

UNITS: PCI/KG WET

RADIONUCLIDES (NO. ANALYSES) (NON-ROUTINE)*	REQUIRED LLD	INDICATOR STATIONS MEAN RANGE NO. DETECTED**	STATION WITH HIGHEST MEAN STA. NO.	MEAN RANGE NO. DETECTED**	CONTROL STATIONS MEAN RANGE NO. DETECTED**
BE-7 (2) (0)		(1.5 ± 0.2)E 3 *(1/ 1)*	21	(2.2 ± 0.2)E 3 *(1/ 1)*	(2.2 ± 0.2)E 3 *(1/ 1)*
K-40 (2) (0)		(6.6 ± 0.4)E 3 *(1/ 1)*	11	(6.6 ± 0.4)E 3 *(1/ 1)*	(3.7 ± 0.3)E 3 *(1/ 1)*
MN-54 (2) (0)	130.	(-6.6 ± 15.2)E 0 *(0/ 1)*	21	(2.7 ± 1.4)E 1 *(0/ 1)*	(2.7 ± 1.4)E 1 *(0/ 1)*
CO-58 (2) (0)	130.	(1.8 ± 1.6)E 1 *(0/ 1)*	11	(1.8 ± 1.6)E 1 *(0/ 1)*	(-1.1 ± 1.3)E 1 *(0/ 1)*
FE-59 (2) (0)	260.	(4.5 ± 3.5)E 1 *(0/ 1)*	11	(4.5 ± 3.5)E 1 *(0/ 1)*	(3.4 ± 2.9)E 1 *(0/ 1)*
CO-60 (2) (0)	130.	(-8.2 ± 21.0)E 0 *(0/ 1)*	21	(2.7 ± 2.1)E 1 *(0/ 1)*	(2.7 ± 2.1)E 1 *(0/ 1)*
ZN-65 (2) (0)	260.	(1.0 ± 3.4)E 1 *(0/ 1)*	11	(1.0 ± 3.4)E 1 *(0/ 1)*	(-5.1 ± 2.7)E 1 *(0/ 1)*
ZR-95 (2) (0)		(-3.7 ± 3.1)E 1 *(0/ 1)*	21	(9.0 ± 23.2)E 0 *(0/ 1)*	(9.0 ± 23.2)E 0 *(0/ 1)*
AG-110M(2) (0)		(-1.2 ± 20.0)E 0 *(0/ 1)*	11	(-1.2 ± 20.0)E 0 *(0/ 1)*	(-1.2 ± 16.6)E 0 *(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 STD DEVIATIONS) IS INDICATED WITH *( )*.

Table 2.14-1 (continued)
Summary of Radioactivity Analysis Results
For Forage - 1990

ENVIRONMENTAL RADIOLOGICAL PROGRAM SUMMARY
PILGRIM NUCLEAR POWER STATION, PLYMOUTH, MA
(JANUARY - DECEMBER 1990)

MEDIUM: FORAGE

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**
RU-103 (2) (0)		(0.0 ± 1.8)E 1 *(0/ 1)*	11	(0.0 ± 1.8)E 1 *(0/ 1)*	(-1.6 ± 1.3)E 1 *(0/ 1)*
RU-106 (2) (0)		(-8.5 ± 11.6)E 1 *(0/ 1)*	21	(1.3 ± 10.1)E 1 *(0/ 1)*	(1.3 ± 10.1)E 1 *(0/ 1)*
I-131 (2) (0)		(-1.2 ± 1.2)E 2 *(0/ 1)*	21	(-3.9 ± 301.0)E -1 *(0/ 1)*	(-3.9 ± 301.0)E -1 *(0/ 1)*
CS-134 (2) (0)	130.	(-2.7 ± 1.4)E 1 *(0/ 1)*	21	(-1.6 ± 1.2)E 1 *(0/ 1)*	(-1.6 ± 1.2)E 1 *(0/ 1)*
CS-137 (2) (0)	130.	(4.3 ± 1.2)E 1 *(1/ 1)*	21	(2.1 ± 0.2)E 2 *(1/ 1)*	(2.1 ± 0.2)E 2 *(1/ 1)*
BA-140 (2) (0)		(-6.8 ± 63.9)E 0 *(0/ 1)*	11	(-6.8 ± 63.9)E 0 *(0/ 1)*	(-1.8 ± 2.7)E 1 *(0/ 1)*
CE-141 (2) (0)		(-1.1 ± 25.6)E 0 *(0/ 1)*	21	(2.4 ± 1.7)E 1 *(0/ 1)*	(2.4 ± 1.7)E 1 *(0/ 1)*
CE-144 (2) (0)		(-2.4 ± 7.2)E 1 *(0/ 1)*	11	(-2.4 ± 7.2)E 1 *(0/ 1)*	(-4.3 ± 6.1)E 1 *(0/ 1)*
TH-232 (2) (0)		(6.4 ± 5.9)E 1 *(0/ 1)*	21	(1.1 ± 0.6)E 2 *(0/ 1)*	(1.1 ± 0.6)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 STD DEVIATIONS) IS INDICATED WITH *( )*.

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.[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 1990 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 (see Figure 1.5-1):

1) shoreline external radiation during fishing and picnicking 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 submersion in gaseous effluents;

2) inhalation of airborne radioactivity;

3) direct radiation from Pilgrim Station;

4) external radiation from soil deposition;

5) consumption of vegetables; and

6) consumption of milk and meat.

The results from the dose calculations based on radioactive effluents are compared with the federal radiation dose limits and natural/man-made radiation levels in Table 3-1. 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, 1990.

Table 3-1
Comparison of 1990 Maximum Estimated Doses from PNPS Effluents to Federal Dose Limits and Natural/Man-Made Radiation Levels

Body Part	1990 Liquid Dose (mrem)	1990 Gaseous Dose (mrem)	1990 Total Dose* (mrem)	EPA Limit (mrem)	NRC Limit (mrem)	Natural/ Man-made (mrem)
Total Body	0.0006	0.234	0.234	25	500	300 - 400
Skin	0.0004	0.085	0.085	-	-	
Thyroid	0.0003	0.571	0.571	75	-	
Organ	0.003	0.571	0.571	25	-	

* Dose due to direct radiation from Pilgrim Station was not included in total dose, as the value for near-plant measurements was not statistically different than that for control locations.

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 500 mrem/yr to be received by the maximum exposed member of the general public. This limit is set forth in Section 105, 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 releases of radioactive effluents during 1990, all values are well within the federal limits specified by the NRC and EPA. In addition, the calculated doses from effluents 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 1990, one special study was performed to determine the dose impact associated with radionuclides detected in blue mussels. These calculations are discussed in detail in Appendix A of this report.

Internal radiation doses associated with ingestion of radioactivity in blue mussels are discussed in Appendix A. The estimated maximum total body dose associated with the hypothetical ingestion of blue mussels taken from the Pilgrim Station Discharge Canal was 0.0006 mrem/yr.

All of the doses calculated from environmental media results, whether considered individually or collectively, are well within federal dose limits specified by the NRC and EPA. In addition, the cumulative dose from such hypothetical exposures represents less than one percent of the typical annual dose received from natural and man-made sources.

Therefore, the radiological impact from Pilgrim Station operation is of insignificant consequence to public health.

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 3, August 1989.

8. United States of America, Code of Federal Regulations, Title 10, Part 20.105.

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.

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. E. R. Cumming, Yankee Atomic Electric Company, "1990 Annual Direct Radiation Survey," REG 206/90, August 28, 1990.

APPENDIX A

SPECIAL STUDIES

BLUE MUSSELS

APPENDIX A

SPECIAL DOSE IMPACT STUDIES

Blue Mussels:

I. Introduction

As a part of the routine radiological environmental sampling program at PNPS, blue mussels are sampled and analyzed on a quarterly basis. During 1990, as in previous years, samples from the outfall of the PNPS discharge canal exhibited measurable quantities of cobalt-60. One sample also showed detectable silver-110m. This special study documents the radiological analysis results as well as the dose calculations to evaluate the maximum radiological impact to a hypothetical member of the general public.

II. Background

Blue mussels (Mytilus edulis) are harvested from the Cape Cod Bay area and sold on the commercial market. Although mussels are not as popular a seafood as lobster or clams, they are eaten regularly (estimated maximum ingestion rate of 9 kg/yr per capita). The uptake and elimination rates of radionuclides discharged by nuclear power plants by these filter-feeding mollusks has been studied and documented.

The uptake rate can be described by the biological accumulation factor which indicates how many times higher the concentration in the mussel will be than the radioactivity concentration in the water. The biological accumulation factors documented in the literature for cobalt-60, cesium-134, cesium-137 and manganese-54 range from 300-50,000 units.[1-4] This filtration or concentration effect by shellfish makes them a good indicator of radionuclide effects on the aquatic food chain because it is possible to detect radionuclides in the edible portions, even though the concentrations released into the discharge canal are well within the Nuclear Regulatory Commission's 10CFR20[5] permissible concentrations.

The following sections of this document will describe:

1) the recent radioactivity concentration measurements on the mussels in the discharge canal outfall,

2) the estimated internal dose from the ingestion of these mussels, and

3) how these levels compare with existing regulatory limits and proposed guides or guidelines.

III. Mussel Radioactivity Measurements and Estimated Maximum Internal Dose From Ingestion

Samples of blue mussels were collected during each calendar quarter from the outfall of the PNPS discharge canal by personnel from the Massachusetts Division of Marine Fisheries as part of the routine radiological environmental monitoring program. The mussel meat and surrounding liquid were removed from the shells to yield approximately 500 grams of sample during each collection. Samples were then submitted to Yankee Atomic Electric Company's Environmental Laboratory for analysis. Samples were counted on a lithium-drifted germanium detector using standard procedures.[6]

The only radionuclides attributable to PNPS operations that were detected in any of the 1990 mussel samples were cobalt-60 and silver-110m. The silver-110m was detected in only one sample (2nd Qtr.), at a concentration of 10.9 ± 1.4 pCi/kg. The activity concentrations of Co-60 observed in the quarterly samples are as follows:

Collection Period	Co-60 Concentration ± S.D. in mussel meat (pCi/kg)
First Quarter	15.9 ± 1.6
Second Quarter	18.5 ± 1.6
Third Quarter	6.4 ± 1.8
Fourth Quarter	5.8 ± 1.5
Average	11.7 ± 5.7

For comparative purposes, the average Co-60 concentration in mussels collected from the discharge canal outfall during 1987 was 89 pCi/kg, the average concentration in 1988 mussel samples was 37 pCi/kg and the average concentration in 1989 mussel samples was 22 pCi/kg. The levels of Co-60 observed in mussels collected during 1990 are considerably lower than the levels detected in samples collected from the discharge canal outfall in previous years.

Based on the average observed concentration of Co-60 and the concentration of Ag-110m in the mussel meat an estimate of the maximum internal dose from the ingestion of these mussels was calculated. This was based on the conservative assumption that the maximum exposed individual would ingest mussels that were raked from the discharge canal outfall. The calculations were performed in accordance with the Pilgrim Nuclear Power Station Off-site Dose Calculation Manual.[7] The results shown in the following table indicate that the maximum organ dose from the ingestion of mussel bodies harvested from the Pilgrim Nuclear Power Station discharge canal outfall would be about 0.01 mrem/yr.

Estimated Maximum Internal Dose from Ingestion of
Blue Mussels taken from Pilgrim Station Discharge Canal Outfall

Organ	Adult (mrem/yr)	Teenager (mrem/yr)	Child (mrem/yr)
Total Body	0.0005	0.0005	0.0006
Maximum Organ (GI)	0.01	0.006	0.002

IV. Comparison of Estimated Dose to Federal Dose Limits and Normal Radiation Levels

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 500 mrem/yr to be received by the maximum exposed member of the general public. This limit is set forth in Section 105, Part 20, Title 10, of the U.S. Code of Federal Regulations (10CFR20)[5]. 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)[6].

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

When the maximum estimated total body dose of 0.0006 mrem/yr is compared to the federal dose limits, such an exposure is well within established guidelines. In addition, this maximum dose is a fraction of a percent of the radiation levels typically received each year by members of the general public.

V. Conclusions

In conclusion, the total radiological impact associated with slightly contaminated mussels present in the Pilgrim Nuclear Power Station discharge canal outfall is insignificant. This conclusion is based on the fact that the dose resulting from ingestion of these mussels would be much less than 0.01 mrem/yr to the exposed individual, which is well below federal radiation limits to the general public set forth by the Environmental Protection Agency and the Nuclear Regulatory Commission. In addition, the maximum estimated dose is much less than one percent of the natural/man-made radiation levels received annually by the average American.

VI. REFERENCES

1. Lowman, F. G., T. R. Rice, and F. A. Richards. 1971. "Accumulation and Redistribution of Radionuclides by Marine Organisms in Radioactivity in the Marine Environment," National Academy of Sciences, pp. 168-169.

2. Chapman, W. H., H. L. Fisher, and M. W. Pratt. 1968. "Concentration Factors of Chemical Elements in Edible Aquatic Organisms". Lawrence Radiation Laboratory, Livermore, Report UCRL-50564.

3. Weaver, C. L., "A Proposed Radioactivity Concentration Guide for Shellfish", U.S. Public Health Service, September, 1967.

4. Harrison, F. Personal communication with D. E. McCurdy, 1972 (from Reference 9).

5. United States of America, Code of Federal Regulations Title 10, Part 20.

6. Yankee Atomic Environmental Laboratory Procedure No. 450, "Identification and Quantitative Determination of Radionuclides by Gamma Ray Spectrometric Techniques", Rev. 4.

7. Boston Edison Company, Pilgrim Nuclear Power Station, Off-site Dose Calculation Manual, Revision 3, August 1989.

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

APPENDIX B

1990 RADIOACTIVE EFFLUENTS

EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT

Supplemental Information (1990)

Facility Pilgrim Nuclear Power Station Licensee 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-lives >8 days, tritium: 1500 mrem/yr to any organ at site boundary.

   d. Liquid effluents: 0.06 mrem/month for total body and 0.20 mrem/month for any organ (without radwaste treatment).

2. **Maximum Permissible Concentration**

   a. Fission and activation gases: 10 CFR 20 Appendix B Table II
   b. Iodines: 10 CFR 20 Appendix B Table II
   c. Particulates, half-lives >8 days: 10 CFR 20 Appendix B Table II
   d. Liquid effluents: 2E-4 µCi/ml for entrained noble gases; 10CFR20 Appendix B Table II values for all other radionuclides.

3. **Average Energy** Not applicable

4. **Methods used to determine radionuclide composition in effluents**

   a. Fission and activation gases:
   b. Iodines:
   c. Particulates:
   d. Liquid effluents:

   High-purity Ge gamma spectroscopy for all gamma emitters; radiochemistry analysis for H-3, Fe-55 (liquids only), Sr-89, and Sr-90.

5. **Batch Releases**

   a. Liquid

	Quarter 1st	Quarter 2nd
1. Number of batch releases:	10	28
2. Total time period for batch releases (minutes):	657 min	2210 min
3. Maximum time period for a batch release (minutes):	182 min	205 min
4. Average time period for batch releases (minutes):	66 min	79 min
5. Minimum time period for a batch release (minutes):	20 min	20 min
6. Average stream flow during periods of release of effluent into a flowing stream (liter/min):	9.43E+5L/m	7.85E+5L/m

   b. Gaseous: Not applicable

6. **Abnormal Releases**

   a. Liquid: None
   b. Gaseous: None

TABLE 1A
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1990)
GASEOUS EFFLUENTS SUMMATION OF ALL RELEASES

	Unit	Quarter 1st	Quarter 2nd	Est. Total Error, %
A. Fission and activation gases				
1. Total release	Ci	1.42E+2	1.97E+2	22%
2. Average release rate for period	µCi/sec	1.80E+1	2.50E+1	
3. Percent of Tech. Spec. limit	%	*	*	
B. Iodines				
1. Total iodine-131	Ci	1.28E-3	1.38E-3	20%
2. Average release rate for period	µCi/sec	1.63E-4	1.75E-4	
3. Percent of Tech. Spec. limit	%	*	*	
C. Particulates				
1. Particul. with half-lives>8 days	Ci	2.29E-4	2.25E-4	21%
2. Average release rate for period	µCi/sec	2.90E-5	2.86E-5	
3. Percent of Tech. Spec. limit	%	*	*	
4. Gross alpha radioactivity	Ci	NDA	NDA	
D. Tritium				
1. Total release	Ci	2.61E+0	2.92E+0	20%
2. Average release rate for period	µCi/sec	3.31E-1	3.71E-1	
3. Percent of Tech. Spec. limit	%	*	*	

Notes for Table 1A:

* Percent of Technical Specification Limit Values in Section A.3 through D.3 are to be provided in the annual supplemental dose assessment report to be issued prior to April 1, 1991.

1. NDA is no detectable activity.

2. LLD for gross alpha listed as NDA is 1E-11 µCi/ml.

TABLE 1B
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1990)
GASEOUS EFFLUENTS - ELEVATED RELEASE

		CONTINUOUS MODE		BATCH MODE	
Nuclides Released	Unit	Quarter 1st	Quarter 2nd	Quarter	Quarter
				Not applicable	
1. Fission gases					
Kr-85m	Ci	2.53E1	4.16E1		
Kr-87	Ci	NDA	5.50E0		
Kr-88	Ci	2.67E1	4.12E1		
Xe-133	Ci	8.47E1	9.18E1		
Xe-135	Ci	1.41E0	8.56E0		
Xe-135m	Ci	NDA	NDA		
Xe-138	Ci	3.52E0	8.61E0		
Total for period	Ci	1.42E2	1.97E2		
2. Iodines					
I-131	Ci	7.87E-4	1.38E-3		
I-133	Ci	3.61E-3	7.86E-3		
Total for period	Ci	4.40E-3	9.24E-3		
3. Particulates					
Sr-89	Ci	1.10E-5	3.95E-5		
Sr-90	Ci	3.10E-7	3.47E-7		
Cs-134	Ci	NDA	NDA		
Cs-137	Ci	NDA	NDA		
Ba/La-140	Ci	6.16E-5	9.88E-5		
Total for period	Ci	7.29E-5	1.39E-4		

Notes for Table 1B:

1. NDA is no detectable activity.

2. LLDs for nuclides listed as NDA are as follows:

Fission gases:	1E-4 µCi/ml
Iodines:	1E-12 µCi/ml
Particulates:	1E-11 µCi/ml

TABLE 1C
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1990)
GASEOUS EFFLUENTS - GROUND LEVEL RELEASE

		CONTINUOUS MODE		BATCH MODE	
Nuclides Released	Unit	Quarter 1st	Quarter 2nd	Quarter	Quarter
				No Batch Mode Releases During 1990	
1. Fission gases					
Kr-85m	Ci	NDA	NDA		
Kr-87	Ci	NDA	NDA		
Kr-88	Ci	NDA	NDA		
Xe-133	Ci	NDA	NDA		
Xe-135	Ci	NDA	NDA		
Xe-135m	Ci	NDA	NDA		
Xe-138	Ci	NDA	NDA		
Total for period	Ci	NDA	NDA		
2. Iodines					
I-131	Ci	4.95E-4	NDA		
I-133	Ci	3.99E-3	NDA		
Total for period	Ci	4.49E-3	NDA		
3. Particulates					
Mn-54	Ci	4.32E-6	NDA		
Co-60	Ci	6.55E-6	6.91E-6		
Sr-89	Ci	6.50E-5	7.97E-5		
Sr-90	Ci	NDA	NDA		
Cs-134	Ci	NDA	NDA		
Cs-137	Ci	1.51E-7	NDA		
Ba/La-140	Ci	8.00E-5	NDA		
Total for period	Ci	1.56E-4	8.66E-5		

Notes for Table 1C:

1. NDA is no detectable activity.
2. LLDs for nuclides listed as NDA are as follows:

Fission gases:	1E-4 µCi/ml
Iodines:	1E-12 µCi/ml
Particulates:	1E-11 µCi/ml

TABLE 2A
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1990)
LIQUID EFFLUENTS SUMMATION OF ALL RELEASES

	Unit	Quarter 1st	Quarter 2nd	Est. Total Error, %
A. Fission and activation products				
1. Total release (not including tritium, noble gases, or alpha)	Ci	1.26E-3	1.22E-2	12%
2. Average diluted concentration during period	µCi/ml	2.03E-9	7.05E-9	
3. Percent of applicable limit	%	9.71E-3%	1.66E-2%	
B. Tritium				
1. Total release	Ci	4.18E-1	2.40E+0	10%
2. Average diluted concentration during period	µCi/ml	6.75E-7	1.39E-6	
3. Percent of applicable limit	%	2.52E-2%	4.62E-2%	
C. Dissolved and entrained gases				
1. Total release	Ci	1.75E-4	NDA	16%
2. Average diluted concentration during period	µCi/ml	2.83E-10	NDA	
3. Percent of applicable limit	%	1.42E-4%	NDA	
D. Gross alpha radioactivity				
1. Total release	Ci	NDA	NDA	34%
E. Volume of waste released (prior to dilution)	liters	2.36E+5	1.15E+6	6%
F. Volume of dilution water used during period	liters	6.19E+8	1.73E+9	10%

Notes for Table 2A:

1. NDA is no detectable activity.
2. LLD for dissolved and entrained gases listed as NDA is 1E-5 µCi/ml.
3. LLD for gross alpha listed as NDA is 1E-7 µCi/ml.

TABLE 2B
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1990)
LIQUID EFFLUENTS

		CONTINUOUS MODE		BATCH MODE	
Nuclides Released	Unit	Quarter	Quarter	Quarter 1st	Quarter 2nd
1. Fission and Activation Products					
Cr-51	Ci	Not Applicable		1.36E-4	4.39E-4
Mn-54	Ci			1.73E-5	3.79E-3
Fe-55	Ci			3.95E-6	6.63E-5
Fe-59	Ci			NDA	8.07E-5
Co-58	Ci			1.79E-5	2.48E-3
Co-60	Ci			4.10E-4	4.52E-3
Zn-65	Ci			NDA	6.11E-7
Sr-89	Ci			1.14E-5	1.46E-5*
Sr-90	Ci			2.78E-6	1.03E-5*
Zr/Nb-95	Ci			NDA	NDA
Mo-99/Tc-99m	Ci			NDA	NDA
Rh-105	Ci			NDA	NDA
Ag-110m	Ci			8.29E-7	5.48E-4
Sb-122	Ci			NDA	NDA
I-131	Ci			NDA	NDA
Cs-134	Ci			1.73E-6	NDA
Cs-137	Ci			3.77E-4	2.44E-4
Ba/La-140	Ci			2.77E-4	NDA
Ce-141	Ci			NDA	NDA
Ce/Pr-144	Ci			NDA	NDA
Hf-181	Ci			NDA	NDA
Total for period	Ci			1.26E-3	1.22E-2
2. Dissolved and Entrained Noble Gases					
Xe-133	Ci			1.63E-5	NDA
Xe-135	Ci			1.59E-4	NDA
Total for period	Ci			1.75E-4	NDA

Notes for Table 2B:

* Activities for 2nd Qtr. include estimates of 1.46E-6 Ci for Sr-89 and 6.76E-6 Ci for Sr-90 based on minimum detectable activities in a sample for which the LLD of 5E-8 µCi/ml was not achieved.

1. NDA is no detectable activity.

2. LLDs for nuclides listed as NDA are as follows:

I-131	1E-6 µCi/ml
Xe-133	1E-5 µCi/ml
Xe-135	1E-5 µCi/ml
All Others	5E-7 µCi/ml

EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT

Supplemental Information (1990)

Facility Pilgrim Nuclear Power Station Licensee 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-lives >8 days, tritium:	1500 mrem/yr to any organ at site boundary.
d.	Liquid effluents:	0.06 mrem/month for total body and 0.20 mrem/month for any organ (without radwaste treatment).

2. **Maximum Permissible Concentration**

a.	Fission and activation gases:	10 CFR 20 Appendix B Table II
b.	Iodines:	10 CFR 20 Appendix B Table II
c.	Particulates, half-lives >8 days:	10 CFR 20 Appendix B Table II
d.	Liquid effluents:	2E-4 µCi/ml for entrained noble gases; 10 CFR 20 Appendix B Table II values for all other radionuclides.

3. **Average Energy** Not applicable

4. **Methods used to determine radionuclide composition in effluents**

a.	Fission and activation gases:	High-purity Ge gamma spectroscopy for all gamma emitters; radiochemistry analysis for H-3, Fe-55 (liquids only), Sr-89, and Sr-90.
b.	Iodines:	
c.	Particulates:	
d.	Liquid effluents:	

5. **Batch Releases**

a. Liquid

		Quarter 3rd	Quarter 4th
1.	Number of batch releases:	24	12
2.	Total time period for batch releases (minutes):	1.00E+3	7.55E+2
3.	Maximum time period for a batch release (minutes):	1.05E+2	1.05E+2
4.	Average time period for batch releases (minutes):	4.17E+1	6.29E+1
5.	Minimum time period for a batch release (minutes):	1.00E+1	2.50E+1
6.	Average stream flow during periods of release of effluent into a flowing stream (liter/min):	1.17E+6	1.17E+6

b. Gaseous: Not applicable

6. **Abnormal Releases**

a. Liquid: None
b. Gaseous: None

TABLE 1A
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1990)
GASEOUS EFFLUENTS SUMMATION OF ALL RELEASES

	Unit	Quarter 3rd	Quarter 4th	Est. Total Error, %
A. Fission and activation gases				
1. Total release	Ci	2.77E+2	2.91E+2	22%
2. Average release rate for period	µCi/sec	3.51E+1	3.69E+1	
3. Percent of Tech. Spec. limit	%	*	*	
B. Iodines				
1. Total iodine-131	Ci	4.46E-3	2.11E-3	20%
2. Average release rate for period	µCi/sec	5.66E-4	2.67E-4	
3. Percent of Tech. Spec. limit	%	*	*	
C. Particulates				
1. Particul. with half-lives>8 days	Ci	1.98E-4	3.31E-4	21%
2. Average release rate for period	µCi/sec	2.51E-5	4.20E-5	
3. Percent of Tech. Spec. limit	%	*	*	
4. Gross alpha radioactivity	Ci	NDA	NDA	
D. Tritium				
1. Total release	Ci	4.40E+0	5.97E+0	20%
2. Average release rate for period	µCi/sec	5.58E-1	7.57E-1	
3. Percent of Tech. Spec. limit	%	*	*	

Notes for Table 1A:

* Percent of Technical Specification Limit Values in Section A.3 through D.3 are to be provided in the annual supplemental dose assessment report to be issued prior to April , 1991.

1. NDA is no detectable activity.

2. LLD for gross alpha listed as NDA is 1E-11 µCi/ml.

TABLE 1B
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1990)
GASEOUS EFFLUENTS - ELEVATED RELEASE

		CONTINUOUS MODE		BATCH MODE	
Nuclides Released	Unit	Quarter 3rd	Quarter 4th	Quarter N/A	Quarter N/A
1. Fission gases					
Kr-85m	Ci	7.80E+1	6.69E+1		
Kr-87	Ci	NDA	NDA		
Kr-88	Ci	5.37E+1	4.80E+1		
Xe-133	Ci	1.19E+2	1.55E+2		
Xe-135	Ci	6.68E+0	4.37E+0		
Xe-135m	Ci	5.11E+0	5.58E+0		
Xe-138	Ci	1.14E+1	NDA		
Total for period	Ci	2.74E+2	2.80E+2		
2. Iodines					
I-131	Ci	3.79E-3	1.89E-3		
I-133	Ci	9.96E-3	9.92E-3		
Total for period	Ci	1.37E-2	1.18E-2		
3. Particulates					
Sr-89	Ci	2.43E-5	2.29E-5		
Sr-90	Ci	1.56E-6	NDA		
Cs-134	Ci	NDA	NDA		
Cs-137	Ci	NDA	NDA		
Ba/La-140	Ci	5.72E-5	3.59E-5		
Total for period	Ci	8.31E-5	5.88E-5		
4. Tritium					
H-3	Ci	2.05E-1	1.62E-1		

Notes for Table 1B:

1. NDA is no detectable activity.
2. LLDs for nuclides listed as NDA are as follows:

Fission gases:	1E-4 µCi/ml
Iodines:	1E-12 µCi/ml
Particulates:	1E-11 µCi/ml

TABLE 1C
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1990)
GASEOUS EFFLUENTS - GROUND LEVEL RELEASE

		CONTINUOUS MODE		BATCH MODE	
Nuclides Released	Unit	Quarter 3rd	Quarter 4th	Quarter N/A	Quarter N/A
1. Fission gases					
Kr-85m	Ci	NDA	NDA		
Kr-87	Ci	NDA	NDA		
Kr-88	Ci	NDA	NDA		
Xe-133	Ci	NDA	5.00E+0		
Xe-135	Ci	2.74E+0	6.25E+0		
Xe-135m	Ci	NDA	NDA		
Xe-138	Ci	NDA	NDA		
Total for period	Ci	2.74E+0	1.13E+1		
2. Iodines					
I-131	Ci	6.73E-4	2.18E-4		
I-133	Ci	1.50E-3	1.29E-3		
Total for period	Ci	2.18E-3	1.51E-3		
3. Particulates					
Sr-89	Ci	1.15E-4	2.61E-4		
Sr-90	Ci	NDA	4.45E-6		
Cs-134	Ci	NDA	NDA		
Cs-137	Ci	NDA	NDA		
Ba/La-140	Ci	NDA	7.00E-6		
Total for period	Ci	1.15E-4	2.72E-4		
4. Tritium					
H-3	Ci	4.19E+0	5.81E+0		

Notes for Table 1C:

1. NDA is no detectable activity.

2. LLDs for nuclides listed as NDA are as follows:

   Fission gases: 1E-4 µCi/ml
   Iodines: 1E-12 µCi/ml
   Particulates: 1E-11 µCi/ml

TABLE 2A
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1990)
LIQUID EFFLUENTS SUMMATION OF ALL RELEASES

	Unit	Quarter 3rd	Quarter 4th	Est. Total Error, %
A. Fission and activation products				
1. Total release (not including tritium, noble gases, or alpha)	Ci	1.62E-3	5.75E-4	12%
2. Average diluted concentration during period	µCi/ml	1.38E-9	6.49E-10	
3. Percent of applicable limit	%	6.23E-3%	3.45E-3%	
B. Tritium				
1. Total release	Ci	8.58E-1	4.58E-3	9.4%
2. Average diluted concentration during period	µCi/ml	7.33E-7	5.17E-9	
3. Percent of applicable limit	%	2.44E-2%	1.72E-4%	
C. Dissolved and entrained gases				
1. Total release	Ci	NDA	NDA	16%
2. Average diluted concentration during period	µCi/ml	NDA	NDA	
3. Percent of applicable limit	%	NDA	NDA	
D. Gross alpha radioactivity				
1. Total release	Ci	NDA	NDA	34%
E. Volume of waste released (prior to dilution)	liters	2.56E+5	1.61E+4	5.7%
F. Volume of dilution water used during period	liters	1.17E+9	8.86E+8	10%

Notes for Table 2A:

1. NDA is no detectable activity.
2. LLD for dissolved and entrained gase: listed as NDA is 1E-5 µCi/ml.
3. LLD for gross alpha listed as NDA is 1E-7 µCi/ml.

TABLE 2B
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1990)
LIQUID EFFLUENTS

		CONTINUOUS MODE		BATCH MODE	
Nuclides Released	Unit	Quarter	Quarter	Quarter	Quarter
		N/A	N/A	3rd	4th
1. Fission and Activation Products					
Cr-51	Ci			4.74E-5	NDA
Mn-54	Ci			4.94E-5	1.32E-5
Fe-55	Ci			3.28E-4	1.05E-4
Fe-59	Ci			NDA	NDA
Co-58	Ci			1.97E-5	2.78E-6
Co-60	Ci			7.15E-4	2.69E-4
Zn-65	Ci			6.85E-6	NDA
Sr-89	Ci			NDA	4.56E-6
Sr-90	Ci			7.73E-6	3.27E-6
Zr/Nb-95	Ci			NDA	NDA
Mo-99/Tc-99m	Ci			NDA	NDA
Rh-105	Ci			NDA	NDA
Ag-110m	Ci			9.57E-6	NDA
Sb-122	Ci			NDA	NDA
I-131	Ci			NDA	NDA
Cs-134	Ci			NDA	NDA
Cs-137	Ci			4.27E-4	1.77E-4
Ba/La-140	Ci			8.17E-6	NDA
Ce-141	Ci			NDA	NDA
Ce/Pr-144	Ci			NDA	NDA
Hf-181	Ci			NDA	NDA
Total for period	Ci			1.62E-3	5.75E-4
2. Dissolved and Entrained Noble Gases					
Xe-133	Ci			NDA	NDA
Xe-135	Ci			NDA	NDA
Total for period	Ci			NDA	NDA

Notes for Table 2B:

1. NDA is no detectable activity.

2. LLDs for nuclides listed as NDA are as follows:

Sr-89	5E-8 µCi/ml
I-131	1E-6 µCi/ml
Xe-133, 135	1E-5 µCi/ml
All Others	5E-7 µCi/ml

APPENDIX C

RADIOLOGICAL ENVIRONMENTAL TECHNICAL SPECIFICATIONS

OPERATIONAL OBJECTIVES

7.0 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

7.1 Monitoring Program

Applicability:

At all times.

Specification:

A. ENVIRONMENTAL MONITORING

An environmental monitoring program shall be conducted to evaluate the effects of station operation on the environs and to verify the effectiveness of the source controls on radioactive materials.

The radiological environmental monitoring program shall be conducted as specified in Table 8.1-1.

Action:

1. With the radiological environmental monitoring program not being conducted as specified in Table 8.1-1, prepare and submit to the Commission, in the Annual Radiological Environmental Monitoring Report required by Specification 6.9.C.2, a description of the reasons for not conducting the program as required and the plans for preventing a recurrence.

2. With the level of radioactivity as the result of plant effluents in an environmental sampling medium at a specified location exceeding the reporting levels of Table 7.1-1 when averaged over any calendar quarter, prepare and submit to the Commission within 30 days, a special report that identifies the cause(s) for exceeding the limit(s) and defines the corrective actions to be taken

Amendment No. 89

SURVEILLANCE REQUIREMENTS

8.0 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

8.1 Monitoring Program

Specification:

A. ENVIRONMENTAL MONITORING

The radiological environmental monitoring samples shall be collected pursuant to Table 8.1-1 from the specific locations given in the table and figure(s) in the Offsite Dose Calculation Manual (ODCM) and shall be analyzed pursuant to the requirements of Table 8.1-1 and the detection capabilities required by Table 8.1-4.

1. Cumulative dose contributions for the curre.t calendar year from radionuclides detected in environmental samples shall be determined in accordance with the methodology and parameters in the ODCM. These results will be reported in the Annual Radiological Environmental Monitoring Report.

229

OPERATIONAL OBJECTIVES	SURVEILLANCE REQUIREMENTS
7.1.A ENVIRONMENTAL MONITORING (Continued) to reduce radioactive effluents so that the potential annual dose to a member of the public is less than the calendar year limits of Specifications 7.2, 7.3, and 7.4. When more than one of the radionuclides in Table 7.1-1 are detected in the sampling medium, this report shall be submitted if:	

$$\frac{\text{concentration (1)}}{\text{reporting level (1)}} + \frac{\text{concentration (2)}}{\text{reporting level (1)}} + \ldots \geq 1.0$$

When radionuclides other than those in Table 7.1-1 are detected and are the result of plant effluents, this report shall be submitted if the potential annual dose to a member of the public is equal to or greater than the calendar year limits of Specifications 7.2, 7.3, and 7.4. This report is not required if the measured level of radioactivity was not the result of plant effluents; however, in such an event, the condition shall be reported and described in the Annual Radiological Environmental Monitoring Report.

3. With milk or fresh leafy vegetable samples unavailable from one or more of the sample locations required by Table B.1-1, identify locations for obtaining replacement samples and add them to the Radiological Environmental Monitoring Program within 30 days. The specific locations from which samples were unavailable may then be deleted from the monitoring program.

OPERATIONAL OBJECTIVES	SURVEILLANCE REQUIREMENTS
7.1.A ENVIRONMENTAL MONITORING (Continued) Pursuant to Specification 6.9.C.2, identify the cause of the unavailability of samples and identify the new location(s) obtaining replacement samples in the next Annual Environmental Radiation Monitoring Report and also include in the report the table for the ODCM reflecting the new location(s).	
B. LAND USE CENSUS A land use census shall be conducted and shall identify, within a distance of 8 km (5 miles), the location in each of the 16 meteorological sectors of the nearest milk animal, the nearest residence and the nearest garden of greater than 50 m^2 (500 ft^2) producing broad leaf vegetation. (For elevated releases as defined in Regulatory Guide 1.111, Revision 1, July 1977, the land use census shall also identify, within a distance of 5 km (3 miles), the locations in each of the 16 meteorological sectors of <u>all</u> milk animals and <u>all</u> gardens of greater than 50 m^2 producing broad leaf vegetation. <u>Action</u> 1. With a land use census identifying a location(s) that yields a calculated dose or dose commitment greater than the values currently being calculated in Specification B.4.A, identify the new location(s) in the next Annual Environmental Radiological Monitoring Report.	B. LAND USE CENSUS The land use census shall be conducted during the growing season, at least once per 12 months using that information that will provide the best results, such as by a door-to-door survey, aerial survey, or by consulting local agriculture authorities. The results of the land use census shall be included in the Annual Radiological Environmental Monitoring Report. Broad leaf vegetation sampling of at least three different kinds of vegetation may be performed at the site boundary in each of the two different direction sectors with the highest predicted D/Qs, in lieu of the garden census. Specifications for broad leaf vegetation sampling in Table 8.1-1 shall be followed, including analysis of control samples.

OPERATIONAL OBJECTIVES	SURVEILLANCE REQUIREMENTS
7.1.B LAND USE CENSUS (Continued) 2. With a land use census identifying a location(s) that yields a calculated dose or dose commitment (via the same exposure pathway) 20 percent greater than at a location from which samples are currently being obtained in accordance with Specification 7.1, add the new location(s) to the Radiological Environmental Monitoring Program within 30 days. The sampling location(s), excluding the control station location, having the lowest calculated dose or dose commitment(s), via the same exposure pathway, may be deleted from this monitoring program after October 31 of the year in which this land use census was conducted. Identify the new location(s) in the next Annual Environmental Radiological Monitoring Report and also include in the report a revised figure(s) and table for the ODCM reflecting the new location(s).	
7.2 Dose - Liquids Applicability: At all times.	8.2 Dose - Liquids Specification:
Specification: A. The dose or dose commitment to a member of the public from radioactive materials in liquid effluents released at and beyond the site boundary shall be limited: 1. During any calendar quarter to $\leq$ 1.5 mrem to the total body and to $\leq$ 5 mrem to any organ, and 2. During any calendar year to $\leq$ 3 mrem to the total body and to $\leq$ 10 mrem to any organ.	A. Dose Calculations - Cumulative dose contributions from liquid effluents shall be determined in accordance with the ODCM for each calendar month during which releases occurred.

OPERATIONAL OBJECTIVES	SURVEILLANCE REQUIREMENTS
7.2 Dose - Liquids (Continued) Action With the calculated dose from the release of radioactive materials in liquid effluents exceeding any of the above limits, prepare and submit to the Commission within 30 days, a special report that identifies the cause(s), corrective actions taken, and corrective actions to be taken.	
7.3 Dose - Noble Gases Applicability: At all times. Specification: A. The air dose in areas at and beyond the site boundary due to noble gases released in gaseous effluents shall be limited to the following: 1. During any calendar quarter, to $\leq$ 5 mrad for gamma radiation and $\leq$ 10 mrad for beta radiation; and 2. During any calendar year, to $\leq$ 10 mrad for gamma radiation and $\leq$ 20 mrad for beta radiation. Action With the calculated air dose from radioactive noble gases in gaseous effluents exceeding any of the above limits, prepare and submit to the Commission within 30 days, a special report which identifies the cause(s), the corrective actions taken, and corrective actions to be taken.	8.3 Dose - Noble Gases Specification: A. Dose Calculations - Cumulative dose contributions for the total time period shall be determined in accordance with the ODCM for each calendar month during which releases occurred.

OPERATIONAL OBJECTIVES	SURVEILLANCE REQUIREMENTS
7.4 Dose - Iodine-131, Iodine-133, Radioactive Material in Particulate Form, and Tritium	8.4 Dose - Iodine-131, Iodine-133, Radioactive Material in Particulate Form, and Tritium
Applicability:	Specification:
At all times	A. Dose Calculations - Cumulative dose contributions for the total time period shall be determined for iodine-131, iodine-133, radioactive material in particulate form with half-lives greater than 8 days, and tritium in accordance with the ODCM for each calendar month during which releases occurred.
Specification:	
A. The dose to a member of the public from iodine-131, iodine-133, radioactive materials in particulate form with half-lives greater than 8 days, and tritium in gaseous effluents released to areas at and beyond the site boundary shall be limited to the following: 1. During any calendar quarter to ≤ 7.5 mrem to any organ, and 2. During any calendar year to ≤ 15 mrem to any organ. Action With the calculated dose from the release of iodine-131, iodine-133, radioactive materials in particulate form, and tritium in gaseous effluents exceeding any of the above limits; prepare and submit to the Commission within 30 days, a special report which identifies the cause(s), corrective actions taken, and the corrective actions to be taken.	
7.5 Total Dose	8.5 Total Dose
Applicability:	Specification:
At all times.	A. Dose Calculations - Cumulative dose contributions from liquid and gaseous effluents shall be determined in accordance with Specifications 7.2.A, 7.3.A, and 7.4.A; and in accordance with the ODCM.
Specification:	
A. The dose or dose commitment to any member of the public from Pilgrim Station sources is limited to ≤ 25 mrem to the total body or any organ (except the thyroid, which	

OPERATIONAL OBJECTIVES	SURVEILLANCE REQUIREMENTS
7.5 Total Dose (Continued) is limited to ≤ 75 mrem) over a period of any calendar year. Action With the calculated dose from the release of radioactive materials in liquid or gaseous effluents exceeding twice the limits of Specifications 7.2.A, 7.3.A, or 7.4.A; prepare and submit a special report to the Commission and limit the subsequent releases such that the dose or dose commitment to any member of the public from all uranium fuel cycle sources is limited to ≤ 25 mrem to the total body or any organ (except thyroid, which is limited to ≤ 75 mrem) over any calendar year. This special report shall include an analysis which demonstrates that radiation exposures to all members of the public from all uranium fuel cycle sources (including all effluent pathways and direct radiation) are less than the 40 CFR, Part 190 standard. Otherwise, obtain a variance from the Commission to permit releases which exceed the 40 CFR, Part 190 standard.	

TABLE 7.1-1
REPORTING LEVELS FOR RADIOACTIVITY CONCENTRATIONS IN ENVIRONMENTAL SAMPLES

Analysis	Reporting Levels				
	Water (pCi/L)	Airborne Particulate or Gases (pCi/M³)	Fish (pCi/kg, wet)	Milk (pCi/l)	Vegetables (pCi/kg, wet
H-3	2×10^4				
Mn-54	1×10^3		3×10^4		
Fe-59	4×10^2		1×10^4		
Co-58	1×10^3		3×10^4		
Co-60	3×10^2		1×10^4		
Zn-65	3×10^2		2×10^4		
Zr-95	4×10^2				
I-131	2	0.9		3	1×10^2
Cs-134	30	10	1×10^3	60	1×10^3
Cs-137	50	20	2×10^3	70	2×10^3
Ba-140	2×10^2			3×10^2	

TABLE 8.1-1

OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway or Sample Type	Locations (Direction-Distance) from Reactor	Sampling and Collection Frequency	Type and Frequency of Analysis
AIRBORNE			
Particulates	11 Locations (See Table 8.1-2)	Continuous sampling over one week	Gross beta radioactivity 24 hours or more after filter change[1]
Quarterly	11 Locations (See Table 8.1-2)		Composite (by location) for gamma isotopic[2]
Radioiodine	11 Locations (See Table 8.1-2)	Continuous sampling with canister collection weekly	Analyze weekly for I-131
DIRECT[3]	40 Locations (See Table 8.1-3)	Quarterly	Gamma exposure quarterly
	Plymouth Beach and Priscilla/White Horse Beach	Annually	Gamma exposure survey[4]
WATERBORNE (Surface Water)	Discharge Canal	Continuous composite sample	Gamma isotopic[2] monthly, and composite for H-3 analysis quarterly[2]
	Bartlett Pond (SE-1.7 mi)	Weekly grab sample	
	Powder Point (NNW-7.8 mi)[4]	Weekly grab sample	
AQUATIC			
Shellfish (clams, mussels or quahogs as available)	Discharge outfall Duxbury Bay Manomet Point Plymouth or Kingston Harbor Marshfield[4]	Quarterly (at approximate 3-month intervals)	Gamma isotopic[2,5]

TABLE 8.1-1 (Continued)
OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway or Sample Type	Locations (Direction-Distance) from Reactor	Sampling and Collection Frequency	Type and Frequency of Analysis
Lobster	Vicinity of discharge point	Four times per season	Gamma isotopic[2] on edible portions
	Offshore[3]	Once per season	
Fish	Vicinity of discharge point	Quarterly (when particular species available) for Groups I and II[5], in season for Groups III and IV[5], annually for each group	Gamma isotopic[2] on edible portions[5]
	Offshore[4]		
Sediments	Rocky Point Plymouth Harbor Duxbury Bay Plymouth Beach Manomet Point Marshfield	Semiannually	Gamma isotopic[2,5,7]
INGESTION (Terrestrial)			
Milk	Plymouth County Farm, when available (W-3.5 mi)[5]	Semimonthly during periods when animals are on pasture, otherwise monthly	Gamma isotopic[2], radioiodine analysis all samples
	Whitman Farm (NW-21 mi)[4]		
Cranberries[8]	Manomet Point Bog (SE-2.6 mi)	At time of harvest	Gamma isotopic[8] on edible portions
	Bartlett Rd. Bog (SSE/S-2.8 mi)		
	Pine St. Bog (WNW-17 mi)[4]		

TABLE 8.1-1 (Continued)
OPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway or Sample Type	Locations (Direction-Distance) from Reactor	Sampling and Collection Frequency	Type and Frequency of Analysis
Tuberous and green leafy vegetables	Plymouth County Farm (W-3.5 mi)[e] Bridgewater Farm (W-20 mi)[e]	At time of harvest	Gamma Isotopic[f] on edible portions
Beef Forage	Plymouth County Farm (W-3.5 mi)[e] Whitman Farm (NW-21 mi)[e]	Annually	Gamma Isotopic[f]

C-11

TABLE B.1-1 (Continued)
NOTES

[1] If gross beta radioactivity is greater than 10 times the control value, gamma isotopic will be performed on the sample.

[2] Gamma isotopic means the identification and quantification of gamma-emitting radionuclides that may be attributable to the effluents from the facility.

[3] If integrated gamma activity (less K-40) is greater than 10 times the control value (less K-40), strontium-90 analysis will be performed on the sample.

[4] Indicates control location.

[5] Fish analyses will be performed on a minimum of 2 sub-samples, consisting of approximately 400 grams each from each of the following groups:

I. Bottom Oriented	II. Near Bottom Distribution	III. Anadromous	IV. Coastal Migratory
Winter flounder	Tautog	Alewife	Bluefish
Yellowtail founder	Cunner	Rainbow smelt	Atlantic herring
	Atlantic cod	Striped bass	Atlantic menhaden
	Pollock		Atlantic mackerel
	Hakes		

[6] Mussel samples from four locations (immediate vicinity of discharge outfall, Manomet Point, Plymouth or Kingston Harbor, and Green Harbor in Marshfield) will be analyzed quarterly as follows:

One kilogram wet weight of mussel bodies, including fluid within shells will be collected. Bodies will be reduced in volume by drying at about 100°C. Sample will be compacted and analyzed by Ge(Li) gamma spectrometry or alternate technique, if necessary, to achieve a sensitivity of 5 pCi/kg for Cs-134, Cs-137, Co-60, Zn-65, and Zr-95; and 15 pCi/kg for Ce-144. Sensitivity values are to be determined in accordance with a 95% confidence level on k_α and a 50% confidence level on k_α (See HASL-300 for definitions).

The mussel shell sample from one location will be analyzed each quarter. One additional mussel shell sample will be analyzed semiannually. Unscrubbed shells to be analyzed will be dried, processed, and analyzed similarly to the mussel bodies.

TABLE B.1-1 (Continued)
NOTES

Because of the small volume reduction in pre-processing of shells, sensitivities attained will be less than that for mussel bodies. The equipment and counting times to be employed for analyses of shells will be the same or comparable to that employed for mussel bodies so that the reduction in sensitivities (relative to those for mussel bodies) will be strictly limited to the effects of poorer geometry related to lower sample volume reduction. Shell samples not scheduled for analysis will be reserved (unscrubbed) for possible later analysis.

If radiocesium (Cs-134 and Cs-137) activity exceeds 200 pCi/kg (wet) in mussel bodies, these samples will be analyzed by radiochemical separation, electrodeposition, and alpha spectrometry for radioisotopes of plutonium, with a sensitivity of 0.4 pCi/kg.

* Sediment samples from four locations (Manomet Point, Rocky Point, Plymouth Harbor, and head of Duxbury Bay) will be analyzed once per year (preferably early summer) as follows:

  Cores will be taken to depths of 30-cm, minimum depth, wherever sediment conditions permit, by a hand-coring sampling device. If sediment conditions do not permit 30-cm deep cores, the deepest cores achievable with a hand-coring device will be taken. In any case, core depths will not be less than 14-cm. Core samples will be sectioned into 2-cm increments; surface and alternate increments will be analyzed, all others will be reserved. Sediment sample volumes (determined by core diameter and/or number of individual cores taken from any single location) and the counting technique will be sufficient to achieve sensitivities of 50 pCi/kg dry sediment for Cs-134, Cs-137, Co-60, Zn-65, and Zr-95 and 150 pCi/kg for Ce-144. In any case, individual core diameters will not be less than 2 inches.

  The top 2-cm section from each core will be analyzed for Pu isotopes (Pu-238, Pu-239, and Pu-240) using radiochemical separations, electrodeposition, and alpha spectrometry with target sensitivity of 25 pCi/kg dry sediment. Two additional core slices per year (mid-depth slice from two core samples) will be similarly analyzed.

* These locations may be altered in accordance with results of surveys discussed in Specification 8.1.B.

* Minimum sensitivities for gamma exposure measurements are as follows:

  Gamma exposure - 1 R/hr average exposure rate.
  Gamma exposure survey - 1 R/hr exposure rate.

TABLE B.1-2

AIR PARTICULATES, GASEOUS RADIOIODINE, AND SOIL SURVEILLANCE STATIONS

Sampling Location (Sample Designation)	Distance and Direction from Reactor
Offsite Stations	
East Weymouth (EW) (Control Station)	21 miles NW
Plymouth Center (PC)	4.0 miles W-WNW
Manomet Substation (MS)	2.5 miles SE
Cleft Rock Area (CR)	0.9 miles S
Onsite Stations	
Rocky Hill Road (ER)	0.8 miles SE
Rocky Hill Road (WR)	0.3 miles W-WNW
Overlook Area (OA)	0.03 miles W
Property Line (PL)	0.34 miles NW
Pedestrian Bridge (PB)	0.14 miles N
East Breakwater (EB)	0.35 miles ESE
Warehouse (WS)	0.03 miles SSE

TABLE B.1-3
EXTERNAL GAMMA EXPOSURE SURVEILLANCE STATIONS

Dosimeter Location (Designation)	Distance and Direction from Station
ONSITE STATIONS	
Property Line (D)	0.17 miles NNW
Property Line (F)	0.12 miles NW
Property Line (I)	0.14 miles W
Property Line (G)	0.20 miles WSW
Rocky Hill Road (A)	0.12 miles SW
Property Line (H)	0.21 miles SSW
Public Parking Area (PA)	0.07 miles N-NNE
Pedestrian Bridge (PB)	0.1 miles NE
Overlook Area (OA)	0.03 miles W
East Breakwater (EB)	0.26 miles ESE
Property Line (C)	3.3 miles ESE-SE
Property Line (HB)	0.34 miles SE
Rocky Hill Road (B)	0.26 miles SSE
Microwave Tower (MT)	0.38 miles S
Emerson Road (EM)	0.68 miles SE-SSE
White Horse Road (WH)	0.89 miles SE-SSE
Property Line (E)	0.75 miles SSE-S
Rocky Hill Road (WR)	0.3 miles W-WNW
Property Line (J)	1.36 miles SSE-S
Property Line (K)	1.42 miles SSE-S
Rocky Hill Road (ER)	0.8 miles SE
Property Line (L)	0.40 miles E

TABLE 8.1-3 (Continued)
EXTERNAL GAMMA EXPOSURE SURVEILLANCE STATIONS[1]

Dosimeter Location (Designation)	Distance and Direction from Station
ONSITE STATIONS (Continued)	
Warehouse (WS)	0.1 miles SE
Property Line (PL)	0.3 miles W
OFFSITE STATIONS	
Duxbury (SS)	6.25 miles SSW-SW
Kingston (KS)	10 miles WNW
North Plymouth (NP)	5.5 miles WNW
Plymouth Center (PC)	4.0 miles W-WNW
South Plymouth (SP)	3 miles WSW
Bayshore Drive (BD)	0.7 miles W-WNW
Cleft Rock Area (CR)	0.9 miles S
Manomet (MP)	2.25 miles ESE-S
Manomet (ME)	2.5 miles SE
Manomet (MS)	2.5 miles SSE
Manomet (MB)	3.5 miles SE-SSE
College Pond (CP)	6.5 miles SSW-SW
Sagamore (CS)	10 miles SSE-S
Plymouth Airport (SA)	8 miles WSW
East Weymouth (EW)[2]	21 miles NW
Saquish Neck (SN)[3]	4.6 miles WNW

1 Thermal Luminescent Dosimeters (TLDs)
2 Control Station
3 TLDs for this location will be provided to a third party and will be analyzed for gamma exposure whenever returned to Boston Edison Company.

Amendment No. 89

244

TABLE 8.1-4

MAXIMUM VALUES FOR THE LOWER LIMITS OF DETECTION (LLD)[a]

Analysis	Water (pCi/kg)	Airborne Particulate or Gas (pCi/M³)	Wet Solids (pCi/kg, wet)	Milk (pCi/g)	Food Products (pCi/kg, wet)	Dry Solids (pCi/kg, dry)
gross beta	4[b]	1×10^{-2}				
^{3}H	2000[d]					
^{54}Mn	15		130			
^{59}Fe	30		260			
$^{58,60}Co$	15		130			50
^{65}Zn	30		260			50
^{95}Zr	15					50
^{131}I	1	7×10^{-2}		1	60[c]	
$^{134,137}Cs$	15, 18	1×10^{-2}	130	15	60	50
^{140}Ba	15			15		
^{144}Ce						150

[a] Refer to ODCM for LLD definition.

[b] LLD for surface water.

[c] LLD for leafy vegetables.

[d] If no drinking water pathway exists, a value of 3000 pci/l may be used.

BASES

7/8.0 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

7/8.1 Monitoring Program

7/8.1.A ENVIRONMENTAL MONITORING

An environmental radiological monitoring program is conducted to verify the adequacy of in-plant controls on the release of radioactive materials. The program is designed to detect radioactivity concentrations to ensure that radiation doses to individuals do not exceed the levels set forth in 10 CFR 50, Appendix I.

A supplemental monitoring program for sediments and mussels has been incorporated into the basic program (see Notes 6 and 7 to Table B.1-1) as a result of an agreement with the Massachusetts Wildlife Federation. This supplemental program is designed to provide information on radioactivity levels at substantially higher sensitivity levels in selected samples to verify the adequacy (or, alternatively, to provide a basis for later modifications) of the long-term marine sampling schedules. As part of the supplemental program, analysis of mussels for isotopes of plutonium will be performed if radiocesium activity should exceed 200 pCi/kg in the edible portions.

The 200 pCi/kg radiocesium "action level" is based on calculations which show that if radiocesium from plant releases reached this level, plutonium could possibly appear at levels of potential interest.[1] The calculations also show that the dose delivered from these levels of plutonium would not be a significant portion of the total dose attributable to liquid effluents.

The program was also designed to be consistent, wherever applicable, with NUREG 0473.

Groundwater flow at the plant site is into Cape Cod Bay; therefore, terrestrial monitoring of groundwater is not included in this program.

Detection capabilities for environmental sample analyses are tabulated in terms of the lower limits of detection (LLD). The LLD in Table B.1.4 is considered optimum for routine environmental measurements in industrial laboratories. It should be recognized that the LLD is defined as an *a priori* (before the fact) limit representing the capability of a measurement system and not as an *a posteriori* (after the fact) limit for a particular measurement.

Detailed discussion of the LLD, and other detection limits can be found in HASL Procedures Manual, HASL-300 (revised annually), curie, L.A.; "Limits for Qualitative Detection and Quantitative Determination - Application to Radiochemistry", Anal. Chem. 40, 586-93 (1968); and Hartwell, J. K., "Detection Limits for Radioanalytical Counting Techniques," Atlantic Richfield Hanford Company Report ARH-SA-215 (June 1975).

[1] In measurable quantities having a potential dose (human food chain) significance comparable to other nuclides if present at their detection limits.

BASES

7/8.1.B LAND USE CENSUS

This section is provided to ensure that changes in the use of areas at and beyond the site boundary are identified and that modifications to the radiological environmental monitoring program are made if required by the results of this census. The best information from the door-to-door survey, from aerial survey, or from consulting with local agricultural authorities shall be used. This census satisfies the requirements of 10CFR50, Appendix I, Section IV.B.3. Restricting the census to gardens of greater than 50 m^2 provides assurance that significant exposure pathways via leafy vegetables will be identified and monitored, since a garden of this size is the minimum required to produce the quantity (26 kg/year) of leafy vegetables assumed in Regulatory Guide 1.109 for consumption by a child. To determine this minimum garden size, the following assumptions were made: 1) 20% of the garden was used for growing broad leaf vegetation (i.e., similar to lettuce and cabbage), and 2) a vegetation yield of 2 kg/m^2.

7/8.2 DOSE - LIQUID

This section is provided to implement the requirements of Sections II.A, III.A, and IV.A of 10CFR50, Appendix I, to assure that the releases of radioactive material in liquid effluents will be kept "as low as is reasonably achievable." Because Pilgrim is not a site where plant operations can conceivably affect drinking water, none of these requirements are intended to assure compliance with 40 CFR 141. The dose calculations in the ODCM implement the requirements of 10CFR50, Appendix I, Section III.A to ensure that the actual exposure of a member of the public through appropriate pathways is unlikely to be substantially underestimated. The equations specified in the ODCM for calculating the doses due to the actual release rates of radioactive materials in liquid effluents will be consistent with the methodology provided in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR Part 50, Appendix I," Revision 1, October 1977 and Regulatory Guide 1.113, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I," April 1977. NUREG-0133 provides methods for dose calculations consistent with Regulatory Guides 1.109 and 1.113.

BASES

7/8.3 DOSE - NOBLE GASES

This section is provided to implement the requirements of 10CFR50, Appendix I, Sections II.B, III.A, and IV.A to ensure that the releases of radioactive material in gaseous effluents will be kept "as low as is reasonably achievable." The surveillance requirements implement the requirements of 10CFR50, Appendix I, Section III.A to ensure that the actual exposure of a member of the public through the appropriate pathways is unlikely to be substantially underestimated. The dose calculations established in the ODCM for calculating the doses due to the actual release rates of radioactive noble gases in gaseous effluents are consistent with the methodology provided in Regulatory Guide 1.109 and Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," Revision 1, July 1977. The ODCM equations provided for determining the air doses at and beyond the site boundary will be based upon the historical average atmospheric conditions. NUREG-0133 provides methods for dose calculations consistent with Regulatory Guides 1.109 and 1.111.

7/8.4 DOSE - IODINE-131, IODINE-133, RADIOACTIVE MATERIAL IN PARTICULATE FORM, AND TRITIUM

This section is provided to implement the requirements of Sections II.C, III.A and IV.A of 10 CFR50, Appendix I, to assure that the releases of radioactive materials in gaseous effluents will be kept "as low as is reasonably achievable." The ODCM calculational methods specified in the surveillance requirements implement the requirements of 10CFR50, Appendix I, Section III.A to ensure that the actual exposure of a member of the public through appropriate pathways is unlikely to be substantially underestimated. The ODCM calculational methods approved by the NRC for calculating the doses due to the actual release rates of the subject materials are required to be consistent with the methodology provided in Regulatory Guides 1.109 and 1.111. These equations also provide for determining the actual doses based upon the historical average atmospheric conditions. The release rate specifications for iodine-131, radioactive material in particulate form with half-lives greater than 8 days, and radionuclides other than noble gases are dependent on the existing radionuclide pathways to man, in areas at and beyond the site boundary. The pathways which are examined in the development of these calculations are: 1) individual inhalation of airborne radionuclides, 2) deposition of radionuclides onto green leafy vegetation with subsequent consumption by man, 3) deposition onto grassy areas where milk animals and meat producing animals graze with consumption of the milk and meat by man, and 4) deposition on the ground with subsequent exposure of man.

7/8.5 TOTAL DOSE

This section is provided to meet the dose limitations of 40CFR190 that have now been incorporated into 10CFR20 by 46 FR 18525. The specification requires the preparation and submittal of a special report whenever the calculated doses from plant radioactive effluents exceed twice the design objective doses of 10CFR50, Appendix I. For sites containing up to 4 reactors, it is highly unlikely that the resultant dose to a member of the public will exceed the dose limits of 40CFR190 if the individual reactors remain within the reporting requirement level. The special report will describe a course of action that should result in the limitation of the annual dose to a member of the public to within the 40CFR190 limits. For the purposes of the special report, it may be assumed that the dose commitment to the member of the public from other uranium fuel cycle sources is negligible, except dose contributions from other nuclear fuel cycle facilities at the same site or within a radius of 8 km must be considered. If the dose to any member of the public is estimated to exceed the limits of 40CFR190, a request for a variance in a special report in accordance with 40CFR190.11 and 10CFR20.405C is considered to be a timely request and fulfills the requirements of 40CFR190 until NRC staff action is completed. This is provided that the release conditions resulting in violation of 40CFR190 have not already been corrected. The variance only relates to the limits of 40CFR190, and does not apply in any way to the other requirements for dose limitation of 10CFR20. An individual is not considered a member of the public during any period in which he/she is engaged in any operation that is part of the nuclear fuel cycle.

APPENDIX D

1990 LAND USE CENSUS RESULTS

APPENDIX D

1990 LAND USE CENSUS RESULTS

The annual land use census for gardens and milk and meat animals in the vicinity of Pilgrim Station was performed between September 11 and 29, 1990. 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. In addition, the Town of Plymouth Animal Inspector was contacted for information regarding milk and meat animals.

A total of 31 gardens were identified in the vicinity of Pilgrim Station. A majority of these gardens had been identified during previous land use censuses.

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 analysis of the gardens identified during the 1990 land use census, sampled vegetables or naturally-growing vegetation were collected at or near gardens at the following locations:

Hall residence - Rocky Hill Road	0.5 mi. SE
Gadbois residence - Brook Road	1.7 mi. SSE
Minahan residence - Beaverdam Road	2.1 mi. S
Fry residence - Jordan Road	2.7 mi. SW
Cotti residence - Bay Colony Drive	1.9 mi. WSW
Hanlon residence - Clay Hill Road	1.0 mi. W

Permission is being sought from owners of these gardens to permanently add these locations to the sampling program. In addition to these special locations, samples were also collected at or near the Plymouth County Farm (3.5 mi. W), Whipple Farm (1.8 mi. SW), Moon residence (2.1 mi. WSW) and from the control location at Bridgewater Farm (20 mi. W).

A Failure and Malfunction Report (F&MR) was filed during 1990 related to the garden census. Four gardens identified during the 1989 land use census were not officially added to the sampling program. Of the four gardens identified during the 1989 census, one was no longer grown and another had changed ownership. However, despite these gardens not officially being part of the program, samples were collected at or near these four locations during 1990.

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 1990 sampling program.

APPENDIX E

PNPS ENVIRONMENTAL MONITORING PROGRAM DISCREPANCIES DURING 1990

APPENDIX E

PNPS ENVIRONMENTAL MONITORING PROGRAM DISCREPANCIES DURING 1990

In the event of major discrepancies, a Failure and Malfunction Report (F&MR) is generated to document the nature of the discrepancy and the corrective actions taken to prevent recurrence. During 1990, two F&MRs were filed related to the radiological environmental monitoring program.

An F&MR was generated in October 1990 to document a degradation of the composite water sampler at the PNPS discharge canal. In this event, the weighted intake filter had become disconnected from the sample line during the last day of the week sampling period. The sample line was allowed to float freely and may have intermittently sampled the discharge canal flow, potentially not meeting the requirement for continuous composite sampling as required in Technical Specification Table 8.1-1. The filter was replaced when the problem was identified and steps taken to ensure proper placement of the sampler intake.

An F&MR was also filed during 1990 related to the garden census. Four gardens identified during the 1989 land use census were not officially added to the sampling program, as required by Technical Specification 7.1.B.2. However, despite these gardens not officially being part of the program, samples were collected at or near these four locations during 1990. Of the four gardens identified during the 1989 census, one was no longer grown and another had changed ownership. Permission to sample replacement gardens is being sought.

There were also a few instances of minor discrepancies in the radiological monitoring program during 1990. These discrepancies are noted below. None of these discrepancies resulted in any appreciable impact on the environmental sampling program.

On a few occasions, low sample flow was obtained on air samplers due to failure of the power supply or pump. Despite the low volumes collected in these instances, all airborne particulate and charcoal iodine samples met the required value for lower level of detection specified in the PNPS Technical Specifications.

Only two of the 160 environmental thermoluminescent dosimeters (TLDs) required by Technical Specifications were not collected during 1990. The TLD at Station J was found missing from its posted location during first quarter TLD retrievals, as was the TLD at Sherman Airport during fourth quarter retrieval.

One Subsample of Group I (bottom-oriented) and both subsamples of Group II (near-bottom distribution) fishes were not collected in the vicinity of the PNPS discharge canal outfall during the first quarter of 1990. Concerted and repeated efforts by personnel from the Massachusetts Division of Marine Fisheries failed to catch required fish samples from these two categories during the January-March sampling period. Species from these two categories tend to move to deeper waters during cold months and were not available in the area for capture.

In general, the minor discrepancies noted during 1990 resulted from circumstances beyond the control of Boston Edison and contractor personnel responsible for collection of samples. None of the discrepancies resulted in an adverse affect on the monitoring program.

APPENDIX F

QUALITY ASSURANCE FOR THE RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM DURING 1990

APPENDIX F

QUALITY ASSURANCE FOR THE RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM DURING 1989

I. 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 1990," and the YAEL "Semi-Annual Quality Assurance Status Report: July - December 1990."

II. Laboratory Analyses

The quality control programs that were performed during 1989 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 interlaboratory 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 1990 for YAEL intralaboratory analyses and EPA interlaboratory cross-check analyses. For accuracy, 68 and 88 percent of the results were within 5 and 10 percent of the known values, respectively, with 96 percent of all results falling within the laboratory criterion of 15 percent. For precision, 84 and 97 percent of the results were within 5 and 10 percent of the mean, respectively, with 99.7 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 1990. A total of 184 analyses were performed on air particulate filters, milk, and water. Based upon this sample analysis total, 180 analyses (i.e., 98 percent) met the EPA's definition of "control limit" acceptance criteria for accuracy.

TABLE 1

INTRALABORATORY AND EPA INTERLABORATORY RESULTS - 1990

Category	Total Number of Measurements	Number of Measurements within deviation range* 0-5%	0-10%	0-15%**
	YAEL INTRALABORATORY ANALYSES			
Accuracy	578	440 (76.1%)	543 (93.9%)	565 (97.8%)
Precision	580	529 (91.2%)	568 (97.9%)	578 (99.7%)
	EPA INTERLABORATORY ANALYSES			
Accuracy	184	79 (42.9%)	129 (70.1%)	163 (88.6%)
Precision	183	115 (62.8%)	173 (94.5%)	183 (100%)
	TOTAL COMBINED ANALYSES			
Accuracy	762	519 (68.1%)	672 (88.2%)	728 (95.5%)
Precision	763	644 (84.4%)	741 (97.1%)	761 (99.7%)

* Values in parentheses indicate percentage of analysis results within the deviation range.

** 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 52 paired samples were submitted by the five sponsor companies for analysis during 1990. 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 was 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, then a two standard deviation range (95 percent confidence level) is established for each of the analyses. If the ranges overlap, agreement is obtained.

From the 51 paired samples, 1321 paired duplicate measurements were analyzed for 1990. All measurements fell within the established criteria discussed above. No trend was evident with respect to repeated failings of measurements for the listed radionuclides and media.

III. Environmental TLD Measurements

Two separate quality control programs were performed during 1990 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. Boston Edison conducted quarterly tests on the environmental TLDs via an independent third party during 1990.

A. Intralaboratory and Independent Third Party Results

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 1990 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 in used as a measure of precision.

The quality control program implemented for dosimetry processing indicated good precision and accuracy in the reported values. In 1990, there were 96 quality control tests. All 48 environmental TLDs tested during January - June 1990 were within the control limits for both accuracy and precision. The comparisons yielded a mean accuracy of - 5.5 percent, with an associated standard deviation of ± 3.5 percent. The comparisons exhibited a precision value with an overall standard deviation of 1.9 percent. The 48 TLDs tested in July - December 1990 showed a mean accuracy of 0.4 percent with an associated standard deviation of ± 4.5 percent. LDs measured during the second semiannual period exhibited a precision value with a standard deviation of 1.8 percent, well within the acceptance criteria. In total, all 96 environmental TLDs tested during 1990 were within the control limits for accuracy (± 20.0%) and precision (± 12.8%).

B. Boston Edison's TLD QA Program

Boston Edison Company personnel evaluate the accuracy of the environmental TLDs on a quarterly basis, per PNPS Station Instruction RP.8010, "Environmental TLD Quality Assurance Program." This instruction establishes acceptance criteria of: 1) the average of the percentage differences must be within ± 10%; and, 2) no one result can be greater than ± 15%. For the 72 environmental TLDs tested during 1990, the average difference was +0.36%. All calculated averages of the percentage differences were within the 10% acceptance criterion, and no individual result exceeded the 15% criterion.

IV. 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 99.8% of all cases.

The environmental TLD measurements for intralaboratory and independent third party comparisons resulted in both mean accuracy and precision within 3 percent deviation.

Therefore, the quality assurance programs for the Boston Edison Company's Radiological Environmental Monitoring Program indicated that the analysis and measurements which were performed by Yankee Atomic Environmental Laboratory during 1990 exhibited acceptable accuracy and precision.