VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

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Gentlemen:

VIRGINIA ELECTRIC AND POWER COMPANY
NORTH ANNA POWER STATION UNIT NOS. 1 AND 2
ANNUAL RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT

Pursuant to Technical Specification 6.9.1.8, enclosed is the Annual Radiological Environmental Operating Report for North Anna Power Station Unit Nos. 1 and 2 for 1990.

If you have any questions or require additional information, please contact us.

Very truly yours,

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VIRGINIA ELECTRIC AND POWER COMPANY

NORTH ANNA POWER STATION

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

FOR 1990

Prepared by

VIRGINIA ELECTRIC AND POWER COMPANY

and

TELEDYNE ISOTOPES

ANNUAL RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT

NORTH ANNA POWER STATION

JANUARY 1, 1990 to DECEMBER 31, 1990

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FORWARD

This report is submitted as required by Technical Specification 6.9.1.8, Annual Radiological Environmental Operating Report for North Anna Power Stations, Units 1 and 2, Virginia Electric and Power Company Docket Nos. 50-338 and 50-339.

EXECUTIVE SUMMARY

This document is a detailed report on the 1990 North Anna Nuclear Power Station Radiological Environmental Monitoring Program (REMP). Radioactivity levels from January 1 through December 31, 1990 in water, silt, shoreline sediment, milk, aquatic biota, food products, vegetation, and direct exposure pathways have been analyzed, evaluated and summarized. The REMP is designed to ensure that radiological effluent releases are As Low As is Reasonably Achievable (ALARA), no undue environmental effects occur, and the health and safety of the public is protected. The program also detects any unexpected environmental processes which could allow radiation accumulations in the environment or food pathway chains.

Radiation and radioactivity in the environment is constantly monitored within a 25 mile radius of the station. Samples are also collected by Virginia Power within this area. A number of sampling locations for each medium were selected using available meteorological, land and water use data. Control samples are collected from areas that are beyond measurable influence of North Anna Nuclear Power Station or any other nuclear facility for use as reference data. Normal background radiation levels or radiation present due to causes other than North Anna Power Station can thus be compared to the environment surrounding the nuclear power station. Indicator samples showing how much radiation is contributed by the plant are taken from areas close to the station where any plant contribution will be at the highest concentration. Measured values are compared with both current control samples and the pre-operational baseline -- radioactive concentrations present in the environment before North Anna became operational -- to determine if changes in radioactivity levels are attributable to station operations, to other causes such as the Chernobyl accident, or to natural variation.

Teledyne Isotopes provides sample analyses for various radioisotopes as appropriate for each sample media. Participation in the Environmental Protection Agency's (EPA) Interlaboratory Comparison Program provides an independent check on the precision and accuracy of sample measurements. Radioactivity in the environment is typically so minimal that radiological analyses frequently fall below the detection limits of state-of-the-art measurement methods. The Nuclear Regulatory Commission (NRC) sets forth minimum Lower Limits of Detection (LLD) to ensure that analyses are as accurate as possible. Samples with extremely low levels of radiation which cannot be detected are therefore reported as being below the LLD. The NRC also mandates a "reporting level." Licensed nuclear facilities must report any releases equal to or greater than this reporting level. Environmental radiation levels are sometimes referred to as a percent of the reporting level.

Analytical results are divided into five categories based on exposure pathways: Airborne, waterborne, aquatic, ingestion, and direct radiation.

- The airborne exposure pathway includes airborne iodine, airborne particulate, precipitation, and soil samples. The overall 1990 airborne results were very similar to previous years and to preoperational levels. No increase was noted and there were no detections for fission products or other man-make isotopes in the airborne particulate media during 1990.

- The waterborne exposure pathway includes ground/well water, river water, and surface water samples. No man-made or natural isotopes were monitored in Lake Anna surface water except for tritium. The average tritium activity in 1990 was 19.5% of the NRC reporting level. This has increased from preoperational levels, but has not increased from 1989 levels.

- The aquatic exposure pathway includes sediment/silt and shoreline samples. North Anna sediment contained some cesium-137 and cesium-134. During the preoperational period, cesium-137 was detected, however, additional man-made isotopes appear to have accumulated. Sediment contamination does not provide a direct dose pathway to man. Shoreline soil, which may provide a direct dose pathway, contained no cesium-134. Cesium-137 levels dropped from 378 pCi/kg in 1989 to 74.6 pCi/kg in 1990.

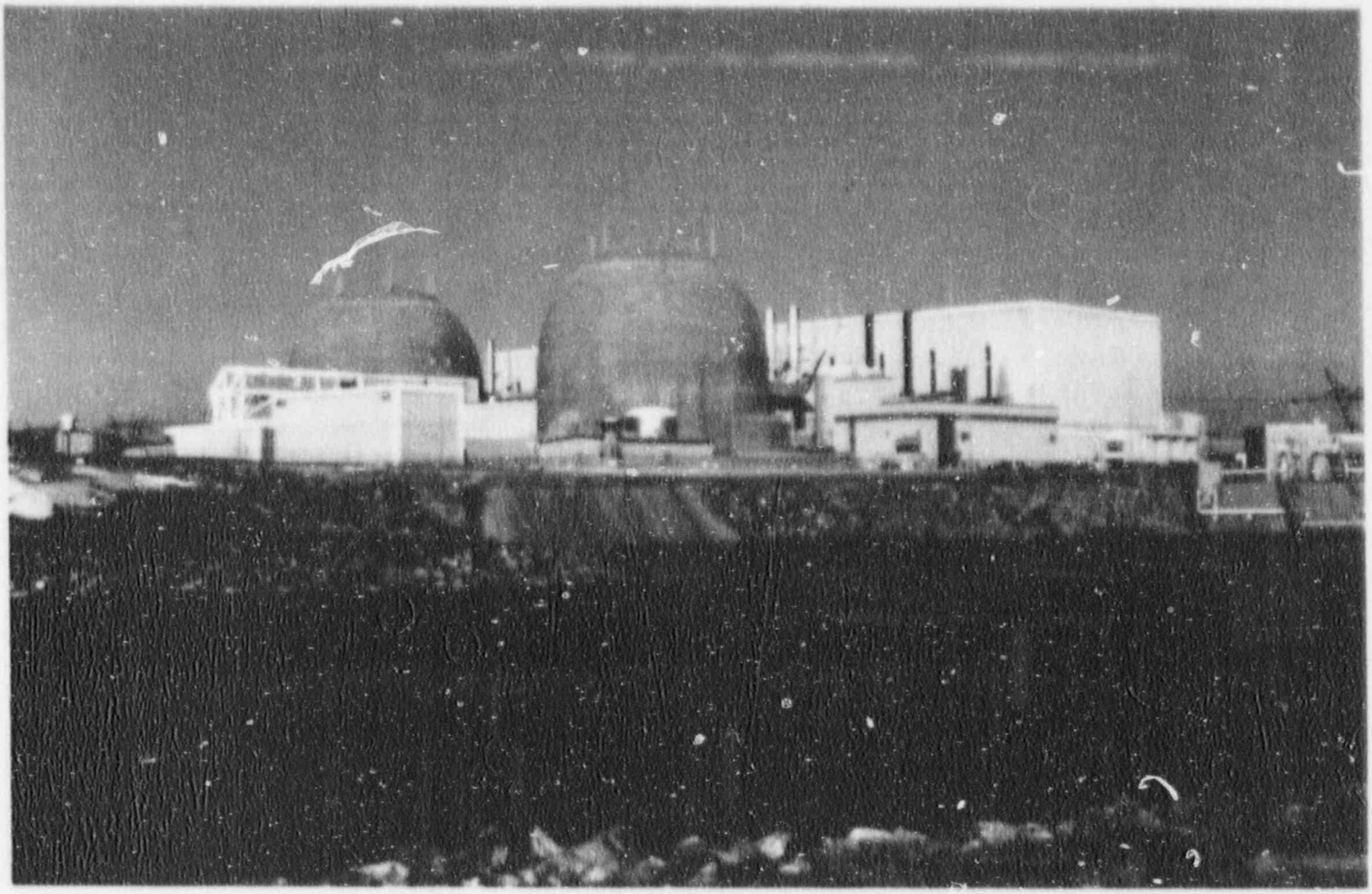
- The ingestion exposure pathway includes milk, fish, and food/vegetation samples. Iodine-131 was not detected in any 1990 milk samples. Although cesium-137 has been detected in the past, it was not detected in 1990 samples. Strontium-90 was detected at levels comparable to 1989, and lower than preoperational years. Both strontium-90 and cesium-137 are attributable to atmospheric nuclear weapons testing in the past. Naturally occurring potassium-40 was detected at normal environmental levels.

  1990 fish samples contained both cesium-134 and cesium-137 at a slightly higher activity than preoperational levels. Steam generator repairs and better liquid waste processing, however, have reduced these activity levels from previous years. Vegetation samples were statistically similar to both control and preoperational levels.

- The direct radiation exposure pathway measures environmental radiation doses by use of thermoluminescent dosimeters (TLDs). TLD results have remained essentially the same since the preoperational period in 1977.

During 1990, as in previous years, operation of the North Anna Nuclear Power Station created no adverse environmental affects or health hazards. The maximum radiation dose calculated for a hypothetical individual at the North Anna Power Station boundary due to liquid and gaseous effluents released from the site during 1990 was 0.799 millirem. For reference this dose may be compared to the 360 millirem average annual exposure to every person in the United States from natural and man-made sources. Natural sources in the environment provide approximately 82% of radiation exposure to man while Nuclear Power contributes less than 0.1%. These results demonstrate not only compliance with federal and state regulations, but also demonstrate the adequacy of radioactive effluent control at the North Anna Nuclear Power Station.

Illumination



VIRGINIA ELECTRIC AND POWER COMPANY

NORTH ANNA POWER STATION

RADIOLOGICAL ENVIRONMENTAL OPERATING PROGRAM

I. INTRODUCTION

The operational radiological environmental monitoring program conducted for the year 1990 for the North Anna Power Station is provided in this report. The results of measurements and analyses of data obtained from samples collected from January 1, 1990 through December 31, 1990 are summarized.

A. The North Anna Power Station of Virginia Electric and Power Company is located on Lake Anna in Mineral, Virginia, approximately 35 miles south west of Fredericksburg, Virginia. The site consists of two units, each with pressurized water reactor (PWR) nuclear steam supply systems and turbine generator furnished by Westinghouse Electric Corporation. Each unit is designed with a gross electrical output of 970 megawatts electric (MWe). Unit 1 achieved commercial operation on June 6, 1978, and Unit 2 on December 14, 1980.

B. The United States Nuclear Regulatory Commission (USNRC) regulations (10CFR50.34a) require that nuclear power plants be designed, constructed, and operated to keep levels of radioactive material in effluents to unrestricted areas as low as reasonably achievable (ALARA). To ensure these criteria are met, the operating license for North Anna Power Station includes Technical Specifications which address the release of radioactive effluents. Inplant monitoring is used to ensure release limits are not exceeded. As a precaution against unexpected or undefined environmental processes which might allow undue accumulation of radioactivity in the environment, a program for monitoring the plant environs is also included in North Anna Power Station Offsite Dose Calculation Manual (ODCM).

C. Virginia Electric and Power Company is responsible for collecting the various indicator and control environmental samples. Teledyne Isotopes is responsible for sample analysis and submitting reports of radioanalyses. The results are used to determine if changes in radioactivity levels could be attributable to station operations. Measured values are compared with control levels, which vary with time due to such external events as cosmic ray bombardment, weapons test fallout, and seasonal variations of naturally occurring isotopes. Data collected prior to the plant operation is used to indicate the degree of natural

variation to be expected. This preoperational data is compared with data collected during the operational phase to assist in evaluating the radiological impact of the plant operation.

D. Occasional samples of environmental media show the presence of man-made isotopes. As a method of referencing the measured radionuclide concentrations in the sample media to a dose consequence to man, the data is compared to the reporting level concentrations listed in the USNRC Regulatory Guide 4.8 and North Anna's ODCM. These concentrations are based upon the annual dose commitment recommended by 10CFR50, Appendix I, to meet the criterion of "As Low As Is Reasonably Achievable".

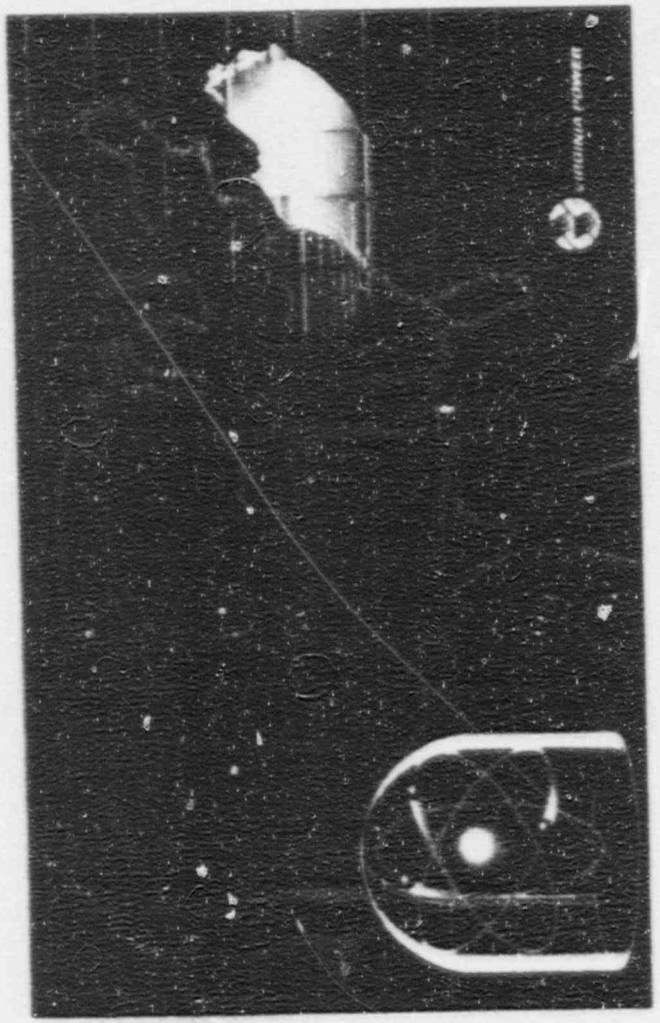
E. This report documents the results of the Radiological Environmental Monitoring Program for 1990 and satisfies the following objectives of the program:

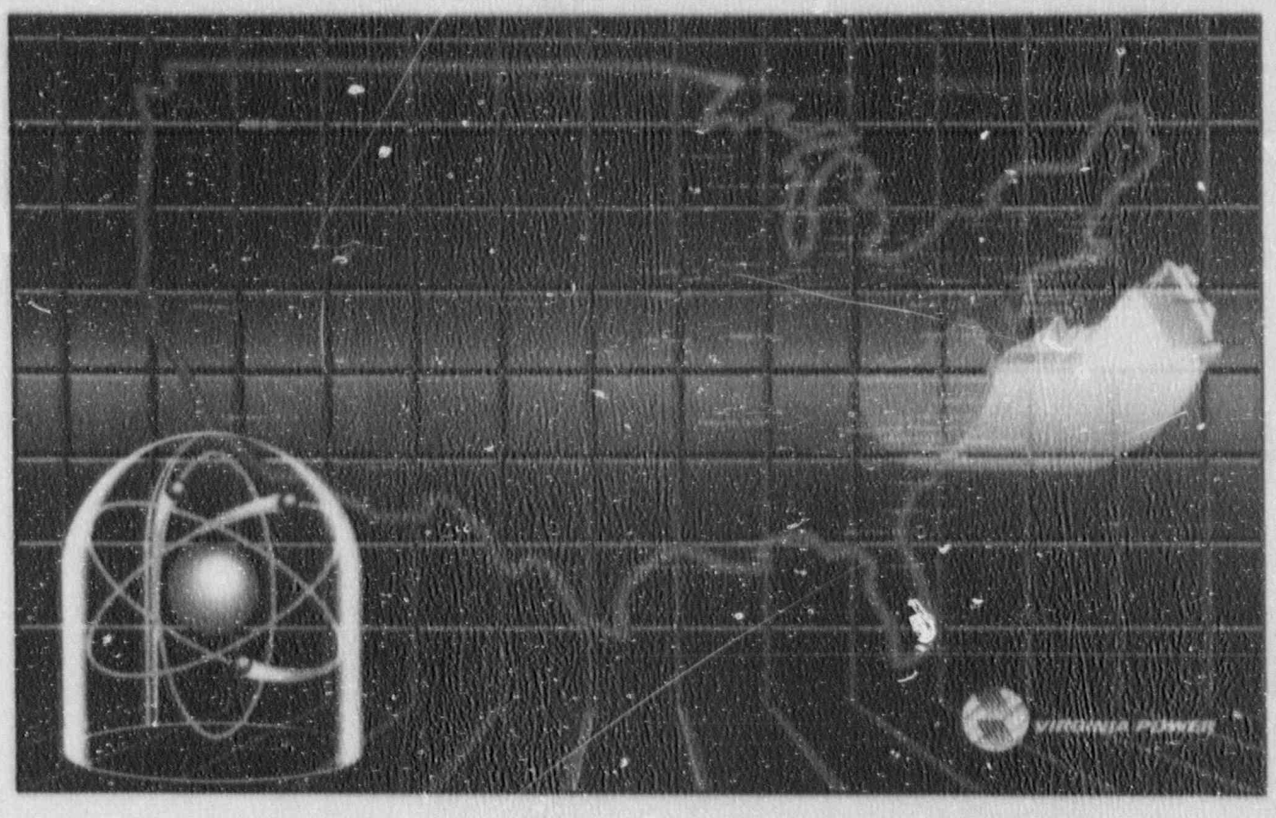
1. To provide measurements of radiation and of radioactive materials in those exposure pathways and for those radionuclides that lead to the highest potential radiation exposure of the maximum exposed members of the public resulting from the station operation.

2. To supplement the radiological effluent monitoring program by verifying that radioactive effluents are within allowable limits.

3. To identify changes of radioactivity in the environment.

4. To verify that the plant operations have no detrimental effect on the health and safety of the public.





II. NUCLEAR POWER AND THE ENVIRONMENT: IN PERSPECTIVE

Coal, oil, natural gas, and hydropower have been used to run the nation's electric generating stations; however, each method has its drawbacks. Coal-fired power can affect the environment through mining, acid rain, and airborne discharges. Oil and natural gas are in limited supply and are therefore costly. Hydropower is limited due to the impact of damming our waterways and the scarcity of suitable sites in our country.

Nuclear energy provides an alternate source of energy which is readily available. The operation of nuclear power stations has a very small impact on the environment. In fact, the hundreds of acres adjoining Surry Power Station is state waterfowl refuge, while at North Anna Power Station Lake Anna is a well-known fishing site and has a state park on its shore.

In order to more fully understand this unique source of energy, background information on basic radiation characteristics, risk assessment, reactor operation, effluent control, and environmental monitoring is provided in this section.

FUNDAMENTALS

The Atom

Everything we encounter is made of atoms. Atoms are the smallest parts of an element that still have all the chemical properties of that element. At the center of an atom is a nucleus. The nucleus consists of neutrons and protons. Electrons move in an orbit around the nucleus and are negatively charged. Protons and neutrons are nearly identical in size and weight, and each is about 2000 times heavier than an electron. However, the proton has a positive charge and the neutron has no charge, it is electrically neutral. Figure 1-1 presents a simple diagram of an atom.

Isotopes

The number of protons in the atom of any single element is always the same. For example, all hydrogen atoms have one proton and all oxygen atoms have eight protons. However, the number of neutrons in the nucleus of an element may vary. Atoms with the same number of protons, but a different number of neutrons, are called isotopes. Table 1-1 lists the isotopes of uranium.

ATOMIC STRUCTURE

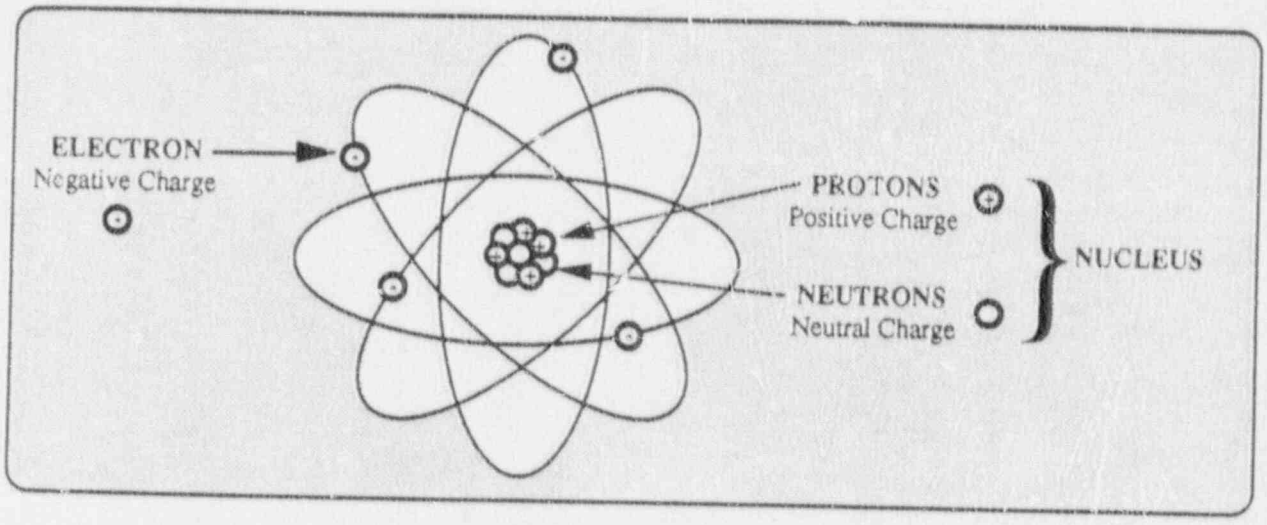


Figure 1-1: Diagram of an Atom

Table 1-1: Isotopes of Uranium

Isotopes	Symbols	Number of Protons	Number of Neutrons
Uranium-235	^{235}U	92	143
Uranium-236	^{236}U	92	144
Uranium-237	^{237}U	92	145
Uranium-238	^{238}U	92	146
Uranium-239	^{239}U	92	147
Uranium-240	^{240}U	92	148

RADIATION AND RADIOACTIVITY

Radionuclides

Normally, the parts of an atom are in a balanced or stable state. If the nucleus of an atom contains excess energy, it may be called a radioactive atom, a radioisotope, or radionuclide. The excess energy is usually due to an imbalance in the number of electrons, protons, and/or neutrons which make up the atom.

Radionuclides can be naturally occurring, such as uranium-238, thorium-232 and potassium-40, or man-made, such as iodine-131, cesium-137, and cobalt-60.

Radioactive Decay

Radioactive atoms attempt to reach a stable (non-radioactive) state through a process known as radioactive decay. Radioactive decay is the release of energy from the atom through the emission of particulate and/or electromagnetic radiation. Particulate radiation may be in the form of electrically charged particles such as alpha (2 protons plus 2 neutrons) or beta particles (1 electron), or may be electrically neutral, such as neutrons. Part of the electromagnetic spectrum consists of gamma rays and X-rays which are similar to light and microwaves, but have a much higher energy.

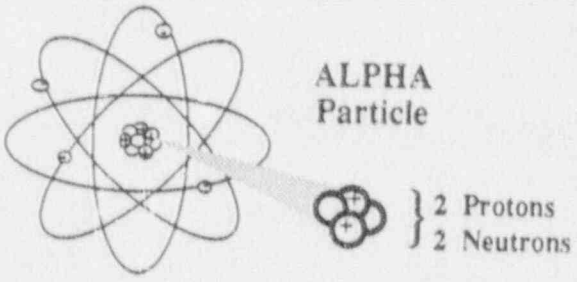
Half-Life

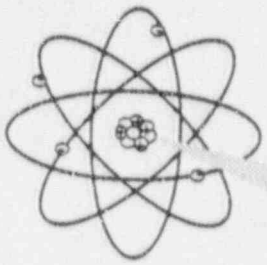
A radioactive half-life is the amount of time required for a radioactive substance to lose half of its activity through the process of radioactive decay. Cobalt-60 has a half-life of about 5 years, so after 5 years 50% of its radioactivity is gone and after 10 years 75% has decayed away. Radioactive half-lives vary from millionths of a second to millions of years.

Radioactive atoms may decay directly to a stable state or may undergo a series of decay stages and produce several daughter products which eventually lead to a stable atom. Naturally occurring radium-226, for example, has 10 successive daughter products (including radon) and has lead-206 as a final stable form.

TYPES OF RADIATION

Two types of radiation are considered in the nuclear industry, particulate and electromagnetic. Particulate radiation may come from the nucleus of an atom in the form of an ejected alpha particle. Alpha particles consists of two protons together with two neutrons. Alpha particles have a very limited ability to penetrate matter. A piece of paper will stop all alpha radiation. For this reason, alpha radiation from sources outside the body are not considered to be a radiation hazard. A beta particle is like an electron

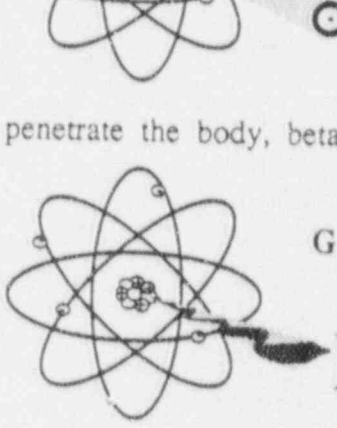




BETA Particle

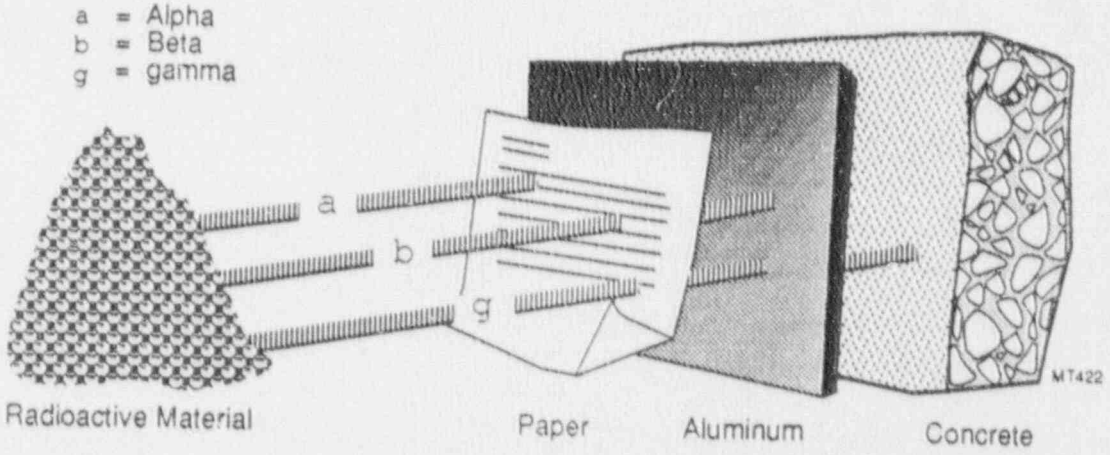
1 Neutron transforms to
1 Electron (ejected beta) +
1 Proton (in nucleus)

that has been ejected from the nucleus of an atom. The outer layers of skin or a thin piece of plastic will stop beta radiation. Exposure to beta radiation can be a hazard to the skin or lens of the eye. Because of their limited ability to penetrate the body, beta and alpha radiation are a health concern primarily if swallowed or inhaled where they might cause internal radiation exposure. Gamma rays are like X-rays except that they come from the nucleus of an atom and X-rays come from the electron rings. Gamma rays may pass through the entire body and thus give a "whole-body" radiation dose. Several inches of concrete or lead will stop gamma and X-rays. Figure 1-2 shows the approximate penetrating ability of various types of radiation.



GAMMA Ray

Electromagnetic radiation indistinguisable from X-rays



As radiation travels, it collides with other atoms and loses energy. Alpha particles can be stopped by a sheet of paper, beta particles by a thin sheet of aluminum, and gamma radiation by several inches of concrete or lead.

Figure 1-2: The Penetrating Ability of Various Types of Radiation

QUANTITIES AND UNITS OF RADIOACTIVE MEASUREMENT

There are several quantities and units used to describe radioactivity and its effects. In the following sections two terms, rem and activity, will be used to describe amounts of radiation.

Rem measures the potential effect of radiation exposure on human cells. Small doses are counted in millirem which are equal to one thousandth of a rem. Federal standards limit

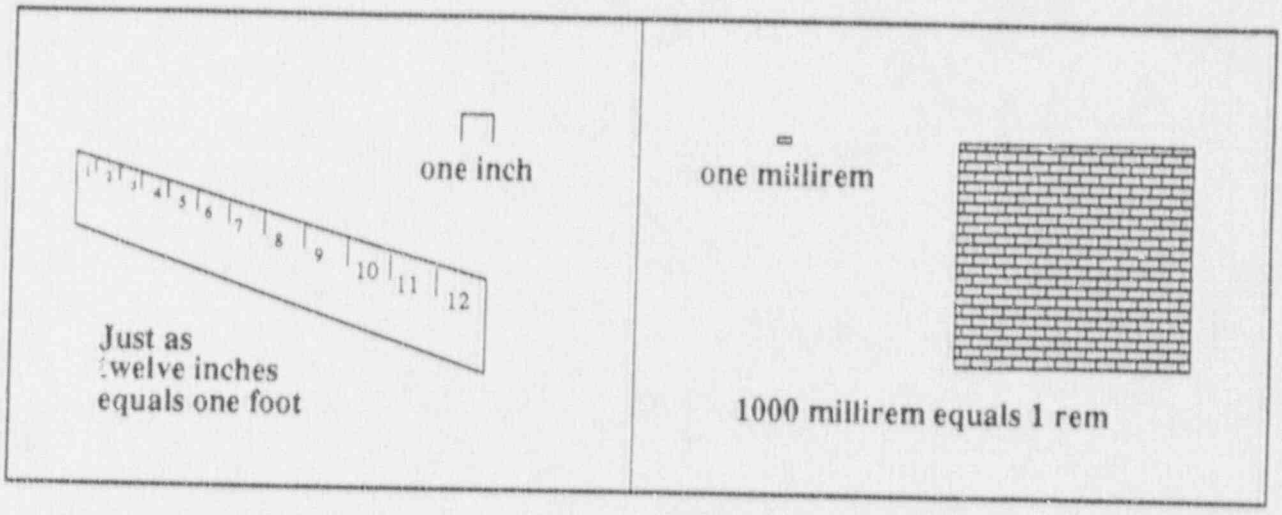
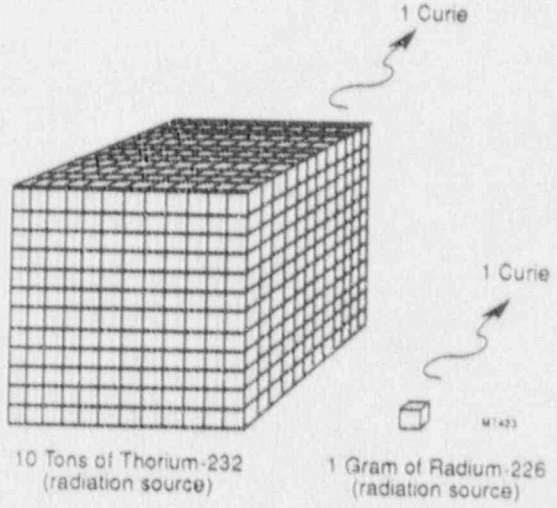


Figure 1-3: Unit Comparison

exposure for an individual member of the public to 500 millirem annually, not counting about 300 millirem received from natural sources and approximately 60 millirem from medical applications.

Activity is the number of nuclei in a sample that disintegrate (decay) every second. Each time a nucleus disintegrates, radiation is emitted. The unit of activity is the curie. A curie (Ci) is the amount of radioactive material which decays at a rate of 37 billion atoms per second. Smaller units of the curie are often used. Two common units are the microcurie (uCi), one millionth of a curie, and the picocurie (pCi), one trillionth of a curie. A curie is a measurement of radioactivity, not a quantity of material. The amount of material to make one curie varies. For example, one gram of radium-226 is one curie of radioactivity, but it would take 9,170,000 grams (about 10 tons) of thorium-232 to obtain one curie.



One gram of radium-226 and 10 tons of thorium-232 are both approximately 1 Curie.

SOURCES OF RADIATION

Background Radiation

Radiation is not a new creation of the nuclear power industry; it is a natural occurrence on the earth. Mankind has always lived with radiation and always will. Every second of our lives, over 7,000 atoms undergo radioactive decay in the body of the average adult. Radioactivity exists naturally in the soil, water, air and space. All of these common sources of radiation contribute to the natural background radiation that we are exposed to each day.

Table 1-2: Sources of Background Radiation

AVERAGE ANNUAL DOSE EQUIVALENT TO PERSONS IN THE U.S. FROM VARIOUS RADIATION SOURCES		
NATURAL BACKGROUND		
Radon and Radon Daughters	200.00	
Cosmic Rays	27.00	
Cosmogenic Radiation	1.00	
Terrestrial Radiation	28.00	
Internal Radiation	40.0	
MAN MADE		
Nuclear Power	0.05	
Miscellaneous Environmental	0.06	
Medical		
Diagnostic X-rays	39.00	
Other Medical	14.00	
Occupational	0.90	
Consumer Products	5.00 to 13.00	
TOTAL	**360.00**	**MREM PER YEAR**

The earth is constantly showered by a steady stream of high energy gamma rays that come from space, known as cosmic radiation. Our atmosphere shields out most of this radiation, but everyone still receives about 20 to 50 millirem each year from this source. The thinner air at higher altitudes provides less protection from cosmic radiation. So, people living at higher altitudes or even flying in an airplane are exposed to more radiation. Radioactive atoms commonly found in the atmosphere as a result of cosmic ray interaction include beryllium-7, carbon-14, tritium, and sodium-22.

Other natural sources of radiation include the radionuclides naturally found in soil, water, food, building materials and even people. People have always been radioactive, in part because the carbon found in our bodies is a mixture of all carbon isotopes, both non-radioactive and radioactive. About one-third of the external terrestrial and internal whole body radiation dose from natural sources is attributable to a natural radioactive isotope of potassium, potassium-40.

Man-Made

In addition to naturally occurring radiation people are also exposed to man-made radiation. The largest sources of these exposures are from medical X-rays, fluoroscopic examinations, radioactive drugs and tobacco. Small doses are received from consumer products such as television, smoke alarms, and fertilizers. Very small doses result from the production of nuclear power. Fallout from nuclear weapons tests is another source of man-made exposure. Fallout radionuclides include strontium-90, cesium-137, carbon-14, and tritium.

EFFECTS OF RADIATION

Studies

The effects of ionizing radiation on human health have been under study for more than eighty years. Scientists have obtained valuable knowledge through the study of laboratory animals that were exposed to radiation under controlled conditions. It has proven difficult, however, to relate the biological effects of irradiated laboratory animals to the potential health effects on humans. Because of this human populations irradiated under various circumstances have been studied in great depth. These groups include:

- Survivors of the atomic bomb.
- Persons undergoing medical radiation treatment.
- Radium dial painters during World War I who ingested large amounts of radioactivity by "tipping" the paint brushes with their lips.
- Uranium miners, who inhaled large amounts of radioactive dust while mining pitchblende (uranium ore).
- Early radiologists, who accumulated large doses of radiation from early X-ray equipment while being unaware of the potential hazards.

The analysis of these groups have increased our knowledge of the health effects from large doses of radiation. However, less is known about the effects of low doses of radiation. To be on the conservative side, we assume that health effects occur proportionally to those observed following a large dose of radiation. That is, if one dose of radiation causes an effect, then half the dose will cause half the effect. Radiation scientists agree that this assumption overestimates the risks associated with low level radiation exposure. The effects predicted in this manner have not been actually observed in individuals exposed to low level radiation.

Health Risks

Since the actual effects of exposure to low level radiation are difficult to measure, scientists often refer to the risk involved. The problem is one of evaluating alternatives, of comparing risks and weighing them against benefits. People make decisions involving risks every day such as whether to wear seat belts or smoke cigarettes. Risks are a part of everyday life. The question is one of determining how great the risks are.

We accept the inevitability of automobile accidents. Building safer cars or wearing seat belts will reduce the risk of injury. You could choose to not drive but even pedestrians and bicyclists are injured by cars. Reducing the risk of injury from automobiles to zero requires moving to a place where there are no automobiles.

While accepting the many daily risks of living, some people feel that their demands for energy should be met on an essentially risk-free basis. Attention is focused on safeguarding the public, developing a realistic assessment of the risks, and placing them in perspective.

Because you cannot see, feel, taste, hear, or smell radiation, it is a source of concern. We have the same lack of sensory perception for things such as radio waves, carbon monoxide, and small concentrations of numerous cancer causing substances. Although these risks are just as real as the risks associated with radiation, they have not generated the same degree of concern as radiation.

Most risks are with us throughout our lives, and their effects can be added up over a lifetime to obtain a total effect on our life span. The typical life span for an American woman is now 76 years, whereas men average 71 years of age. Figure 1-4 shows a number of different factors that decreased our average life expectancy.

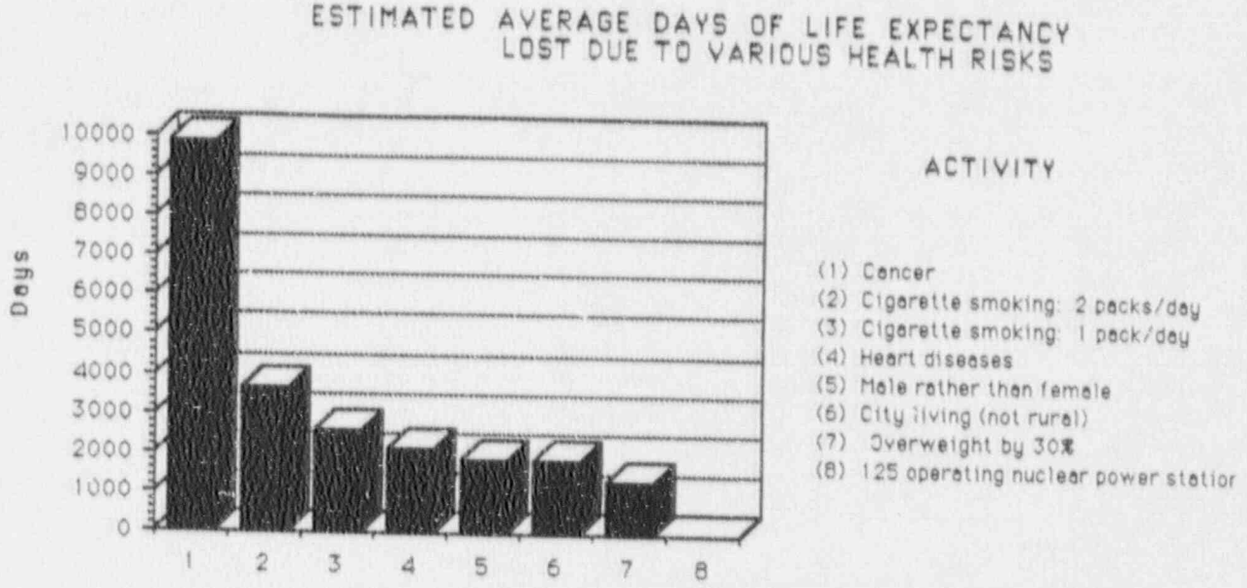


Figure 1-4: Loss of Life From Various Health Risks

The American Cancer Society estimates that about 30 percent of all Americans will develop cancer at some time in their lives from all possible causes. So, in a group of 10,000 people it is expected that 3,000 of them will develop cancer. If each person were to receive a radiation exposure of one rem in addition to natural background radiation, then it is expected that three more may develop cancer during their lifetime. This increases the risk from 30 percent to 30.03 percent. Hence, the risks of radiation exposure are small when compared to the risks of everyday life.

These comparisons should give you some idea of the risk involved in activities that you are familiar with. They give a basis for judging what smoking, eating, or driving a car could mean to your health and safety. Everyone knows that life is full of risks. If you have the basis for judgment, you can decide what to do or what not to do.

NUCLEAR REACTOR OPERATION

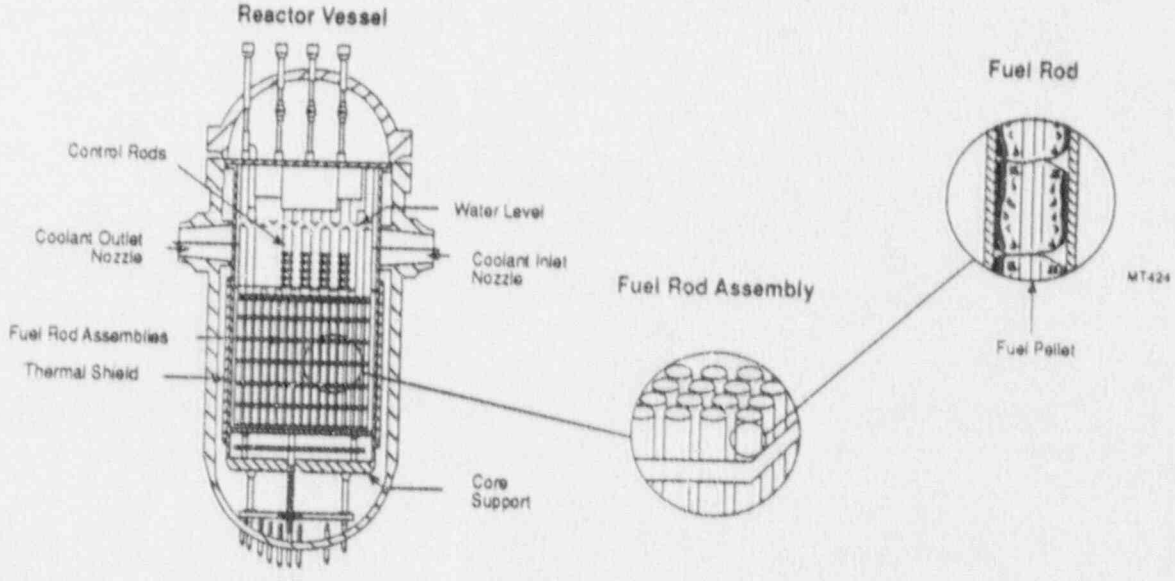
Electricity in the United States is being produced using fossil fuel, uranium, or falling water. A fossil-fueled power station burns coal, oil or natural gas in a boiler to produce energy. Nuclear power stations use uranium fuel and the heat produced from the fission process to make energy. In both cases, they heat and boil water to produce steam. The steam is used to drive a turbine which turns a generator and produces electricity.

Nuclear Fuel

Uranium (U) is the basic ingredient in nuclear fuel, consisting of atoms of U-235 and U-238. Natural uranium contains less than one percent U-235 when it is mined. Commercial nuclear power plants use fuel with a U-235 content of approximately three percent. The process used to increase the concentration of U-235 is known as enrichment.

Reactor Operation

After enrichment, the uranium fuel is chemically changed to uranium dioxide, a dry black powder. This powder is compressed into small ceramic pellets. Each fuel pellet is about 3/4 inches long and 3/8 inches in diameter. The pellets are placed into 12 foot long metal tubes made of zirconium alloy, to make a fuel rod. About five pounds of pellets are used to fill each rod. A total of 204 fuel rods make a single fuel assembly. Virginia Power nuclear reactors contains 157 fuel assemblies (Figure 1-5).

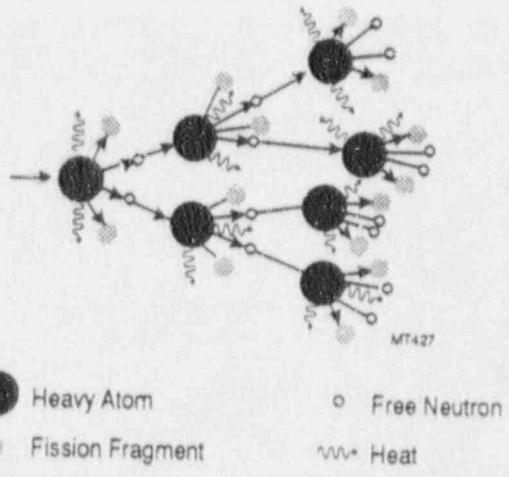


Reactor Vessel With Fuel Assemblies, Rods, and Fuel Pellets

Figure 1-5: Reactor Core Design

Fission

Nuclear energy is produced by a process called fission. Fission occurs in a reactor when uranium is split into fragments producing heat and releasing neutrons. These neutrons strike other uranium atoms, causing them to split (fission) and release more heat and neutrons. This is called a chain reaction (Figure 1-6) and is controlled by the use of reactor control rods.



Fission: A Chain Reaction

Control rods are an essential part of the nuclear reactor. Control rods contain cadmium, indium, and silver metals which absorb and control the amount of neutrons produced in the reactor. The control rods act to slow down or stop the chain reaction. A chain reaction cannot occur when the control rods are inserted completely into the core. When the control rods are withdrawn, the chain reaction begins and heat is generated.

Design & Operation

The Surry Power Station and North Anna Power Station use a Pressurized Water Reactor (PWR) system to generate electricity. There are two complete and independent PWR systems on site at both Surry and North Anna Power Stations. These are called Unit-1 and Unit-2.

The reactor core is inside a large steel container called the Reactor Pressure Vessel. The reactor core is always surrounded by water. The fissioning of the uranium fuel makes the fuel rods get hot. The hot fuel rods heat the water, which serves as a coolant that carries away heat.

In a pressurized water reactor, heat is moved from place to place by moving water, the reactor's coolant. The water flows in closed loops. As (primary) water moves through the core it gets very hot (605°F), but because it is under such high pressure, 2235 pounds per square inch (psi), it doesn't boil. The hot water then flows to the steam generator. The steam generator is a heat exchanger. Reactor coolant passes through it but doesn't mix with the steam generator (secondary) water. Instead, heat from the primary water is transferred through thousands of tubes to the cooler secondary water. The water in the steam generator is under much less

pressure, and the heat boils the secondary water to steam. At Virginia Electric and Power stations, each unit has 3 steam generators.

The steam is piped to a steam turbine that turns an electric generator. The exhausted steam from the turbine is cooled and converted back to water in a condenser. The condenser is also a heat exchanger; in it heat passes from the steam to a third loop of water. In Surry's case the James River provides the third loop water. At North Anna Power Station third loop water is from Lake Anna. The steam turns back to liquid and is pumped back to the steam generator. Figure 1-6 is a diagram of typical nuclear reactor systems.

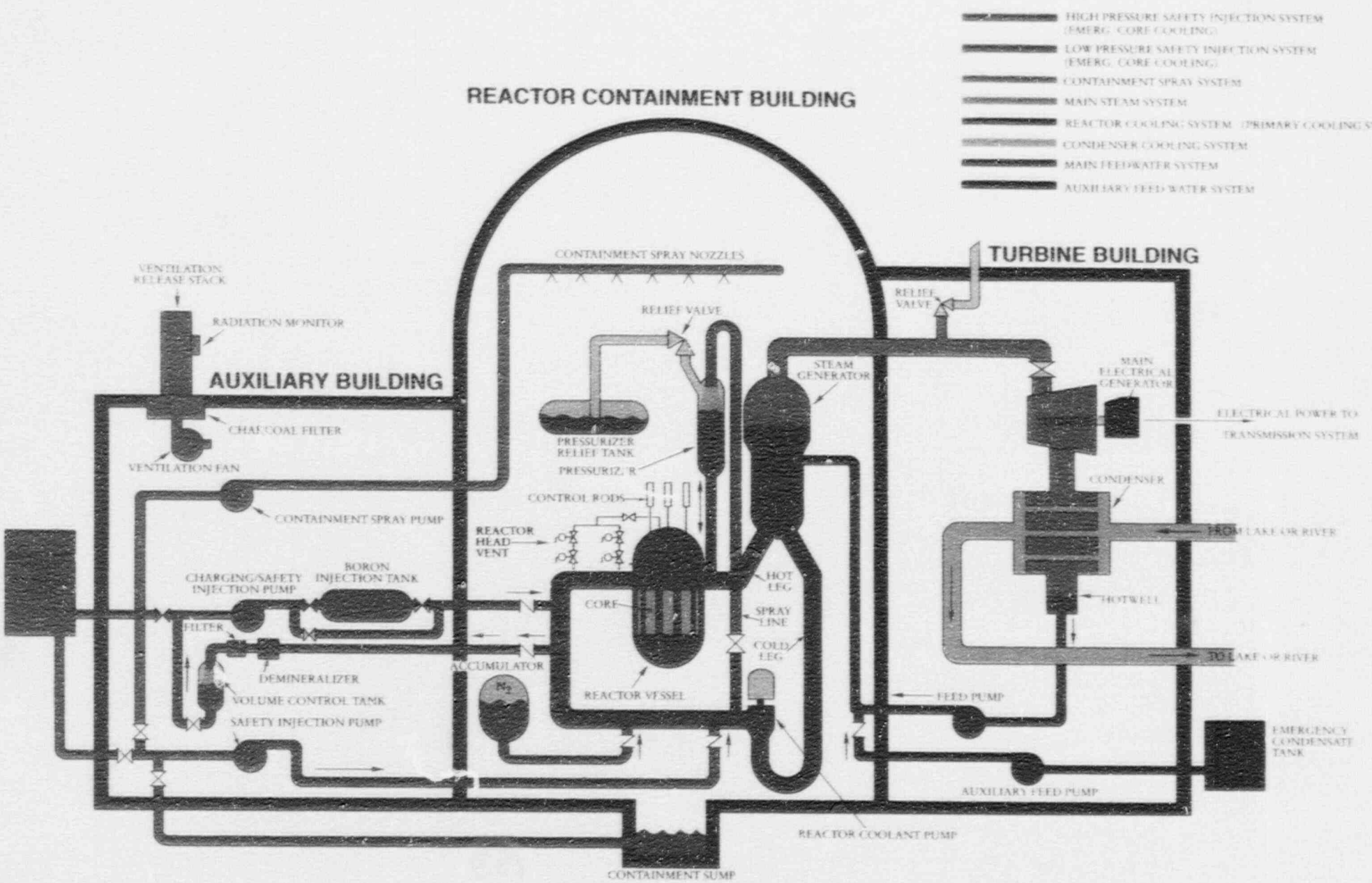
Containment

Nuclear power plants are designed to prevent the escape of large quantities of radiation and radioactive substances. Two principles are used. First, thick, heavy walls are used as shielding to absorb radiation and prevent its escape. Second, strong, airtight walls called containment, are used to prevent the escape of radioactive materials.

The reactor pressure vessel and the containment building that houses it is enormously strong (Figue 1-7). Strong enough, in fact, to withstand a direct hit from a 707 jetliner. The reactor core lies within a sealed pressure vessel. Like all boilers its walls must be very strong because the water inside must be kept under high pressure. The reactor pressure vessel in a nuclear power plant is even heavier than an ordinary steam boiler because of the need to minimize the chance of rupture and release of any radioactive materials. The reactor pressure vessel is made from a stainless steel alloy 6 to 8 inches thick.

Around the reactor pressure vessel is a thick concrete wall. This wall acts as shielding, protecting workers by absorbing radiation resulting from the nuclear chain reaction. Next an airtight $1/2$ inch steel liner surrounds the entire interior of the containment. If the reactor pressure vessel or any of the primary piping should break, the escaping steam would be trapped inside the liner.

Finally, the building's reinforced concrete outer wall is $4\,1/2$ feet thick tapering to $2\,1/2$ feet at the top of the dome. It is designed to act as shielding and is also intended to withstand natural and man-made events like earthquakes and even the direct impact from a large commercial jet aircraft.



- PWR SYSTEM DIAGRAM -

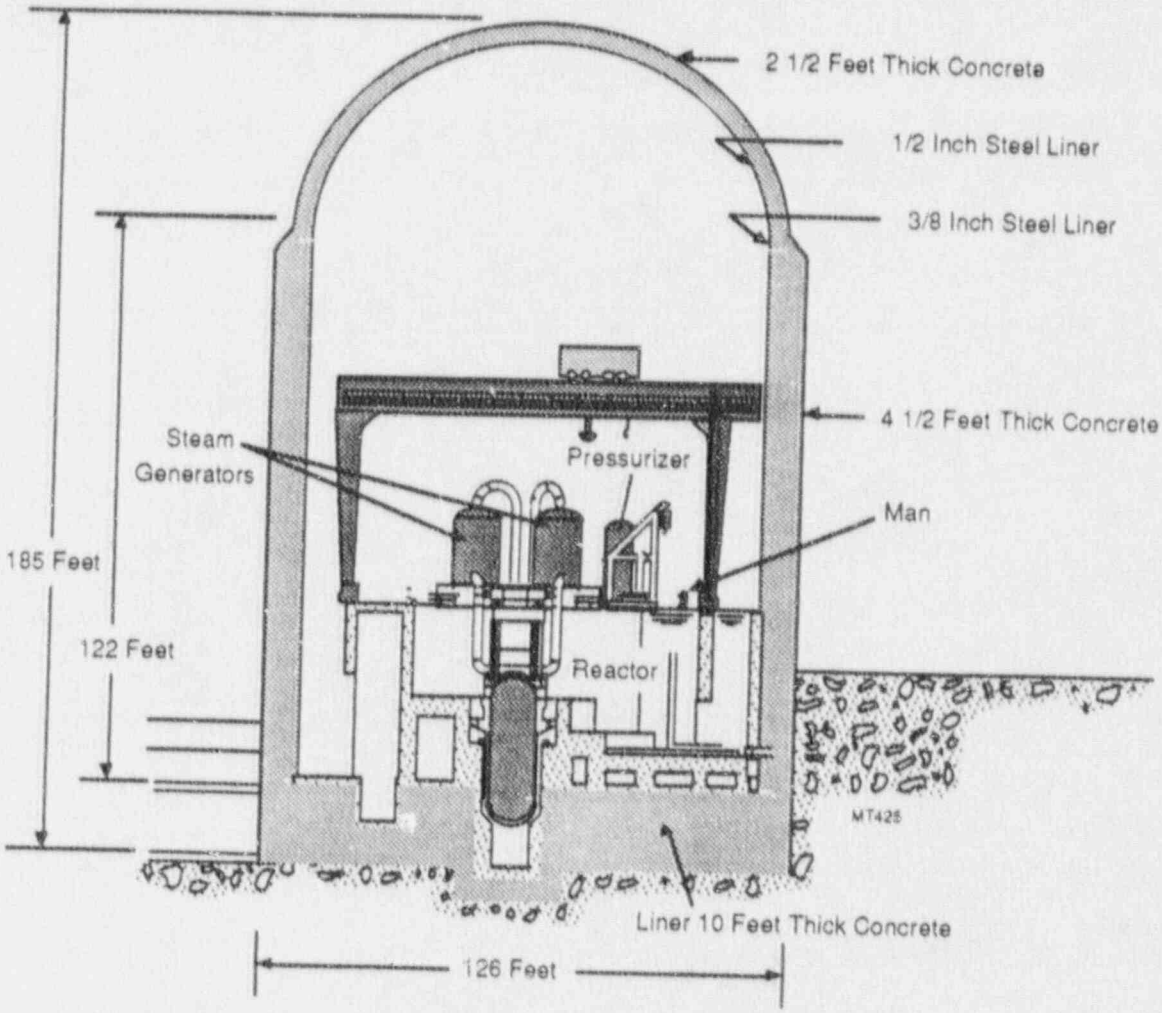


Figure 1-7: Containment Dimensions

Operating the Reactor Safely

Accidents

The most serious accident that could happen in a nuclear power plant involves overheating in the nuclear reactor core. Such an accident would result from a loss-of-coolant accident or LOCA. During a LOCA primary coolant would no longer circulate through the reactor core to remove heat. Circulation could be lost if a combination of pipes burst, for example. Conceivably, a dry, overheated reactor core could melt through the pressure vessel.

The reactor itself is designed to respond automatically to such an emergency. Operators are also trained to make corrections for any system failure. The automatic and operator responses have two goals: to prevent damage to the reactor, and prevent the release of radiation. Shutting the reactor down is relatively easy. Control rods drop in and chemical to stop the nuclear reaction are injected into the coolant. Losing the coolant itself tends to stop the chain reaction because the coolant is needed to keep the nuclear chain reaction going. Within 10 seconds of shutdown, the amount of heat is less than 5 percent of the amount produced at full power and within 15 minutes, less than 1 percent.

To carry heat away during an accident, all reactors have Emergency Core Cooling Systems (ECCS). The ECCS consists of primary and backup pumps and reservoirs of coolant that operate separately from those that normally circulate through the system. A nuclear reactor has many different back-up safety systems designed so that if one fails another is always available.

Workers

There are many different jobs at a nuclear power plant and they are filled by people with diverse backgrounds. All employees are initially trained and then retrained annually by the company. Virginia Power's Training centers are fully accredited by the National Academy for Nuclear Training and the Institute for Nuclear Power Operations. The operators are tested and certified by the United States Nuclear Regulatory Commission (NRC).

Safety Statistics

Job safety is another measure of assurance that the station is being properly operated. Surry Power Station was awarded the Virginia Power Presidential Safety Award for attaining 1,349,415 man hours without a lost time accident and we are continuing that record into 1991, while North Anna reached 5,000,000 man hours without a lost time accident in March 1991.

SUMMARY

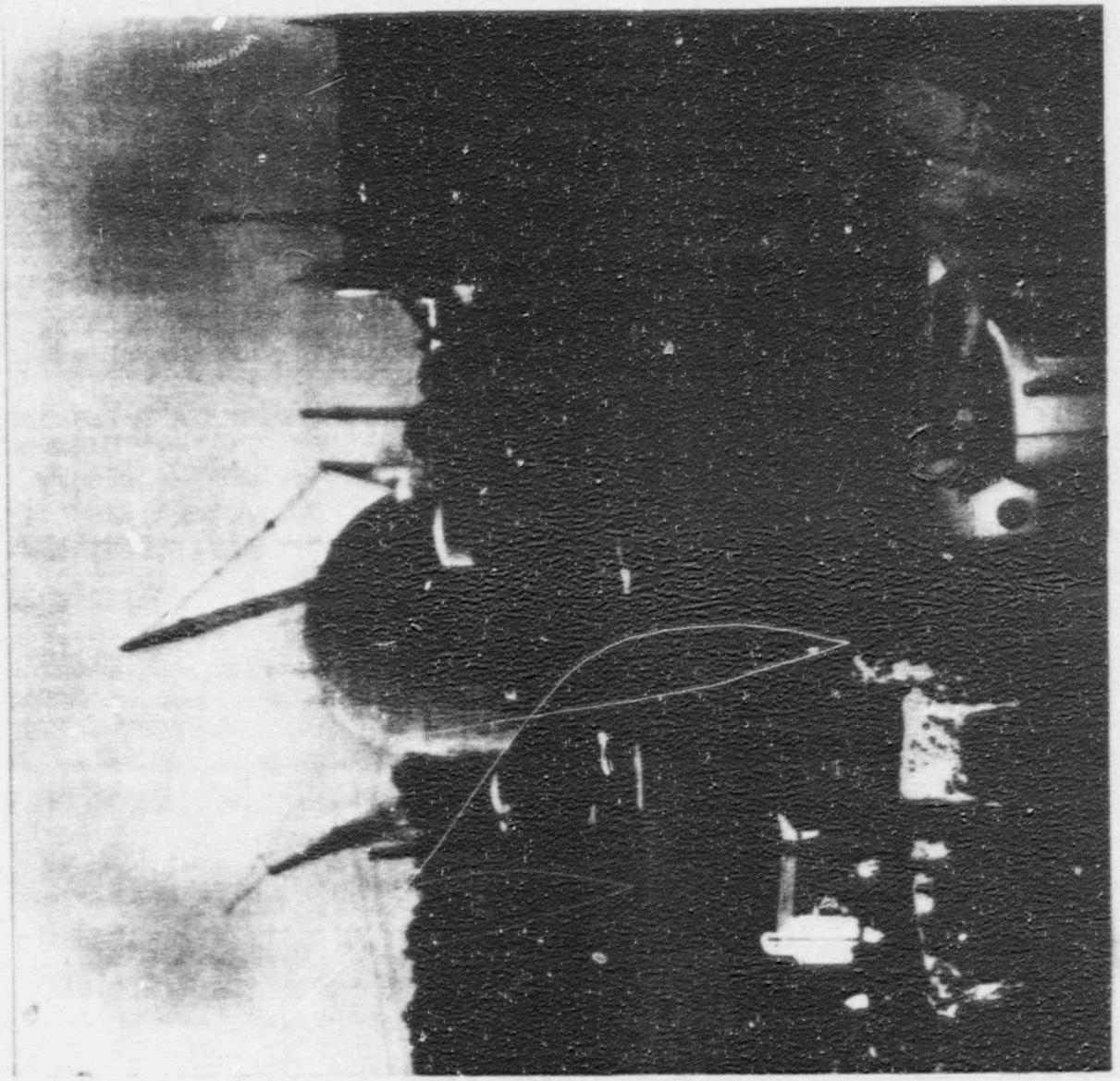
- Nuclear energy provides an alternate source of energy which is readily available. The operation of a nuclear power station has a very small impact on the environment.

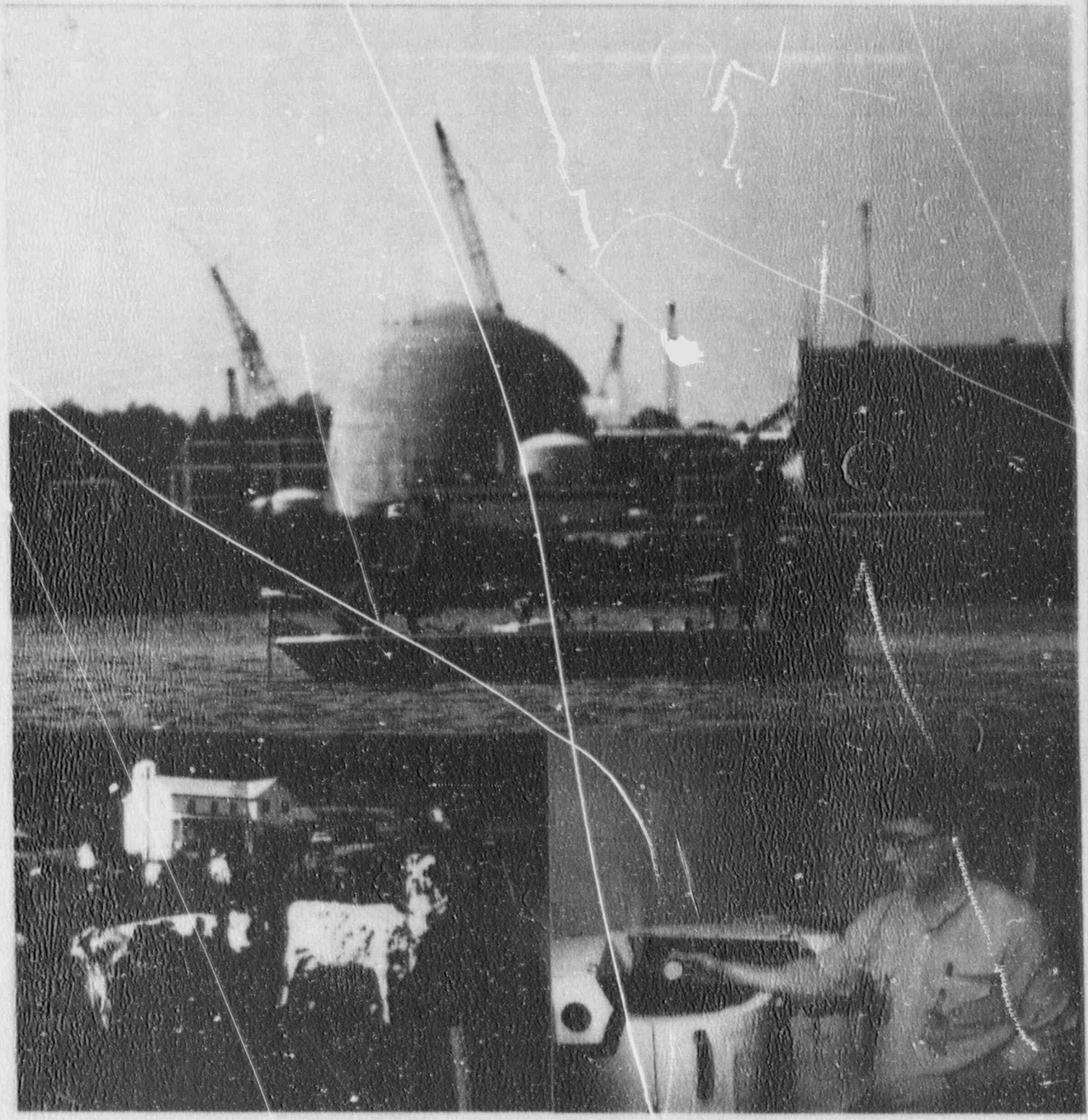
- Radiation is not a new creation of the nuclear power industry; it is a natural occurrence on the earth. Mankind has always lived with radiation and always will. Radioactivity exists naturally in the soil, water, air and space. All these common sources of radiation contribute to the natural background radiation to which we are exposed.

- In addition to naturally occurring radiation and radioactivity, people are also exposed to man-made radiation. Very small doses result from the production of nuclear power.

- Nuclear power plants are designed to prevent the escape of radiation and radioactive substances.

- A nuclear reactor has many different back-up safety systems designed so that if one fails another is available.





III. SAMPLING AND ANALYSIS PROGRAM

A. SAMPLING PROGRAM

1. Table 1 summarizes the sampling program for North Anna Power Station during 1990. Figure 1 indicates the locations of the environmental monitoring stations.

2. For routine TLD measurements, two dosimeters made of $CaSO_4$:Dy in a teflon card are deployed at each sampling location. Several TLDs are co-located with NRC and Commonwealth of Virginia direct radiation recording devices. These are indicated as "co-location" samples.

3. In addition to the Radiological Environmental Monitoring Program required by North Anna Technical Specifications, Virginia Electric and Power Company (VEPCO) splits samples with the Commonwealth of Virginia. All samples listed in Table 1 are collected by VEPCO personnel except for those labeled state split. All samples are shipped to Teledyne Isotopes in Westwood, New Jersey.

4. All samples listed in Table 1 are taken at indicator locations except those labeled "control".

TABLE 1

(Page 1 of 5)

North Anna Power Station - 1990

RADIOLOGICAL SAMPLING STATIONS

DISTANCE AND DIRECTION FROM UNIT NO. 1

Sample Media	Location	Station	Distance Miles	Compass Direction	Degrees	Collection Frequency	Remarks
Environmental Thermoluminescent Dosimetry (TLD)	NAPS Sewage Treatment Plant	01	0.20	NE	42°	Quarterly & Annually	On-site, State Split
	Fredericks Hall	02	5.30	SSW	225°	Quarterly & Annually	State Split
	Mineral, Va	03	7.10	WSW	243°	Quarterly & Annually	
	Wares Crossroads	04	5.10	WNW	287°	Quarterly & Annually	State Split
	Route 752	05	4.20	NNE	20°	Quarterly & Annually	
	Sturgeon's Creek Marina	05A	3.20	N	11°	Quarterly & Annually	
	Levy, VA	06	4.70	ESE	115°	Quarterly & Annually	State Split, Co-Location
	Bumpass, VA	07	7.30	SSE	167°	Quarterly & Annually	State Split
	End of Route 685	21	1.00	WNW	301°	Quarterly & Annually	Exclusion Boundary
	Route 700	22	1.00	WSW	242°	Quarterly & Annually	State Split, Co-Location Exclusion Boundary
	"Aspen Hills"	23	0.93	SSE	158°	Quarterly & Annually	State Split Exclusion Boundary
	Orange, VA	24	22.00	NW	325°	Quarterly & Annually	State Split, Co-Location Control
	Bearing Cooling Tower	N-1/33	0.06	N	10°	Quarterly	On-Site
	Sturgeon's Creek Marina	N-2/34	3.20	N	11°	Quarterly	
	Parking Lot "C" (on-site)	NNE-3/35	0.25	NNE	32°	Quarterly	On-Site
	Good Hope Church	NNE-4/36	4.96	NNE	25°	Quarterly	State Split
	Parking Lot "B"	NE-5/37	0.20	NE	42°	Quarterly	On-Site
	Lake Anna Marina	NE-6/38	1.49	NE	34°	Quarterly	
	Weather Tower Fence	ENE-7/39	0.36	ENE	74°	Quarterly	On-Site
	Route 689	ENE-8/40	2.43	ENE	65°	Quarterly	
	Near Training Facility	E-9/41	0.30	E	91°	Quarterly	On-Site

TABLE 1

(Page 2 of 5)

North Anna Power Station - 1990

RADIOLOGICAL SAMPLING STATIONS

DISTANCE AND DIRECTION FROM UNIT NO. 1

Sample Media	Location	Station	Distance Miles	Compass Direction	Degrees	Collection Frequency	Remarks
Environmental Thermoluminescent Dosimetry (TLD)	"Morning Glory Hill"	E-10/42	2.85	E	93°	Quarterly	
	Island Dike	ESE-11/43	0.12	ESE	103°	Quarterly	On-Site
	Route 622	ESE-12/44	4.70	ESE	115°	Quarterly	
	VEPCO Biology Lab	SE-13/45	0.75	SE	138°	Quarterly	On-Site
	Route 701 (Dam Entrance)	SE-14/46	5.88	SE	137°	Quarterly	
	"Aspen Hills"	SSE-15/47	0.93	SSE	158°	Quarterly	Exclusion Boundary
	Elk Creek	SSE-16/48	2.33	SSE	165°	Quarterly	
	Warehouse Compound Gate	S-17/49	0.22	S	173°	Quarterly	On-Site
	Elk Creek Church	S-18/50	1.55	S	178°	Quarterly	
	NAPS Access Road	SSW-19/51	0.36	SSW	197°	Quarterly	On-Site
	Route 618	SSW-20/52	5.30	SSW	205°	Quarterly	
	NAPS Access Road	SW-21/53	0.30	SW	218°	Quarterly	On-Site
	Route 700	SW-22/54	4.36	SW	232°	Quarterly	
	500 kv Tower	WSW-23/55	0.40	WSW	237°	Quarterly	On-Site
	Route 700 (Exclusion Boundary)	WSW-24/56	1.00	WSW	242°	Quarterly	Exclusion Boundary
	NAPS Radio Tower	W-25/57	0.31	W	279°	Quarterly	On-Site
	Route 685	W-26/58	1.55	W	274°	Quarterly	
	End of Route 685	WNW-27/59	1.00	WNW	301°	Quarterly	Exclusion Boundary
	H. Purcell's Private Rd.	WNW-28/60	1.52	WNW	303°	Quarterly	Co-Location
	End of #1/#2 Intake	NW-29/61	0.15	NW	321°	Quarterly	On-Site
	Lake Anna Campground	NW-30/62	2.54	NW	319°	Quarterly	
	#1/#2 Intake	NNW-31/63	0.07	NNW	349°	Quarterly	On-Site
	Route 208	NNW-32/64	3.43	NNW	344°	Quarterly	
	Bumpass Post Office	C-1/2	7.30	SSE	167°	Quarterly	Control
	Orange, VA	C-3/4	22.00	NW	325°	Quarterly	Control
	Mineral, VA	C-5/6	7.10	WSW	243°	Quarterly	Control
	Louisa, VA	C-7/8	11.54	WSW	257°	Quarterly	Control

TABLE 1

(Page 3 of 5)

North Anna Power Station - 1990

RADIOLOGICAL SAMPLING STATIONS

DISTANCE AND DIRECTION FROM UNIT NO. 1

Sample Media	Location	Station	Distance Miles	Compass Direction	Degrees	Collection Frequency	Remarks
Airborne Particulate and Radioiodine	NAPS Sewage Treatment Plant	01	0.20	NE	42°	Weekly	On-Site, State Split
	Fredericks Hall	02	5.30	SSW	205°	Weekly	
	Mineral, VA	03	7.10	WSW	243°	Weekly	
	Wares Crossroads	04	5.10	WNW	287°	Weekly	
	Route 752	05	4.20	NNE	20°	Weekly	
	Sturgeon's Creek Marina	05A	3.20	N	11°	Weekly	
	Levy, VA	06	4.70	ESE	115°	Weekly	
	Bumpass, VA	07	7.30	SSE	167°	Weekly	
	End of Route 685	21	1.00	WNW	301°	Weekly	Exclusion Boundary
	Route 700	22	1.00	WSW	242°	Weekly	Exclusion Boundary State Split
	"Aspen Hills"	23	0.93	SSE	158°	Weekly	Exclusion Boundary
	Orange, VA	24	22.00	NW	325°	Weekly	Control
Surface Water	Waste Heat Treatment Facility (Second Cooling Lagoon)	08	1.10	SSE	148°	Monthly	State Split
	Lake Anna (upstream) (Route 208 Bridge)	09	2.20	NW	320°	Monthly	Control, State Split
River Water	North Anna River (downstream)	11	5.80	SE	128°	Quarterly	
Ground Water (Well Water)	Biology Lab	01A	0.75	SE	138°	Quarterly	State Split
Precipitation	Biology Lab	01A	0.75	SE	138°	Monthly	
Aquatic Sediment	Waste Heat Treatment Facility (Second Cooling Lagoon)	08	1.10	SSE	148°	Semi-Annually	State Split
	Lake Anna (upstream)	09	2.20	NW	320°	Semi-Annually	Control, State Split
	North Anna River (Downstream)	11	5.80	SSE	128°	Semi-Annually	

TABLE 1

(Page 4 of 5)

North Anna Power Station - 1990

RADIOLOGICAL SAMPLING STATIONS

DISTANCE AND DIRECTION FROM UNIT NO. 1

Sample Media	Location	Station	Distance Miles	Compass Direction	Degrees	Collection Frequency	Remarks
Shoreline Soil	Lake Anna (upstream) (Route 208 Bridge)	09	2.20	NW	320°	Semi-Annually	State Split
Soil	NAPS Sewage Treatment Plant	01	0.20	NE	42°	Once/3 years	On-Site
	Fredericks Hall	02	5.30	SSW	205°	Once/3 years	
	Mineral, VA	03	7.10	WSW	243°	Once/3 years	
	Wares Crossroads	04	5.10	WNW	287°	Once/3 years	
	Route 752	05	4.20	NNE	20°	Once/3 years	
	Sturgeon's Creek Marina	05A	3.20	N	11°	Once/3 years	
	Levy, VA	06	4.70	ESE	115°	Once/3 years	
	Bumpass, VA	07	7.30	SSE	167°	Once/3 years	
	End of Route 685	21	1.00	WNW	301°	Once/3 years	Exclusion Boundary
	Route 700 (Exclusion Boundary)	22	1.00	WSW	242°	Once/3 years	Exclusion Boundary
	"Aspen Hills"	23	0.93	SSE	158°	Once/3 years	Exclusion Boundary
	Orange, VA	24	22.00	NW	325°	Once/3 years	Control
Milk	Holladay Dairy (R.C. Goodwin)	12	8.30	NW	310°	Monthly	State Split
	Terrell's Dairy (Fredericks Hall)	13	5.60	SSW	205°	Monthly	State Split
Fish	Waste Heat Treatment Facility (Second Cooling Lagoon)	08	1.10	SSE	148°	Semi-Annually	State Split
	Lake Anna (upstream) (Route 208 Bridge)	09	2.20	NW	320°	Semi-Annually	State Split
	Lake Orange *	25	16.5	NW	312°	Semi-Annually	Control
Food Products (Broadleaf Vegetation)	Route 713	14	1.20	NE	43°	Monthly if available or at harvest	
	Route 614	15	1.70	SE	133°	Monthly if available or at harvest	

* Added as result of 1990 Quality Assurance Audit.

TABLE 1

(Page 5 of 5)

North Anna Power Station - 1990

RADIOLOGICAL SAMPLING STATIONS

DISTANCE AND DIRECTION FROM UNIT NO. 1

Sample Media	Location	Station	Distance Miles	Compass Direction	Degrees	Collection Frequency	Remarks
Food Products (Broadleaf Vegetation)	Route 629/522	16	12.60	NW	314°	Monthly if available or at harvest	
	End of Route 685	21	1.00	WNW	301°	Monthly if available or at harvest	
	Aspen Hills	23	0.93	SSE	158°	Monthly if available or at harvest	

* Added as result of 1990 Quality Assurance Audit.

LEGEND FOR THE NORTH ANNA POWER STATION

ENVIRONMENTAL MONITORING STATIONS OVERVIEW MAPS

(FIGURES 1

MAP DESIGNATION	ENVIRONMENTAL STATION IDENTIFICATION	MAP DESIGNATION	ENVIRONMENTAL STATION IDENTIFICATION
1	N-1/33	23	WSW-23/55
2	N-2/34,05A	24	WSW-24/56,22
3	NNE-3/35	25	W-25/57
4	NNE-4/36	26	W-26/58
5	NE-5/37,01	27	WNW-27/59,21
6	NE-6/38,14	28	WNW-28/60
7	ENE-7/39	29	NW-29/61
8	ENE-8/40	30	NW-30/62,09
9	E-9/41	31	NNW-31/63
10	E-10/42	32	NNW-32/64
11	ESE-11/43	33	03, C-5&6
12	ESE-12/44,06	34	04
13	SE-13/45,01A	35	05
14	SE-14/46	36	07, C-1&2
15	SSE-15/47,23	37	08
16	SSE-16/48	38	11
17	S-17/49	39	12
18	S-18/50	40	13
19	SSW-19/51	41	15
20	SSW-20/52,02	42	16
21	SW-21/53	43	24, C-3&4
22	SW-22/54	44	C-7&8

Map Designation # Road Numbers

URE 1

(Page 1 of 3)

NORTH ANNA POWER STATION
ENVIRONMENTAL MONITORING STATIONS OVERIEW MAP

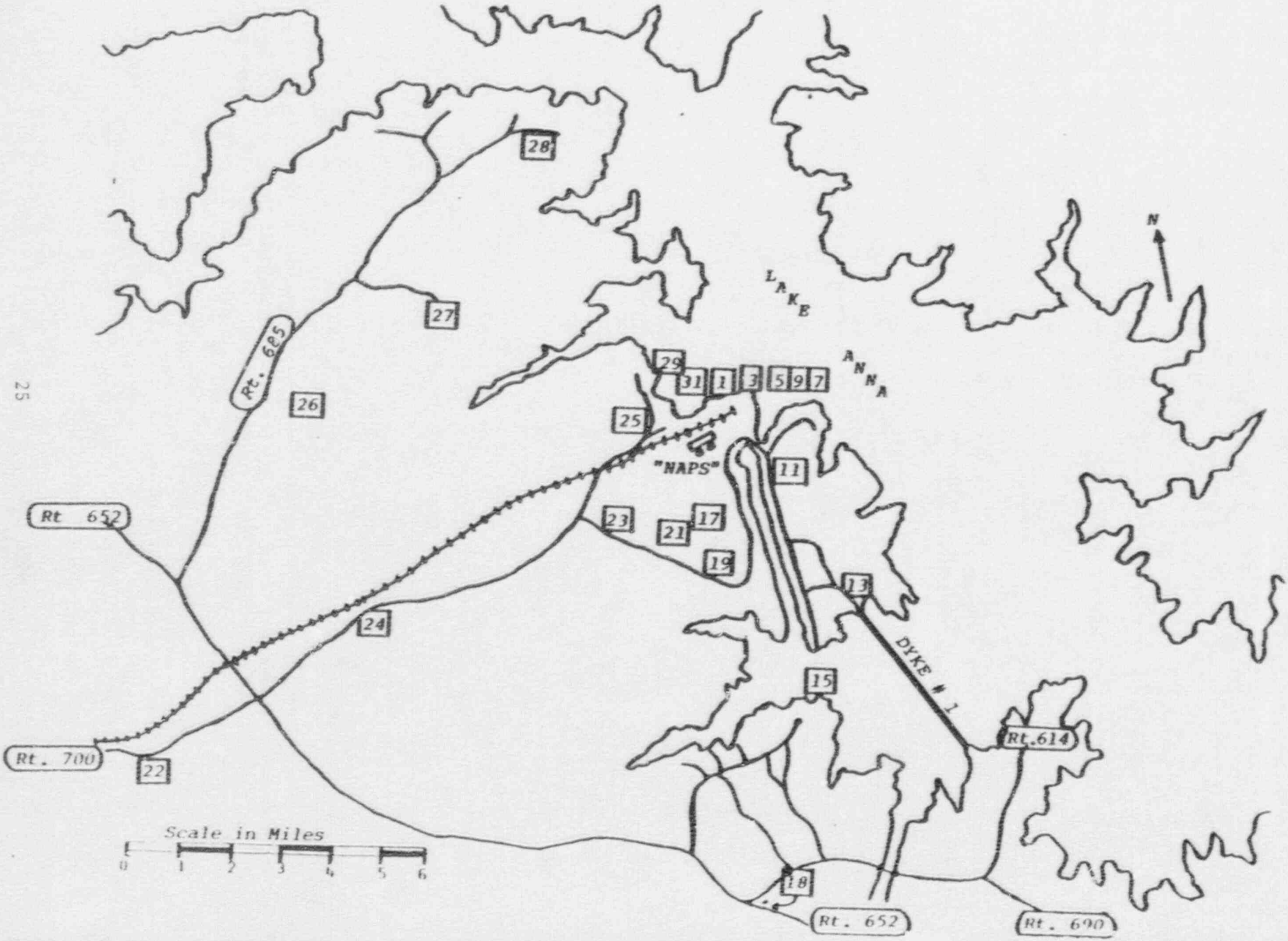


FIGURE 1

(Page 2 of 3)

NORTH ANNA POWER STATION

ENVIRONMENTAL MONITORING STATIONS OVERIEW MAP

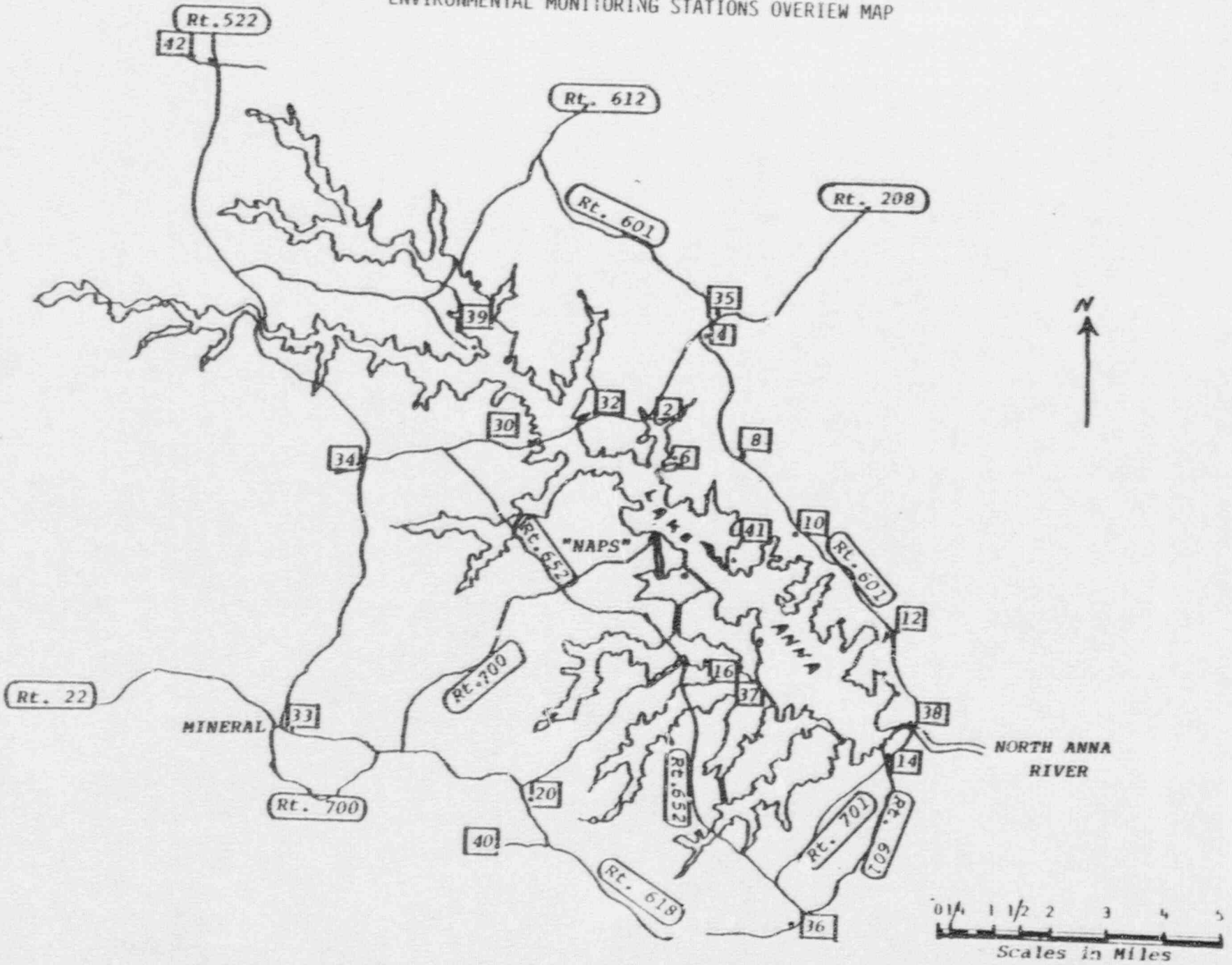
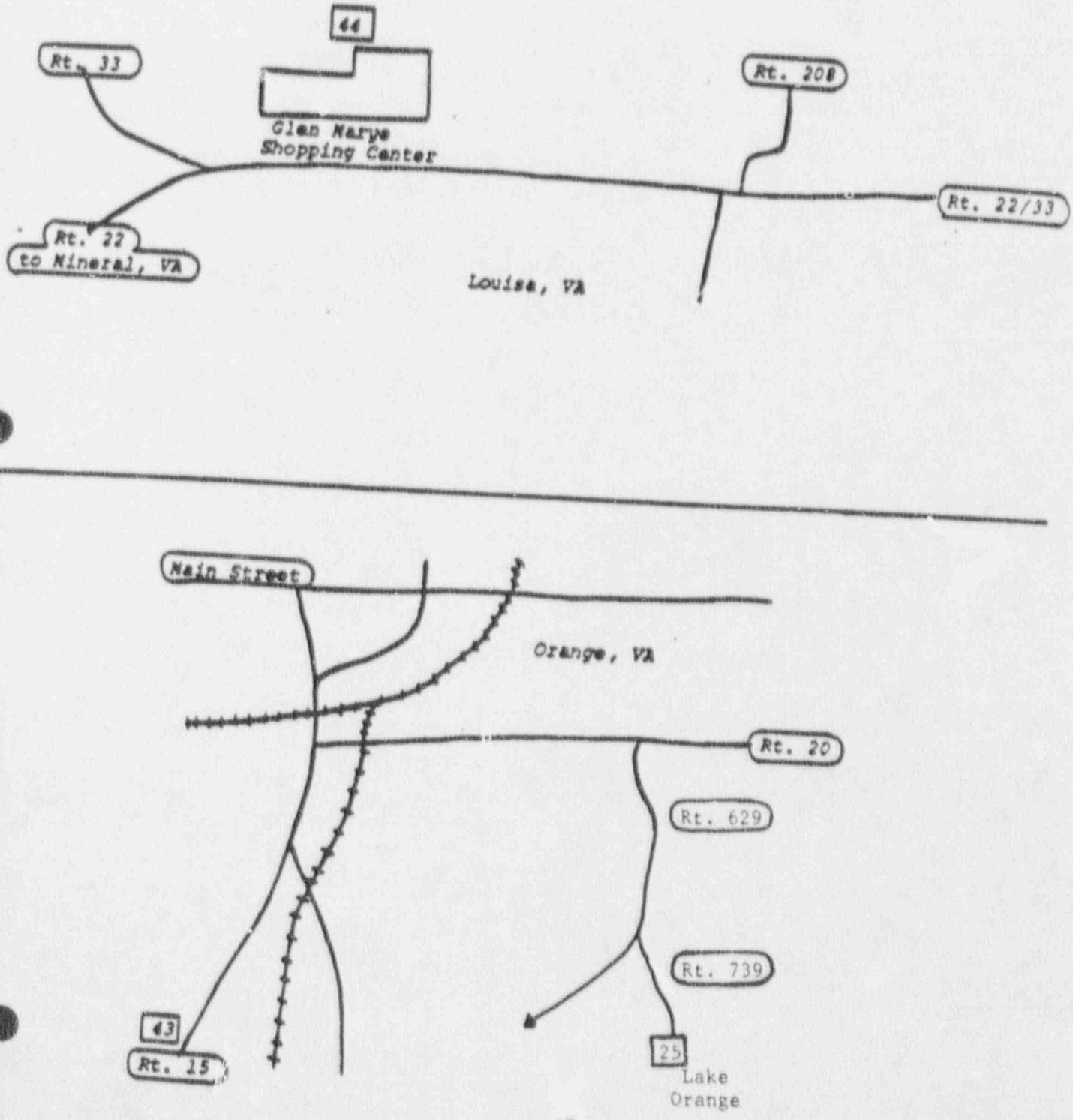


FIGURE 1

(Page 3 of 3)

NORTH ANNA POWER STATION

ENVIRONMENTAL MONITORING STATIONS OVERIEW MAP



B. ANALYSIS PROGRAM

1. Table 2 summarizes the analysis program conducted by Teledyne Isotopes for North Anna Power Station during 1990.

TABLE 2

(Page 1 of 3)

NORTH ANNA POWER STATION

SAMPLE ANALYSIS PROGRAM

SAMPLE MEDIA	FREQUENCY	ANALYSIS	LLD*	REPORT UNITS
Thermoluminescent Dosimetry (TLD) (84 Routine Station TLD's)	Quarterly	Gamma Dose	2mR±2mR	mR/std. month
12 Station TLD's	Annually	Gamma Dose	2mR±2mR	mR/std. month
Airborne Radioiodine	Weekly	I-131	0.07	pCi/m^3
Airborne Particulate	Weekly	Gross Beta	0.01	pCi/m^3
	Quarterly (1)	Gamma Isotopic		pCi/m^3
		Cs-134	0.05	
		Cs-137	0.06	
	Annually (2nd Quarter Composite)	Sr-89	0.005	pCi/m^3
		Sr-90	0.0002	
Surface Water	Monthly	I-131	1	pCi/l
		Gamma Isotopic		pCi/l
		Mn-54	15	
		Fe-59	30	
		Co-58, 60	15	
		Zn-65	30	
		Zr-Nb-95	15	
		Cs-134	15	
		Cs-137	18	
		Ba-La-140	15	
	Quarterly (1) 2nd Quarterly Composite	Tritium (H-3)	2000	pCi/l
		Sr-89	5	pCi/l
		Sr-90	1	

(1) Quarterly Composites of each location's samples will be used for the required analysis.

* LLD's indicate those levels that the environmental samples should be analyzed to, in accordance with the North Anna Radiological Environmental Program. Actual analysis of the samples by Teledyne Isotopes may be lower than those listed.

TABLE 2

(Page 2 of 3)

NORTH ANNA POWER STATION

SAMPLE ANALYSIS PROGRAM

SAMPLE MEDIA	FREQUENCY	ANALYSIS	LLD*	REPORT UNITS
River Water	Monthly	I-131	1	pCi/l
		Gamma Isotopic		pCi/l
		Mn-54	15	
		Fe-59	30	
		Co-58,60	15	
		Zn-65	30	
		Zr-Nb-95	15	
		Cs-134	15	
		Cs-137	18	
		Ba-La-140	15	
	Quarterly	Tritium (H-3)	2000	pCi/l
	2nd Quarter	Sr-89	5	pCi/l
	Sample	Sr-90	1	
Ground Water (Well Water)	Quarterly	Gamma Isotopic		pCi/l
	2nd Quarter	Mn-54	15	
	Composite	Fe-59	30	
		Co-58,60	15	
		Zn-65	30	
		Zr-Nb-95	15	
		I-131	1	
		Cs-134	15	
		Cs-137	18	
		Ba-La-140	15	
	Quarterly	Tritium (H-3)	2000	pCi/l
	2nd Quarter	Sr-89	5	
	Composite	Sr-90	1	
Aquatic Sediment	Semi-Annually	Gamma Isotopic		pCi/kg (dry)
		Cs-134	150	
		Cs-137	180	
	Annually	Sr-89	200	pCi/kg (dry)
		Sr-90	40	
Shoreline Soil	Semi-Annual	Gamma Isotopic		pCi/kg (dry)
		Cs-134	150	
		Cs-137	180	
	Annually	Sr-89	200	
		Sr-90	40	

* LLD's indicate those levels that the environmental samples should be analyzed to, in accordance with the North Anna Radiological Environmental Program. Actual analysis of the samples by Teledyne Isotopes may be lower than those listed.

TABLE 2

(Page 3 of 3)

NORTH ANNA POWER STATION

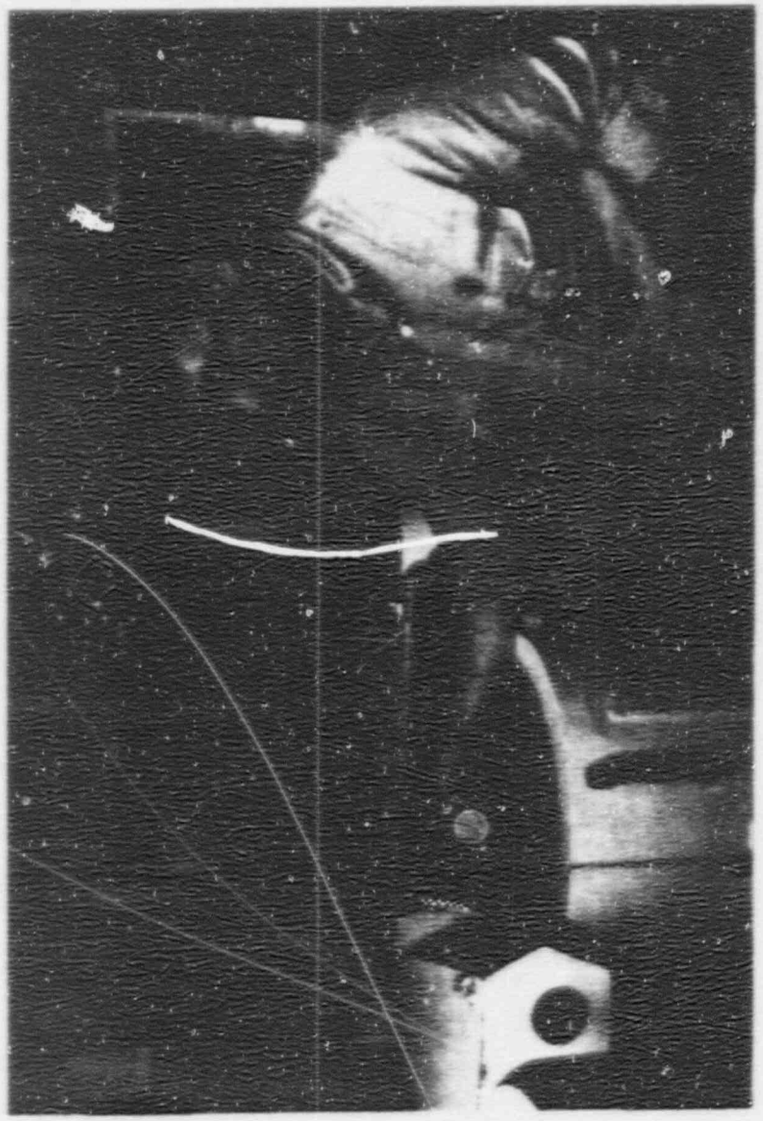
SAMPLE ANALYSIS PROGRAM

SAMPLE MEDIA	FREQUENCY	ANALYSIS	LLD*	REPORT UNITS
Soil	Once per 3 yrs.	Gamma Isotopic		pCi/kg (dry)
		Cs-134	150	
		Cs-137	180	
	Once per 3 yrs.	Sr-89	200	pCi/kg (dry)
		Sr-90	40	
Milk	Monthly	I-131	1	pCi/l
	Monthly	Gamma Isotopic		pCi/l
		Cs-134	15	
		Cs-137	18	
		Ba-La-140	15	
	Quarterly	Sr-89	5	pCi/l
		Sr-90	1	
Fish	Semi-Annual	Gamma Isotopic		pCi/kg (wet)
		Mn-54	130	
		Fe-59	260	
		Co-58, 60	130	
		Zn-65	260	
		Cs-134	130	
		Cs-137	150	
Food Products (Broadleaf Vegetation)	Monthly if available or at harvest	Gamma Isotopic		pCi/kg (wet)
		Cs-134	60	
		Cs-137	80	
		I-131	60	pCi/kg (wet)

Note:

This table is not a complete listing of nuclides which can be detected and reported. Other peaks that are measurable and identifiable, together with the above nuclides, shall also be identified and reported.

* LLD's indicate those levels that the environmental samples should be analyzed to, in accordance with the North Anna Radiological Environmental Program. Actual analysis of the samples by Teledyne Isotopes may be lower than those listed.



Program Exceptions

IV. REMP EXCEPTIONS

REMP exceptions for 1990 are listed in this chapter. Where possible, the causes of the deviations have been corrected to prevent recurrence.

There were several air sampler malfunctions which occurred during the year. The most common malfunctions were breaks in sample hose lines, timer malfunctions, unplugged samplers, or stuck rotometers. In those cases where the elapse timer was inoperable, start/stop times were used to estimate sample volume for the collection period. Some sample analyses results were lost during chemical separation and lost during radioanalysis resulting in more yield. When sampler malfunctions occurred, sample volume was estimated based on best available data.

North Anna began using continuous air sample pumps in the fourth quarter which has eliminated the cause of timer malfunctions. North Anna is also assessing the need to purchase newer air samplers which are designed with enclosures for electrical components to better protect components from the elements.

The effect of sampler malfunctions on reported results were evaluated by comparing air particulate gross beta analyses and iodine-131 analyses against other stations for the weekly period and against historical data. The results indicated values were within expected ranges.

Seven TLDs were not collected during the year because the TLD packs were missing from the sample location when collection was attempted. Some TLD packs were mounted on fence post and utility poles which were removed or replaced during the collection period, resulting in loss of the TLD pack.

During the reporting period, as a result of a Quality Assurance audit, the control fish sample location in Lake Anna, though far upstream, was determined as being potentially influenced by power station operation (documented on Station Deviation Report N90-416). A new control fish sample location was thereafter established at Lake Orange. The new site designation number is 25.

REMP EXCEPTIONS FOR SCHEDULED SAMPLING AND ANALYSIS DURING 1990 - NORTH ANNA

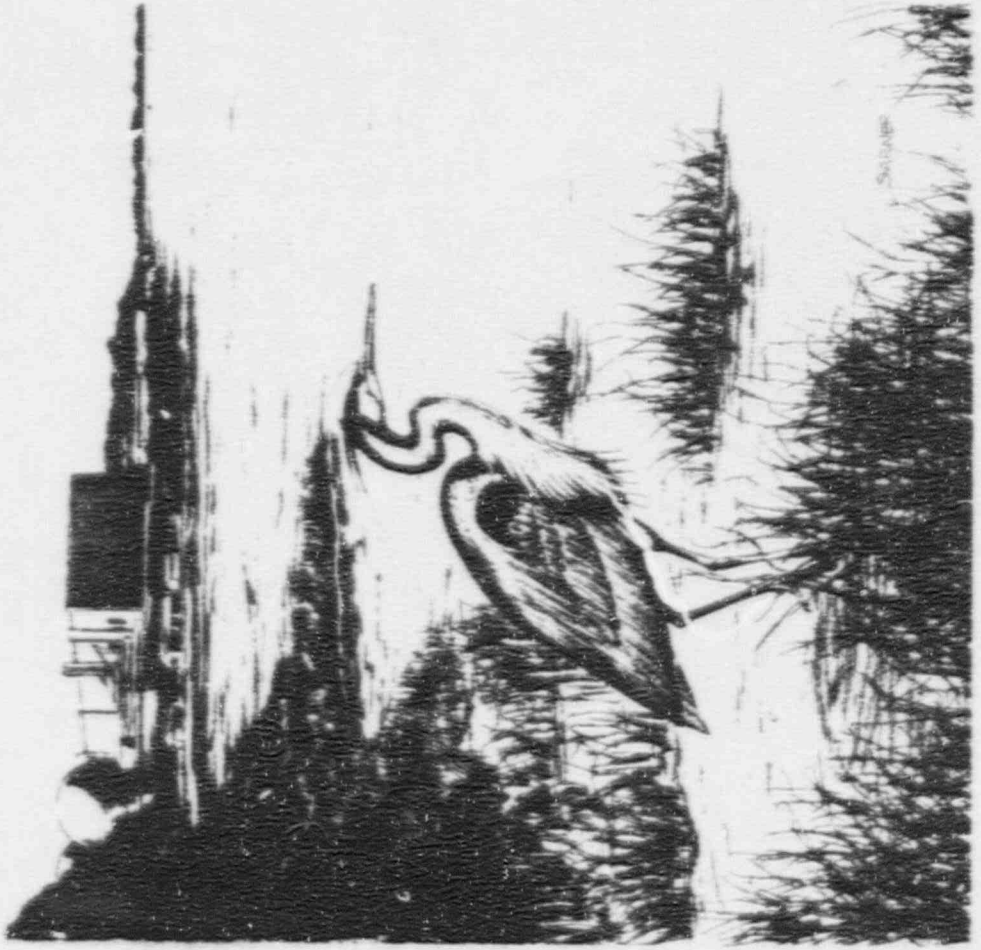
Location	Description	Date of Sampling	Reasons(s) for Loss/Exception
07	Air Particulare	01/03/90-01/10/90	Elevated result due to low sample volume; not included in averages.
05	Air Particulate/ Air Iodine	01/10/90-01/17/90	Sampler found not running upon arrival. Elapsed time = 0 Est. Vol. 140 m^3
06	Air Particulate/ Air Iodine	01/10/90-01/17/90	Sampler found unplugged upon arrival. Elapsed time = .8 hrs. Est. Vol. 140 m^3
01	Air Iodine	01/24/90-01/30/90	Sample lost in analysis; it had a zero yield.
05A	Air Particulate/ Air Iodine	01/30/90-02/07/90	Bad On/Off Switch on Sampler. Elapsed time = 15.5 hrs. Vol. = 18.6 m^3
07	Air Particulate Air Iodine	01/30/90-02/07/90	Broken elapsed timer. Vol. est. since still running Vol. = 154 m^3
02	Air Particulate Air Iodine	02/21/90-02/28/90	Sampler found unplugged upon arrival. Elapsed timer = 61.2 hrs. vol. = 73 m^3
06	Air Particulate/ Air Iodine	02/21/90-02/28/90	Bad On/Off switch on sampler. Elapsed time = 59.9 hrs. vol. = 72 m^3
03	Air Particulate/ Air Iodine	03/14/90-03/21/90	Rotometer stuck on-0 - Air sampler still running. Vol. Est. = 134 m^3
06	Air Particulate	03/14/90-03/21/90	Elevated result due to low sample volume; not included in averages.
06	Air Particulate	03/14/90-03/21/90	LLD not met due to due to low sample.
01A	Ground/Well Water	03/29/90	LLD of 1 pCi/l was not attempted by the more sensitive radiochmeical method because that analysis was not requested on the sample receipt form.
03	Air Particulate/ Air Iodine	04/04/90-04/11/90	Timer malfunction on sampler. Sampler still running. Vol. Est. 202.2 m^3

REMP EXCEPTIONS FOR SCHEDULED (Cont.)
SAMPLING AND ANALYSIS DURING 1990 - NORTH ANNA

Location	Description	Date of Sampling	Reasons(s) for Loss/Exception
03	Air Particulate/ Air Iodine	04/11/90-04/18/90	Timer malfunction on sampler. Sampler still running. Vol. Est. 201 m^3
07	Air Particulate/ Air Iodine	04/11/90-04/18/90	Timer malfunction on sampler. Sampler still running. Vol. Est. 197 m^3
01	Air Particulate/ Air Iodine	06/27/90-07/03/90	Sampler malfunction. Vol = 3.48 m^3
05A	Air Particulate/ Air Iodine	06/27/90-07/03/90	Sample not in original shipment; received 07/17/90.
22	Air Particulate/ Air Iodine	07/26/90-08/01/90	Elapsed timer malfunction Stop/Start times used for volume. Vol. = 169 m^3
01	Air Particulate/ Air Iodine	07/26/90-08/01/90	Elapsed timer malfunction Stop/Start times used for volume. Vol. = 173 m^3
24	Air Particulate/ Air Iodine	07/26/90-08/01/90	Elapsed timer malfunction Start/Stop times used for volume. Vol. = 174 m^3
01	Air Particulate/ Air Iodine	08/15/90-08/22/90	Elapsed timer malfunction Start/Stop timess used for volume. Vol = 202 m^3
05, 07, 22	Air Particulate/ Air Iodine	08/22/90-08/29/90	Elapsed timer malfunction. Results reported in total pCi.
06	Air Particulate/ Air Iodine	08/22/90-08/29/90	Elapsed timer malfunction Start/Stop times used for volume.
05A	Air Particulate/ Air Iodine	08/29/90-09/05/90	Hose broke on sampler. No sample collected.
23	Air Particulate/ Air Iodine	09/05/90-09/12/90	Elapsed timer malfunction Start/Stop times used for volume.

REMP EXCEPTIONS FOR SCHEDULED (Cont.)
SAMPLING AND ANALYSIS DURING 1990 - NORTH ANNA

Location	Description	Date of Sampling	Reasons(s) for Loss/Exception
06	Air Particulate/ Air Iodine	09/26/90-10/03/90	Elapsed timer malfunction Start/Stop times used for volume. Est. Vol. = 197 m^2. Elapsed time = 0.1 hrs.
21	Air Particulate/ Air Iodine	09/19/90-09/26/90	Elapsed time malfunction. Start/Stop times used for volume.
24	Air Iodine	10/10/90-10/17/90	Sample lost during chemical separation and could not be recovered.
03	Air Iodine	12/05/90-12/12/90	Original sample had low volume due to low air flow. Substiture sample sent and received at laboratory on 12/28/90.
07, 22, 24	Air Iodine	12/12/90-12/19/90	Sampler malfunctioned. Volume was estimated from sample start and stop times.
WNW-27	Direct Radiation TLD	3rd Quarter	Lost/missing upon arrival at collection point.
SE-14/46	Direct Radiation TLD	2nd Quarter	Lost/missing upon arrival at collection point.
SW-22/54	Direct Radiation TLD	2nd Quarter	Lost/missing upon arrival at collection point.
ESE-43	Direct Radiation TLD	2nd Quarter	Lost/missing upon arrival at collection point.
SSE-48	Direct Radiation TLD	4th Quarter	Lost/missing upon arrival at collection point.



V. SUMMARY AND DISCUSSION OF 1990 ANALYTICAL RESULTS

Data from the radiological analyses of environmental media collected during the report period are tabulated and discussed below. The procedures and specifications followed in the laboratory for these analyses are as required in the Teledyne Isotopes Quality Assurance Manual and are explained in the Teledyne Isotopes Analytical Procedures. A synopsis of analytical procedures used for the environmental samples is provided in Appendix D. In addition to internal quality control measures performed by Teledyne, the laboratory also participates in the Environmental Protection Agency's Interlaboratory Comparison Program. Participation in this program ensures that independent checks on the precision and accuracy of the measurements of radioactive material in environmental samples are performed. The results of the EPA Interlaboratory Comparison are provided in Appendix E.

Radiological analyses of environmental media characteristically approach and frequently fall below the detection limits of state-of-the-art measurement methods. The "less than" values in the data tables were calculated for each specific analysis and are dependent on sample size, detector efficiency, length of counting time, chemical yield, when appropriate, and the radioactive decay factor from time of counting to time of collection. Teledyne Isotopes analytical methods meet the Lower Limit of Detection (LLD) requirements given in Table 2 of the USNRC Branch Technical Position of Radiological Monitoring (November 1979, Revision 1) and the ODCM.

The following is a discussion and summary of the results of the environmental measurements taken during the 1990 reporting period.

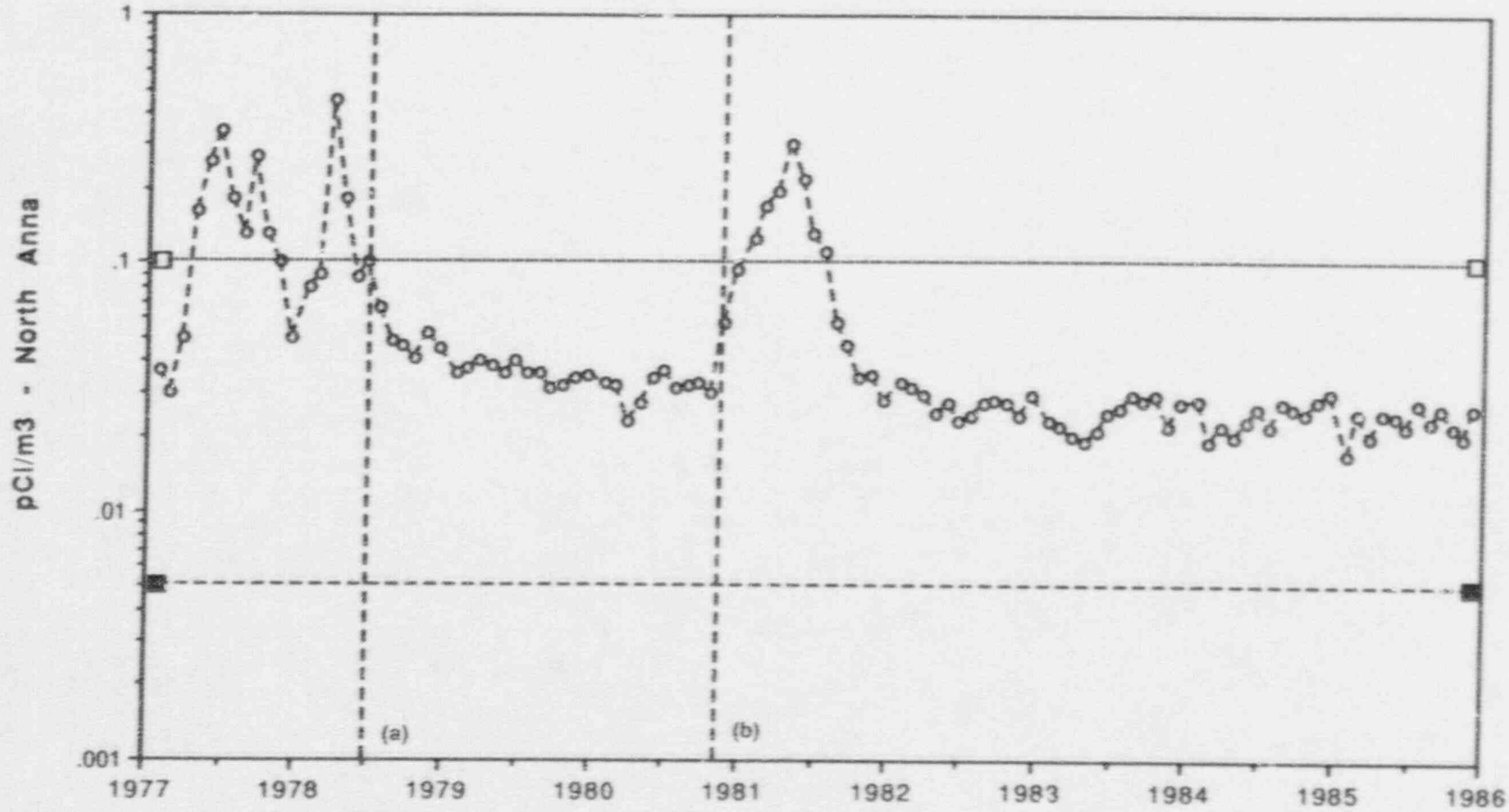
A. Airborne Exposure Pathway

1. Air Iodine/Particulates

Charcoal cartridges used to collect airborne iodine were collected weekly and analyzed by a radiochemical separation procedure for iodine-131. The results are presented in Table B-1. All results were below the required lower limit of detection. Gross beta activity was observed in all fifty-two control samples with an average concentration of 0.019 pCi/m^3 and a range of 0.009 to 0.035 pCi/m^3. The average measurement for the indicator locations was 0.020 pCi/m^3 with a range of 0.004 to 0.087 pCi/m^3. The results of the gross beta activities are presented in Table B-2. The gross beta activities for 1990 were comparable to levels measured in the 1982-1989 period. Prior to that period the gross beta activities were higher due to atmospheric nuclear weapons testing by other countries.

TRENDING GRAPH - 1

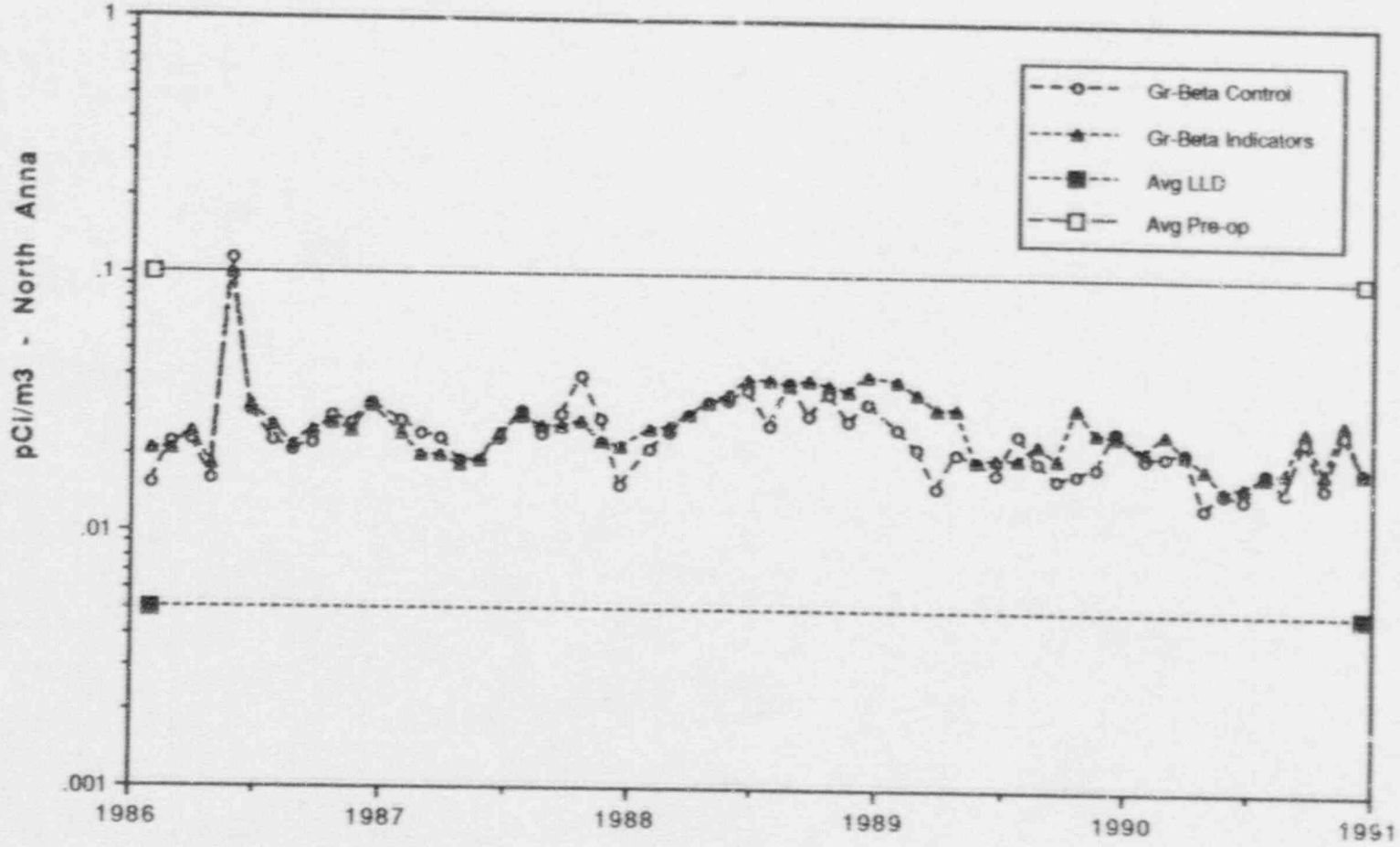
GROSS BETA IN AIR PARTICULATES



(a) Unit 1 critical on 06/06/78.
(b) Unit 2 critical on 12/14/80.

TRENDING GRAPH - 1 (Cont.)

GROSS BETA IN AIR PARTICULATES



During the preoperational period of July 1, 1974 through March 31, 1978 gross beta activities ranged from a low of 0.005 pCi/m^3 to a high of 0.75 pCi/m^3.

Air particulate filters were composited by locations on a quarterly basis and were analyzed by gamma ray spectroscopy. The results are listed in Table B-3. Beryllium-7, which is produced continuously in the upper atmosphere by cosmic radiation, was measured in all 48 composite samples. The average measurement for the control location was 0.059 pCi/m^3 with a range of 0.036 to 0.096 pCi/m^3. The indicator locations had an average concentration of 0.068 pCi/m^3 and a range of 0.032 to 0.118 pCi/m^3. During the preoperational period, beryllium-7 was measured at comparable levels, as would be expected. Naturally occurring potassium-40 was detected in three indicator samples with an average measurement of 0.010 pCi/m^3 and a range of 0.009 to 0.012 pCi/m^3. All other gamma emitters were below the detection limits. During the preoperational period gamma ray spectroscopy measured several fission products in numerous air particulate filters. All isotopes were attributed to atmospheric nuclear weapons testing conducted before the preoperational period. Among the isotopes measured were zirconium-95, ruthenium-103, ruthenium-106, cesium-137, cerium-141 and cerium-144.

The second quarter composites of air particulate filters from all twelve stations were analyzed for strontium-89 and 90. There was no detection of these fission products at any of the eleven indicator stations nor at the control stations.

2. Precipitation

A sample of rain water was collected monthly at station 01A, on site, 0.75 miles, 138 degrees SE and analyzed for gross beta activity. The results are presented in Table B-4. The average gross beta activity for 1990 was 6.4 pCi/liter with a range from 1.9 to 16 pCi/liter. A semi-annual composite was prepared and analyzed for gamma emitting isotopes and tritium. All gamma emitters were below their detection limits. Tritium was not detected in the semi-annual composite sample. These results were comparable to or lower than those measured in 1986 thru 1989. During the preoperational period gross beta activity in rain water was expressed in nCi per square meter of the collector surface, thus a direct comparison can not be made to the 1990 period. Tritium was measured in over half of the few quarterly composites made. The tritium activity ranged from 100 to 330 pCi/liter.

3. Soil

Soil samples are collected and analyzed every three years from twelve stations. Since the samples were collected in 1989 they were not collected during 1990.

B. Waterborne Exposure Pathway

1. Ground/Well Water

Water was sampled quarterly from the on site well at the biology laboratory. These samples were analyzed for gamma radiation and for tritium. The results are presented in Table B-6. No gamma emitting isotopes were detected. Tritium was detected in the first quarter sample with an activity of 210 pCi/liter. This is a normal environmental level. The second quarter sample was analyzed for strontium-89 and strontium-90. There were no detections of these isotopes above the detection level. No gamma emitting isotopes were detected during the preoperational period. Tritium was measured in most of the samples during that period with concentrations between 80 and 370 pCi/liter.

2. River Water

A sample of water from the North Anna River was collected monthly at station 11, 5.8 miles downstream from the discharge lagoon, 128 degrees SSE. The results are presented in Table B-7. The samples were analyzed by gamma spectroscopy, and for tritium. The second quarter samples were analyzed in addition for strontium-89 and strontium-90.

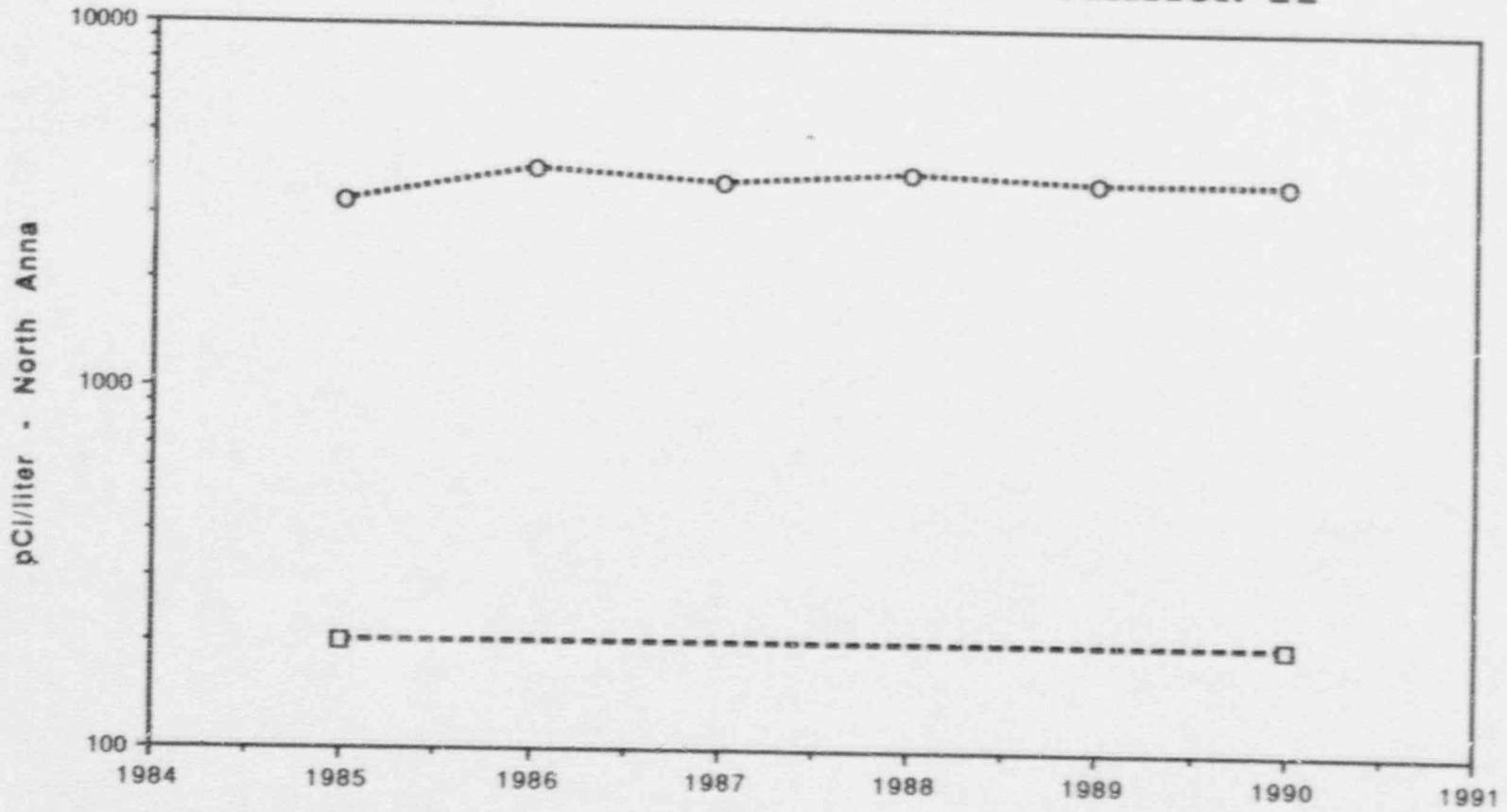
All gamma emitters were below the detection level. No detections of strontium-89 or strontium-90 occurred. Tritium was measured in all samples with an average level of 3783 pCi/liter and a range of 3000 to 4900 pCi/liter. This compares favorably with the average tritium activity for 1989 of 3749 pCi/liter and 1988 was 3925 pCi/liter. No river water samples were collected in the preoperational period.

3. Surface Water

Samples of surface water were collected monthly from two stations. Station 08 is at the discharge lagoon, 1.1 miles, 148 degrees SSE on Lake Anna. Station 09 is 2.2 miles upstream on Lake Anna, 320 degrees NW. The samples were analyzed for iodine-131 by

TRENDING GRAPH 2

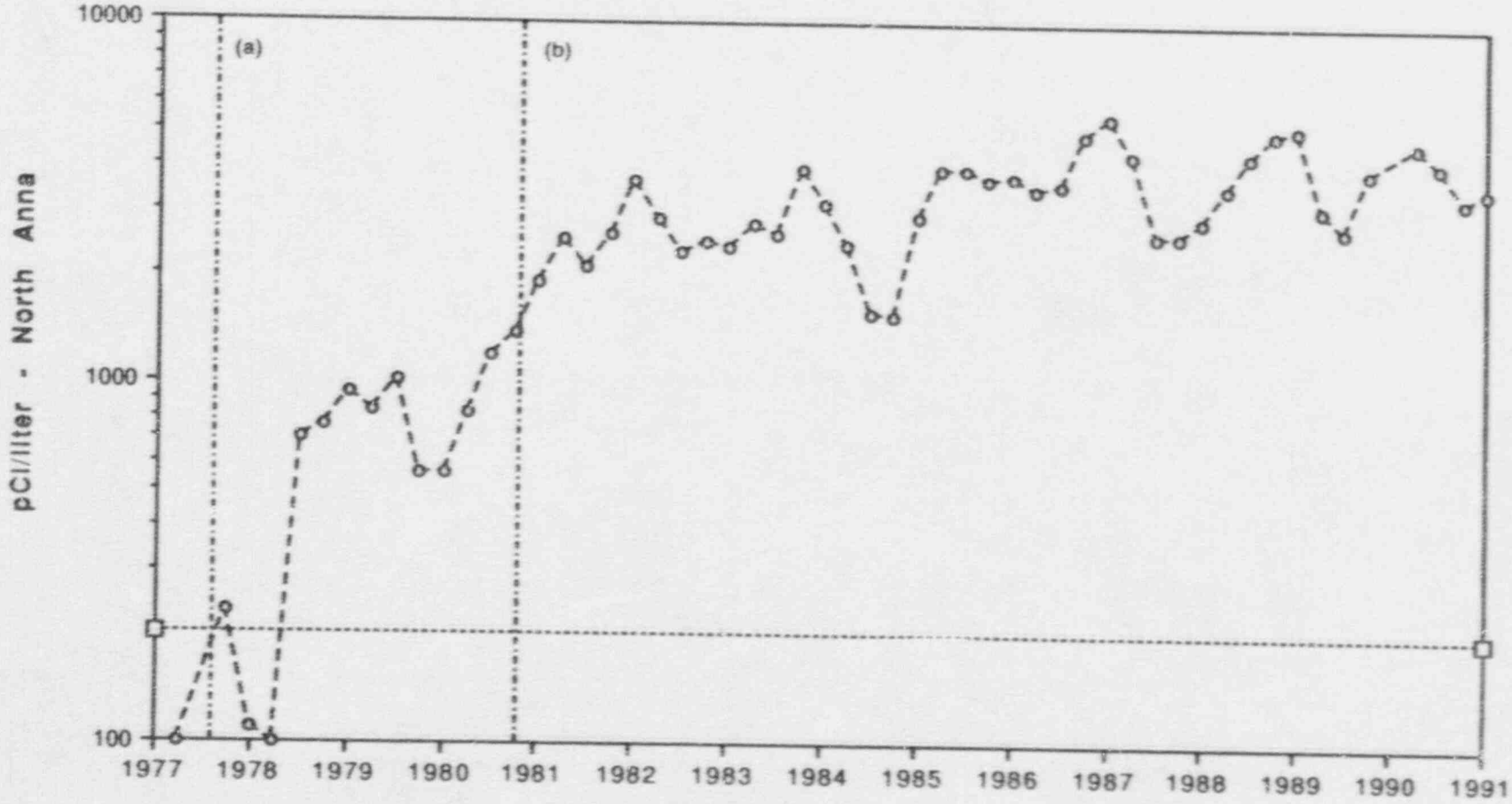
TRITIUM IN RIVER WATER - STATION 11



During pre-operational period tritium in river water was not measured.

TRENDING GRAPH - 3

TRITIUM IN SURFACE WATER - STA 08



(a) Unit 1 critical on 06/06/78.
(b) Unit 2 critical on 12/14/80.

radiochemical separation. No iodine was detected in the 24 samples analyzed. The results are presented in Table B-8. The samples were also analyzed by gamma ray spectrometry. All gamma emitters were below the detection levels at both station.

A quarterly composite from each station was prepared and analyzed for tritium. The tritium activity at station 08 for the quarterly composites was at an average level of 3900 pCi/liter with a range of 3300 to 4700 pCi/liter. The tritium level had been increasing since the middle of 1978 when the average level was below 300 pCi/liter. However, during 1990 the results were within the same range as those measured in 1986 thru 1989. During the preoperational period tritium was measured in several samples with concentrations between 90 and 250 pCi/liter

The tritium activity from station 09 was at an average level of 3200 pCi/liter with a range of 3100 to 3300 pCi/liter. The level of tritium for 1990 for station 09 is also within the same range as those measured in 1986 thru 1989.

Samples of surface water were collected by the Commonwealth of Virginia from two stations. Station W-33 is located at the discharge lagoon while station W-27 is located on the North Anna River at the RT. 208 Bridge, which is upstream of the site. Twenty-four samples were collected and analyzed by gamma ray spectroscopy and for tritium. Potassium-40 was measured in two samples, one from W-27 and one from station W-33 with levels of 60.3 and 86.8 pCi/liter respectively. The results are presented in Table B-9. All other gamma emitters were below their detection levels.

Since the tritium level had been increasing during the last several years, seven samples from each station were analyzed for tritium during 1990. This was an increase in tritium analyses from these stations during the past years. The average activity at station W-33 in all seven samples was 3200 pCi/liter with a range of 2500 to 3800 pCi/liter. This compares favorably with the activity of 4500 pCi/liter during 1989 at this station. Tritium was measured in six of the seven samples at station W-27 with an average activity of 1098 pCi/liter and a range of 350 to 2200 pCi/liter. This is higher than the one measurement of 150 pCi/liter for 1989 at this station.

C. Aquatic Exposure Pathway

1. Sediment/Silt

Sediment samples were collected during March and September from each of three locations and were analyzed by gamma spectrometry. The results are presented in Table B-10. A number of man-made and naturally occurring radioisotopes were detected in these samples. Cesium-137 was detected in all samples with an average activity of 147 pCi/kg (dry weight) and a range from 45.8 to 318 pCi/kg (dry weight). Cesium-134 was measured in one indicator sample from station 08 with an activity of 72.5 pCi/kg (dry weight). The highest readings for cesium-134 and cesium-137 were obtained from station 08 located 1.10 miles downstream into second cooling lagoon, 148° SSE.

Naturally occurring potassium-40 was observed in five of the six samples with an average activity of 10017 pCi/kg (dry weight) and a range from 3760 to 20100 pCi/kg (dry weight). Radium-226 was measured in four samples with an average concentration of 1454 pCi/kg (dry weight) and a range of 862 to 2100 pCi/kg (dry weight). Cobalt-60 was measured in two indicator stations from station 08 with an average activity of 84 pCi/kg (dry weight) and a range of 63.1 to 105 pCi/kg (dry weight). Also naturally occurring, thorium 228 was observed in all six samples with an average concentration of 809 pCi/kg (dry weight) and a range of 316 to 1320 pCi/kg (dry weight). The September samples were analyzed for strontium-89 and strontium-90. There were no detections of strontium-89 in aquatic sediment/silt. Strontium-90 was measured in two samples with an average concentration of 210 pCi/kg (dry weight) and a range of 130 to 290 pCi/kg (dry weight).

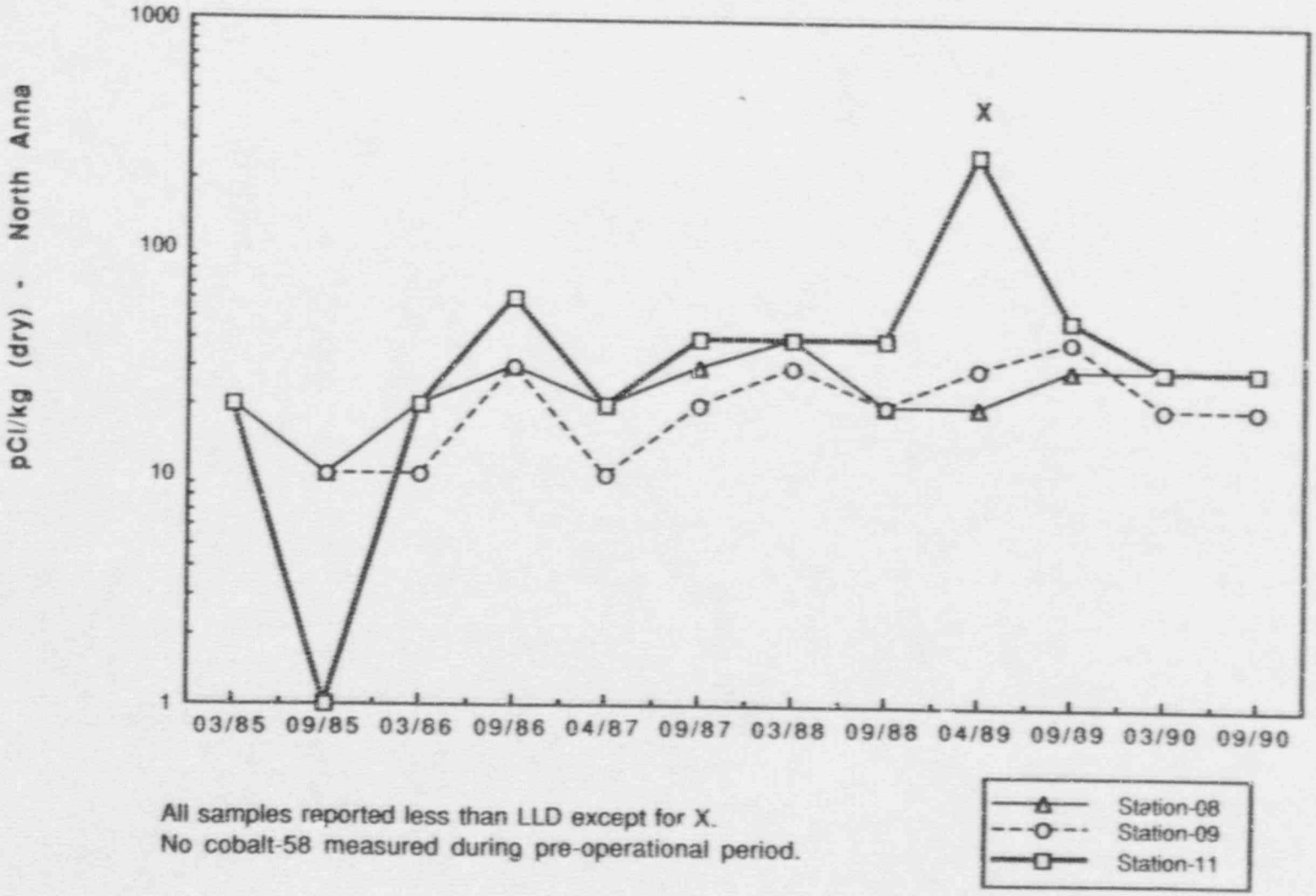
During the preoperational period sediment samples were analyzed by gamma ray spectroscopy. Cesium-137 was measured in most of the samples with concentrations between 33 and 1210 pCi/kg (dry weight). Strontium-90 was measured in most of the samples with concentrations between 60 and 540 pCi/kg (dry weight). Strontium-89 was not measured. Potassium-40, radium-226, and thorium-228, all naturally occurring, were measured at background levels.

2. Shoreline Soil

A sample of shoreline sediment was collected in March and September from station 09, 2.2 miles upstream of the North Anna Power Station. The samples were analyzed by gamma ray spectrometry. The results are presented in Table B-11. The naturally occurring nuclide potassium-40 was measured in one sample with an activity of 9210 pCi/kg (dry

TRENDING GRAPH - 4

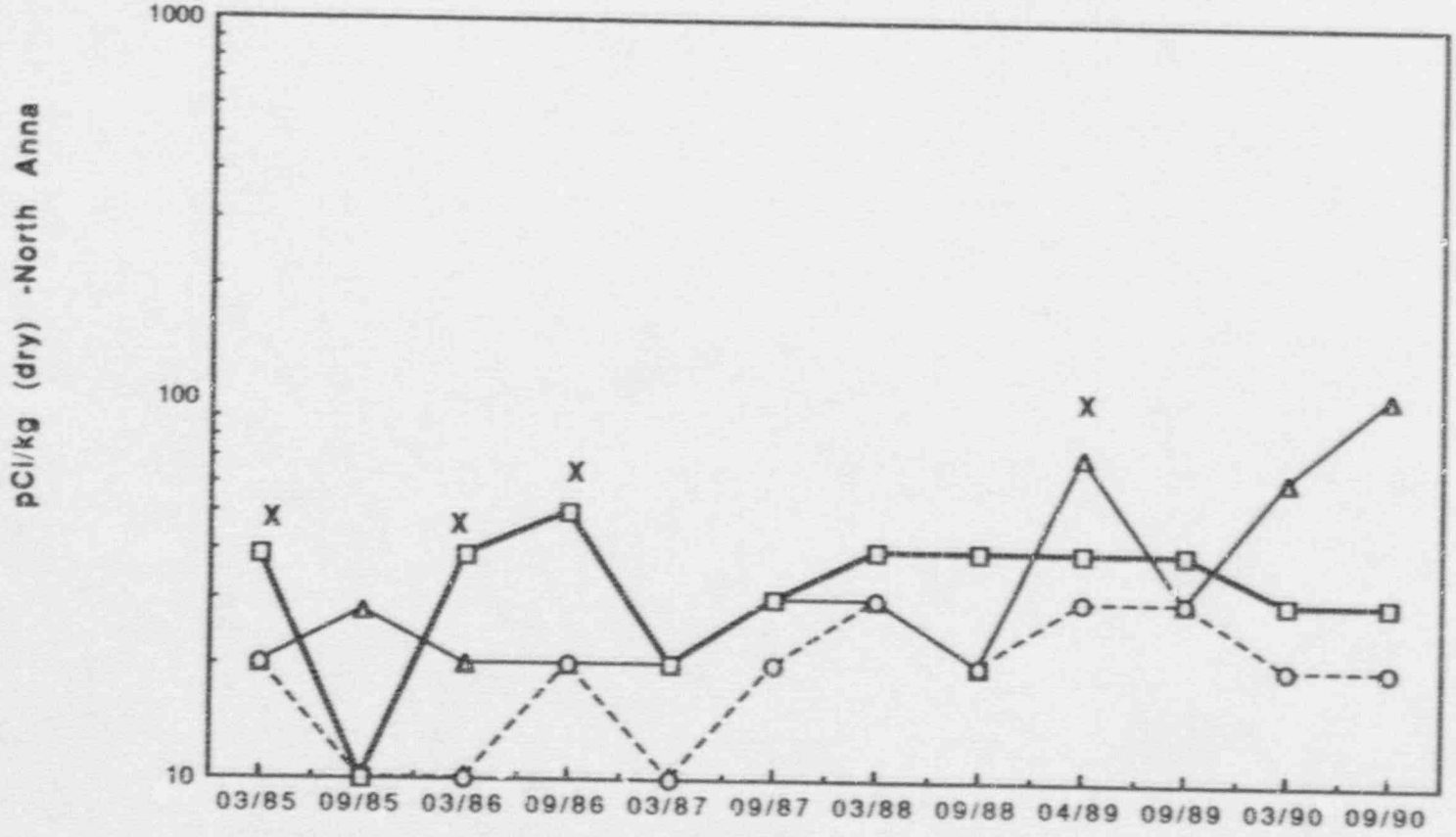
COBALT-58 IN SEDIMENT SILT



All samples reported less than LLD except for X.
No cobalt-58 measured during pre-operational period.

TRENDING GRAPH - 5

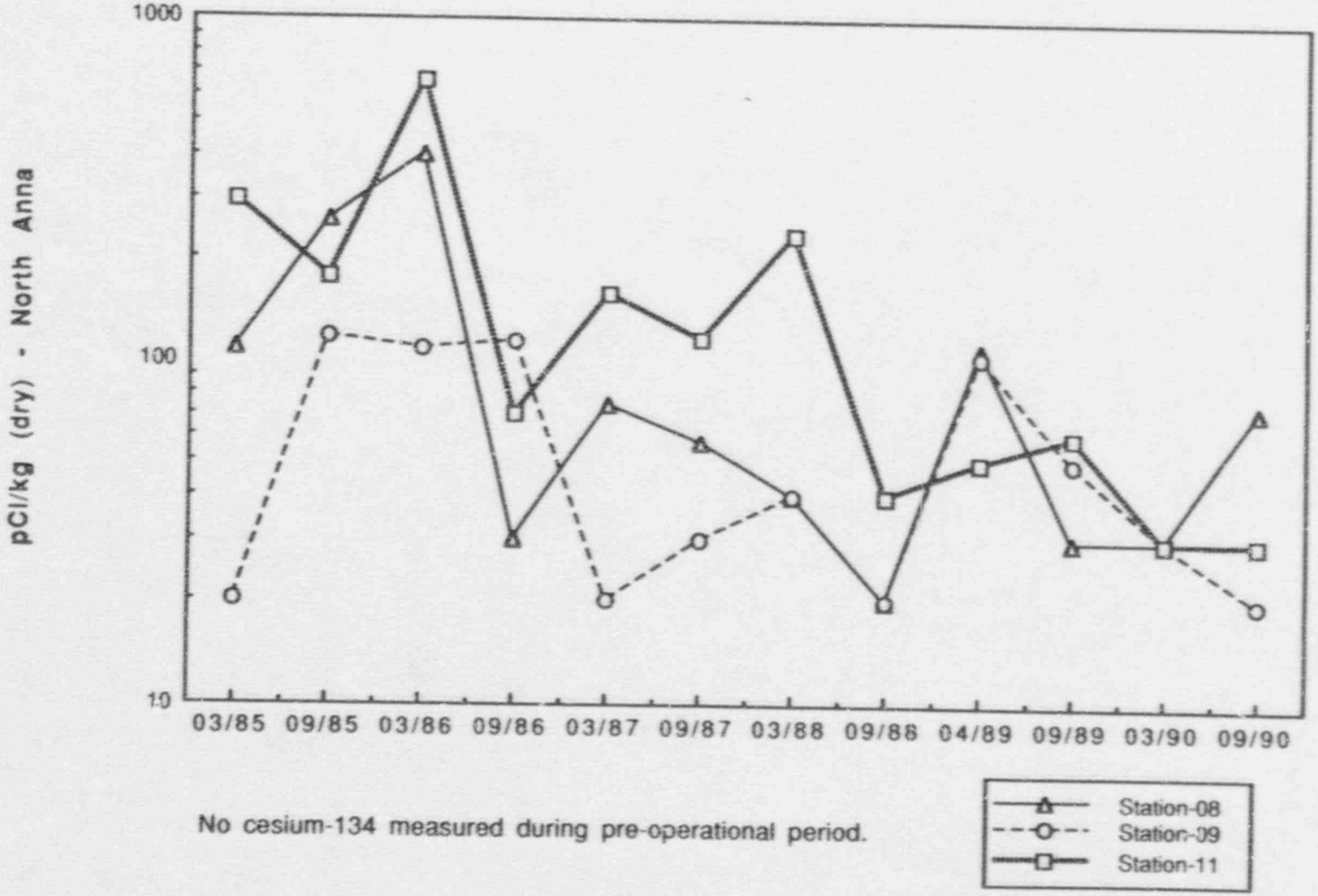
COBALT-60 IN SEDIMENT SILT



All samples reported less than LLD except for X.
No cobalt-60 measured during pre-operational period.

TRENDING GRAPH - 6

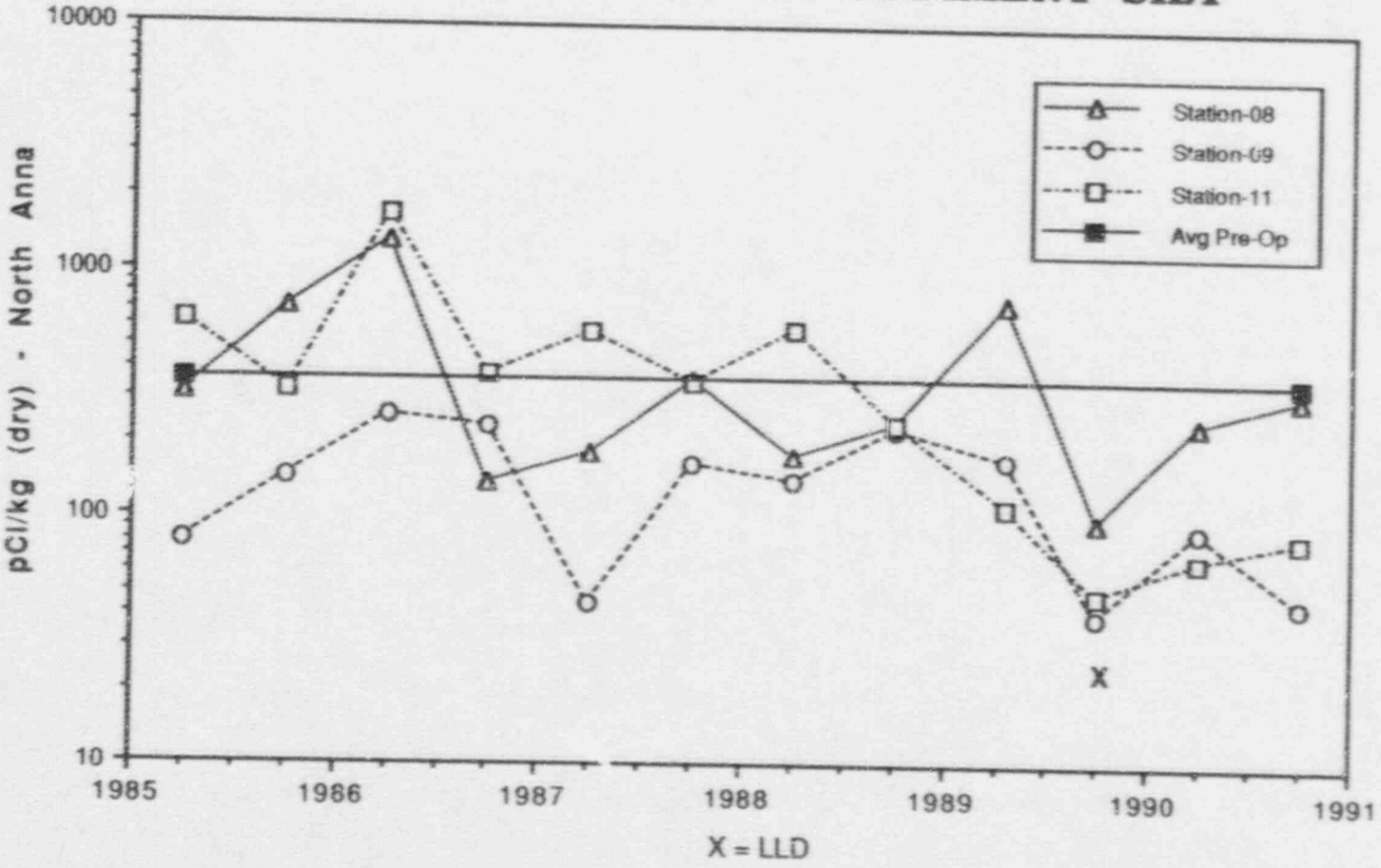
CESIUM-134 IN SEDIMENT SILT



No cesium-134 measured during pre-operational period.

TRENDING GRAPH - 7

CESIUM-137 IN SEDIMENT SILT



weight). Thorium-228 was measured in both samples at an average of 244 pCi/kg (dry weight) and a range of 192 to 295 pCi/kg (dry weight). Radium-226 was measured in one sample with an activity of 804 pCi/kg (dry weight). Cesium-137, a fission product, was monitored in one sample with an activity of 74.6 pCi/kg (dry weight).

The September sample was analyzed for strontium and there were no detections of strontium-89. Strontium-90 was measured at 48 pCi/kg (dry weight).

D. Ingestion Exposure Pathway

1. Milk

The results of the iodine-131 analysis of milk samples are presented in Table B-12. A sample was collected monthly from two stations. A total of 24 samples were analyzed during 1990. There were no measurements of iodine-131 above the detection limits.

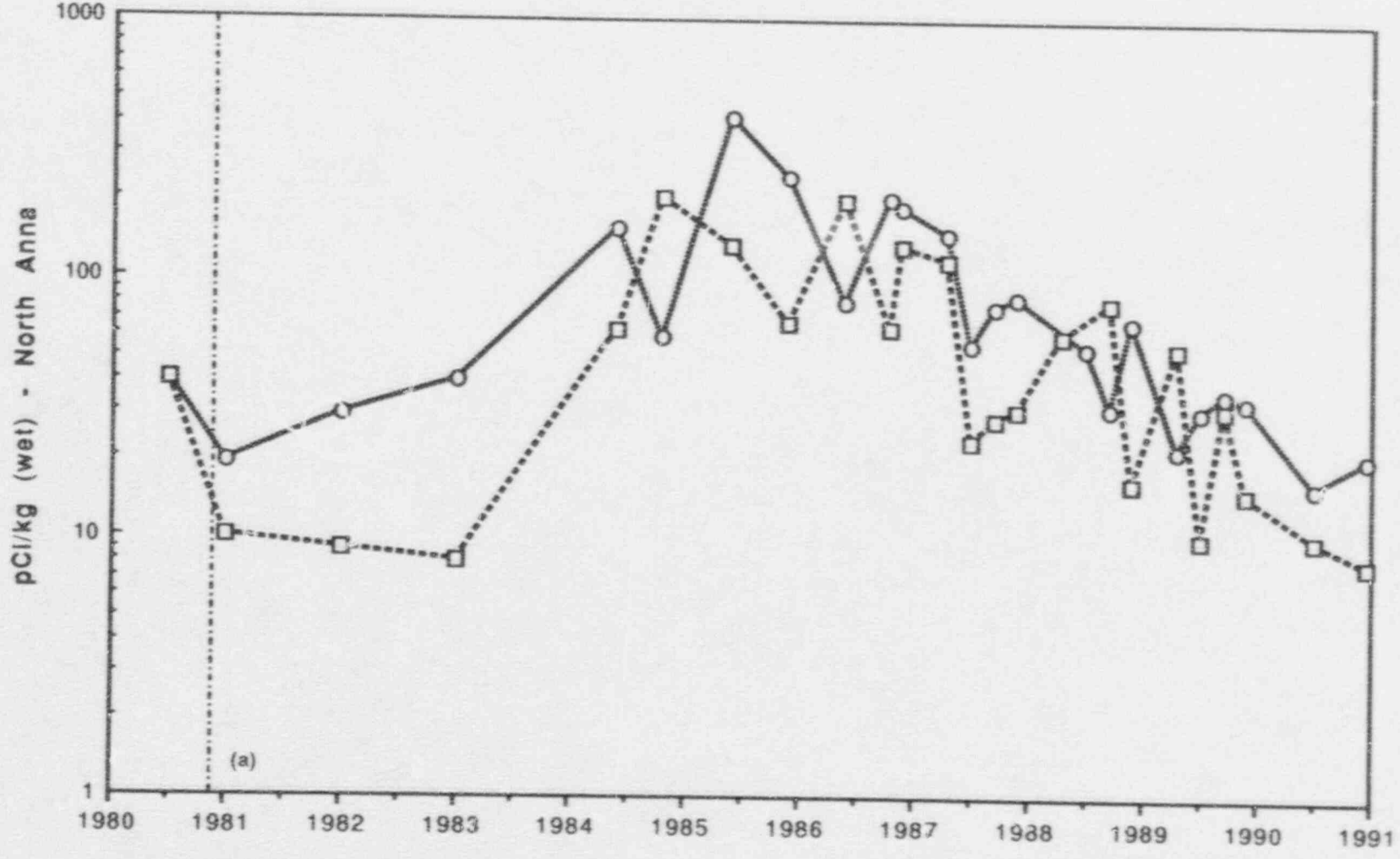
The milk samples were also analyzed by gamma ray spectroscopy and the results are also presented in Table B-12. A total of 24 samples were analyzed. Naturally occurring potassium-40 was measured in all of the samples with an average of 1288 pCi/liter and a range of 1150 to 1540 pCi/liter. The fission product cesium-137 has been detected sporadically in recent years and the activity has been attributed to global fallout from past atmospheric weapons testing. However, cesium-137 was not detected at levels above LLD in any milk samples in 1990. All other gamma emitters were below their detection levels. A quarterly composite was prepared from each of the two collection stations and analyzed for strontium-89 and strontium-90. Strontium-89 was not detected at levels above LLD in any of the samples monitored. Strontium-90 was detected in seven of the eight samples monitored with an average level of 1.5 pCi/liter and a range of 0.58 to 2.7 pCi/liter. This is similar to activities determined in previous years and lower than the preoperational levels of 2.2 to 5.4 pCi/liter.

2. Fish

Aquatic biota can be sensitive indicators of radionuclide accumulation in the environment because of their ability to concentrate certain chemical elements which have radioactive isotopes. The results are presented in Table B-13. Five samples of fish were collected during 1990. These samples were analyzed by gamma ray spectroscopy and the naturally occurring isotope potassium-40 was found in all samples at an average of 1552 pCi/kg (wet weight) with a range of 1580 to 1640 pCi/kg (wet weight). Cesium-134, a

TRENDING GRAPH - 8

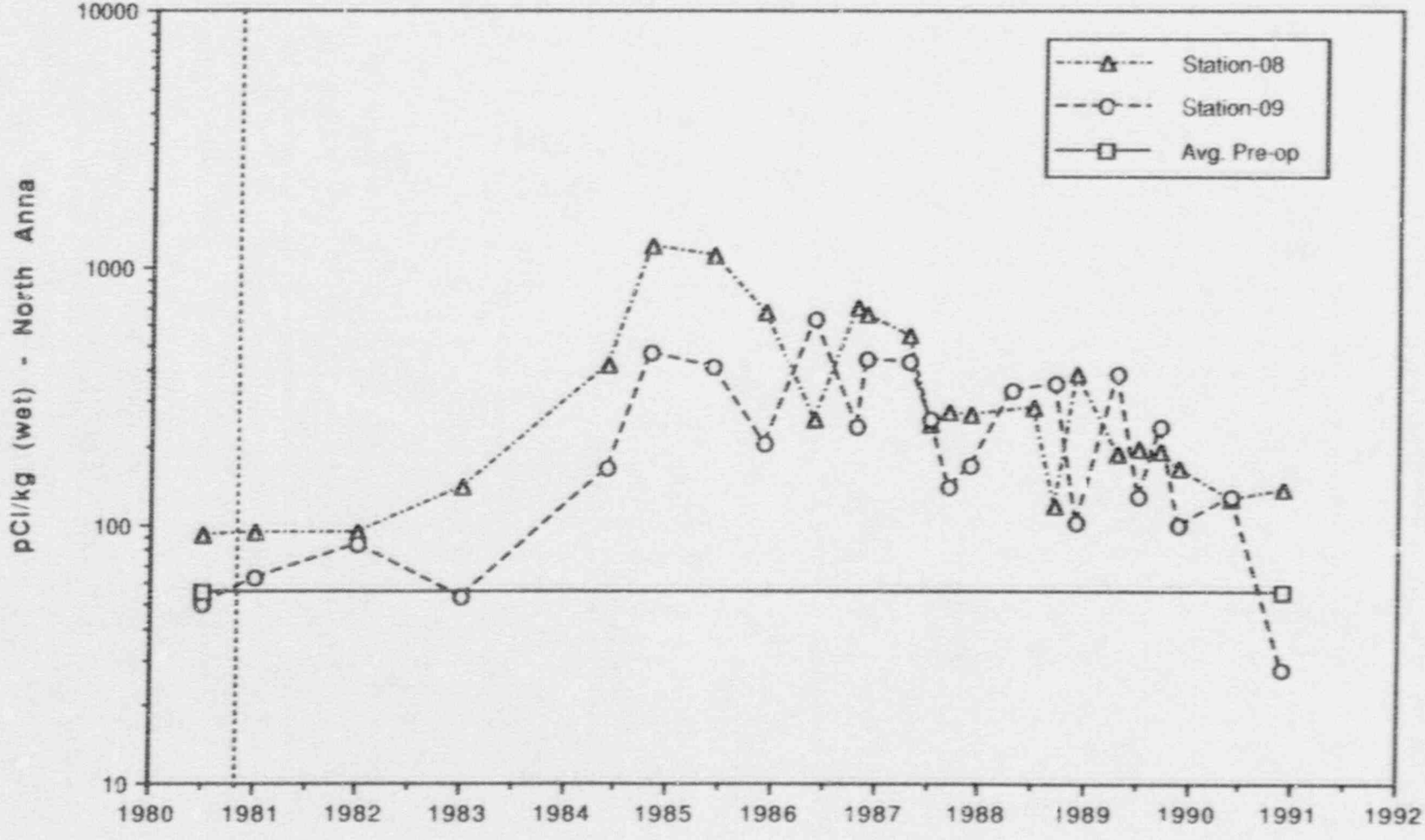
CESIUM-134 IN FISH



(a) Unit 2 critical on 12/14/80.
During the pre-operational period cesium-134 was not measured.

TRENDING GRAPH - 9

CESIUM-137 IN FISH



(a) Unit 2 critical on 12/14/80.

fission product, was observed in two samples from station 08 with an average concentration of 18.4 pCi/kg (wet weight) and a range of 15.9 to 20.8 pCi/kg (wet weight). The fission product cesium-137 was measured in four samples at an average of 105 pCi/kg (wet weight) and a range of 27.6 to 139 pCi/kg (wet weight). During the preoperational period cesium-137 was measured in one-fourth of the fish samples collected with concentrations between 31 and 66 pCi/kg (wet weight).

3. Food/Vegetation

Forty food samples were collected from five locations and analyzed by gamma spectrometry. The results are presented in Table B-14. Naturally occurring potassium-40 was monitored in all of the samples with an average activity level of 10915 pCi/kg (wet weight) and a range of 2750 to 48600 pCi/kg (wet weight). Cosmogenic beryllium-7 was detected in 36 of the 40 samples with an average concentration of 3331 pCi/kg (wet weight) and a range of 290 to 11400 pCi/kg (wet weight). The terrestrial nuclide thorium-228 was detected in five of the samples at an average activity of 243 pCi/kg (wet weight) and a range of 141 to 450 pCi/kg (wet weight).

The fission product cesium-134 was not detected at levels above LLD during 1990. Cesium-137 was detected in nine of the forty samples with an average activity of 71.9 pCi/kg (wet weight) and a range of 13.5 to 161 pCi/kg (wet weight). These results are consistent with those measured in previous years. Cesium-137 was measured in broadleaf garden vegetation during the preoperational period with concentrations between 53 and 9[illegible] pCi/kg (wet weight).

E. Direct Radiation Exposure Pathway

1. TLD Dosimeters

Thermoluminescent dosimeters (TLDs) determined environmental radiation doses and the results are presented in Table B-15. Individual measurements of external radiation levels in the environs of the North Anna site had an average dose of 5.6 mR/standard month with a range of 3.7 to 8.7 mR/standard month. The control station, No 24 had an average reading of 4.2 mR/standard month with a range of 3.7 to 4.5 mR/standard month.

Sector TLDs are deployed quarterly at thirty-two locations in the environs of the North Anna site. Two badges are placed at each location. The results are presented in

TRENDING GRAPH - 10

ENVIRONMENTAL RADIATION - TLD's

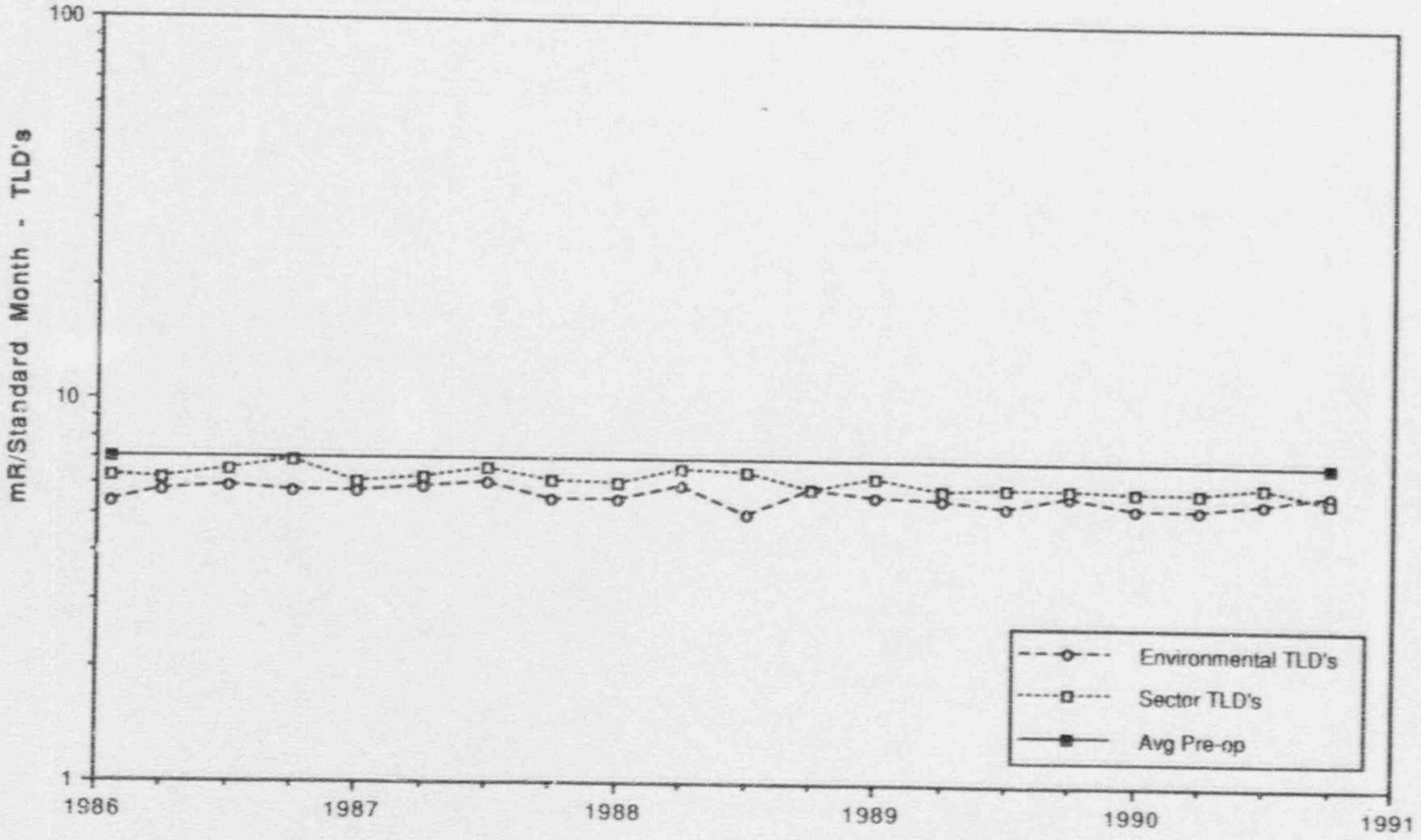


Table B-16. The average level of the 32 locations (two badges at each location) was 5.9 mR/standard month with a range of 3.2 to 9.5 mR/standard month. The thirty-two control TLDs from eight locations showed an average reading of 4.7 mR/standard month with a range of 3.2 to 7.0 mR/standard month. Seven of the badges from the second, third and fourth quarters were missing. Although a thorough search was made of the area the TLD's could not be located. During the part (starting in 1977) of the preoperational period that the calculation of the TLD dose included a correction for the in-transit dose, the doses were measured between 4.3 and 8.8 mR/standard month.

The data for the operational radiological environmental monitoring program for the North Anna Power Station has been presented. Based upon this evidence the North Anna Power Station is operating within regulatory limits.

Conclusion

VI. CONCLUSIONS

The results of the 1990 Radiological Environmental Monitoring Program for the North Anna Nuclear Power Station have been presented. The following sections discuss each pathway individually followed by a program summary.

Airborne Exposure Pathway

Air particulate gross beta concentrations of all the indicator locations for 1990 followed the gross beta concentrations at the control location. The gross beta concentrations were comparable to levels observed since 1982 except for a five week period in 1986 which was influenced by the Chernobyl accident. Gross beta concentrations in the preoperational period were highly variable, ranging from 0.0043 to 0.75 pCi/CuM, due to occasional atmospheric nuclear weapons tests. Gamma isotopic analysis of the particulate samples identified the gamma emitting isotopes as natural products (beryllium-7 and potassium-40). There were no detections above the LLD for fission products nor other man-made isotopes in the particulate media during 1990. Iodine-131 was not detected in the 621 charcoal filters analyzed during 1990.

A precipitation sample was collected monthly during 1990 and analyzed for gross beta activity. All the gross beta activities were comparable to those measured in previous years. During the preoperational period the average gross beta activity was 0.92 pCi/liter. Semi-annual composites were analyzed for gamma emitting isotopes and tritium. All gamma emitters were below their detection limits. Tritium was not observed above the LLD during 1990. During the preoperational period the average tritium activity was 165 pCi/liter.

Waterborne Exposure Pathway

No man-made or natural isotopes were monitored in the surface water of Lake Anna except tritium. The average tritium activity in 1990 at the waste heat treatment facility was 3900 pCi/liter which is 19.5% of the reporting level for a water sample. In 1989 the tritium level was 3900 pCi/liter. The preoperational level was 150 pCi/liter and has been rising since 1977. The tritium level upstream of the site was 3200 pCi/liter as compared with 2850 pCi/liter in 1989.

Tritium concentrations for surface water samples collected by the Commonwealth of Virginia from the waste heat treatment facility in 1990 were 2230 pCi/liter, compared to 4500 pCi/liter in 1989. The upstream location in 1990 had a tritium concentrations of 1098 pCi/liter, compared to 150 pCi/liter for 1989. No gamma emitting isotopes were detected.

River water collected from the North Anna River, 5.8 miles downstream of the site had an average tritium level of 3783 pCi/liter. The average tritium in 1989 had been 3783 pCi/liter. No gamma emitters were detected.

Ground water from the environmental well on site contained no gamma emitters. There was only one detection of tritium in ground/well water at 210 pCi/liter which is a low environmental level.

Aquatic Pathway

Sediment/silt samples provide a sensitive indicator of discharges from nuclear power stations. The sediment from North Anna environmental samples indicated that two man-made isotopes were present. Cesium-137 was detected in all six samples at three locations. During the preoperational period, cesium-137 was measured in samples of aquatic sediment; however, additional man-made isotopes appear to have accumulated. Cesium-134 was monitored in two samples. Sediment contamination does not provide a direct dose pathway to man.

The samples of shoreline soil monitored downstream of the site contained no cesium-134. Cesium-137 was measured at an average of 74.6 pCi/kg as compared to 378 pCi/kg in 1989.

Ingestion Pathway

Iodine-131 was not detected in any of the twenty-four milk samples using the radiochemical separation method. Although cesium-137 has been detected occasionally in previous years and attributed to past atmospheric nuclear weapons testing there were no detections during 1990. Strontium-90 was measured in seven of the eight milk samples. The values were comparable to the levels in 1989 and somewhat lower than preoperational years. Strontium-90 from those years is attributed to past atmospheric nuclear weapons testing. No strontium-89 was detected in any of the milk samples. Naturally occurring potassium-40 was measured in all the milk samples at normal environmental levels.

Activity in fish and vegetation samples along with milk does present a direct dose pathway to man. Fish samples in 1990 showed the presence of the man-made isotopes cesium-134 and cesium-137. These isotopes were at an activity level somewhat higher than preoperational levels but statistically similar to levels in 1987, 1988 and 1989. Only cesium-137 was measured in preoperational environmental fish samples. Due to primary and secondary steam generator problems experienced at North Anna during 1984/1985, a build up in activity levels both in

effluents and fish did occur. Repairs to the steam generators and better liquid waste processing have reduced these activity levels in effluents and thus decreased activity levels are now being observed in the fish. The average level of activity in 1990 of cesium-134 was 1.8% of the reporting level and cesium-137 was 5.3% of the reporting level.

Vegetation samples contained the man-made isotope cesium-137. The cesium-137 activity levels in 1989 and in preoperational samples were statistically similar to the 1990 level.

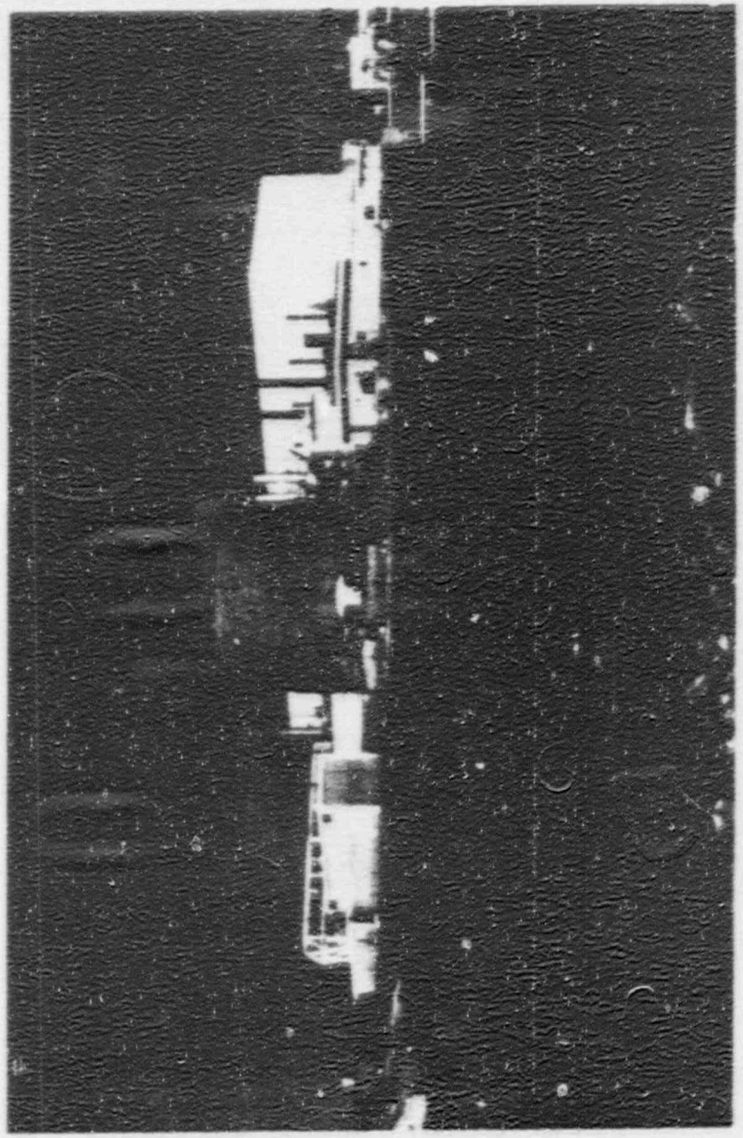
Direct Exposure Pathway

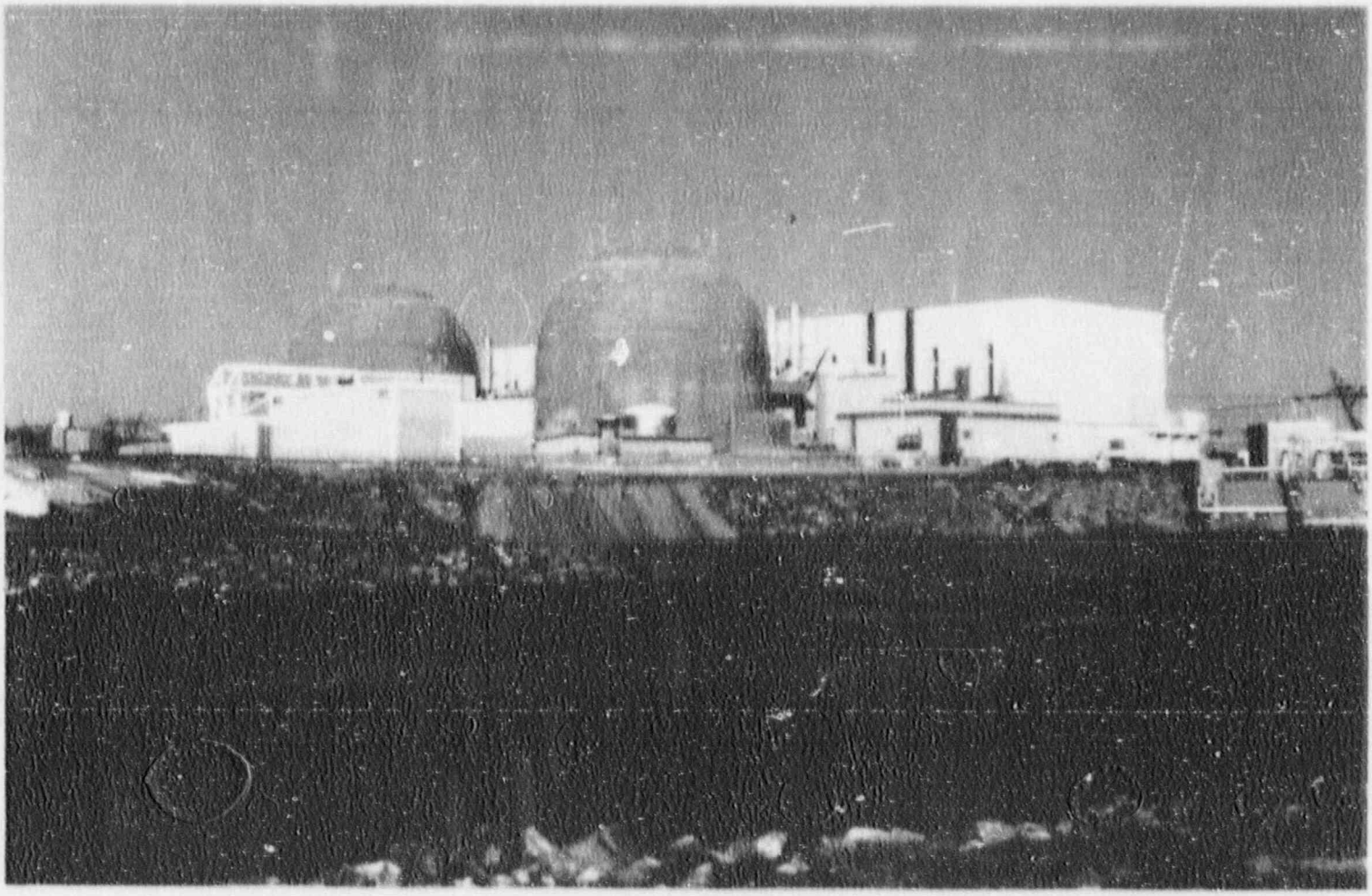
The direct exposure pathway as measured in the environment of the North Anna site by thermoluminescent dosimetry has remained essentially the same since the preoperational period in 1977 at 6 milliroentgens per month or 0.2 milliroentgens per day. The average dose levels monitored have shown a normal fluctuation about these levels which are less than the estimated whole body does due to natural terrestrial and cosmic radiation and the internal dosage from natural radionuclides.

Program Conclusions

The results were as expected for normal environmental samples. Naturally occurring activity was observed in sample media in the expected activity ranges. Occasional samples of nearly all media showed the presence of man-made isotopes. These have been discussed individually in the text. Observed activities were at very low concentrations and had no significant dose consequence.

As a method of referencing the measured radionuclide concentrations in sample media to the dose consequence, the data are compared to the Reporting Level Concentrations given in the ODCM. These concentrations are based upon USNRC Branch Technical Position. Based upon the evidence of the environmental monitoring program the station is operating within regulatory limits. Thus, no unusual radiological characteristics were observed in the environs of the North Anna Nuclear Power Station in 1990.





VII. REFERENCES

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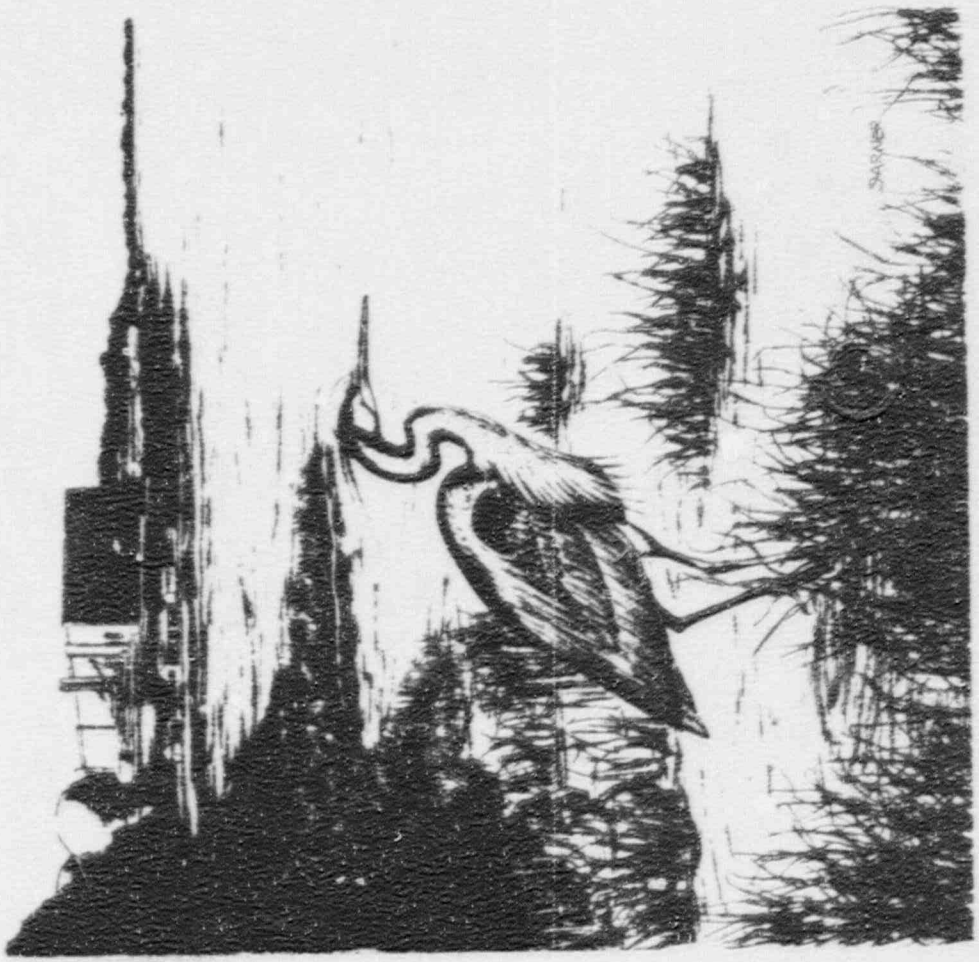
Appendices



Enhancement

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

NORTH ANNA POWER STATION — DOCKET NO. 50-338/339

LOUISA COUNTY, VIRGINIA — JANUARY 1 to DECEMBER 31, 1990

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	ANALYSIS AND TOTAL NUMBER OF ANALYSES PERFORMED		LOWER LIMIT OF DETECTION (LLD) (1)	ALL INDICATOR LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST MEAN NAME DISTANCE AND DIRECTION	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
Air Iodine (pCi/m^3)	I-131	621	0.04	-(0/570)	NA	NA	-(0/51)	0
Airborne Particulates (1E-03 pCi/m^3)	Gross Beta	623	5	20.3(571-571) (4.2-87)	04 5.10 mi WNW	22.8(52/52) (9.6-47)	18.59(52/52) (8.5-35)	0
	Gamma	48						
	Be-7	48	10	67.6(44/44) (31.9-118)	04 5.10 mi WNW	87.8(4/4) (57.3-117)	59.3(4/4) (36.1-95.8)	0
	K-40	48	10	10.2(3/44) (8.65-11.5)	01 0.20 mi NE	11.5(1/4)	-(0/4)	0
	Sr-89	12	3	-(0/11)	NA	NA	-(0/1)	0
	Sr-90	12	0.4	-(0/11)	NA	NA	-(0/1)	0

(1) LLD is lower limit of detection as defined and required in USNRC Branch Technical Position on an Acceptable Radiological Environmental Monitoring Program, Revision 1, November 1979.

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

NORTH ANNA POWER STATION — DOCKET NO. 50-338/339

LOUISA COUNTY, VIRGINIA — JANUARY 1 to DECEMBER 31, 1990

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	ANALYSIS AND TOTAL NUMBER OF ANALYSES PERFORMED	LOWER LIMIT OF DETECTION (LLD) (1)	ALL INDICATOR LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST MEAN NAME DISTANCE AND DIRECTION	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
Precipitation (pCi/liter)	Monthly						
	Gross Beta 12	4	6.41(12/12) (1.9-16)	01A 0.2 mi NE	6.41(12/12) (1.9-16)	NONE	0
	Gamma 2 (Semi-Annually)						
	Be-7 2	70	-(0/2)	NA	NA	NONE	0
	Tritium 2	2000	-(0/2)	NA	NA	NONE	0

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Ground/Well Water (pCi/liter)	Gamma	4						
	K-40	4	60	-(0/4)	N/A	N/A	NONE	0
	Tritium	4	2000	210(1/4)	01A	210(1/4)	NONE	0
River Water (pCi/liter)	Gamma	12						
	K-40	12	200	-(0/12)	N/A	N/A	NONE	0
	Tritium	12	2000	3783(12/12) (3000-4900)	11 5.8 mi SSE	3783(12/12) (3000-4900)	NONE	0

(1) LLD is lower limit of detection as defined and required in USNRC Branch Technical Position on an Acceptable Radiological Environmental Monitoring Program, Revision 1, November 1979.

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

NORTH ANNA POWER STATION — DOCKET NO. 50-338/339

LOUISA COUNTY, VIRGINIA — JANUARY 1 to DECEMBER 31, 1990

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	ANALYSIS AND TOTAL NUMBER OF ANALYSES PERFORMED		LOWER LIMIT OF DETECTION (LLD) (1)	ALL INDICATOR LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST MEAN NAME DISTANCE AND DIRECTION	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
Surface Water (pCi/liter) Regular Monthlies	I-131	24	0.5	-(0/12) -	N/A	N/A	-(0/12) -	0
	Gamma	24						
	K-40	24	200	-(0/12) -	N/A	N/A	-(0/12) -	0
	Tritium	8	2000	3900(4/4) (3300-4700)	8 1.1 mi SSE	3900(4/4) (3300-4700)	3200(4/4) (3100-3300)	0
Surface Water (pCi/liter) State Splits	Gamma	24						
	K-40	24	200	73.6(2/24) (60.3-86.8)	W33	73.6(1/12) -	NONE	0
	Tritium	14	2000	2230(13/14) (350-3800)	W33	3200(7/7) (2500-3800)	NONE	0

(1) LLD is lower limit of detection as defined and required in USNRC Branch Technical Position on an Acceptable Radiological Environmental Monitoring Program, Revision 1, November 1979.

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

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LOUISA COUNTY, VIRGINIA — JANUARY 1 to DECEMBER 31, 1990

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Sediment Silt (pCi/kg (dry))	Gamma 6						
	K-40 6	200	10378(4/4) (3760-20100)	11 5.8 mi SSE	16550(2/2) (13000-20100)	3990(1/2) -	0
	Co-60 6	150	84.1(2/4) (63.1-105)	8 1.1 mi SSE	84.1(2/2) (63.1-105)	-(0/2) -	0
	Cs-134 6	150	72.5(1/4) -	8 1.1 mi SSE	72.5(1/2) -	-0/2) -	0
	Cs-137 6	180	179(4/4) (68.5-318)	8 1.1 mi SSE	281(2/2) (244-318)	68.8(2/2) (45.8-91.8)	0
	Ra-226 6	100	1747(3/4) (1280-2100)	11 5.8 mi SSE	1980(2/2) (1860-2100)	862(1/2) -	0
	Th-228 6	30	988(4/4) (316-1520)	11 5.8 mi SSE	1455(2/2) (1390-1520)	538(2/2) (383-693)	0
	Sr-89 (Annually) 3	4.0	-(0/2) -	NA	NA	-(0/1) -	0
	Sr-90 (Annually) 3	0.8	130(1/2) -	9 2.2 mi NW	290(1/2) -	290(1/1) -	0

(1) LLD is lower limit of detection as defined and required in USNRC Branch Technical Position on an Acceptable Radiological Environmental Monitoring Program, Revision 1, November 1979.

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

NORTH ANNA POWER STATION — DOCKET NO. 50-338/339

LOUISA COUNTY, VIRGINIA — JANUARY 1 to DECEMBER 31, 1990

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	ANALYSIS AND TOTAL NUMBER OF ANALYSES PERFORMED		LOWER LIMIT OF DETECTION (LLD) (1)	ALL INDICATOR LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST MEAN NAME DISTANCE AND DIRECTION	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
Shoreline Soil (pCi/kg (dry)	Gamma	2						
	K-40	2	200	9210(1/2) -	9 2.2 mi NW	9210(1/2) -	NONE	0
	Cs-137	2	40	74.6(1/2) -	9 2.2 mi NW	74.6(1/2) -	NONE	0
	Ra-226	2	100	804(1/2) -	9 2.2 mi NW	804(1/2) -	NONE	0
	Th-228	2	30	244(2/2) (192-295)	9 2.2 mi NW	244(2/2) (192-295)	NONE	0
	Sr-89 (Annually)	1	4.0	-(0/2)	NA	NA	NONE	0
	Sr-90 (Annually)	1	0.8	48(1/2) -	9 2.2 mi NW	48(1/2) -	NONE	0

(1) LLD is lower limit of detection as defined and required in USNRC Branch Technical Position on an Acceptable Radiological Environmental Monitoring Program, Revision 1, November 1979.

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

NORTH ANNA POWER STATION — DOCKET NO. 50-338/339

LOUISA COUNTY, VIRGINIA — JANUARY 1 to DECEMBER 31, 1990

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	ANALYSIS AND TOTAL NUMBER OF ANALYSES PERFORMED		LOWER LIMIT OF DETECTION (LLD) (1)	ALL INDICATOR LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST MEAN NAME DISTANCE AND DIRECTION	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
Milk (pCi/liter)	I-131	24	0.5	-(0/24) -	N/A	N/A	NONE	0
	Gamma	24						
	K-40	24	100	1288(24/24) (1150-1540)	12 8.3 mi NW	1292(12/12) (1150-1540)	NONE	0
	Sr-89 (Quarterly)	8	5	-(0/8) -	N/A	N/A	NONE	0
	Sr-90 (Quarterly)	8	0.8	1.45(7/8) (0.58-2.7)	12 8.3 mi NW	1.6(4/4) (1.1-2.7)	NONE	0
Fish PCi/kg (wet)	Gamma	5						
	K-40	5	200	1590(4/4) (1510-1640)	08 1.10 mi SSE	1635(2/2) (1630-1640)	1400(1/1) -	0
	Cs-134	5	40	18.4(2/4) (15.9-20.8)	08 1.10 mi SSE	18.4(2/2) (15.9-20.8)	-(0/1) -	0
	Cs-137	5	40	105(4/4) (27.6-139)	08 1.10 mi SSE	133(2/2) (126-139)	-(0/1) -	0

(1) LLD is lower limit of detection as defined and required in USNRC Branch Technical Position on an Acceptable Radiological Environmental Monitoring Program, Revision 1, November 1979.

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

NORTH ANNA POWER STATION — DOCKET NO. 50-338/339

LOUISA COUNTY, VIRGINIA — JANUARY 1 to DECEMBER 31, 1990

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	ANALYSIS AND TOTAL NUMBER OF ANALYSES PERFORMED	LOWER LIMIT OF DETECTION (LLD) (1)	ALL INDICATOR LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST MEAN NAME DISTANCE AND DIRECTION	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
Direct Radiation (mR/std. month) (Regular TLDs)	Gamma Dose 48	0.2	5.68(44/44) (3.8-8.7)	01 0.2 mi NE	8.0(4/4) (7.4-8.7)	4.2(4/4) (3.7-4.5)	0
Direct Radiation (mR/std. Month) (Annual TLDs)	Gamma Dose 12	0.2	5.31(11/11) (4.0-6.8)	01 0.2 mi NE	6.8(1/1) -	4.4(1/1) -	0
Direct Radiation (mR/std. Month) (Sector TLDs)	Gamma Dose 281	0.2	6.05(249/249) (3.2-9.5)	19/51 0.36 mi SSW	8.56(8/8) (7.9-9.5)	4.74(32/32) (3.2-7.0)	0

(1) LLD is lower limit of detection as defined and required in USNRC Branch Technical Position on an Acceptable Radiological Environmental Monitoring Program, Revision 1, November 1979.

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

NORTH ANNA POWER STATION — DOCKET NO. 50-338/339

LOUISA COUNTY, VIRGINIA — JANUARY 1 to DECEMBER 31, 1990

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	ANALYSIS AND TOTAL NUMBER OF ANALYSES PERFORMED	LOWER LIMIT OF DETECTION (LLD) (1)		ALL INDICATOR LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST MEAN NAME DISTANCE AND DIRECTION	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
Food/Vegetation pCi/kg (wet)	Gamma Dose	40						
	Be-7	40	-	3331(36/40) (290-11400)	16 12.60 mi NW	4877(6/8) (2360-7760)	NONE	0
	K-40	40	-	10915(40/40) (2750-48600)	14 1.70 mi SE	13285(8/8) (5340-23200)	NONE	0
	Cs-137	40	80	71.9(9/40) (13.5-161)	21 1.0 mi WNW	105.7(4/8) (44.8-161)	NONE	0
	Th-228	40	-	243(5/40) (141-450)	16 12.60 mi NW	300(2.8) (150-450)	NONE	0

(1) LLD is lower limit of detection as defined and required in USNRC Branch Technical Position on an Acceptable Radiological Environmental Monitoring Program, Revision 1, November 1979.

APPENDIX B
DATA TABLES

TABLE B-1

(Page 1 of 4)

NORTH ANNA - 1990

CONCENTRATIONS OF IODINE-131 IN FILTERED AIR

pCi/m^3 ± 2 Sigma

1990 COLLECTION DATE	01	02	03	04	05	05A	06	07	21	22	23	24
JANUARY												
01/03-01/10	<.02	<.01	<.02	<.02	<.01	<.02	<.02	<.03	<.02	<.02	<.02	<.02
01/10-01/17	<.02	<.02	<.02	<.02	<.02	<.02	<.01	<.02	<.02	<.02	<.02	<.02
01/17-01/24	<.01	<.02	<.02	<.01	<.02	<.005	<.01	<.02	<.007	<.01	<.007	<.008
01/24-01/30	(a)	<.008	<.008	<.005	<.004	<.003	<.008	<.005	<.005	<.005	<.006	<.006
FEBRUARY												
01/30-02/07	<.007	<.007	<.006	<.01	<.008	<.005	<.009	<.006	<.005	<.01	<.01	<.02
02/07-02/14	<.02	<.01	<.01	<.03	<.01	<.02	<.01	<.02	<.02	<.02	<.006	<.02
02/14-02/21	<.02	<.01	<.01	<.01	<.01	<.02	<.02	<.01	<.02	<.01	<.006	<.01
02/21-02/28	<.02	<.02	<.01	<.01	<.008	<.01	<.02	<.02	<.01	<.02	<.008	<.01
MARCH												
02/28-03/07	<.01	<.01	<.008	<.008	<.008	<.007	<.007	<.01	<.009	<.01	<.008	<.009
03/07-03/14	<.02	<.03	<.03	<.02	<.02	<.02	<.02	<.02	<.02	<.01	<.02	<.02
03/14-03/21	<.008	<.009	<.009	<.02	<.02	<.01	<200 (b)	<.01	<.007	<.01	<.01	<.01
03/21-03/28	<.005	<.005	<.004	<.007	<.009	<.005	<.004	<.004	<.004	<.004	<.006	<.005
03/28-04/04	<.004	<.004	<.005	<.005	<.004	<.004	<.004	<.004	<.004	<.004	<.004	<.006

(a) Sample lost in analysis: it had a zero yield.
(b) LLD not met due to low sample volume.

TABLE B-1

NORTH ANNA - 1990

CONCENTRATIONS OF IODINE-131 IN FILTERED AIR

$pCi/m^3 \pm 2$ Sigma

1990 COLLECTION DATE	01	02	03	04	05	05A	06	07	21	22	23	24
APRIL												
04/04-04/11	<.02	<.01	<.02	<.02	<.02	<.02	<.01	<.01	<.02	<.01	<.01	<.01
04/11-04/18	<.01	<.01	<.005	<.01	<.01	<.008	<.007	<.006	<.01	<.02	<.008	<.009
04/18-04/25	<.01	<.009	<.009	<.007	<.007	<.007	<.006	<.01	<.005	<.009	<.005	<.007
04/25-05/02	<.005	<.009	<.007	<.004	<.006	<.004	<.008	<.005	<.004	<.005	<.003	<.003
MAY												
05/02-05/09	<.01	<.008	<.02	<.008	<.02	<.009	<.008	<.02	<.01	<.007	<.008	<.008
05/09-05/16	<.006	<.01	<.005	<.01	<.005	<.005	<.005	<.01	<.01	<.005	<.006	<.006
05/16-05/23	<.007	<.009	<.008	<.01	<.01	<.01	<.006	<.01	<.009	<.007	<.009	<.006
05/23-05/30	<.007	<.02	<.004	<.01	<.006	<.003	<.003	<.008	<.004	<.003	<.007	<.005
JUNE												
05/30-06/06	<.004	<.002	<.002	<.003	<.002	<.001	<.003	<.002	<.003	<.003	<.002	<.003
06/06-06/13	<.009	<.008	<.008	<.007	<.02	<.006	<.007	<.007	<.008	<.008	<.01	<.008
06/13-06/20	<.008	<.008	<.008	<.008	<.01	<.006	<.008	<.009	<.008	<.009	<.01	<.007
06/20-06/27	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.02	<.01	<.01	<.01	<.01
06/27-07/03	<.006	<.02	<.01	<.02	<.02	<.02 (a)	<.02	<.02	<.01	<.01	<.01	<.02

(a) Sample not in original shipment; received 07/17/90.

TABLE B-1

(Page 3 of 4)

NORTH ANNA - 1990

CONCENTRATIONS OF IODINE-131 IN FILTERED AIR

$pCi/m^3 \pm 2$ Sigma

1990 COLLECTION DATE	01	02	03	04	05	05A	06	07	21	22	23	24
JULY												
07/03-07/11	<.03	<.006	<.009	<.008	<.01	<.02	<.008	<.01	<.01	<.02	<.02	<.02
07/11-07/18	<.005	<.007	<.009	<.006	<.009	<.008	<.006	<.006	<.008	<.008	<.006	<.006
07/18-07/26	<.002	<.002	<.009	<.009	<.008	<.008	<.009	<.008	<.005	<.008	<.009	<.004
07/26-08/01	<.007	<.008	<.007	<.008	<.008	<.007	<.01	<.02	<.01	<.02	<.009	<.008
AUGUST												
08/01-08/08	<.008	<.006	<.006	<.01	<.009	<.004	<.007	<.009	<.009	<.009	<.009	<.009
08/08-08/15	<.003	<.005	<.004	<.005	<.006	<.006	<.005	<.005	<.005	<.006	<.006	<.007
08/15-08/22	<.01	<.01	<.009	<.01	<.009	<.01	<.009	<.01	<.01	<.01	<.01	<.009
08/22-08/29	<.01	<.007	<.03	<.01	< 4 (a)	<.01	<.01	< 2 (a)	<.008	< 2 (a)	<.007	<.008
SEPTEMBER												
08/29-09/05	<.02	<.009	<.01	<.01	<.01	(b)	<.01	<.005	<.005	<.005	<.006	<.009
09/05-09/12	<.01	<.02	<.01	<.01	<.01	<.02	<.01	<.01	<.01	<.01	<.02	<.03
09/12-09/19	<.009	<.009	<.01	<.01	<.007	<.01	<.008	<.01	<.01	<.01	<.01	<.008
09/19-09/26	<.009	<.008	<.008	<.008	<.007	<.006	<.007	<.006	<.007	< 007	<.008	<.008
09/26-10/03	<.01	<.006	<.01	<.02	<.01	<.009	<.01	<.01	<.006	<.005	<.005	<.005

(a) Equipment malfunction; result in total pCi.
(b) Sampler malfunction; sample not collected.

TABLE B-1

(Page 4 of 4)

NORTH ANNA - 1990

CONCENTRATIONS OF IODINE-131 IN FILTERED AIR

$pCi/m^3 \pm 2$ Sigma

1990 COLLECTION DATE	01	02	03	04	05	05A	06	07	21	22	23	24
OCTOBER												
10/03-10/10	<.003	<.004	<.004	<.003	<.003	<.003	<.004	<.006	<.005	<.004	<.004	<.004
10/10-10/17	<.005	<.006	<.006	<.006	<.005	<.005	<.005	<.006	<.006	<.005	<.005	(a)
10/17-10/24	<.008	<.008	<.01	<.008	<.008	<.009	<.005	<.005	<.004	<.005	<.005	<.004
10/24-10/31	<.004	<.007	<.007	<.006	<.01	<.007	<.007	<.009	<.008	<.008	<.004	<.009
NOVEMBER												
10/31-11/07	<.02	<.02	<.02	<.008	<.009	<.02	<.006	<.007	<.006	<.004	<.007	<.02
11/07-11/14	<.005	<.007	<.002	<.006	<.01	<.007	<.007	<.006	<.007	<.009	<.007	<.007
11/14-11/21	<.01	<.01	<.02	<.02	<.01	<.02	<.02	<.02	<.02	<.02	<.01	<.02
11/21-11/28	<.02	<.02	<.02	<.02	<.01	<.01	<.01	<.02	<.02	<.02	<.02	<.02
DECEMBER												
11/28-12/05	<.01	<.009	<.008	<.008	<.01	<.01	<.01	<.01	<.009	<.01	<.01	<.01
12/05-12/12	<.02	<.007	<.005 (b)	<.007	<.007	<.006	<.009	<.008	<.01	<.007	<.01	<.01
12/12-12/19	<.003	<.004	<.003	<.003	<.004	<.003	<.004	<.004 (c)	<.004	<.003 (c)	<.005	<.003 (c)
12/19-12/26	<.01	<.05	<.003	<.01	<.005	<.008	<.006	<.006	<.006	<.006	<.006	<.007
12/26-01/02	<.009	<.01	<.01	<.02	<.009	<.008	<.007	<.01	<.02	<.01	<.01	<.01

(a) Sample lost during one step of the chemical separation and could not be recovered.
(b) Original sample had low volume due to low air flow. Substitute sample sent and received at laboratory on 12/28/90.
(c) Sampler malfunctioned. Volume was estimated from sample start and stop times.

TABLE B-2

(Page 1 of 4)

NORTH ANNA - 1990

CONCENTRATIONS OF GROSS BETA IN AIR PARTICULATES

10^{-3} pCi/m^3 ± 2 Sigma

COLLECTION DATE	1990 01	02	03	04	05	05A	06	07	21	22	23	24	AVERAGE ± 2 s.d.
JANUARY													
01/03-01/10	29 ± 6	20 ± 5	21 ± 5	12 ± 4	11 ± 3	12 ± 3	25 ± 4	100 ± 2 (a)	9.7 ± 3.9	31 ± 5	18 ± 4	25 ± 5	19 ± 15
01/10-01/17	26 ± 6	21 ± 5	14 ± 4	28 ± 5	16 ± 4	12 ± 3	25 ± 5	28 ± 7	11 ± 4	23 ± 5	18 ± 4	15 ± 4	20 ± 12
01/17-01/24	26 ± 5	19 ± 4	14 ± 4	35 ± 6	32 ± 7	6.3 ± 2.6	51 ± 8	20 ± 5	8.5 ± 3.8	32 ± 5	15 ± 4	26 ± 5	24 ± 25
01/24-01/30	46 ± 7	20 ± 5	21 ± 5	20 ± 5	18 ± 5	13 ± 3	30 ± 6	20 ± 5	22 ± 5	24 ± 5	25 ± 5	15 ± 5	23 ± 17
FEBRUARY													
01/30-02/07	15 ± 4	20 ± 4	16 ± 4	16 ± 4	18 ± 4	64 ± 27	19 ± 4	16 ± 4	20 ± 4	21 ± 4	17 ± 3	11 ± 4	21 ± 28
02/07-02/14	28 ± 6	20 ± 4	13 ± 4	20 ± 5	22 ± 4	27 ± 5	20 ± 4	25 ± 6	28 ± 5	25 ± 5	22 ± 3	25 ± 6	23 ± 9
02/14-02/21	87 ± 9	21 ± 5	15 ± 4	26 ± 5	23 ± 5	23 ± 5	28 ± 6	20 ± 5	23 ± 5	23 ± 5	22 ± 4	25 ± 6	28 ± 38
02/21-02/28	15 ± 4	52 ± 9	27 ± 5	26 ± 5	18 ± 4	24 ± 5	48 ± 9	29 ± 5	24 ± 5	24 ± 4	15 ± 4	21 ± 5	27 ± 23
MARCH													
02/28-03/07	35 ± 6	25 ± 5	20 ± 5	43 ± 6	39 ± 6	26 ± 5	36 ± 6	31 ± 6	37 ± 6	39 ± 6	30 ± 5	26 ± 6	32 ± 14
03/07-03/14	29 ± 6	19 ± 4	20 ± 4	28 ± 5	19 ± 4	18 ± 5	28 ± 5	32 ± 6	31 ± 5	24 ± 5	29 ± 5	22 ± 5	25 ± 10
03/14-03/21	17 ± 4	14 ± 4	14 ± 4	20 ± 5	15 ± 4	14 ± 4	260 ± 80 (a)	20 ± 5	15 ± 4	21 ± 5	17 ± 4	17 ± 4	17 ± 5
03/21-03/28	18 ± 3	15 ± 3	17 ± 3	24 ± 4	17 ± 3	12 ± 3	16 ± 3	20 ± 3	18 ± 3	19 ± 3	24 ± 4	17 ± 3	18 ± 7
03/28-04/04	11 ± 3	15 ± 3	12 ± 3	9.6 ± 2.8	9.0 ± 2.7	7.5 ± 2.6	13 ± 3	13 ± 3	11 ± 3	14 ± 3	11 ± 3	27 ± 4	13 ± 10
Average ± 2 s.d.	**29 ± 40**	**22 ± 19**	**17 ± 9**	**24 ± 18**	**20 ± 16**	**20 ± 30**	**28 ± 24**	**23 ± 12**	**20 ± 18**	**25 ± 13**	**20 ± 11**	**21 ± 11**	**22 ± 7**

(a) Elevated result due to low sample volume; not included in averages.

TABLE B-2

(Page 2 of 4)

NORTH ANNA - 1990

CONCENTRATIONS OF GROSS BETA IN AIR PARTICULATES

10^{-3} pCi/m^3 ± 2 Sigma

COLLECTION DATE	1990 01	02	03	04	05	05A	06	07	21	22	23	24	AVERAGE ± 2 s.d.
APRIL													
04/04-04/11	17 ± 3	11 ± 3	17 ± 3	22 ± 3	14 ± 3	11 ± 3	12 ± 3	15 ± 3	21 ± 3	24 ± 4	22 ± 3	17 ± 3	17 ± 9
04/11-04/18	20 ± 3	16 ± 3	16 ± 3	18 ± 3	19 ± 3	16 ± 3	19 ± 3	20 ± 4	24 ± 4	18 ± 3	5.4 ± 2.6	8.5 ± 2.8	17 ± 10
04/18-04/25	19 ± 4	18 ± 3	22 ± 4	21 ± 4	18 ± 3	19 ± 4	20 ± 4	23 ± 4	27 ± 4	23 ± 4	25 ± 4	12 ± 3	21 ± 8
04/25-05/02	14 ± 3	12 ± 3	16 ± 3	27 ± 4	14 ± 3	17 ± 4	15 ± 3	23 ± 4	26 ± 4	19 ± 4	25 ± 4	15 ± 3	19 ± 11
MAY													
05/02-05/09	19 ± 4	12 ± 3	13 ± 3	25 ± 4	15 ± 3	15 ± 3	14 ± 3	21 ± 4	36 ± 6	21 ± 4	20 ± 4	16 ± 3	19 ± 13
05/09-05/16	15 ± 3	9.4 ± 2.8	11 ± 3	16 ± 3	10 ± 3	11 ± 3	11 ± 3	18 ± 3	20 ± 3	18 ± 3	15 ± 3	13 ± 3	14 ± 7
05/16-05/23	17 ± 3	17 ± 3	15 ± 3	14 ± 3	17 ± 3	14 ± 3	16 ± 3	20 ± 4	18 ± 3	13 ± 3	20 ± 3	22 ± 4	17 ± 6
05/23-05/30	8.5 ± 3.0	12 ± 3	11 ± 3	9.7 ± 3.1	17 ± 4	10 ± 3	8.8 ± 3.1	12 ± 3	10 ± 3	17 ± 4	8.1 ± 3.0	8.5 ± 3.0	11 ± 6
JUNE													
05/30-06/06	11 ± 3	12 ± 3	14 ± 3	16 ± 3	12 ± 3	13 ± 3	15 ± 3	12 ± 3	14 ± 3	15 ± 3	15 ± 4	13 ± 3	14 ± 3
06/06-06/13	17 ± 3	12 ± 3	11 ± 3	11 ± 3	13 ± 3	16 ± 3	16 ± 3	13 ± 3	14 ± 3	15 ± 3	17 ± 3	13 ± 3	14 ± 4
06/13-06/20	13 ± 3	7.0 ± 2.7	4.2 ± 2.5	11 ± 3	9.2 ± 2.9	16 ± 3	11 ± 3	9.1 ± 2.9	9.0 ± 2.9	14 ± 3	12 ± 3	11 ± 3	11 ± 6
06/20-06/27	19 ± 3	16 ± 3	21 ± 4	22 ± 4	21 ± 3	15 ± 3	19 ± 3	19 ± 3	12 ± 3	17 ± 3	18 ± 3	16 ± 3	18 ± 5
06/27-07/03	450 ± 160(a)	27 ± 4	26 ± 4	28 ± 4	22 ± 4	25 ± 5 (b)	26 ± 4	24 ± 4	22 ± 4	19 ± 4	26 ± 4	18 ± 4	24 ± 7
Average ± 2 s.d.	**16 ± 7**	**14 ± 10**	**15 ± 11**	**19 ± 12**	**15 ± 8**	**15 ± 8**	**16 ± 9**	**18 ± 10**	**19 ± 15**	**18 ± 7**	**18 ± 13**	**14 ± 7**	**16 ± 4**

(a) Elevated result due to low sample volume; not included in aveage.
(b) Sampler malfunction. Sample not in original shipment; received 07/17/90.

TABLE B-2

(Page 3 of 4)

NORTH ANNA - 1990

CONCENTRATIONS OF GROSS BETA IN AIR PARTICULATES

10^{-3} pCi/m^3 ± 2 Sigma

COLLECTION DATE	1990 01	02	03	04	05	05A	06	07	21	22	23	24	AVERAGE ± 2 s.d.
JULY													
07/03-07/11	26 ± 3	26 ± 4	26 ± 4	21 ± 3	17 ± 3	16 ± 3	20 ± 3	20 ± 3	20 ± 3	17 ± 3	23 ± 3	16 ± 3	20 ± 7
07/11-07/18	12 ± 3	14 ± 3	19 ± 4	18 ± 4	7.2 ± 2.8	14 ± 3	14 ± 3	15 ± 3	15 ± 3	14 ± 3	18 ± 3	18 ± 4	15 ± 7
07/18-07/26	25 ± 4	11 ± 3	21 ± 3	19 ± 3	18 ± 3	15 ± 3	18 ± 3	19 ± 3	15 ± 3	16 ± 3	18 ± 3	20 ± 3	18 ± 7
07/26-08/01	17 ± 4	18 ± 4	20 ± 4	19 ± 4	16 ± 3	12 ± 3	21 ± 4	19 ± 4	16 ± 4	13 ± 3	18 ± 4	18 ± 4	17 ± 5
AUGUST													
08/01-08/08	22 ± 4	16 ± 3	22 ± 4	21 ± 4	22 ± 4	9.1 ± 2.9	18 ± 3	16 ± 3	18 ± 3	17 ± 3	20 ± 4	16 ± 3	18 ± 8
08/08-08/15	15 ± 3	16 ± 3	24 ± 4	26 ± 4	21 ± 4	9.0 ± 2.9	19 ± 4	17 ± 3	18 ± 4	21 ± 4	21 ± 4	13 ± 3	18 ± 10
08/15-08/22	17 ± 3	19 ± 3	23 ± 4	22 ± 4	18 ± 3	6.5 ± 2.7	20 ± 4	8.5 ± 2.9	16 ± 3	18 ± 3	25 ± 4	16 ± 3	17 ± 11
08/22-08/29	23 ± 4	14 ± 4	22 ± 4	25 ± 4	1.4 ± 0.6 (a)	12 ± 3	14 ± 4 (b)	2.3 ± 0.7 (a)	13 ± 3	1.5 ± 0.6 (a)	18 ± 4	16 ± 4	17 ± 10
SEPTEMBER													
08/29-09/05	26 ± 4	23 ± 4	32 ± 4	28 ± 4	23 ± 4	(c)	24 ± 4	24 ± 4	30 ± 4	20 ± 4	36 ± 5	21 ± 4	26 ± 10
09/05-09/12	33 ± 4	14 ± 3	31 ± 4	37 ± 4	23 ± 4	37 ± 4	29 ± 4	22 ± 4	34 ± 4	22 ± 4	34 ± 4	26 ± 4	29 ± 14
09/12-09/19	21 ± 4	17 ± 4	20 ± 4	23 ± 4	30 ± 4	24 ± 4	21 ± 4	14 ± 4	23 ± 4	15 ± 4	21 ± 4	17 ± 4	21 ± 9
09/19-09/26	25 ± 4	19 ± 3	25 ± 4	29 ± 4	19 ± 3	24 ± 4	17 ± 3	13 ± 3	22 ± 4	21 ± 4	24 ± 4	23 ± 4	22 ± 9
09/26-10/03	37 ± 4	26 ± 4	35 ± 4	44 ± 5	32 ± 4	42 ± 5	25 ± 4	20 ± 4	39 ± 4	28 ± 4	40 ± 4	35 ± 4	34 ± 15
Average ± 2 s.d.	**23 ± 14**	**18 ± 9**	**25 ± 10**	**26 ± 15**	**21 ± 13**	**18 ± 23**	**20 ± 8**	**17 ± 9**	**21 ± 16**	**19 ± 8**	**24 ± 15**	**20 ± 12**	**21 ± 6**

(a) Sampler malfunction; results in total pCi and not included in averages.
(b) Timer inoperable; volume low.
(c) Sampler malfunction; sample not collected.

TABLE B-2

(Page 4 of 4)

NORTH ANNA - 1990

CONCENTRATIONS OF GROSS BETA IN AIR PARTICULATES

10^{-3} pCi/m^3 ± 2 Sigma

COLLECTION DATE	1990 01	02	03	04	05	05A	06	07	21	22	23	24	AVERAGE ± 2 s.d.
OCTOBER													
10/03-10/10	21 ± 4	8.7 ± 2.8	26 ± 4	30 ± 4	17 ± 3	22 ± 4	15 ± 3	25 ± 4	24 ± 4	20 ± 4	27 ± 4	18 ± 3	21 ± 12
10/10-10/17	16 ± 3	12 ± 3	15 ± 3	17 ± 3	17 ± 3	17 ± 3	13 ± 3	12 ± 3	19 ± 3	12 ± 3	19 ± 3	13 ± 3	15 ± 5
10/17-10/24	17 ± 3	13 ± 3	16 ± 3	21 ± 3	13 ± 3	14 ± 3	13 ± 3	13 ± 3	18 ± 3	14 ± 3	20 ± 3	11 ± 3	15 ± 6
10/24-10/31	24 ± 4	19 ± 4	20 ± 4	23 ± 4	20 ± 4	18 ± 4	19 ± 4	20 ± 4	20 ± 4	21 ± 4	24 ± 4	22 ± 4	21 ± 4
NOVEMPER													
10/31-11/07	39 ± 5	6.8 ± 2.7	47 ± 5	47 ± 5	38 ± 5	42 ± 5	36 ± 4	33 ± 4	36 ± 4	36 ± 4	45 ± 5	31 ± 4	36 ± 21
11/07-11/14	23 ± 4	20 ± 3	25 ± 4	25 ± 4	27 ± 4	21 ± 4	15 ± 3	18 ± 3	15 ± 3	25 ± 4	18 ± 3	21 ± 4	21 ± 8
11/14-11/21	30 ± 4	22 ± 4	35 ± 4	30 ± 4	26 ± 4	27 ± 4	23 ± 4	26 ± 4	28 ± 4	32 ± 4	27 ± 4	24 ± 4	28 ± 8
11/21-11/28	28 ± 4	26 ± 4	22 ± 4	27 ± 4	38 ± 6	28 ± 4	22 ± 4	24 ± 4	27 ± 4	23 ± 4	31 ± 4	29 ± 4	27 ± 9
DECEMBER													
11/28-12/05	23 ± 4	15 ± 3	20 ± 4	17 ± 4	21 ± 4	23 ± 4	24 ± 4	13 ± 3	12 ± 3	6.2 ± 2.9	12 ± 3	13 ± 3	17 ± 11
12/05-12/12	6.8 ± 0.9	21 ± 4	24 ± 4	24 ± 4	30 ± 4	27 ± 4	32 ± 4	22 ± 4	22 ± 4	15 ± 3	23 ± 4	26 ± 4	23 ± 13
12/12-12/19	13 ± 3	8.7 ± 2.8	19 ± 3	18 ± 3	29 ± 4	31 ± 4	25 ± 4	16 ± 3	14 ± 3	10 ± 3	12 ± 3	21 ± 4	18 ± 15
12/19-12/26	16 ± 3	7.7 ± 2.9	14 ± 3	9.9 ± 3.0	24 ±	22 ± 4	17 ± 4	12 ± 3	13 ± 3	6.1 ± 2.8	18 ± 4	16 ± 3	15 ± 11
12/26-01/02	14 ± 3	14 ± 3	17 ± 3	16 ± 3	23 ± 4	24 ± 4	19 ± 3	17 ± 3	18 ± 3	22 ± 4	19 ± 4	17 ± 3	18 ± 7
Quarter Avg. ± 2 s.d.	**21 ± 17**	**15 ± 12**	**23 ± 18**	**23 ± 18**	**25 ± 15**	**24 ± 14**	**21 ± 14**	**19 ± 13**	**20 ± 14**	**19 ± 18**	**23 ± 17**	**20 ± 12**	**21 ± 5**
Annual Avg. ± 2 s.d.	**22 ± 24**	**17 ± 14**	**20 ± 15**	**23 ± 17**	**20 ± 15**	**19 ± 21**	**21 ± 17**	**19 ± 12**	**20 ± 15**	**20 ± 13**	**21 ± 15**	**19 ± 12**	**20 ± 3**

TABLE B-3

(Page 1 of 3)

NORTH ANNA - 1990

CONCENTRATIONS OF STRONTIUM 89/90 AND GAMMA EMITTERS* IN AIR PARTICULATES

10^{-3} pCi/m^3 ± 2 Sigma

STATION	NUCLIDE	FIRST QUARTER 01/03-04/04	SECOND QUARTER 04/04-07/03	THIRD QUARTER 07/03-10/03	FOURTH QUARTER 10/03-01/02	AVERAGE ± 2 s.d.
STA-01	Sr-89	(a)	< 2	(a)	(a)	
	Sr-90	(a)	< 0.2	(a)	(a)	
	Be-7	51.9 ± 12.7	32.8 ± 7.1	48.2 ± 7.8	75.2 ± 14.9	52.0 ± 3.5
	K-40	< 20	< 10	< 30	11.5 ± 5.9	11.5 ± 5.9
	Co-60	< 1	< 0.8	< 0.9	< 1	-
	Ru-103	< 2	< 0.8	< 1	< 2	-
	Cs-134	< 1	< 0.7	< 0.9	< 0.9	-
	Cs-137	< 1	< 0.7	< 0.8	< 0.8	-
	Th-228	< 2	< 1	< 1	< 1	-
STA-02	Sr-89	(a)	< 2	(a)	(a)	
	Sr-90	(a)	< 0.2	(a)	(a)	
	Be-7	31.9 ± 10.6	45.2 ± 6.3	81.5 ± 13.2	52.7 ± 15.3	52.8 ± 41.9
	K-40	< 20	< 10	< 10	< 20	-
	Co-60	< 1	< 0.7	< 0.7	< 1	-
	Ru-103	< 2	< 0.7	< 2	< 2	-
	Cs-134	< 1	< 0.5	< 0.7	< 0.9	-
	Cs-137	< 1	< 0.6	< 0.6	< 0.8	-
	Th-228	< 2	< 1	< 1	< 1	-
STA-03	Sr-89	(a)	< 1	(a)	(a)	
	Sr-90	(a)	< 0.3	(a)	(a)	
	Be-7	36.8 ± 10.4	41.1 ± 6.4	118 ± 15	94.3 ± 14.8	72.6 ± 80.0
	K-40	< 20	< 10	< 10	< 20	-
	Co-60	< 1	< 0.8	< 0.7	< 0.9	-
	Ru-103	< 2	< 0.8	< 2	< 2	-
	Cs-134	< 1	< 0.8	< 0.7	< 0.8	-
	Cs-137	< 1	< 0.7	< 0.7	< 0.8	-
	Th-228	< 2	< 1	< 1	< 1	-
STA-04	Sr-89	(a)	< 1	(a)	(a)	
	Sr-90	(a)	< 0.2	(a)	(a)	
	Be-7	67.9 ± 10.9	57.3 ± 7.4	117 ± 14	109 ± 13	87.8 ± 59.2
	K-40	< 20	< 20	< 10	< 9	-
	Co-60	< 0.9	< 0.7	< 0.6	< 0.7	-
	Ru-103	< 1	< 0.8	< 2	< 2	-
	Cs-134	< 0.9	< 0.7	< 0.6	< 0.6	-
	Cs-137	< 0.9	< 0.7	< 0.6	< 0.6	-
	Th-228	< 1	< 1	< 1	< 0.9	-

* All other gamma emitters were <LLD.

(a) Strontium-89/90 analyses performed sanually.

TABLE B-3

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NORTH ANNA - 1990

CONCENTRATIONS OF STRONTIUM 89/90 AND GAMMA EMITTERS* IN AIR PARTICULATES

10^{-3} pCi/m^3 ± 2 Sigma

STATION	NUCLIDE	FIRST QUARTER 01/03-04/04	SECOND QUARTER 04/04-07/03	THIRD QUARTER 07/03-10/03	FOURTH QUARTER 10/03-01/02	AVERAGE ± 2 s.d.
STA-05	Sr-89	(a)	< 1	(a)	(a)	
	Sr-90	(a)	< 0.3	(a)	(a)	
	Be-7	51.0 ± 10.3	41.8 ± 6.5	73.3 ± 12.0	111 ± 19	69.3 ± 61.6
	K-40	< 20	< 10	< 9	< 40	-
	Co-60	< 0.9	< 0.5	< 0.6	< 1	-
	Ru-103	< 1	< 0.5	< 1	< 3	-
	Cs-134	< 1	< 0.5	< 0.5	< 1	-
	Cs-137	< 0.9	< 0.5	< 0.5	< 1	-
	Th-228	< 1	< 0.8	< 0.7	< 2	-
STA-05A	Sr-89	(a)	< 2	(a)	(a)	
	Sr-90	(a)	< 0.2	(a)	(a)	
	Be-7	37.2 ± 8.5	56.7 ± 8.2	87.1 ± 13.9	90.2 ± 14.4	67.8 ± 50.8
	K-40	< 20	< 40	8.65 ± 4.17	< 10	8.65 ± 4.17
	Co-60	< 0.7	< 1	< 0.7	< 0.9	-
	Ru-103	< 1	< 1	< 2	< 2	-
	Cs-134	< 0.8	< 0.9	< 0.5	< 0.7	-
	Cs-137	< 0.7	< 0.9	< 0.5	< 0.6	-
	Th-228	< 1	< 1	< 0.9	< 1	-
STA-06	Sr-89	(a)	< 1	(a)	(a)	
	Sr-90	(a)	< 0.2	(a)	(a)	
	Be-7	67.9 ± 14.8	46.9 ± 6.9	65.5 ± 17.8	87.7 ± 15.1	67.0 ± 33.4
	K-40	< 30	10.3 ± 5.4	< 40	< 10	10.3 ± 5.4
	Co-60	< 1	< 0.6	< 1	< 0.7	-
	Ru-103	< 2	< 0.7	< 3	< 2	-
	Cs-134	< 1	< 0.6	< 1	< 0.6	-
	Cs-137	< 1	< 0.6	< 1	< 0.8	-
	Th-228	< 2	< 0.9	< 1	< 1	-
STA-07	Sr-89	(a)	< 2	(a)	(a)	
	Sr-90	(a)	< 0.2	(a)	(a)	
	Be-7	59.4 ± 14.5	57.0 ± 6.3	67.9 ± 17.3	74.2 ± 15.3	64.6 ± 15.8
	K-40	< 50	< 10	< 20	< 30	-
	Co-60	< 1	< 0.7	< 0.9	< 1	-
	Ru-103	< 2	< 0.6	< 2	< 2	-
	Cs-134	< 2	< 0.5	< 0.8	< 0.9	-
	Cs-137	< 1	< 0.5	< 0.9	< 0.9	-
	Th-228	< 2	< 0.8	< 1	< 1	-

* All other gamma emitters were <LLD.

(a) Strontium-89/90 analyses performed annually.

TABLE B-3

(Page 3 of 3)

NORTH ANNA - 1990

CONCENTRATIONS OF STRONTIUM 89/90 AND GAMMA EMITTERS* IN AIR PARTICULATES

10^{-3} pCi/m^3 ± 2 Sigma

STATION	NUCLIDE	FIRST QUARTER 01/03-04/04	SECOND QUARTER 04/04-07/03	THIRD QUARTER 07/03-10/03	FOURTH QUARTER 10/03-01/02	AVERAGE ± 2 s.d.
STA-21	Sr-89	(a)	< 1	(a)	(a)	
	Sr-90	(a)	< 0.2	(a)	(a)	
	Be-7	57.7 ± 12.2	56.5 ± 8.3	59.1 ± 12.2	79.4 ± 16.9	63.2 ± 21.7
	K-40	< 20	< 20	< 7	< 10	-
	Co-60	< 1	< 0.8	< 0.5	< 0.7	-
	Ru-103	< 1	< 0.8	< 1	< 2	-
	Cs-134	< 1	< 0.6	< 0.4	< 0.6	-
	Cs-137	< 1	< 0.7	< 0.4	< 0.5	-
	Th-228	< 2	< 1	< 0.6	< 1	-
STA-22	Sr-89	(a)	< 4	(a)	(a)	
	Sr-90	(a)	< 0.6	(a)	(a)	
	Be-7	58.9 ± 12.2	62.3 ± 8.2	77.0 ± 17.4	65.5 ± 13.4	65.9 ± 15.7
	K-40	< 20	< 10	< 20	< 10	-
	Co-60	< 2	< 0.8	< 1	< 0.6	-
	Ru-103	< 2	< 0.7	< 2	< 1	-
	Cs-134	< 1	< 0.8	< 0.9	< 0.5	-
	Cs-137	< 1	< 0.8	< 0.8	< 0.5	-
	Th-228	< 2	< 1	< 1	< 0.7	-
STA-23	Sr-89	(a)	< 2	(a)	(a)	
	Sr-90	(a)	< 0.2	(a)	(a)	
	Be-7	58.2 ± 11.5	53.5 ± 8.1	97.0 ± 14.4	105 ± 20	78.4 ± 52.7
	K-40	< 20	< 30	< 20	< 10	-
	Co-60	< 0.9	< 0.9	< 0.7	< 0.5	-
	Ru-103	< 1	< 0.9	< 2	< 2	-
	Cs-134	< 1	< 0.9	< 0.8	< 0.6	-
	Cs-137	< 0.9	< 0.8	< 0.7	< 0.6	-
	Th-228	< 1	< 1	< 1	< 1	-
STA-24	Sr-89	(a)	< 2	(a)	(a)	
	Sr-90	(a)	< 0.2	(a)	(a)	
	Be-7	43.0 ± 10.5	36.1 ± 7.1	95.8 ± 12.5	62.2 ± 21.8	59.3 ± 53.5
	K-40	< 20	< 30	< 10	< 30	-
	Co-60	< 0.9	< 0.8	< 0.6	< 1	-
	Ru-103	< 1	< 0.9	< 1	< 3	-
	Cs-134	< 0.8	< 0.8	< 0.5	< 1	-
	Cs-137	< 0.8	< 0.8	< 0.6	< 1	-
	Th-228	< 2	< 1	< 0.9	< 2	-

* All other gamma emitters were <LLD.

(a) Strontium-89/90 analyses performed annually.

TABLE B-4

NORTH ANNA - 1990

CONCENTRATIONS OF GROSS BETA, TRITIUM AND GAMMA EMITTERS* IN PRECIPITATION

pCi/liter ± 2 Sigma

STATION 01A - (ON SITE)

COLLECTION DATES	GROSS BETA	RAINFALL (Inches)
01/02/90-01/30/90	10 ± 1	4.05
01/30/90-02/28/90	5.5 ± 0.8	2.54
03/29/90	4.7 ± 0.8	2.80
03/29/90-05/02/90	12 ± 1	3.47
05/30/90	3.3 ± 0.7	9.67
05/30/90-06/27/90	16 ± 1 (a)	1.25
06/27/90-08/02/90	12 ± 1	0.55
08/01/90-08/29/90	2.7 ± 0.7	2.50
08/29/90-09/26/90	4.1 ± 0.8	0.17
10/31/90	2.5 ± 0.7	3.56
11/01/90-11/28/90	2.2 ± 0.6	2.20
11/28/90-12/31/90	1.9 ± 0.6	3.24
Average ± 2 s.d.	**6.4 ± 9.6**	

SEMI-ANNUAL COMPOSITES OF PRECIPITATION

01/02/90-06/27/90	06/27/90-12/31/90
Be-7 = < 40	Be-7 = < 40
H-3 = < 100	H-3 = < 100

* All other gamma emitters were <LLD.

(a) Confirmed by a recount.

B-5 SOIL

Soil samples are collected every three years from twelve stations. Since the samples were collected in 1989 Table B-5 will not be included in the 1990 report.

TABLE B-6

NORTH ANNA - 1990

CONCENTRATIONS OF STRONTIUM, TRITIUM AND GAMMA EMITTERS* IN GROUND/WELL WATER

pCi/liter ± 2 Sigma

COLLECTION DATES	H-3	Sr-89	Sr-90	Be-7	K-40	I-131	Ba-140	Th-228
STATION 01A								
03/29/90	210 ± 80	(a)	(a)	< 40	< 100	< 10 (b)	< 7	< 8
07/03/90	< 100	< 2	< 0.6	< 40	< 60	< 0.5	< 8	< 7
10/04/90	< 200	(a)	(a)	< 40	< 50	< 0.3	< 10	< 6
12/31/90	< 200	(a)	(a)	< 30	< 50	< 0.2	< 6	< 7
Average ± 2 s.d.	**216 ± 80**							

* All other gamma emitters were < LLD.

(a) Strontium-89/90 analyses performed only on second quarter sample.

(b) The LLD of 1 pCi/l was not attempted by the more sensitive radiochemical method because that analysis was not requested on the Sample Receipt Form.

TABLE B-7

NORTH ANNA - 1990

CONCENTRATIONS OF TRITIUM, STRONTIUM AND GAMMA EMITTERS* IN RIVER WATER

pCi/l ± 2 Sigma

COLLECTION DATES	Sr-89	Sr-90	H-3	Be-7	K-40	I-131	Cs-137	Ba-140	Ra-226	Th-228
STATION - 11										
01/05/90	(a)	(a)	4900 ± 100	< 50	< 100	< 0.4	< 5	< 10	< 90	< 7
02/15/90			4300 ± 100	< 50	< 100	< 0.2	< 5	< 9	< 90	< 8
03/15/90			4800 ± 100	< 20	< 40	< 0.2	< 3	< 4	< 60	< 5
04/12/90	< 2	< 0.5	4600 ± 100	< 40	< 80	< 0.1	< 4	< 10	< 100	< 8
05/16/90	< 3	< 0.8	4000 ± 100	< 40	< 60	< 0.2	< 4	< 10	< 100	< 8
06/18/90	< 2	< 0.5	3000 ± 100	< 40	< 70	< 0.2	< 4	< 8	< 90	< 7
07/12/90			3300 ± 200	< 40	< 100	< 0.1	< 5	< 8	< 90	< 8
08/14/90			3100 ± 100	< 100	< 400	< 0.5	< 10	< 15	< 200	< 20
09/13/90			3400 ± 200	< 50	< 100	< 0.3	< 5	< 10	< 90	< 8
10/18/90			3300 ± 200	< 40	< 60	< 0.4	< 3	< 10	< 80	< 7
11/15/90			3400 ± 100	< 40	< 60	< 0.3	< 4	< 9	< 80	< 7
12/18/90			3300 ± 100	< 30	< 50	< 0.2	< 3	< 8	< 70	< 5
Average ± 2 s.d.			**3783 ± 1393**							

* All other gamma emitters were < LLD.

(a) Sr-89/90 analyses performed on second quarter samples.

TABLE B-8

NORTH ANNA - 1990

CONCENTRATIONS OF TRITIUM, STRONTIUM AND GAMMA EMITTERS* IN SURFACE WATER

pCi/liter ± 2 Sigma

COLLECTION DATES	H-3	I-131(a)	Sr-89	Sr-90	Be-7	K-40	Cs-137	Ba-140	Ra-226	Th-228
STATION - 08										
01/05/90	(b)	< 0.4	(c)	(c)	< 30	< 70	< 4	< 10	< 100	< 8
02/15/90		< 0.2			< 30	< 50	< 4	< 7	< 80	< 7
03/15/90	4700 ± 400	< 0.2			< 30	< 40	< 3	< 4	< 60	< 5
04/12/90		< 0.2			< 30	< 50	< 4	< 9	< 70	< 6
05/16/90		< 0.1			< 60	< 200	< 6	< 10	< 100	< 10
06/18/90	4100 ± 100	< 0.3	< 4	< 0.6	< 30	< 50	< 4	< 8	< 80	< 7
07/12/90		< 0.1			< 30	< 60	< 4	< 6	< 80	< 7
08/14/90		< 0.2			< 30	< 50	< 4	< 8	< 70	< 6
09/13/90	3300 ± 100	< 0.2			< 30	< 50	< 4	< 7	< 80	< 7
10/18/90		< 0.4			< 30	< 50	< 3	< 10	< 60	< 6
11/15/90		< 0.3			< 50	< 90	< 4	< 10	< 100	< 8
12/18/90	3500 ± 200	< 0.4			< 30	< 50	< 4	< 8	< 60	< 6
Average ± 2. s.d.	**3900 ± 1265**									
STATION - 09										
01/05/90	(b)	< 0.3	(c)	(c)	< 50	< 100	< 5	< 10	< 90	< 8
02/15/90		< 0.2			< 30	< 60	< 4	< 8	< 100	< 8
03/15/90	3300 ± 400	< 0.2			< 30	< 50	< 3	< 5	< 70	< 5
04/12/90		< 0.2			< 50	< 90	< 6	< 10	< 100	< 10
05/16/90		< 0.1			< 30	< 50	< 3	< 8	< 70	< 6
06/18/90	3300 ± 100	< 0.2	< 4	< 0.5	< 30	< 50	< 3	< 9	< 60	< 6
07/12/90		< 0.2			< 30	< 50	< 3	< 6	< 80	< 6
08/14/90		< 0.2			< 40	< 60	< 3	< 10	< 80	< 7
09/13/90	3100 ± 100	< 0.3			< 30	< 70	< 4	< 8	< 90	< 8
10/18/90		< 0.4			< 30	< 40	< 3	< 10	< 60	< 5
11/15/90		< 0.4			< 40	< 100	< 5	< 10	< 100	< 8
12/18/90	3100 ± 100	< 0.3			< 40	< 100	< 4	< 10	< 80	< 6
Average ± 2 s.d.	**3200 ± 231**									

* All other gamma emitters were < LLD.
(a) I-131 by radiochemistry
(b) Analysis performed quarterly.
(c) Analysis performed only with second quarter.

TABLE B-9

NORTH ANNA - 1990

CONCENTRATIONS OF TRITIUM, STRONTIUM AND GAMMA EMITTERS* IN SURFACE WATER

pCi/liter ± 2 Sigma - STATE SPLIT

COLLECTION DATES	H-3	Be-7	K-40	I-131	Cs-137	Ba-140	Ra-226	Th-228
STATION - W-27								
02/08/90		< 40	< 60	< 0.3	< 4	< 10	< 100	< 8
02/15/90		< 40	60.3 ± 22.5	< 2	< 3	< 20 (a)	< 70	< 6
03/15/90	350 ± 60	< 50	< 60	< 2	< 3	< 30 (a)	< 80	< 7
04/30/90		< 30	< 50	< 10	< 4	< 9	< 70	< 6
05/31/90	< 100	< 30	< 90	< 0.4	< 3	< 10	< 60	< 5
06/30/90	470 ± 90	< 40	< 60	< 30 (a)	< 3	< 10	< 80	< 7
07/31/90	1300 ± 100	< 50	< 50	< 50 (a)	< 4	< 20 (a)	< 80	< 7
08/31/90		< 30	< 60	< 0.5	< 3	< 10	< 60	< 5
09/30/90	2200 ± 100	< 30	< 50	< 30 (a)	< 3	< 10	< 70	< 6
10/31/90	1600 ± 100	< 40	< 40	< 1	< 3	< 30 (a)	< 70	< 6
11/30/90	670 ± 100	< 40	< 100	< 0.5	< 4	< 10	< 80	< 7
12/31/90		< 40	< 50	< 0.5	< 4	< 10	< 70	< 6
STATION - W-33								
02/08/90		< 50	86.8 ± 37.3	< 0.3	< 5	< 10	< 90	< 8
02/15/90		< 40	< 60	< 3	< 3	< 20 (a)	< 90	< 8
03/15/90	2500 ± 100	< 40	< 50	< 2	< 3	< 30 (a)	< 70	< 7
04/30/90		< 50	< 80	< 20 (a)	< 5	< 10	< 100	< 8
05/31/90	3800 ± 100	< 20	< 30	< 0.5	< 4	< 10	< 40	< 4
06/30/90	3300 ± 100	< 30	< 50	< 30 (a)	< 3	< 10	< 70	< 6
07/31/90	3300 ± 200	< 40	< 50	< 60 (a)	< 4	< 20 (a)	< 80	< 7
08/31/90		< 40	< 100	< 0.4	< 3	< 10	< 70	< 6
09/30/90	3600 ± 100	< 30	< 50	< 40 (a)	< 3	< 10	< 70	< 6
10/31/90	2900 ± 200	< 40	< 50	< 1	< 3	< 30 (a)	< 80	< 7
11/30/90	3000 ± 200	< 30	< 40	< 0.5	< 3	< 9	< 70	< 6
12/31/90		< 40	< 60	< 0.5	< 4	< 10	< 80	< 7
Average ± 2 s.d.	**2230 ± 2455**		**73.6 ± 37.5**					

* All other gamma emitters were < LLD.

(a) LLD could not be met due to delay in receipt of sample from the State of Virginia.

TABLE B-10

NORTH ANNA - 1990

CONCENTRATIONS OF GAMMA EMITTERS* IN SEDIMENT SILT

pCi/kg ± 2 Sigma

NUCLIDE	STA-08 03/15/90	STA-09 03/15/90	STA-11 03/15/90	STA-08 09/13/90	STA-09 09/13/90	STA-11 09/13/90	Average ± 2 Sigma
Sr-89	(a)	(a)	(a)	< 200	< 200	< 200	-
Sr-90	(a)	(a)	(a)	< 40	290 ± 40	130 ± 30	210 ± 226
Be-7	< 300	< 200	< 300	< 300	< 300	< 300	-
K-40	4650 ± 460	3990 ± 400	13000 ± 1300	3760 ± 380	< 400	20100 ± 2000	10017 ± 13736
Mn-54	< 20	< 20	36.3 ± 12.9	< 30	< 20	< 30	36.3 ± 12.9
Co-58	< 30	< 20	< 30	< 30	< 20	< 30	-
Co-60	63.1 ± 27.4	< 20	< 30	105 ± 26	< 20	< 30	84 ± 59
Cs-134	< 30	< 30	< 30	72.5 ± 25.4	< 20	< 30	72.5 ± 25.4
Cs-137	244 ± 35	91.8 ± 22.0	68.5 ± 23.2	318 ± 32	45.8 ± 24.6	85.2 ± 16.6	147 ± 20.5
Ra-226	< 500	862 ± 292	2100 ± 400	1280 ± 430	< 400	1860 ± 410	1454 ± 1022
Th-228	316 ± 43	693 ± 69	1520 ± 150	724 ± 72	383 ± 38	1390 ± 140	809 ± 937

* All other gamma emitters were < LLD.

(a) Strontium 89/90 analyses performed annually.

TABLE B-11

NORTH ANNA - 1990

CONCENTRATIONS OF GAMMA EMITTERS* IN SHORELINE SOIL

pCi/kg ± 2 Sigma

NUCLIDE	STATION-09 03/15/90	STATION-09 09/13/90	AVERAGE ± 2 Sigma
Sr-89	(a)	< 200	-
Sr-90	(a)	[illegible] 21	48 ± 21
Be-7	< 200	[illegible]	-
K-40	9210 ± 920	< 303	9210 ± 920
Mn-54	< 20	< 20	-
Co-58	< 20	< 20	-
Co-60	< 20	< 20	-
Cs-134	< 20	< 20	-
Cs-137	74.6 ± 18.1	< 20	74.6 ± 18.1
Ra-226	804 ± 289	< 300	804 ± 289
Th-228	295 ± 30	192 ± 19	244 ± 146

* All other gamma emitters were < LLD.

(a) Strontium 89/90 analyses performed annually.

TABLE B-12

(Page 1 of 3)

VIRGIN'A POWER - NORTH ANNA - 1990

CONCENTRATIONS OF GAMMA EMITTERS* MILK

pCi/l ± 2 Sigma

MONTH	NUCLIDE	STATION-12	STATION-13
JANUARY	Sr-89	(a)	(a)
	Sr-90	(a)	(a)
	K-40	1280 ± 130	1220 ± 120
	Cs-137	< 4	< 4
	I-131	< 0.2	< 0.1
FEBRUARY	Sr-89	(a)	(a)
	Sr-90	(a)	(a)
	K-40	1270 ± 130	1210 ± 120
	Cs-137	< 4	< 4
	I-131	< 0.2	< 0.2
MARCH	Sr-89	< 4	< 4
	Sr-90	2.7 ± 0.6	< 0.1
	K-40	1330 ± 130	1240 ± 120
	Cs-137	< 4	< 5
	I-131	< 0.2	< 0.3
APRIL	Sr-89	(a)	(a)
	Sr-90	(a)	(a)
	K-40	1240 ± 120	1260 ± 130
	Cs-137	< 4	< 4
	I-131	< 0.5	< 0.5

* All other gamma emitters were < LLD.

(a) Strontium 89/90 analyses performed quarterly.

TABLE B-12

(Page 2 of 3)

VIRGINIA POWER - NORTH ANNA - 1990

CONCENTRATIONS OF GAMMA EMITTERS* MILK

pCi/l ± 2 Sigma

MONTH	NUCLIDE	STATION-12	STATION-13
MAY	Sr-89	(a)	(a)
	Sr-90	(a)	(a)
	K-40	1280 ± 130	1320 ± 130
	Cs-137	< 4	< 4
	I-131	< 0.2	< 0.2
JUNE	Sr-89	< 4	< 3
	Sr-90	1.3 ± 0.2	0.58 ± 0.24
	K-40	1150 ± 120	1320 ± 130
	Cs-137	< 3	< 4
	I-131	< 0.2	< 0.4
JULY	Sr-89	(a)	(a)
	Sr-90	(a)	(a)
	K-40	1280 ± 130	1310 ± 130
	Cs-137	< 4	< 4
	I-131	< 0.2	< 0.2
AUGUST	Sr-89	(a)	(a)
	Sr-90	(a)	(a)
	K-40	1170 ± 120	1380 ± 140
	Cs-137	< 4	< 4
	I-131	< 0.3	< 0.2

* All other gamma emitters were <LLD.

(a) Strontium 89/90 analyses performed quarterly.

TABLE B-12

(Page 3 of 3)

VIRGINIA POWER - NORTH ANNA - 1989

CONCENTRATIONS OF GAMMA EMITTERS* MILK

pCi/l ± 2 Sigma

MONTH	NUCLIDE	STATION-12	STATION-13
SEPTEMBER	Sr-89	< 3	< 4
	Sr-90	1.3 ± 0.2	1.5 ± 0.2
	K-40	1190 ± 120	1320 ± 130
	Cs-137	< 4	< 5
	I-131	< 0.3	< 0.3
OCTOBER	Sr-89	(a)	(a)
	Sr-90	(a)	(a)
	K-40	1540 ± 150	1250 ± 120
	Cs-137	< 5	< 5
	I-131	< 0.4	< 0.4
NOVEMBER	Sr-89	(a)	(a)
	Sr-90	(a)	(a)
	K-40	1390 ± 140	1270 ± 130
	Cs-137	< 4	< 4
	I-131	< 0.2	< 0.4
DECEMBER	Sr-89	< 3	< 4
	Sr-90	1.1 ± 0.2	1.7 ± 0.2
	K-40	1380 ± 140	1310 ± 130
	Cs-137	< 4	< 4
	I-131	< 0.3	< 0.3

* All other gamma emitters were <LLD.

(a) Strontium 89/90 analyses performed quarterly.

TABLE B-13

NORTH ANNA - 1990

CONCENTRATIONS OF GAMMA EMITTERS* IN FISH

pCi/kg (wet) ± 2 Sigma

COLLECTION DATE	STATION	SAMPLE TYPE	K-40	Co-58	Cs-134	Cs-137
04/12/90	08		1640 ± 160	< 9	15.9 ± 8.8	126 ± 13
10/26/90	08		1630 ± 160	< 9	20.8 ± 7.5	139 ± 14
04/12/90	09 (b)		1580 ± 160	< 10	< 10	129 ± 14
10/26/90	09 (b)		1510 ± 150	< 8	< 8	27.6 ± 7.3
10/25/90	25 (a)		1400 ± 140	< 6	< 6	< 8
Average ± 2 s.d.			**1552 ± 199**		**18.4 ± 6.9**	**105 ± 104**

* All other gamma emitters were <LLD.
(a) Included in 1990 as a control.
(b) Original control

TABLE B-14

(Page 1 of 2)

NORTH ANNA - 1990

CONCENTRATIONS OF GAMMA EMITTERS* IN FOOD/VEGETATION

pCi/kg (wet) ± 2 Sigma

COLLECTION DATE	Be-7	K-40	I-131	Ru-103	Cs-134	Cs-137	Th-228	Ra-226
STATION 14								
04/23/90	1840 ± 180	11700 ± 1200	< 10	< 20	< 20	< 20	< 30	< 300
05/23/90	692 ± 258	5340 ± 530	< 10	< 40	< 30	< 30	< 50	< 500
06/22/90	526 ± 146	7950 ± 800	< 30	< 20	< 20	< 20	< 30	< 400
07/26/90	< 80	6990 ± 700	< 7	< 9	< 7	13.5 ± 6.0	< 10	< 100
08/22/90	5870 ± 600	23200 ± 2300	< 40	< 70	< 50	< 60	< 100	< 1000
09/19/90	4410 ± 500	19600 ± 2000	< 20	< 60	< 40	< 40	< 70	< 700
10/24/90	1340 ± 290	15500 ± 1500	< 9	< 40	< 30	< 30	< 60	< 600
11/27/90	6900 ± 690	16000 ± 1600	< 10	< 30	< 30	< 30	< 50	< 500
STATION 15								
04/23/90	290 ± 95	7540 ± 750	< 7	< 10	< 10	< 10	< 30	< 300
05/23/90	334 ± 136	3600 ± 360	< 10	< 20	< 20	< 20	< 30	< 300
06/22/90	1820 ± 330	8160 ± 820	< 50	< 40	< 30	< 30	< 70	< 800
07/26/90	550 ± 232	12700 ± 1300	< 7	< 40	< 30	63.2 ± 23.7	< 50	< 600
08/22/90	3270 ± 550	24200 ± 2400	< 50	< 80	< 60	< 60	< 100	< 1000
09/19/90	1140 ± 150	7740 ± 770	< 40	< 20	< 10	< 10	< 20	< 200
10/24/90	6500 ± 650	5790 ± 580	< 20	< 40	< 30	83.2 ± 23.2	256 ± 26	< 600
11/27/90	2900 ± 290	6570 ± 660	< 10	< 30	< 30	< 30	< 50	< 500
STATION 16								
04/23/90	2360 ± 240	12900 ± 1300	< 10	< 30	< 30	36.4 ± 21.3	150 ± 18	< 400
05/23/90	< 400	6000 ± 600	< 10	< 40	< 30	< 30	< 70	< 600
06/22/90	3530 ± 400	12600 ± 1300	< 30	< 50	< 40	< 40	< 70	< 800
07/26/90	< 200	5210 ± 520	< 7	< 20	< 20	< 20	< 30	< 400
08/22/90	5650 ± 680	22700 ± 2300	< 60	< 90	< 60	< 70	< 100	< 1000
09/19/90	7760 ± 780	10400 ± 1000	< 40	< 100	< 60	< 70	450 ± 106	< 1000
10/24/90	3330 ± 330	5180 ± 520	< 60	< 40	< 30	< 30	< 50	< 500
11/27/90	6630 ± 660	4290 ± 430	< 10	< 40	< 30	< 30	< 60	< 600

* All other gamma emitters were < LLD.

TABLE B-14

(Page 2 of 2)

NORTH ANNA - 1990

CONCENTRATIONS OF GAMMA EMITTERS* IN FOOD/VEGETATION

pCi/kg (wet) ± 2 Sigma

COLLECTION DATE	Be-7	K-40	I-131	Ru-103	Cs-134	Cs-137	Th-228	Ra-226
STATION 21								
04/23/90	1576 ± 160	6930 ± 690	< 7	< 10	< 10	< 10	< 20	< 300
05/23/90	433 ± 210	4240 ± 420	< 10	< 30	< 20	161 ± 24	< 40	< 500
06/22/90	505 ± 139	2750 ± 280	< 30	< 20	< 20	< 20	< 40	< 400
07/26/90	209 ± 120	12000 ± 1200	< 10	< 20	< 10	44.8 ± 10.7	< 20	< 300
08/22/90	2470 ± 450	48600 ± 4900	< 30	< 70	< 50	109 ± 38	< 90	< 1000
09/19/90	2600 ± 490	8350 ± 840	< 60	< 70	< 40	< 50	< 90	< 900
10/24/90	9670 ± 970	9300 ± 930	< 20	< 40	< 30	< 40	< 50	< 600
11/27/90	8080 ± 810	5180 ± 520	< 7	< 60	< 50	108 ± 44	< 100	< 1000
STATION 23								
04/23/90	< 200	5600 ± 560	< 7	< 10	< 10	< 10	< 20	< 300
05/23/90	553 ± 166	5720 ± 570	< 9	< 20	< 20	< 20	141 ± 15	< 300
06/22/90	686 ± 227	6370 ± 640	< 30	< 30	< 30	< 30	< 50	< 600
07/26/90	618 ± 103	12000 ± 1200	< 8	< 10	< 10	28.4 ± 9.3	< 20	< 200
08/22/90	6070 ± 610	8680 ± 870	< 40	< 50	< 40	< 40	< 70	< 800
09/19/90	3180 ± 340	19500 ± 2000	< 20	< 50	< 30	< 30	< 60	< 700
10/24/90	11400 ± 1100	13000 ± 1300	< 7	< 60	< 40	< 40	< 70	< 800
11/27/90	4220 ± 420	6530 ± 650	< 10	< 30	< 30	< 30	217 ± 26	< 600
Average ± 2 s.d.	**3331 ± 5955**	**10915 ± 16597**				**71.9 ± 95.2**	**243 ± 250**	

* All other gamma emitters were < LLD.

TABLE B-15

NORTH ANNA - 1990

DIRECT RADIATION MEASUREMENTS - QUARTERLY & ANNUAL TLD RESULTS

mR/standard month ± 2 Sigma

STATION NUMBER	1ST QTR 12/29/89-03/28/90	2ND QTR 03/28/90-06/27/90	3RD QTR 06/27/90-09/26/90	4th QTR 09/26/90-12/27/90	QUARTERLY AVERAGE	ANNUAL TLD 07/04/89-06/27/90
01	7.6 ± 0.5	8.4 ± 1.0	7.4 ± 0.2	8.7 ± 0.4	8.0 ± 1.2	6.8 ± 0.9
02	4.2 ± 0.3	3.8 ± 0.2	4.3 ± 0.2	4.8 ± 0.3	4.3 ± 0.8	4.0 ± 0.2
03	4.4 ± 0.2	4.0 ± 0.2	4.7 ± 0.2	4.3 ± 0.8	4.4 ± 0.6	4.0 ± 0.4
04	4.2 ± 0.2	4.6 ± 0.5	4.5 ± 0.7	4.9 ± 0.5	4.6 ± 0.6	4.9 ± 0.2
05	5.6 ± 0.5	5.7 ± 0.5	5.7 ± 0.4	6.3 ± 1.0	5.8 ± 0.6	5.0 ± 0.2
05A	4.9 ± 0.3	5.0 ± 0.4	5.6 ± 0.2	5.7 ± 0.3	5.3 ± 0.8	5.0 ± 0.3
06	7.0 ± 0.3	6.6 ± 0.4	6.0 ± 0.3	6.6 ± 1.0	6.7 ± 0.4	5.8 ± 0.3
07	5.4 ± 0.1	5.3 ± 0.7	4.8 ± 0.3	4.9 ± 0.5	5.1 ± 0.6	5.2 ± 0.4
21	4.7 ± 0.1	4.5 ± 0.8	5.0 ± 0.1	5.5 ± 0.4	4.9 ± 0.9	5.6 ± 0.4
22	6.1 ± 0.7	6.1 ± 0.7	6.1 ± 0.3	6.9 ± 0.8	6.3 ± 0.8	5.8 ± 0.9
23	6.4 ± 0.4	6.8 ± 0.8	7.5 ± 0.4	7.7 ± 0.7	7.1 ± 1.2	6.3 ± 0.3
24	3.7 ± 0.1	4.0 ± 0.7	4.5 ± 0.2	4.5 ± 0.4	4.2 ± 0.8	4.4 ± 0.1
Average ± 2 s.d.	**5.4 ± 2.4**	**5.4 ± 2.8**	**5.6 ± 2.3**	**5.9 ± 2.7**	**5.6 ± 0.5**	**5.2 ± 1.7**

* Standard month = 30.4 days.

TABLE B-16

(Page 1 of 2)

NORTH ANNA - 1990

DIRECT RADIATION MEASUREMENTS - SECTOR QUARTERLY TLD RESULTS

mR/standard month ± 2 Sigma

STATION NUMBER	FIRST QUARTER 12/29-03/28	SECOND QUARTER 03/28-06/27	THIRD QUARTER 06/27-09/26	FOURTH QUARTER 09/26-12/27	AVERAGE ± 2 S.d.
N-1	6.1 ± 0.3	6.9 ± 0.6	6.7 ± 0.1	6.4 ± 0.3	6.5 ± 0.7
N-2	5.6 ± 0.4	4.9 ± 0.3	5.7 ± 0.2	4.4 ± 0.1	5.2 ± 1.2
NNE-3	5.2 ± 0.2	5.0 ± 0.4	7.7 ± 1.0	6.4 ± 0.3	6.1 ± 2.5
NNE-4	5.3 ± 0.6	6.0 ± 0.3	6.3 ± 0.2	4.9 ± 0.2	5.6 ± 1.3
NE-5	7.9 ± 0.4	8.3 ± 0.3	7.8 ± 0.4	7.2 ± 0.3	7.8 ± 0.9
NE-6	4.1 ± 0.2	4.3 ± 0.1	3.9 ± 0.1	3.2 ± 0.2	3.9 ± 1.0
ENE-7	6.3 ± 0.3	7.1 ± 1.0	6.9 ± 0.3	5.6 ± 0.2	6.5 ± 1.4
ENE-8	4.3 ± 0.2	3.6 ± 0.2	3.7 ± 0.2	3.5 ± 0.2	3.8 ± 0.7
E-9	7.4 ± 0.4	6.3 ± 0.4	8.4 ± 1.2	7.6 ± 0.4	7.4 ± 1.7
E-10	5.4 ± 0.2	6.7 ± 1.0	6.7 ± 1.1	4.9 ± 0.3	5.9 ± 1.8
ESE-11	6.2 ± 0.3	5.7 ± 0.4	6.1 ± 0.2	5.6 ± 0.2	5.9 ± 1.6
ESE-12	7.1 ± 0.2	7.0 ± 0.1	7.3 ± 0.4	6.5 ± 0.6	7.0 ± 0.7
SE-13	6.4 ± 0.2	6.9 ± 0.5	6.0 ± 0.5	7.0 ± 0.4	6.6 ± 0.9
SE-14	9.3 ± 0.6	(a)	6.6 ± 0.5	6.2 ± 0.5	7.4 ± 3.4
SSE-15	6.6 ± 0.5	7.7 ± 1.1	7.5 ± 0.5	6.9 ± 1.2	7.2 ± 1.0
SSE-16	5.1 ± 0.4	5.5 ± 0.3	5.0 ± 0.2	5.7 ± 0.5	5.3 ± 0.7
S-17	7.2 ± 0.3	8.6 ± 1.3	7.9 ± 0.2	7.9 ± 0.4	7.9 ± 1.1
S-18	4.5 ± 0.2	4.1 ± 0.1	5.1 ± 0.8	4.3 ± 0.3	4.5 ± 0.9
SSW-19	8.2 ± 0.4	8.8 ± 0.3	9.1 ± 1.7	9.0 ± 1.6	8.8 ± 0.8
SSW-20	4.0 ± 0.2	4.0 ± 0.2	4.3 ± 0.3	3.6 ± 0.2	4.0 ± 0.6
SW-21	8.2 ± 0.4	8.3 ± 0.4	8.3 ± 0.7	8.1 ± 0.7	8.2 ± 0.2
SW-22	6.6 ± 0.4	(a)	6.1 ± 0.4	5.7 ± 0.3	6.1 ± 0.9
SW-23	5.6 ± 0.4	6.3 ± 0.1	6.6 ± 0.2	5.1 ± 0.1	5.9 ± 1.4
SW-24	6.2 ± 0.2	6.9 ± 1.6	7.1 ± 0.4	5.5 ± 0.7	6.4 ± 1.5
SW-25	7.8 ± 1.2	7.1 ± 0.3	7.6 ± 0.4	6.7 ± 1.0	7.3 ± 1.0
SW-26	4.8 ± 0.3	6.5 ± 0.8	5.2 ± 0.3	4.7 ± 0.2	5.3 ± 1.7
WNW-27	4.8 ± 0.4	5.4 ± 0.3	(a)	4.4 ± 0.4	4.9 ± 1.0
WNW-28	5.5 ± 0.3	6.4 ± 0.8	5.6 ± 0.2	4.8 ± 0.2	5.6 ± 1.3
NW-29	7.9 ± 0.4	7.7 ± 0.7	8.1 ± 0.8	7.4 ± 0.1	7.8 ± 0.6
NW-30	4.7 ± 0.3	4.4 ± 0.1	5.5 ± 0.8	4.4 ± 0.2	4.8 ± 1.0
NNW-31	5.7 ± 0.5	6.9 ± 0.3	5.9 ± 0.2	4.9 ± 0.2	5.9 ± 1.6
NNW-32	5.2 ± 0.3	6.2 ± 0.4	5.0 ± 0.2	5.9 ± 0.2	5.6 ± 1.1
N-33	6.7 ± 0.5	6.0 ± 0.2	8.1 ± 1.6	6.4 ± 0.4	6.8 ± 1.8
N-34	5.4 ± 0.3	5.0 ± 0.3	5.2 ± 0.5	4.5 ± 0.4	5.0 ± 0.8
NNE-35	5.3 ± 0.4	4.6 ± 0.2	7.2 ± 0.4	7.4 ± 0.4	6.1 ± 2.8

* Standard month = 30.4 days

(a) TLD lost.

TABLE B-16

(Page 2 of 2)

NORTH ANNA - 1990

DIRECT RADIATION MEASUREMENTS - SECTOR QUARTERLY TLD RESULTS

mR/standard month ± 2 Sigma

STATION NUMBER	FIRST QUARTER 12/29-03/28	SECOND QUARTER 03/28-06/27	THIRD QUARTER 06/27-09/26	FOURTH QUARTER 09/26-12/27	AVERAGE ± 2 S.d.
NNE-36	5.1 ± 0.4	5.9 ± 0.5	6.2 ± 0.3	4.9 ± 0.3	5.5 ± 1.2
NE-37	8.7 ± 0.7	7.6 ± 0.1	8.6 ± 0.6	6.7 ± 0.3	7.9 ± 1.9
NE-38	4.0 ± 0.2	3.6 ± 0.1	3.6 ± 0.1	3.2 ± 0.2	3.6 ± 0.7
ENE-39	6.3 ± 0.4	5.8 ± 0.2	6.1 ± 0.2	5.6 ± 0.3	6.0 ± 0.6
ENE-40	4.1 ± 0.2	4.6 ± 0.3	5.3 ± 0.6	3.4 ± 0.2	4.4 ± 1.6
E-41	6.6 ± 0.1	7.5 ± 1.1	7.6 ± 0.3	6.4 ± 0.3	7.0 ± 1.2
E-42	5.4 ± 0.3	6.4 ± 0.7	6.5 ± 0.3	5.1 ± 0.1	5.9 ± 1.4
ESE-43	6.3 ± 0.2	(a)	6.7 ± 0.6	5.4 ± 0.4	6.1 ± 1.3
ESE-44	5.6 ± 0.3	6.8 ± 0.5	6.4 ± 0.3	5.7 ± 0.5	6.1 ± 1.1
SE-45	6.2 ± 0.2	6.2 ± 0.6	5.3 ± 1.2	6.3 ± 0.3	6.0 ± 0.9
SE-46	7.8 ± 0.1	(a)	6.4 ± 0.3	5.4 ± 0.1	6.5 ± 2.4
SSE-47	6.4 ± 0.0	6.3 ± 0.5	6.8 ± 0.4	6.2 ± 0.4	6.4 ± 0.5
SSE-48	4.8 ± 0.1	5.6 ± 0.4	5.8 ± 0.7	(a)	5.4 ± 1.1
S-49	7.0 ± 0.2	8.1 ± 0.5	8.2 ± 0.2	7.1 ± 0.4	7.6 ± 1.3
S-50	3.8 ± 0.1	4.2 ± 0.2	3.4 ± 0.7	3.5 ± 0.2	3.7 ± 0.7
SSW-51	8.1 ± 0.3	7.9 ± 0.2	9.5 ± 0.5	7.9 ± 0.4	8.4 ± 1.5
SSW-52	4.9 ± 0.2	3.9 ± 0.6	4.0 ± 0.4	3.6 ± 0.2	4.1 ± 1.1
SW-53	8.1 ± 0.1	8.4 ± 0.2	8.8 ± 0.3	8.2 ± 0.6	8.4 ± 0.6
SW-54	6.0 ± 0.4	(a)	6.5 ± 0.3	5.7 ± 0.3	6.1 ± 0.8
WSW-55	5.1 ± 0.8	5.7 ± 0.5	5.5 ± 0.1	5.1 ± 0.2	5.4 ± 0.6
WSW-56	6.8 ± 0.2	5.0 ± 0.4	6.2 ± 0.3	7.0 ± 0.2	6.3 ± 1.8
W-57	6.8 ± 0.5	7.2 ± 0.5	7.0 ± 0.1	6.7 ± 0.3	6.9 ± 0.4
W-58	5.2 ± 0.3	5.5 ± 0.3	5.5 ± 0.2	4.5 ± 0.3	5.2 ± 0.9
WNW-59	4.7 ± 0.3	5.6 ± 0.2	4.8 ± 0.2	4.3 ± 0.2	4.9 ± 1.1
WNW-60	5.8 ± 0.2	5.0 ± 0.2	5.3 ± 0.2	4.9 ± 0.2	5.3 ± 0.8
NW-61	7.6 ± 0.5	7.0 ± 0.4	7.3 ± 0.1	7.4 ± 0.4	7.3 ± 0.5
NW-62	5.1 ± 0.2	5.0 ± 0.2	4.6 ± 0.3	5.5 ± 0.3	5.1 ± 0.7
NWW-63	5.9 ± 0.1	6.3 ± 0.8	5.7 ± 0.1	5.1 ± 0.3	5.8 ± 1.0
NNW-64	6.6 ± 0.6	5.4 ± 0.3	5.1 ± 0.1	5.1 ± 0.3	5.6 ± 1.4
C-1	4.9 ± 0.8	4.8 ± 0.3	5.1 ± 0.4	4.6 ± 0.5	4.9 ± 0.4
C-2	4.6 ± 0.2	4.5 ± 0.7	5.4 ± 0.3	5.7 ± 0.4	5.1 ± 1.2
C-3	3.9 ± 0.2	3.7 ± 0.6	4.0 ± 0.1	4.2 ± 2.0	4.0 ± 0.4
C-4	3.7 ± 0.1	4.3 ± 0.4	4.5 ± 0.4	4.6 ± 0.3	4.3 ± 0.8
C-5	4.3 ± 0.1	3.2 ± 0.7	4.0 ± 0.1	5.1 ± 0.5	4.2 ± 1.6
C-6	4.3 ± 0.2	3.9 ± 0.6	4.5 ± 0.1	4.6 ± 0.3	4.3 ± 0.6
C-7	5.8 ± 0.3	5.4 ± 0.8	6.1 ± 0.4	6.8 ± 1.0	6.0 ± 1.2
C-8	7.0 ± 0.4	6.2 ± 0.6	5.6 ± 0.2	6.7 ± 0.3	6.4 ± 1.2
Average ± 2 s.d.	**5.9 ± 2.6**	**5.9 ± 2.8**	**6.2 ± 2.8**	**5.7 ± 2.7**	**5.9 ± 0.4**

* Standard month = 30.4 days

(a) TLD lost.

APPENDIX C
LAND USE CENSUS - 1990

VIRGINIA POWER

NORTH ANNA POWER STATION

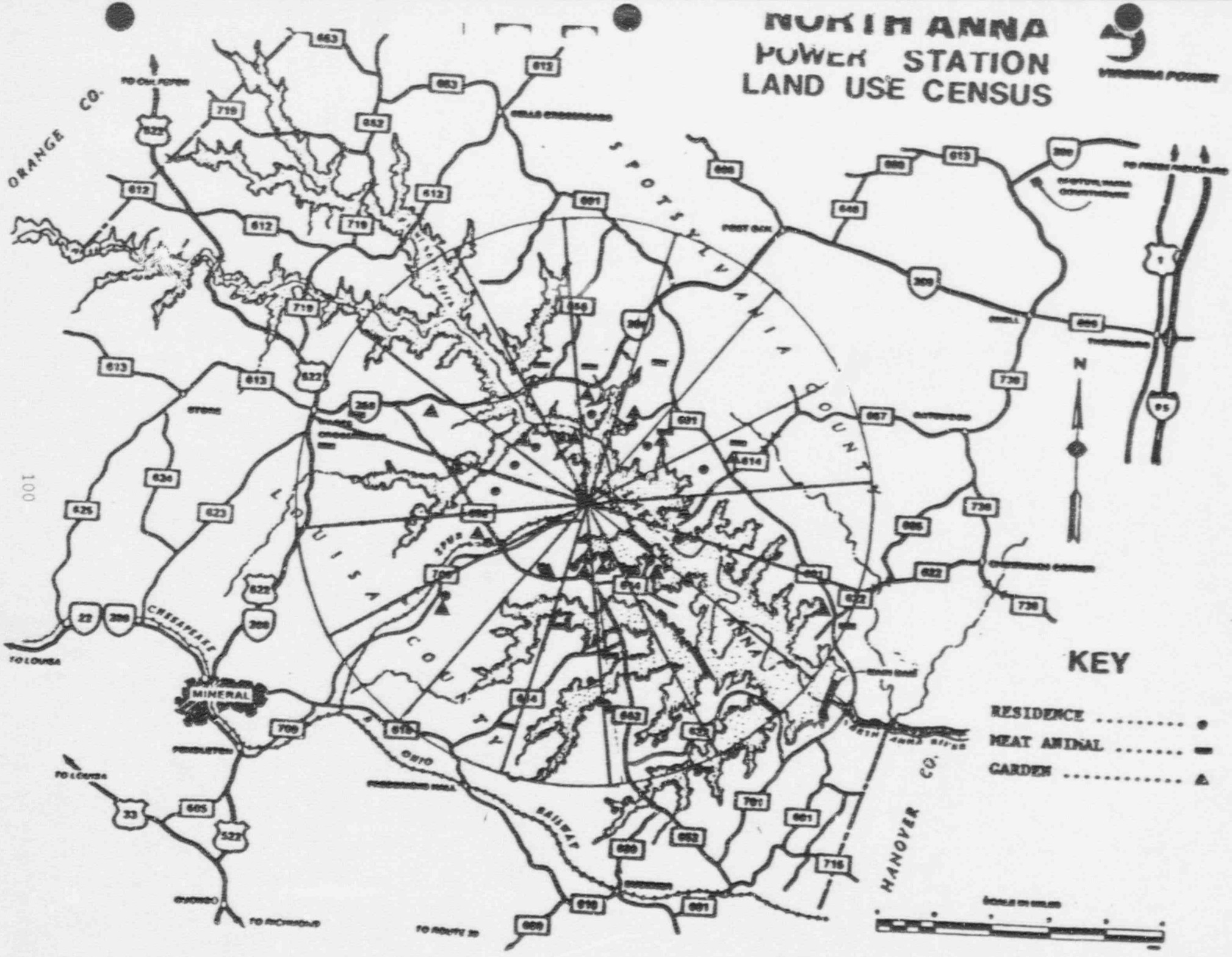
Annual Radiological Environmental Land Use Census Data for 1990

August (1-31)

Sector	Nearest Resident M	Nearest Site Boundary M	Milk * Cow M	Meat Animal M	Milk * Goat M	Veg. Garden 500 Sq Ft. M
N	1.35	0.87		2.01		1.91
NNE	1.35	0.85		2.62		1.35
NE	1.18	0.82		1.56		1.56
ENE	1.97	0.81		2.56		2.51
E	1.26	0.83				1.57
ESE	1.62	0.85		4.81		4.31
SE	1.37	0.88		1.37		1.37
SSE	0.91	0.91		2.38		0.91
S	1.04	0.94		1.99		1.22
SSW	1.43	1.01		3.68		1.43
SW	3.00	1.06				3.00
WSW	1.78	1.09				1.78
W	1.53	1.06		4.43		2.43
WNW	1.37	1.02		4.43		3.06
NW	1.18	0.97				1.18
NNW	1.19	0.90		2.22		1.19

* Note: No milk cow or goats within a five mile radius of North Anna Power Station
M = Mile

NORTH ANNA POWER STATION LAND USE CENSUS



APPENDIX D
SYNOPSIS OF ANALYTICAL PROCEDURES

ANALYTICAL PROCEDURES SYNOPSIS

Appendix D is a synopsis of the analytical procedures performed on samples collected for the North Anna Power Station's Radiological Environmental Monitoring Program. All analyses have been mutually agreed upon by VEPCO and Teledyne Isotopes and include those recommended by the USNRC Branch Technical Position, Rev. 1, November 1979.

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DETERMINATION OF GROSS BETA ACTIVITY IN WATER SAMPLES

1.0 INTRODUCTION

The procedures described in this section are used to measure the overall radioactivity of water samples without identifying the radioactive species present. No chemical separation techniques are involved.

One liter of the sample is evaporated on a hot plate. A smaller volume may be used if the sample has a significant salt content as measured by a conductivity meter. If requested by the customer, the sample is filtered through No. 54 filter paper before evaporation, removing particles greater than 30 microns in size.

After evaporating to a small volume in a beaker, the sample is rinsed into a 2-inch diameter stainless steel planchet which is stamped with a concentric ring pattern to distribute residue evenly. Final evaporation to dryness takes place under heat lamps.

Residue mass is determined by weighing the planchet before and after mounting the sample. The planchet is counted for beta activity on an automatic proportional counter. Results are calculated using empirical self-absorption curves which allow for the change in effective counting efficiency caused by the residue mass.

2.0 DETECTION CAPABILITY

Detection capability depends upon the sample volume actually represented on the planchet, the background and the efficiency of the counting instrument, and upon self-absorption of beta particles by the mounted sample. Because the radioactive species are not identified, no decay corrections are made and the reported activity refers to the counting time.

The minimum detectable level (MDL) for water samples is nominally 1.6 picocuries per liter for gross beta at the 4.66 sigma level (1.0 pCi/l at the 2.83 sigma level), assuming that 1 liter of sample is used and that $\frac{1}{2}$ gram of sample residue is mounted on the planchet. These figures are based upon a counting time of 50 minutes and upon representative values of counting efficiency and background of 0.2 and 1.2 cpm, respectively.

The MDL becomes significantly lower as the mount weight decreases because of reduced self-absorption. At a zero mount weight, the 4.66 sigma MDL for gross beta is 0.9 picocuries per liter. These values reflect a beta counting efficiency of 0.38.

GROSS BETA ANALYSIS OF SAMPLES

Air Particulates

After a delay of five or more days, allowing for the radon-222 and radon-220 (thoron) daughter products to decay, the filters are counted in a gas-flow proportional counter. An unused air particulate filter, supplied by Vepco, is counted as the blank.

Calculations of the results, the two sigma error and the lower limit of detection (LLD):

RESULT (pCi/m^3) = $((S/T) - (B/t))/(2.22\ V\ E)$

TWO SIGMA ERROR (pCi/m^3) = $2((S/T^2) + (B/t^2))^{1/2}/(2.22\ V\ E)$

LLD (pCi/m^3) = $4.66\ (B^{1/2})/(2.22\ V\ E\ t)$

where:

S = Gross counts of sample including blank
B = Counts of blank
E = Counting efficiency
T = Number of minutes sample was counted
t = Number of minutes blank was counted
V = Sample aliquot size (cubic meters)

ANALYSIS OF SAMPLES FOR TRITIUM

Water

Approximately 2 ml of water are converted to hydrogen by passing the water, heated to its vapor state, over a granular zinc conversion column heated to 400° C. The hydrogen is loaded into a one liter proportional detector and the volume is determined by recording the pressure.

The proportional detector is passively shielded by lead and steel and an electronic, anticoincidence system provides additional shielding from cosmic rays.

Calculation of the results, the two sigma error and the lower limit detection (LLD) in pCi/l:

$$\text{RESULT} = 2(3.234)\, T_N\, V_N(C_G - B)/(C_N\, V_S)$$

$$\text{TWO SIGMA ERROR} = 2(3.234)\, T_N\, V_N(E)^{1/2}/(C_N\, V_S)$$

$$\text{LLD} = 3.3\,(3.234) T_N\, V_N(E)^{1/2}/(C_N\, V_S)$$

where:

T_N	=	tritium units of the standard
3.234	=	conversion factor changing tritium units to pCi/l
V_N	=	volume of the standard used to calibrate the efficiency of the detector in psia
V_S	=	volume of the sample loaded into the detector in psia
C_N	=	the net cpm of the standard of volume V_N
CG	=	the gross cpm of the sample of volume V_S
B	=	the background of the detector in cpm
Δt	=	counting time for the sample
E	=	$S/T^2 + B/t^2$

ANALYSIS OF SAMPLES FOR STRONTIUM-89 AND -90

Water

Stable strontium carrier is added to 1 liter of sample and the volume is reduced by evaporation. Strontium is precipitated as $Sr(NO_3)_2$ using nitric acid. A barium scavenge and an iron (ferric hydroxide) scavenge are performed followed by addition of stable yttrium carrier and a minimum of 5 day period for yttrium ingrowth. Yttrium is then precipitated as hydroxide, dissolved and re-precipitated as oxalate. The yttrium oxalate is mounted on a nylon planchet and is counted in a low level beta counter to infer Sr-90 activity. Strontium-89 activity is determined by precipitating $SrCO_3$ from the sample after yttrium separation. This precipitate is mounted on a nylon planchet and is covered with an 80 mg/cm^2 aluminum absorber for low level beta counting.

Milk

Stable strontium carrier is added to 1 liter of sample and the sample is first evaporated, then ashed in a muffle furnace. The ash is dissolved and strontium is precipitated as phosphate, then is dissolved and precipitated as $SrNO_3$ using fuming (90%) nitric acid. A barium chromate scavenge and an iron (ferric hydroxide) scavenge are then performed. Stable yttrium carrier is added and the sample is allowed to stand for a minimum of 5 days for yttrium ingrowth. Yttrium is then precipitated as hydroxide, dissolved and re-precipitated as oxalate. The yttrium oxalate is mounted on a nylon planchet and is counted in a low level beta counter to infer Sr-90 activity. Strontium-89 is determined by precipitating $SrCO_3$ from the sample after yttrium separation. This precipitate is mounted on a nylon planchet and is covered with an 80 mg/cm^2 aluminum absorber for low level beta counting.

Soil and Sediment

The sample is first dried under heat lamps and an aliquot is taken. Stable strontium carrier is added and the sample is leached in hydrachloric acid. The mixture is filtered and strontium is precipitated from the liquid portion as phosphate. Strontium is precipitated as $Sr(NO_3)_2$ using fuming (90%) nitric acid. A barium chromate scavenge and an iron (ferric hydroxide) scavenge are then performed. Stable yttrium carrier is added and the sample is allowed to stand for a minimum of 5 days for yttrium ingrowth. Yttrium is then precipitated as hydroxide, dissolved and re-precipitated as oxalate. The yttrium oxalate is mounted on a nylon planchet and is counted in a low level beta counter to infer Sr-90 activity. Strontium-89 activity is determined by precipitating

$SrC0_3$ from the sample after yttrium separation. This precipitate is mounted on a nylon planchet and is covered with an 80 mg/cm2 aluminum absorber for low level beta counting.

Organic Solids

A wet portion of the sample is dried and then ashed in a muffle furnace. Stable strontium carrier is added and the ash is leached in hydrochloric acid. The sample is filtered and strontium is precipitated from the liquid portion as phosphate. Strontium is precipitated as $Sr(N0_3)$ using fuming (90%) nitric acid. An iron (ferric hydroxide) scavenge is performed, followed by addition of stable yttrium carrier and a minimum of 5 days period for yttrium ingrowth. Yttrium is then precipitated as hydroxide, dissolved and re-precipitated as oxalate. The yttrium oxalate is mounted on a nylon planchet and is counted in a low level beta counter to infer strontium-90 activity. Strontium-89 activity is determined by precipitating $SrC0_3$ from the sample after yttrium separation. This precipitate is mounted on a nylon planchet and is covered with an 80 mg/cm^2 aluminum absorber for low level beta counting.

Air Particulates

Stable strontium carrier is added to the sample and it is leached in nitric acid to bring deposits into solution. The mixture is then filtered and the filtrate is reduced in volume by evaporation. Strontium is precipitated as $Sr(N0_3)_2$ using fuming (90%) nitric acid. A barium scavenge is used to remove some interfering species. An iron (ferric hydroxide) scavenge is performed, followed by addition of stable yttrium carrier and a 7 to 10 day period for yttrium ingrowth. Yttrium is then precipitated as hydroxide, dissolved and re-precipitated as oxalate. The yttrium oxalate is mounted on a nylon planchet and is counted in a low level beta counter to infer strontium-90 activity. Strontium-89 activity is determined by precipitating $SrC0_3$ from the sample after yttrium separation. This precipitate is mounted on a nylon planchet and is covered with 80 mg/cm^2 aluminum absorber for low level beta counting.

Calculations of the results, two sigma errors and lower limits of detection (LLD) are expressed in activity of pCi/volume or pCi/mass:

RESULT Sr-89 = $(N/Dt-B_C-B_A)/(2.22\ V\ Y_S\ DF_{SR-89}\ E_{SR-89})$

TWO SIGMA ERROR Sr-89 = $2((N/Dt+B_C+B_A)/\Delta t)^{1/2}/(2.22\ V\ Y_S\ DF_{SR-89}\ E_{SR-89})$

LLD Sr-89 = $4.66((B_C+B_A)/\Delta t)^{1/2}/(2.22\ V\ YS\ DF_{SR-89}\ E_{SR-89})$

RESULT Sr-90 = $(N/\Delta t - B)/(2.22\ V\ Y_1\ Y_2\ DF\ IF\ E)$

TWO SIGMA ERROR Sr-90 = $2((N/\Delta t+B)/\Delta t)^{1/2}/(2.22\ V\ Y_1\ Y_2\ DF\ E\ IF))$

LLD Sr-90 = $4.66(B/\Delta t)^{1/2}/(2.22\ V\ Y_1\ Y_2\ IF\ DF\ E)$

where:

N	=	total counts from sample (counts)
Δt	=	counting time for sample (min)
B_C	=	background rate of counter (cpm) using absorber configuration
2.22	=	dpm/pCi
V	=	volume or weight of sample analyzed
B_A	=	background addition from Sr-90 and ingrowth of Y-90
B_A	=	$0.016\,(K) + (K)\,E_{Y/abs})\,(IG_{Y\text{-}90})$
Y_S	=	chemical yield of strontium
$DF_{SR\text{-}89}$	=	decay factor from the mid collection date to the counting date for SR-89
$E_{SR\text{-}89}$	=	efficiency of the counter for SR-89 with the 80 mg/cm.sq. aluminum absorber
K	=	$(N\Delta t - B_C)_{Y\text{-}90}/(E_{Y\text{-}90}\,IF_{Y\text{-}90}\,DF_{Y\text{-}90}Y_1)$
$DF_{Y\text{-}90})$	=	the decay factor for Y-90 from the "milk" time to the mid count time
$E_{Y\text{-}90}$	=	efficiency of the counter for Y-90
$IF_{Y\text{-}90}$	=	ingrowth factor for Y-90 from scavenge time to milking time
$IG_{Y\text{-}90}$	=	the ingrowth factor for Y-90 into the strontium mount from the "milk" time to the mid count time
0.016	=	the efficiency of measuring SR-90 through a No. 6 absorber
$EY_{/abs}$	=	the efficiency of counting Y-90 through a No. 6 absorber
B	=	background rate of counter (cpm)
Y_1	=	chemical yield of yttrium
Y_2	=	chemical yield of strontium
DF	=	decay factor of yttrium from the radiochemical milking time to the mid count time
E	=	efficiency of the counter for Y-90
IF	=	ingrowth factor for Y-90 from scavenge time to the radiochemical milking time

ANALYSIS OF SAMPLES FOR IODINE-131

Milk or Water

Two liters of sample are first equilibrated with stable iodide carrier. A batch treatment with anion exchange resin is used to remove iodine from the sample. The iodine is then stripped from the resin with sodium hypochlorite solution, reduced with hydroxylamine hydrochloride and extracted into carbon tetrachloride as free iodine. It is then back-extracted as iodide into sodium bisulfite solution and is precipitated as palladium iodide. The sodium bisulfite solution is precipitated as palladium iodide. The precipitate is weighed for chemical yield and is mounted on a nylon planchet for low level beta counting. The chemical yield is corrected by measuring the stable iodide content of the milk or the water with a specific ion electrode.

Calculations of results, two sigma error and the lower limit of detection (LLD) in pCi/l:

RESULT		=	$(N/\Delta t - B)/(2.22\ E\ V\ Y\ DF)$
TWO SIGMA ERROR		=	$2((N/\Delta t + B)/\Delta t)^{1/2}(2.22\ E\ V\ Y\ DF)$
LLD		=	$= 4.66(B/\Delta t)^{1/2}/(2.22\ E\ V\ Y\ DF)$
where:	N	=	total counts from sample (counts)
	Δt	=	counting time for sample (min)
	B	=	background rate of counter (cpm)
	2.22	=	dpm/pCi
	V	=	volume or weight of sample analyzed
	Y	=	chemical yield of the mount or sample counted
	DF	=	decay factor from the collection to the counting date
	E	=	efficiency of the counter for I-131, corrected for self absorption effects by the formula
	E	=	$E_s(\exp -0.0061M)/(\exp -0.0061M_s)$
	E_s	=	efficiency of the counter determined from an I-131 standard mount
	Ms	=	mass of PdI_2 on the standard mount, mg
	M	=	mass of PdI_2 on the sample mount, mg

GAMMA SPECTROMETRY OF SAMPLES

Milk and Water

A 1.0 liter Marinelli beaker is filled with a representative aliquot of the sample. The sample is then counted for approximately 1000 minutes with a shielded Ge(Li) detector coupled to a mini-computer-based data acquisition system which performs pulse height analysis.

Dried Solids Other Than Soils and Sediments

A large quantity of the sample is dried at a low temperature, less than 100°C. As much as possible (up to the total sample) is loaded into a tared 1-liter Marinelli and weighed. The sample is then counted for approximately 1000 minutes with a shielded Ge(Li) detector coupled to a mini-computer-based data acquisition system which performs pulse height analysis.

Fish

As much as possible (up to the total sample) of the edible portion of the sample is loaded into a tared Marinelli and weighed. The sample is then counted for approximately 1000 minutes with a shielded Ge(Li) detector coupled to a mini-computer-based data acquisition system which performs pulse height analysis.

Soils and Sediments

Soils and sediments are dried at a low temperature, less than 100°C. The soil or sediment is loaded fully into a tared, standard 300 cc container and weighed. The sample is then counted for approximately six hours with a shielded Ge(Li) detector coupled to a mini-computer-based data acquisition system which performs pulse height and analysis.

Charcoal Cartridges (Air Iodine)

Charcoal cartridges are counted up to five at a time, with one positioned on the face of a Ge(Li) detector and up to four on the side of the Ge(Li) detector. Each Ge(Li) detector is calibrated for both positions. The detection limit for I-131 of each charcoal cartridge can be determined (assuming no positive I-131) uniquely from the volume of air which passed through it. In the event I-131 is observed in the initial counting of a set, each charcoal cartridge is then counted separately, positioned on the face of the detector.

Air Particulate

The thirteen airborne particulate filters for a quarterly composite for each field station are aligned one in front of another and then counted for at least six hours with a shielded Ge(Li) detector coupled to a mini-computer-based data acquisition system which performs pulse height analysis.

A mini-computer software program defines peaks by certain changes in the slope of the spectrum. The program also compares the energy of each peak with a library of peaks for isotope identification and then performs the radioactivity calculation using the appropriate fractional gamma ray abundance, half life, detector efficiency, and net counts in the peak region. The calculation of results, two sigma error and the lower limit of detection (LLD) in pCi/volume of pCi/mass:

RESULT = $(S-B)/2.22\ t\ E\ V\ F\ DF)$

TWO SIGMA ERROR = $2(S+B)^{1/2}/(2.22\ t\ E\ V\ F\ DF)$

LLD = $4.66(B)^{1/2}/(2.22\ t\ E\ V\ F\ DF)$

where:

S = Area, in counts, of sample peak and background (region of spectrum of interest)

B = Background area, in counts, under sample peak, determined by a linear interpolation of the representative backgrounds on either side of the peak

t = length of time in minutes the sample was counted

2.22 = dpm/pCi

E = detector efficiency for energy of interest and geometry of sample

V = sample aliquot size (liters, cubic meters, kilograms, or grams)

F = fractional gamma abundance (specific for each emitted gamma)

DF = decay factor from the mid-collection date to the counting date

ENVIRONMENTAL DOSIMETRY

Teledyne Isotopes uses a $CaSO_4$:Dy thermoluminescent dosimeter (TLD) which the company manufactures. This material has a high light output, negligible thermally induced signal loss (fading), and negligible self dosing. The energy response curve (as well as all other features) satisfies NRC Reg. Guide 4.13. Transit doses are accounted for by use of separate TLDs.

Following the field exposure period the TLDs are placed in a Teledyne Isotopes Model 8300. One fourth of the rectangular TLD is heated at a time and the measured light emission (luminescence) is recorded. The TLD is then annealed and exposed to a known Cs-137 dose; each area is then read again. This provides a calibration of each area of each TLD after every field use. The transit controls are read in the same manner.

Calculations of results and the two sigma error in net milliRoentgen (mR):

RESULT = $D = (D_1+D_2+D_3+D_4)/4$

TWO SIGMA ERROR = $2((D_1-D)^2+(D_2-D)^2+(D_3-D)^2+(D_4-D)^2)/3)^{1/2}$

WHERE:

D_1 = the net mR of area 1 of the TLD, and similarly for D_2, D_3, and D_4

$D1 = I_1 K/R_1 - A$

I_1 = the instrument reading of the field dose in area 1

K = the known exposure by the Cs-137 source

R_1 = the instrument reading due to the Cs-137 dose on area 1

A = average dose in mR, calculated in similar manner as above, of the transit control TLDs

D = the average net mR of all 4 areas of the TLD.

APPENDIX E
EPA INTERLABORATORY COMPARISON PROGRAM

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US EPA INTERLABORATORY COMPARISON PROGRAM 1990

(Page 1 of 3)

EPA Preparation	Date TI Mailed Results	Date EPA Issued Results	Media	Nuclide	EPA Results(a)		TI Results(b)		Norm Dev. (Known)	**Warning ***Action
01/12/90	03/21/90	04/09/90	Water	Sr-89	25.00 ±	5.00	24.00 ±	1.73	-0.35	
				Sr-90	20.00 ±	1.50	19.67 ±	2.52	-0.38	
01/26/90	02/23/90	03/30/90	Water	Gr-Alpha	12.0 ±	5.0	10.00 ±	1.73	-0.69	
				Gr-Beta	12.0 ±	5.0	12.33 ±	1.53	0.12	
02/09/90	03/23/90	04/09/90	Water	Co-60	15.00 ±	5.00	15.00 ±	3.46	0.00	
				Zn-65	139.00 ±	14.00	131.33 ±	9.07	-0.95	
				Ru-106	139.00 ±	14.00	113.67 ±	4.04	-3.13	***(c)
				Cs-134	18.00 ±	5.00	15.33 ±	2.31	-0.92	
				Cs-137	18.00 ±	5.00	19.33 ±	3.21	0.46	
				Ba-133	74.00 ±	7.00	66.00 ±	3.46	-1.98	
02/23/90	03/22/90	04/09/90	Water	H-3	4976.00 ±	498.00	4900.00 ±	100.00	-0.26	
03/09/90	05/03/90	05/21/90	Water	Ra-226	4.9 ±	0.7	4.73 ±	0.47	-0.41	
				Ra-228	12.7 ±	1.9	13.00 ±	1.00	0.27	
03/30/90	06/08/90	07/03/90	Air Filter	Gr-Alpha	5.0 ±	5.0	6.33 ±	0.58	0.46	
				Gr-Beta	31.0 ±	5.0	31.67 ±	0.58	0.23	
				Sr-90	10.0 ±	1.5	9.33 ±	0.58	-0.77	
				Cs-137	10.0 ±	5.0	10.67 ±	1.15	0.23	
04/17/90	06/22/90	07/20/90	Water	Gr-Alpha	90.00 ±	23.0	79.33 ±	2.89	-0.80	
				Ra-226	5.0 ±	0.8	5.67 ±	0.15	1.44	
				Ra-228	10.2 ±	1.5	9.37 ±	1.44	-0.96	
				Gr-Beta	52.0 ±	5.0	53.33 ±	1.53	0.46	
				Sr-89	10.0 ±	5.0	10.67 ±	1.15	0.23	
				Sr-90	10.0 ±	1.5	9.67 ±	0.58	-0.38	
				Cs-134	15.0 ±	5.0	12.67 ±	1.53	-0.81	
				Cs-137	15.0 ±	5.0	16.33 ±	1.15	0.46	
04/27/90	06/22/90	07/27/90	Milk	Sr-89	23.0 ±	5.0	24.67 ±	1.53	0.58	
				Sr-90	23.0 ±	5.0	24.00 ±	0.00	0.35	
				I-131	99.0 ±	10.0	89.67 ±	3.21	-1.62	
				Cs-137	24.0 ±	5.0	27.33 ±	2.52	1.15	
				K	1550.0 ±	78.0	1483.33 ±	75.06	-1.48	

* See footnotes at end of table.

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EPA Preparation	Date TI Mailed Results	Date EPA Issued Results	Media	Nuclide	EPA Results(a)		TI Results(b)		Norm Dev. (Known)	**Warning ***Action
05/04/90	06/22/90	07/31/90	Water	Sr-89	7.0 ±	5.0	6.67 ±	0.58	-0.12	
				Sr-90	7.0 ±	5.0	6.67 ±	0.58	-0.12	
05/11/90	06/08/90	07/03/90	Water	Gr-Alpha	22.0 ±	6.0	16.00 ±	1.00	-1.73	
				Gr-Beta	15.0 ±	5.0	17.00 ±	1.00	0.69	
06/08/90	07/17/90	08/14/90	Water	Co-60	24.0 ±	5.0	25.33 ±	2.52	0.46	
				Zn-65	148.0 ±	15.0	148.67 ±	3.06	0.08	
				Ru-106	210.0 ±	21.0	196.00 ±	20.66	-1.15	
				Cs-134	24.0 ±	5.0	23.67 ±	2.89	-0.12	
				Cs-137	25.0 ±	5.0	24.67 ±	2.08	-0.12	
				Ba-133	99.0 ±	10.0	93.00 ±	6.08	-1.04	
06/22/90	07/19/90	08/14/90	Water	H-3	2933.0 ±	358.0	2900. ±	100.00	-0.16	
07/13/90	09/06/90	10/09/90	Water	Ra-226	12.1 ±	1.8	11.37 ±	0.60	-0.71	
				Ra-228	5.1 ±	1.3	4.20 ±	0.75	-1.20	
08/10/90	08/30/90	10/26/90	Water	I-131	39.0 ±	6.0	36.00 ±	3.00	-0.87	
08/31/90	11/06/90	11/29/90	Air Filter	Gr-Alpha	10.0 ±	5.0	16.00 ±	1.00	2.08	** (d)
				Gr-Beta	62.0 ±	5.0	63.33 ±	1.53	0.46	
				Sr-90	20.0 ±	5.0	18.00 ±	1.00	-0.69	
				Cs-137	20.0 ±	5.0	18.33 ±	3.21	-0.58	
09/14/90	11/20/90	12/11/90	Water	Sr-89	10.0 ±	5.0	8.67 ±	0.58	-0.46	
				Sr-90	9.0 ±	5.0	9.0 ±	1.00	0.00	
09/21/90	10/17/90	11/05/90	Water	Gr-Alpha	10.0 ±	5.0	11.00 ±	1.00	0.35	
				Gr-Beta	10.0 ±	5.0	11.00 ±	1.00	0.35	
09/28/90	12/04/90	12/24/90	Milk	Sr-89	16.0 ±	5.0	9.0 ±	2.65	-2.42	** (e)
				Sr-90	20.0 ±	5.0	15.33 ±	0.58	-1.62	
				I-131	58.0 ±	6.0	54.67 ±	1.53	-0.96	
				Cs-137	20.0 ±	5.0	23.00 ±	1.73	1.04	
				K	1700.0 ±	85.0	1710.00 ±	65.51	0.20	

* See footnotes at end of table.

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US EPA INTERLABORATORY COMPARISON PROGRAM 1990

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EPA Preparation	Date TI Mailed Results	Date EPA Issued Results	Media	Nuclide	EPA Results(a)	TI Results(b)	Norm Dev. (Known)	**Warning ***Action
10/15/90	11/16/90	12/04/90	Water	Co-60	20.0 ± 5.0	21.00 ± 1.00	0.35	
				Zn-65	115.0 ± 12.0	115.00 ± 11.53	0.00	
				Ru-106	151.0 ± 15.0	142.00 ± 8.66	-1.04	
				Cs-134	12.0 ± 5.0	11.00 ± 0.00	-0.35	
				Cs-137	12.0 ± 5.0	16.33 ± 2.52	1.50	
				Ba-133	110.0 ± 11.0	94.67 ± 5.13	-2.41	** (f)
10/19/90	11/16/90	12/04/90	Water	H-3	7203.0 ± 720.0	7133.33 ± 251.66	-0.17	
10/30/90	01/10/91	02/04/91	Lab Perf.	Gr-Alpha	62.00 ± 16.00	57.00 ± 1.00	-0.54	
			Sample A	Ra-226	13.6 ± 2.0	12.67 ± 1.27	-0.81	
				Ra-228	5.0 ± 1.3	4.87 ± 0.23	-0.18	
			Sample B	Gr-Beta	53.0 ± 5.0	51.00 ± 2.31	-0.12	
				Sr-89	20.0 ± 5.0	19.00 ± 3.61	-0.35	
				Sr-90	15.0 ± 5.0	14.33 ± 0.58	-0.23	
				Cs-134	7.0 ± 5.0	9.00 ± 0.00	0.69	
				Cs-137	5.0 ± 5.0	7.67 ± 1.15	0.92	
11/09/90	01/04/91	01/29/91	Water	Ra-226	7.4 ± 1.1	7.27 ± 0.38	-0.21	
				Ra-228	7.7 ± 1.9	7.57 ± 0.32	-0.12	

(a) Average ± experimental sigma.

(b) Expected laboratory precision (1 sigma, 1 determination).

(c) No apparent cause for the low results were found. Three aliquots of the sample were counted on three separate detectors. The results of all three were similar. The calibration curve fit is good (0.997). Ruthenium-106 was obtained from the EPA. Results of spikes were acceptable. Subsequent cross-checks from the EPA did not exceed two normalized standard deviation. No additional follow-up is necessary, but we will continue to monitor the results. New calibrations were completed March, 1991.

(d) The EPA deposit occupies a smaller area than our calibration planchet and hence has a higher counting efficiency. No further corrective action is required, since our calibration standard better represents an air particulate filter.

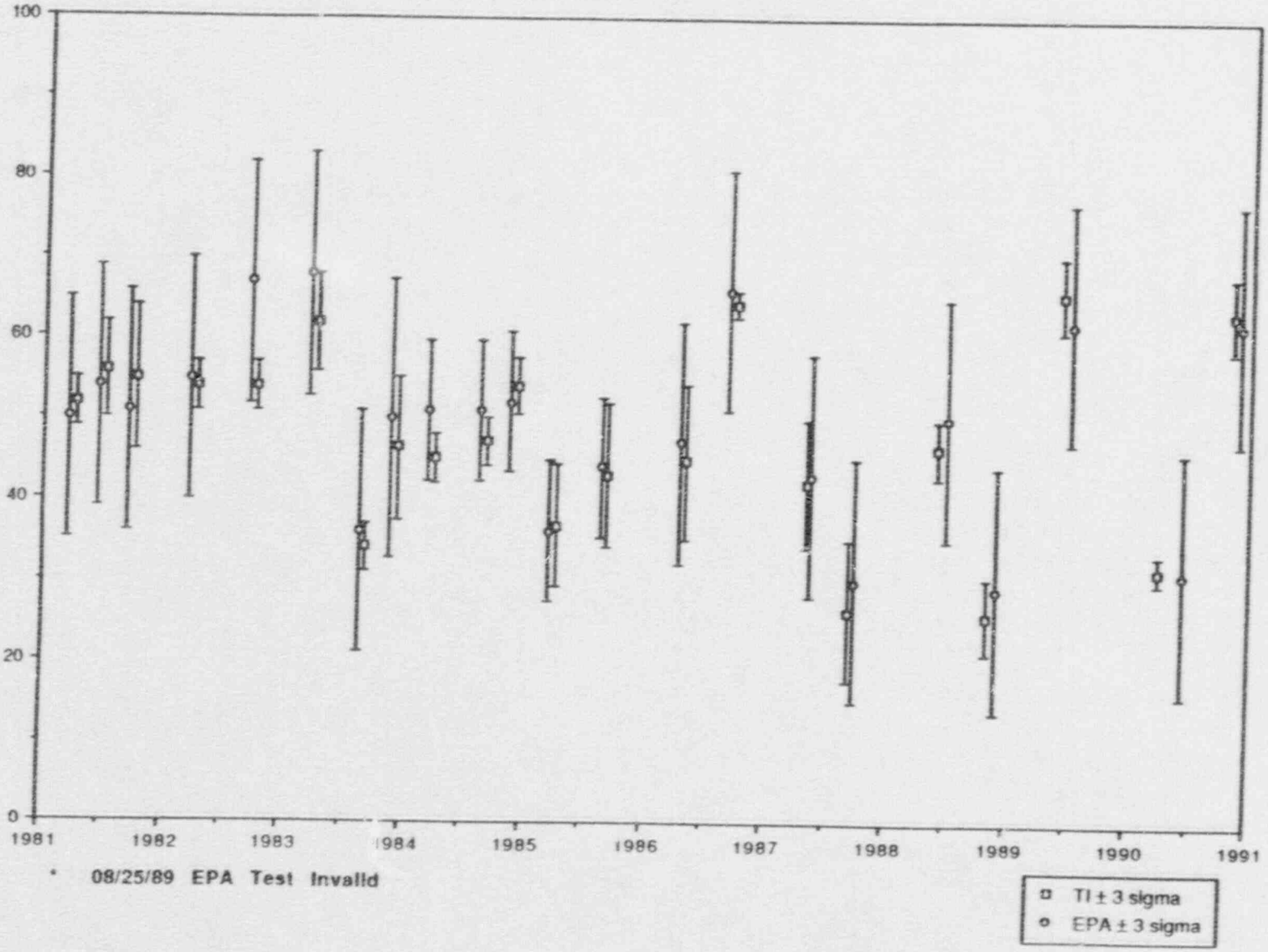
(e) Incomplete removal of calcium, lead to erroneously high strontium yields. More care is being taken in the strontium nitrate and strontium sulfate precipitation steps to ensure a final volume of at least 20 ml in the strontium sulfate step. Reanalysis of internal QC samples produced good results after implementing the corrective action.

(f) There is no apparent reason for the deviation between the EPA and Teledyne Isotopes values. Other isotopes in the sample were measured accurately. The calculations were reviewed and activities calculated from other Ba-133 gamma rays. Results were reproduced as reported.

TRENDING GRAPH - 11

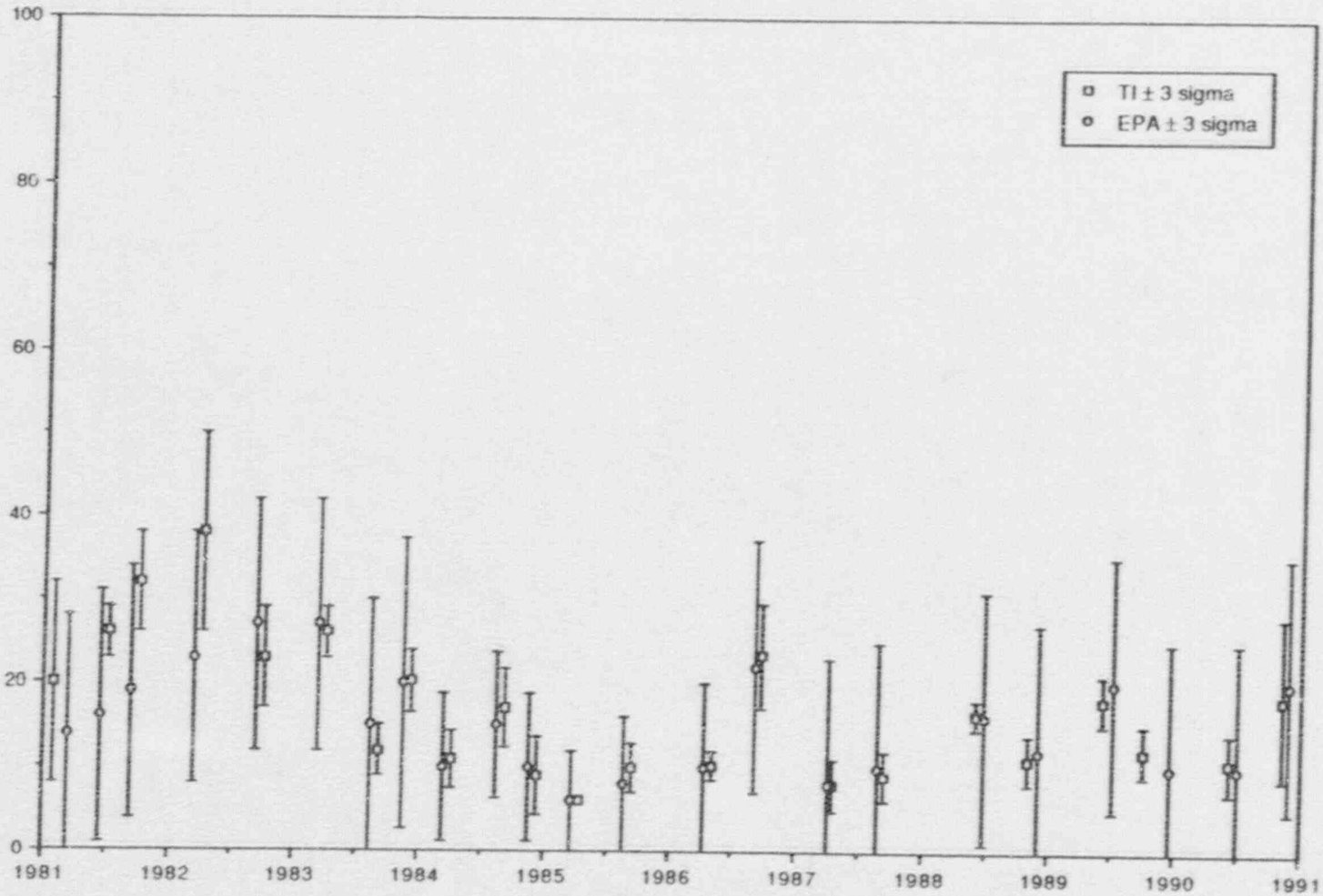
US EPA CROSS CHECK PROGRAM

GROSS BETA IN AIR PARTICULATES



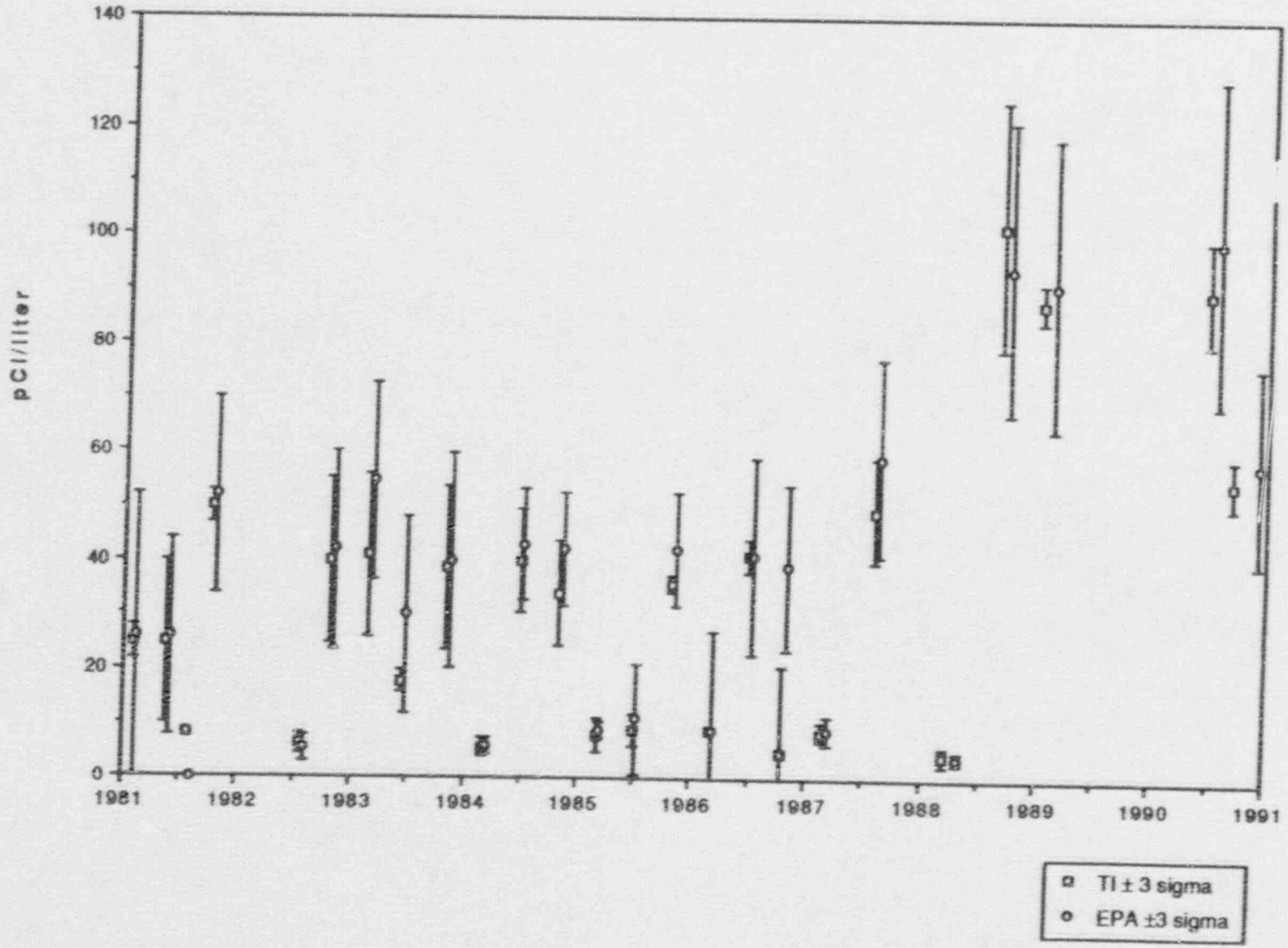
US EPA CROSS CHECK PROGRAM

CESIUM-137 IN AIR PARTICULATES



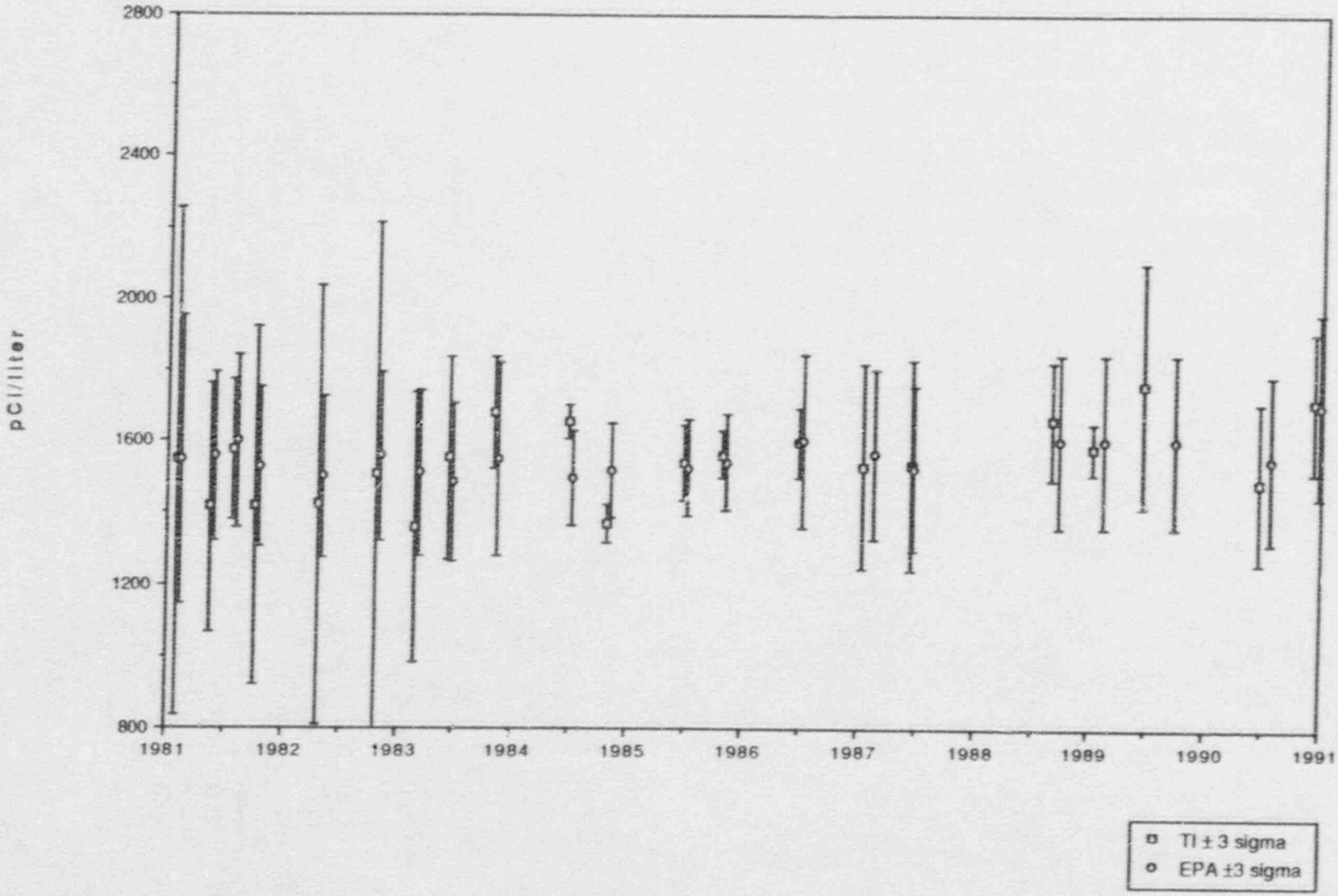
US EPA CROSS CHECK PROGRAM

IODINE-131 IN MILK



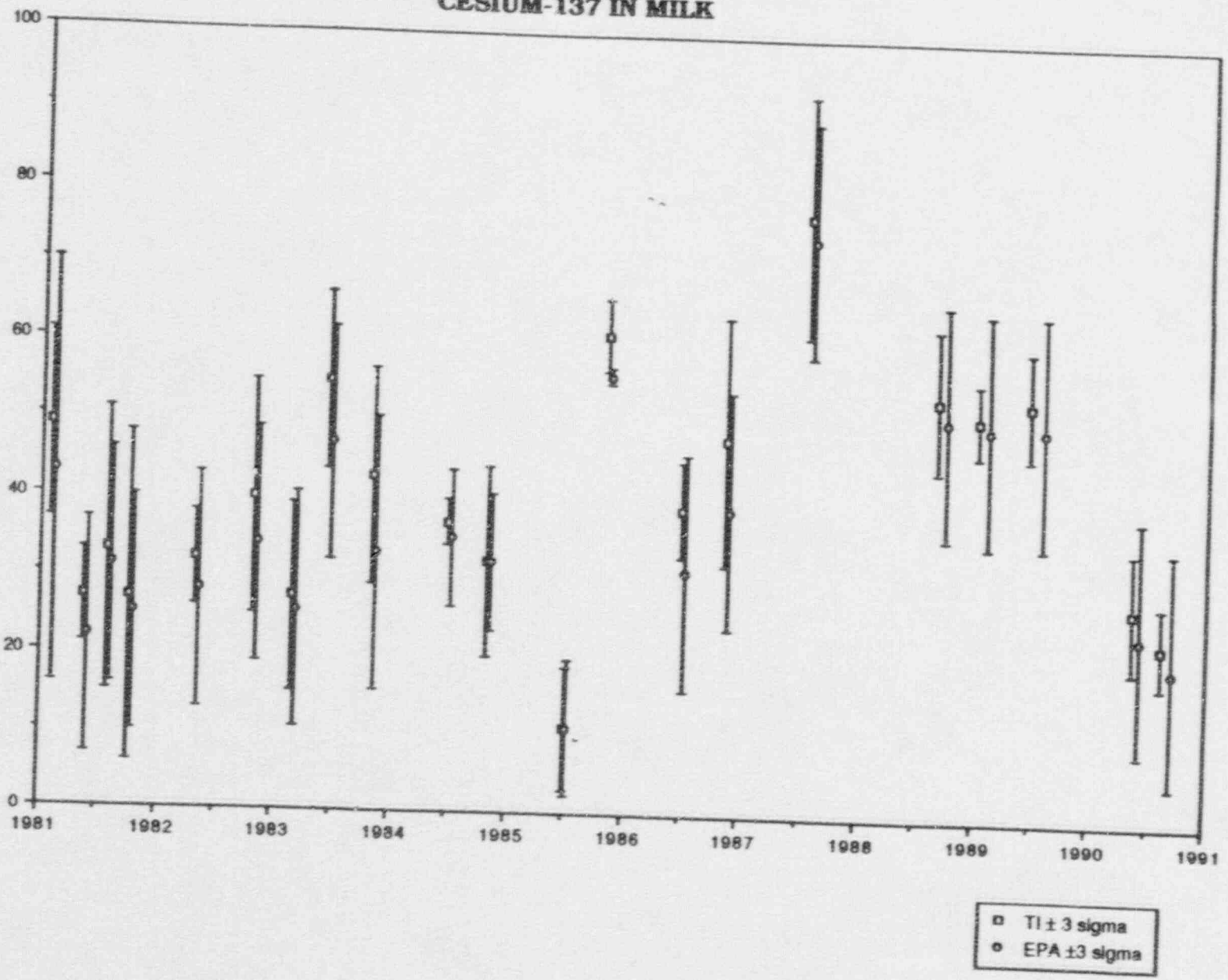
US EPA CROSS CHECK PROGRAM

POTASSIUM-40 IN MILK



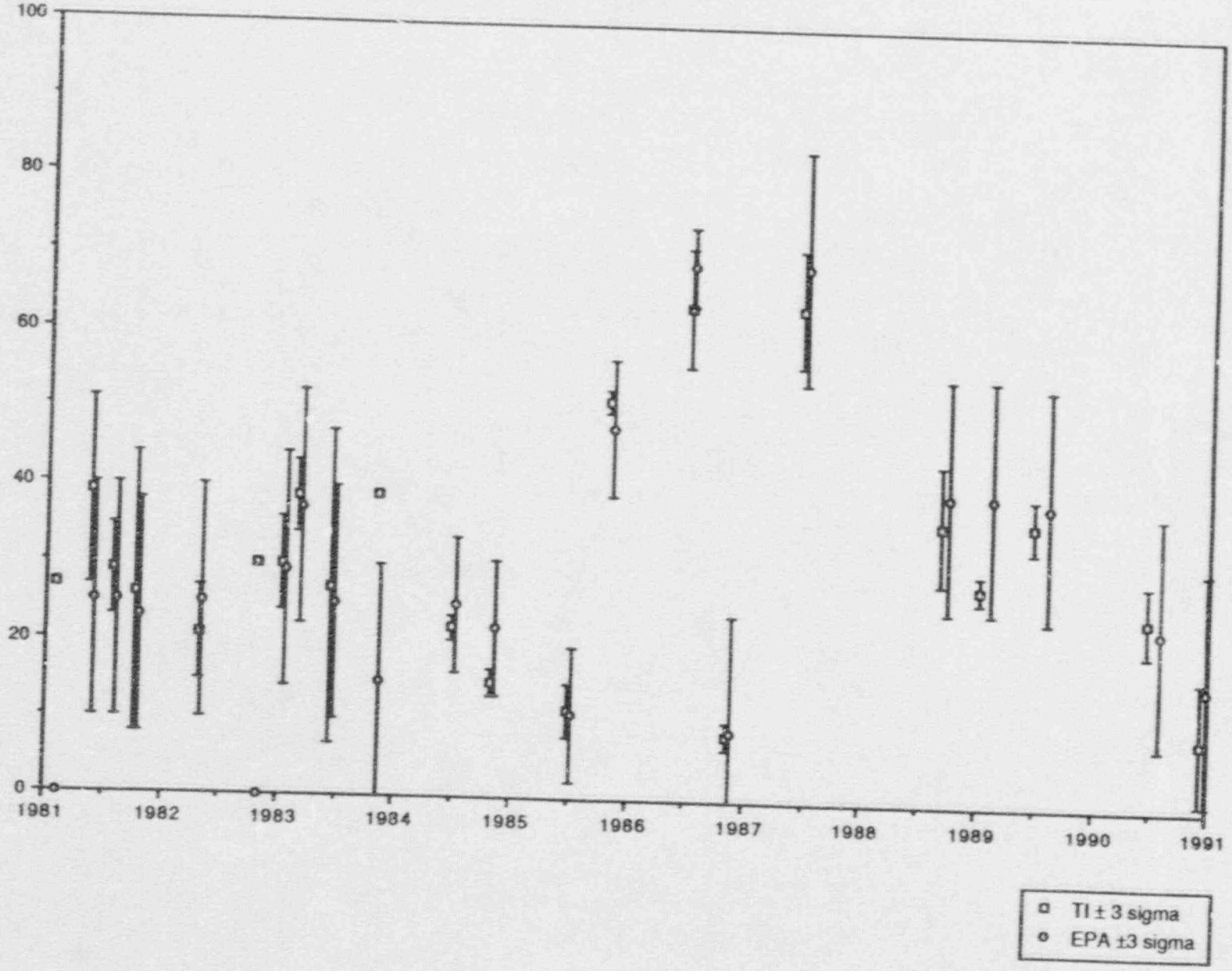
US EPA CROSS CHECK PROGRAM

CESIUM-137 IN MILK



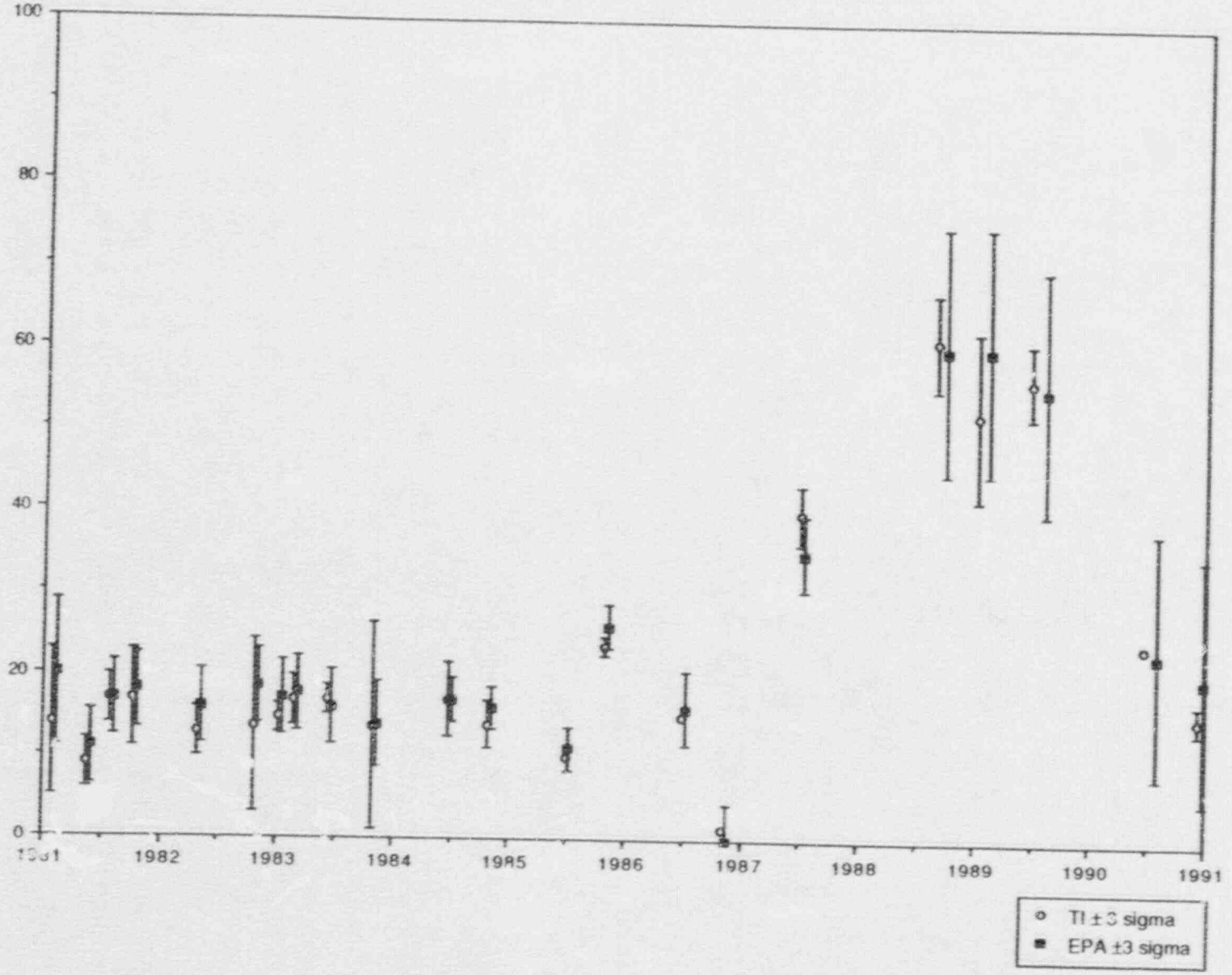
US EPA CROSS CHECK PROGRAM

STRONTIUM 89 IN MILK



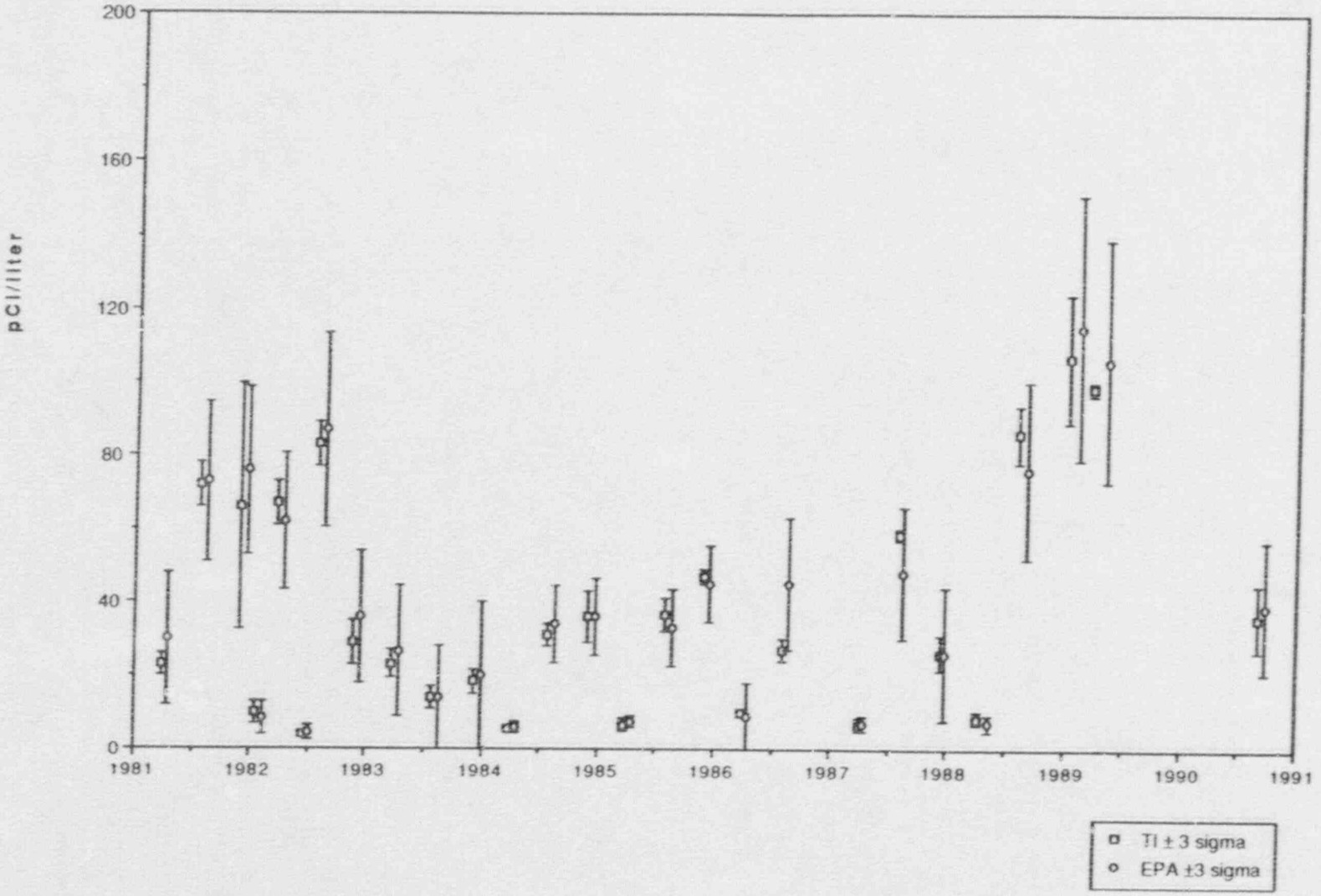
US EPA CROSS CHECK PROGRAM

STRONTIUM-90 IN MILK



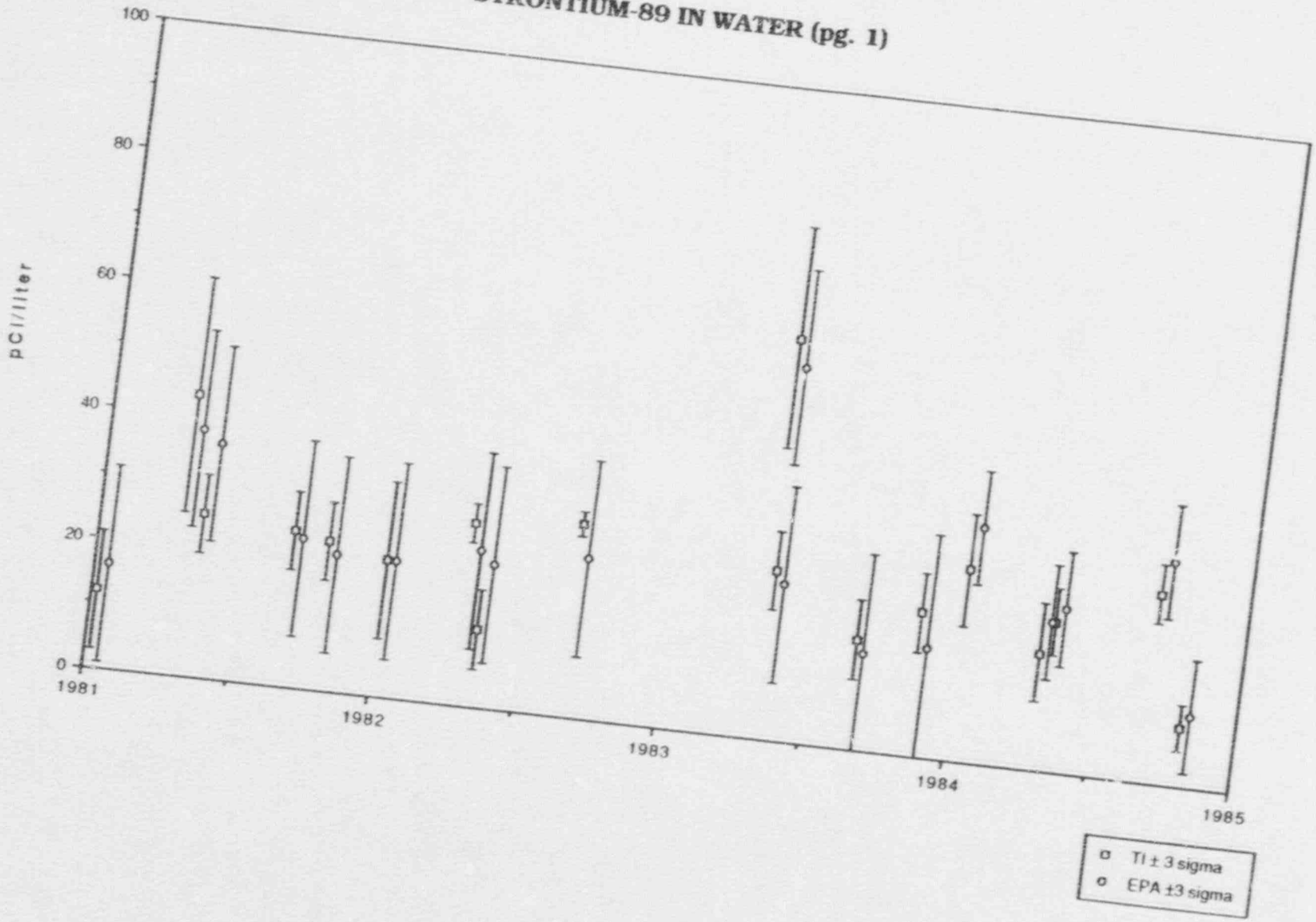
US EPA CROSS CHECK PROGRAM

IODINE-131 IN WATER



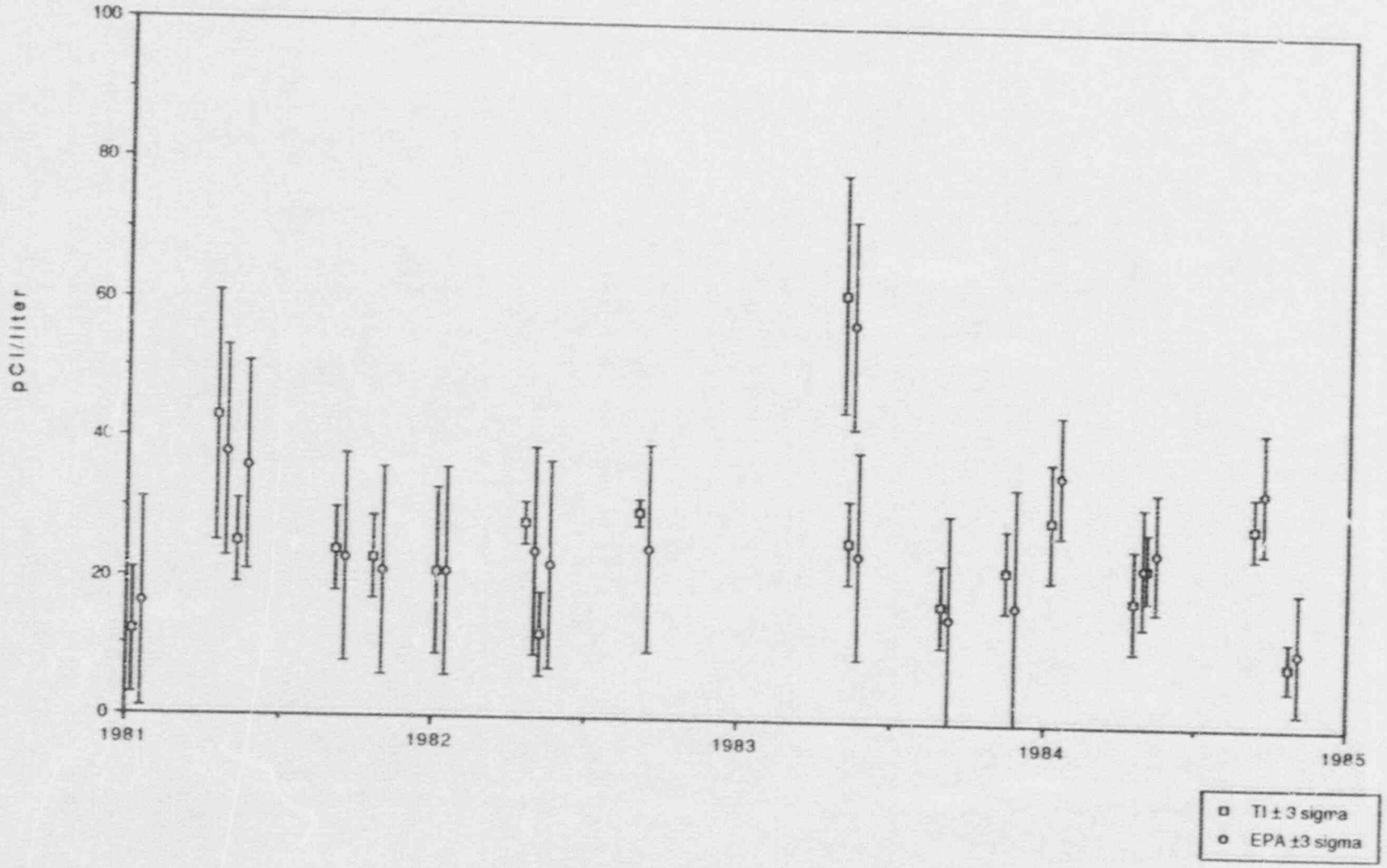
CROSS CHECK PROGRAM

STRONTIUM-89 IN WATER (pg. 1)



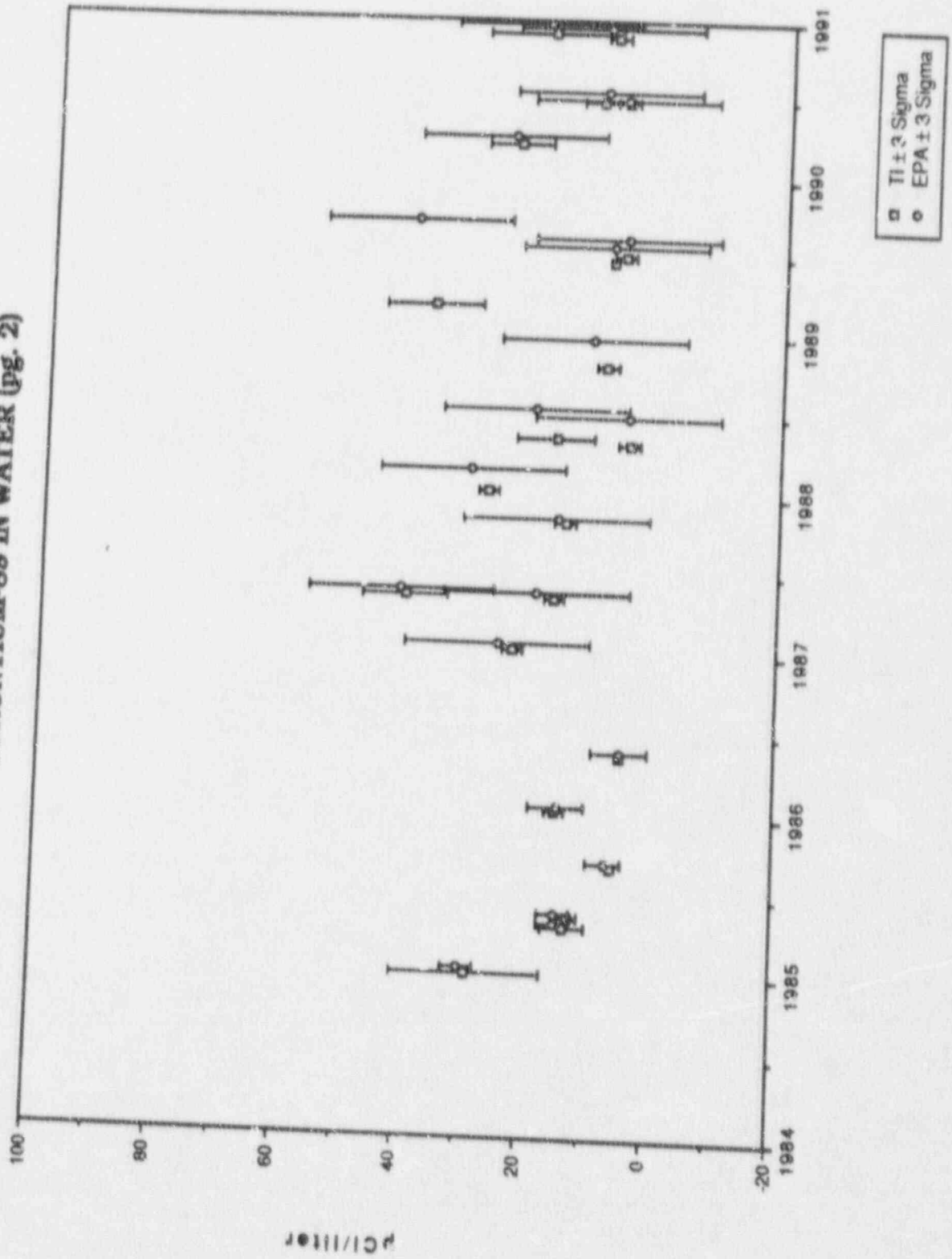
US EPA CROSS CHECK PROGRAM

STRONTIUM-89 IN WATER (pg. 1)



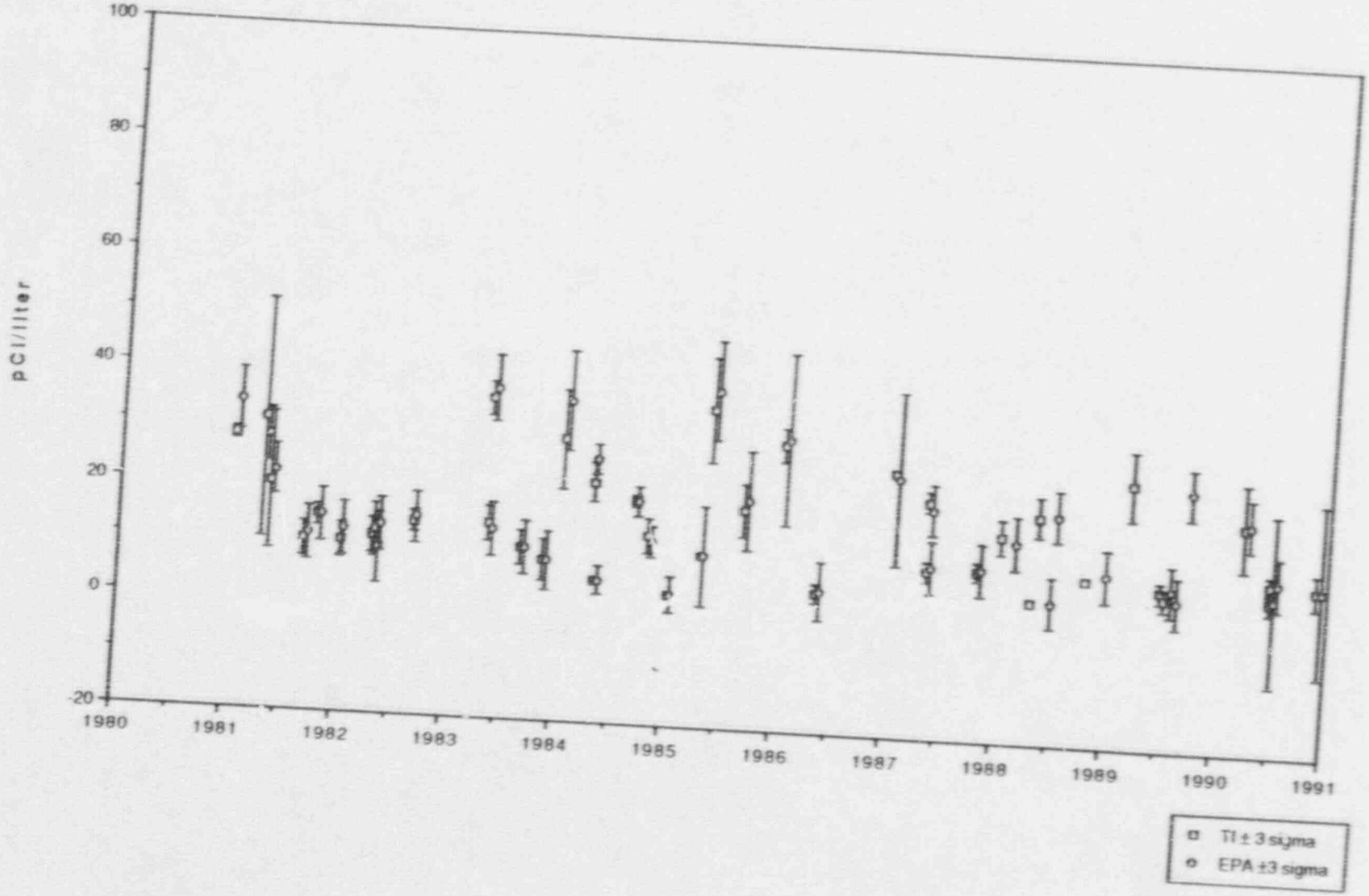
US EPA CROSS CHECK PROGRAM

STRONTIUM-89 IN WATER (pg. 2)



US EPA CROSS CHECK PROGRAM

STRONTIUM-90 IN WATER



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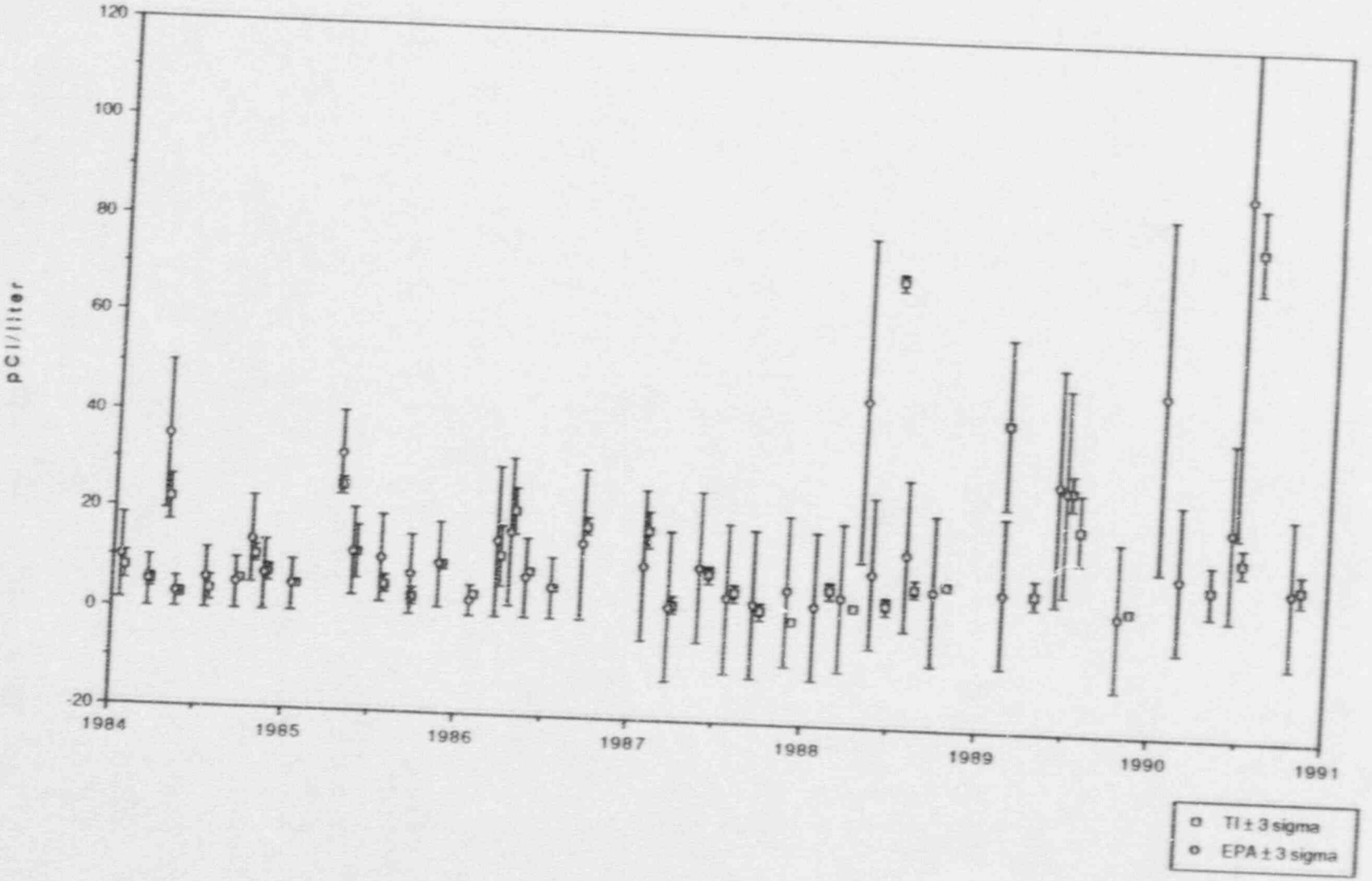
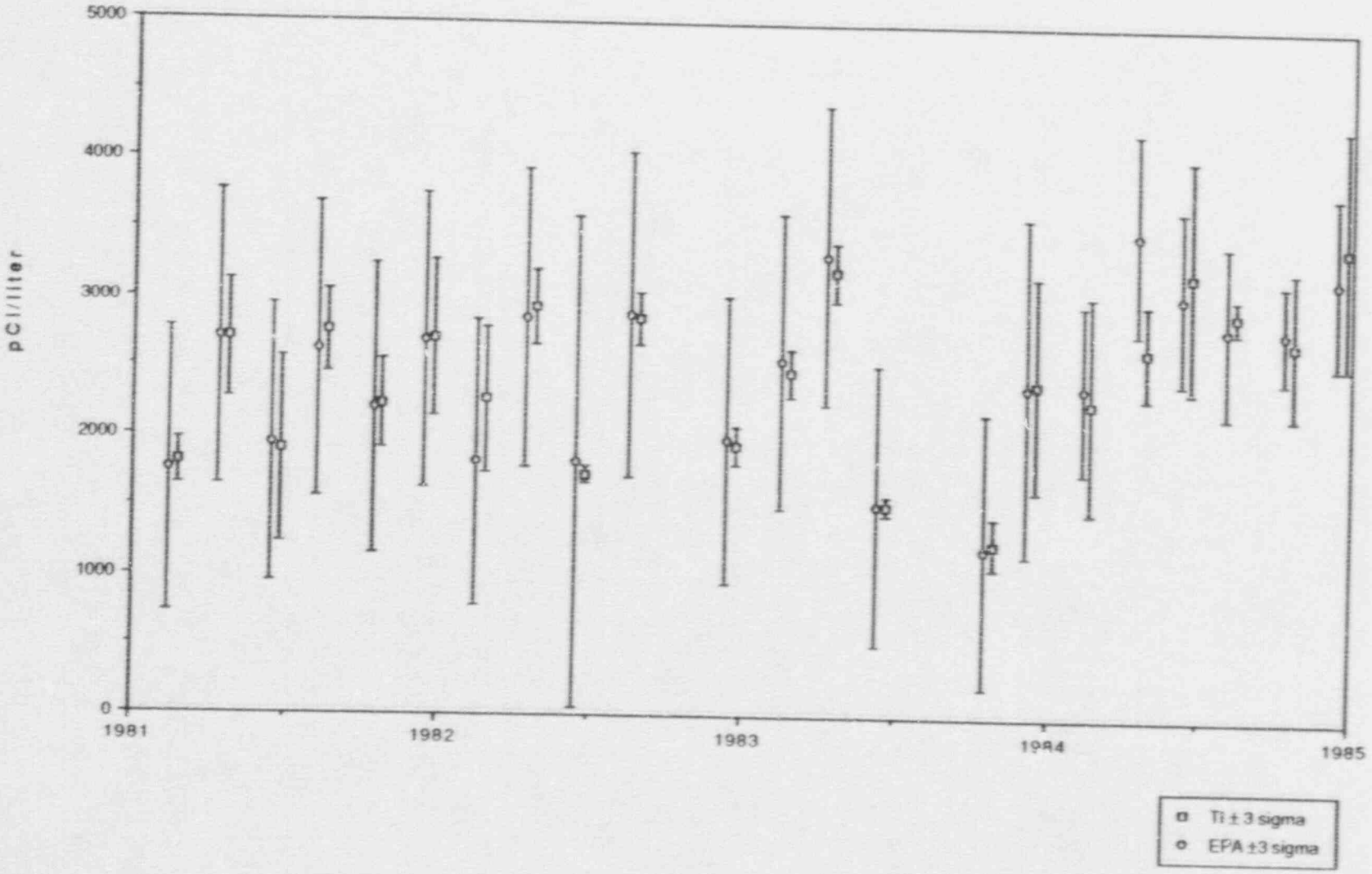
US EPA CROSS CHECK PROGRAM

GROSS ALPHA IN WATER



US EPA CROSS CHECK PROGRAM

TRITIUM IN WATER (pg. 1)



US EPA CROSS CHECK PROGRAM

TRITIUM IN WATER (pg. 2)