VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

April 28, 1991

United States Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D. C. 20555

Serial No. 91-243
NL&P/RBP
Docket Nos. 50-280
50-281
License Nos. DPR-32
DPR-37

Gentlemen:

VIRGINIA ELECTRIC AND POWER COMPANY
SURRY POWER STATION UNITS 1 AND 2
ANNUAL RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT

Attached is the 1990 Radiological Environmental Monitoring Program Report for Surry Power Station which fulfills the requirement for the Annual Radiological Environmental Operating Report per Technical Specification 6.6.B.2.

Very truly yours,

W. L. Stewart
Senior Vice President - Nuclear

Attachment

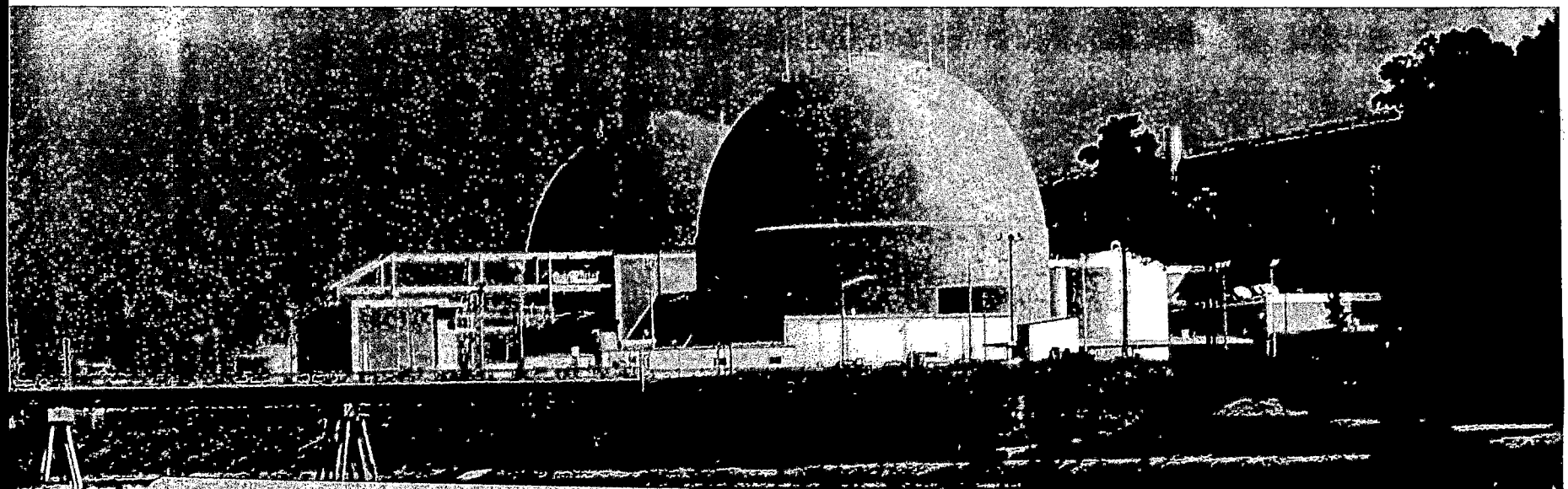
cc: U. S. Nuclear Regulatory Commission
Region II
101 Marietta Street, N. W.
Suite 2900
Atlanta, Georgia 30323

Mr. W. E. Holland
NRC Senior Resident Inspector
Surry Power Station

Commissioner
Department of Health
Room 400
109 Governor Street
Richmond, Virginia 23219

IE22
1/1

ATTACHMENT



Surry Power Station

1990 Annual Radiological Environmental Operating Report

VIRGINIA POWER

VIRGINIA ELECTRIC AND POWER COMPANY

SURRY POWER STATION

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

FOR 1990

Prepared by

VIRGINIA ELECTRIC AND POWER COMPANY

and

TELEDYNE ISOTOPES

ANNUAL RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT

SURRY POWER STATION

JANUARY 1, 1990 to DECEMBER 31, 1990

Prepared by: _____

Doug Noce
Radiological Engineering

Reviewed by: Peter F. Blount

Peter F. Blount
Supervisor Radiological Analysis

Reviewed by: Barry A. Garber

Barry A. Garber
Supervisor Technical Services
Health Physics

Approved by: Dean L. Erickson

Dean L. Erickson
Superintendent Radiological Protection

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont)

LIST OF FIGURES

LIST OF TRENDING GRAPHS

LIST OF TABLES

FORWARD

This report is submitted as required by Technical Specification 6.6.B.2, Annual Radiological Environmental Operating Report for Surry, Units 1 and 2, Virginia Electric and Power Company Docket Nos. 50-280 and 50-281.

EXECUTIVE SUMMARY

This document is a detailed report on the 1990 Surry Nuclear Power Station Radiological Environmental Monitoring Program (REMP). Radioactivity levels from January 1 through December 31, 1990 in air, 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 Surry 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 Surry 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 Surry 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 and airborne particulates. The 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-made isotopes in the airborne particulate media during 1990.

- The waterborne exposure pathway includes well water and river water. No man-made or natural isotopes were detected in the James River with the exception of naturally occurring potassium-40 and tritium. The average tritium activity in 1990 was 1.06% of the NRC reporting level. This has decreased from preoperational levels and is less than the average for the previous five years. No man-made or naturally occurring isotopes were detected in well water. This trend is consistent throughout the operational monitoring program.

- The aquatic exposure pathway includes silt and shoreline sediment samples. Silt contained some cesium-137, cesium-134 and cobalt-60. During the preoperational period, there were no man-made isotopes detected for this pathway, however, man-made isotopes have accumulated. The concentrations of the gamma-emitting isotopes in 1990 indicate a decreasing trend compared to the previous five year period. Shoreline sediment, which may provide a direct exposure pathway, contained no man-made isotopes. Naturally occurring isotopes detected in 1990 sediment samples revealed a steady trend over the recent past.

- The ingestion exposure pathway includes milk, aquatic biota, and food product samples. Iodine-131 was not detected in any 1990 milk samples and has not been detected in milk prior to and since the 1986 Chernobyl accident. Although cesium-137 has been detected in the past, it was not detected in 1990 samples. Strontium-90 was detected at levels less than the previous two years 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 aquatic biota sample results revealed gamma-emitting isotopes with the exception of one fish sample in which cesium-137 was detected at a concentration less than the average for the previous five years and lower than both the LLD and reporting level concentration. This is consistent with preoperational data. Naturally occurring

potassium-40 was detected in each of the aquatic biota samples with a decreasing trend compared to the previous five years. Vegetation samples revealed naturally occurring potassium-40 and beryllium-7 at levels which were statistically similar to both control and preoperational levels. Cesium-137 was detected in two soybean samples at concentrations less than the average for the previous five years and lower than the LLD and reporting levels.

- The direct exposure pathway measures environmental radiation doses by use of thermoluminescent dosimeters (TLDs). TLD results have remained statistically the same since the preoperational period. 1990 results are slightly less than the previous five years.

During 1990, as in previous years, operation of the Surry Nuclear Power Station created no adverse environmental affects or health hazards. The maximum dose calculated for the hypothetical individual at the Surry Power Station site boundary due to liquid and gaseous effluents released from the site during 1990 was 0.663 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 Surry Nuclear Power Station.

VIRGINIA ELECTRIC AND POWER COMPANY

SURRY POWER STATION

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

I. INTRODUCTION

The operational Radiological Environmental Monitoring Program (REMP) conducted for the year 1990 for the Surry 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 Surry Power Station of Virginia Electric and Power Company is located on the Gravel Neck peninsula adjacent to the James River, approximately 25 miles upstream of the Chesapeake Bay. The site consists of two units, each with pressurized water reactor (PWR) nuclear steam supply system and turbine generator furnished by Westinghouse Electric Corporation. Each unit is designed with a gross electrical output of 822.6 megawatts electric (MWe). Unit 1 achieved commercial operation on December 22, 1972, and Unit 2 on May 1, 1973.

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 Surry Power Station includes Technical Specifications which address the release of radioactive effluents. Inplant monitoring is used to ensure that these 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 Surry Power Station Technical Specifications.

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 any 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 Table 4.9-4 of Surry Power Station's Technical Specifications. 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:

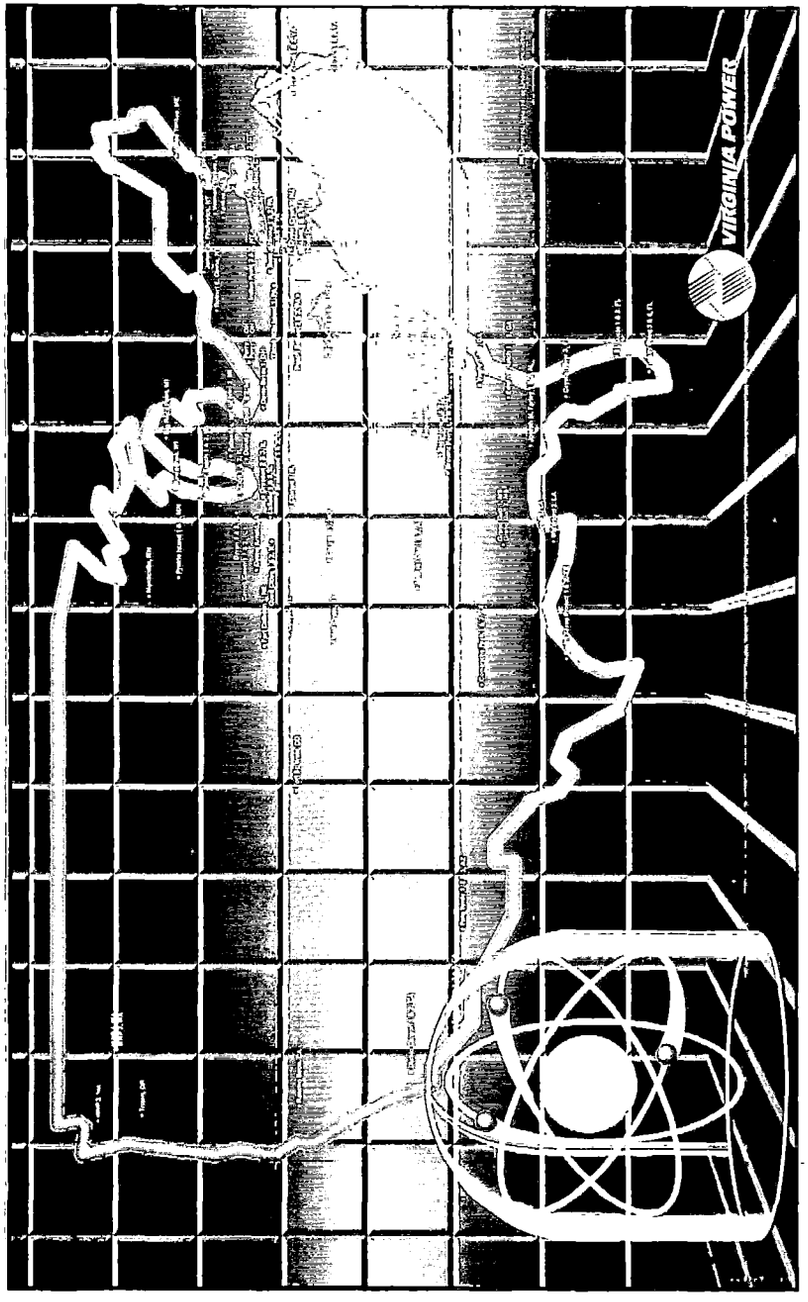
1. To provide measurements of radiation and of radioactive materials in those exposure pathways and for those radionuclides that lead to the highest potential radiation exposure of the maximum exposed members of the public resulting from the station operation.

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.

Nuclear Power And The Environment In Perspective



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

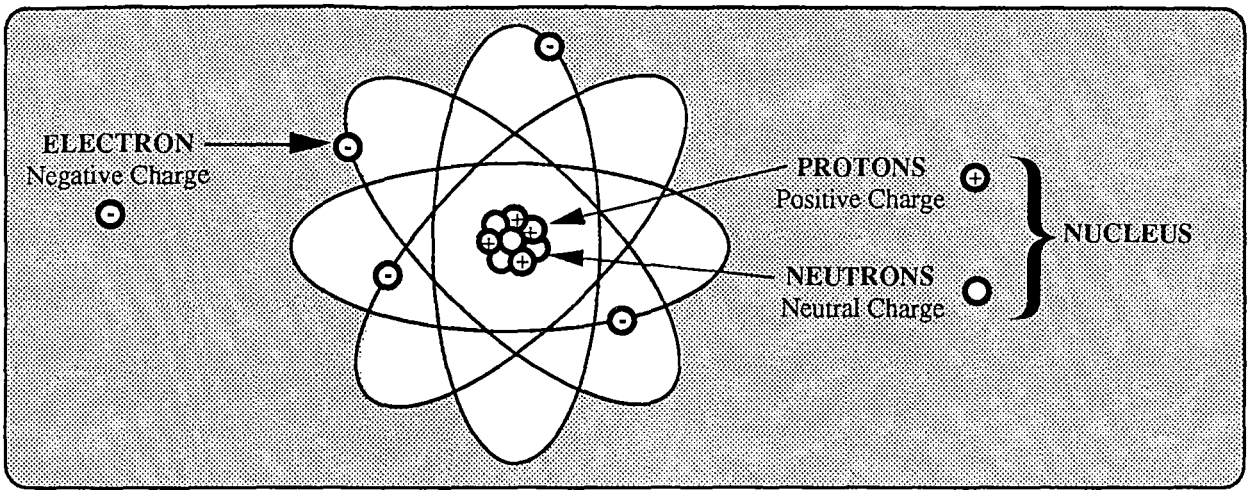


Figure 1-1: Diagram of an Atom

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.

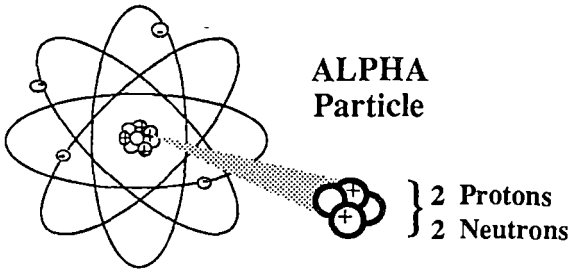
Half-Life

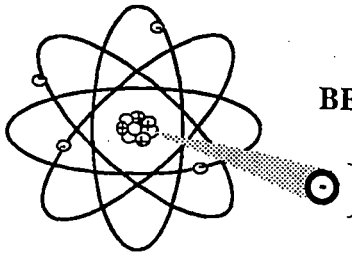
A radioactive half-life is the amount of time required for a radioactive substance to lose half of its activity through the process of radioactive decay. Cobalt-60 has a half-life of about 5 years, so after 5 years 50% of its radioactivity is gone and after 10 years 75% has decayed away. Radioactive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

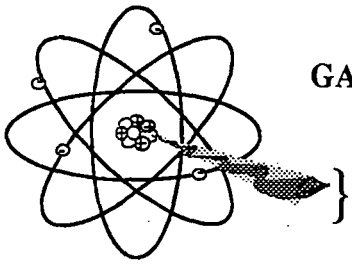




BETA Particle

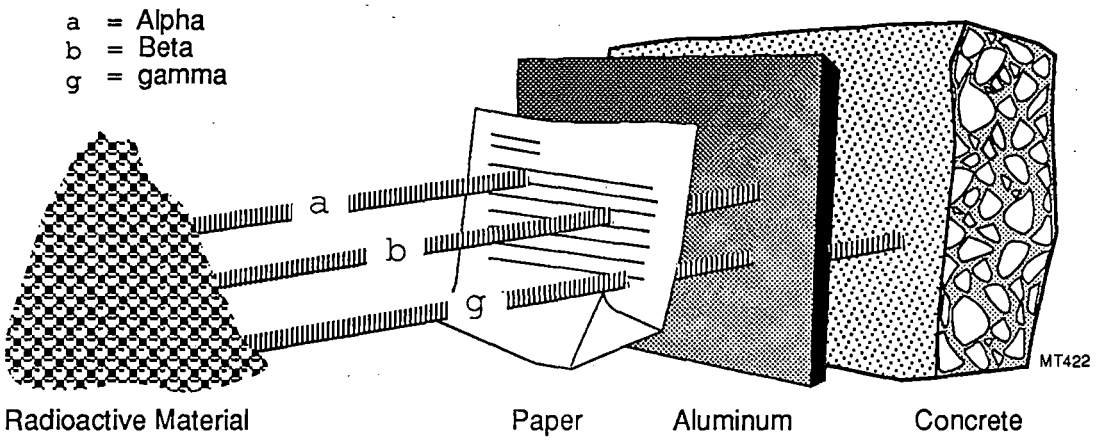
1 Neutron transforms to 1 Electron (ejected beta) + 1 Proton (in nucleus)

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

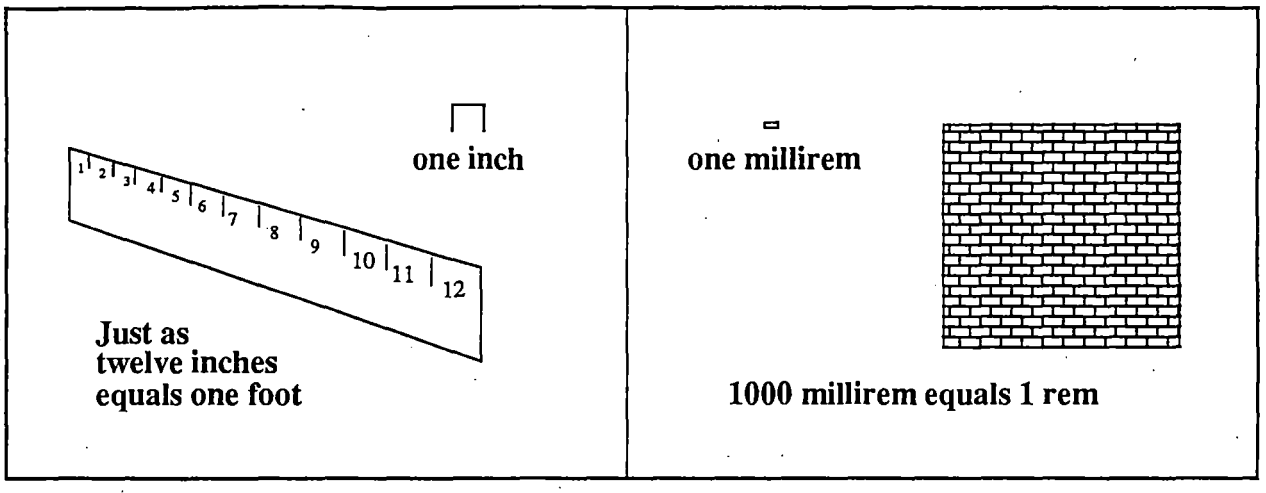
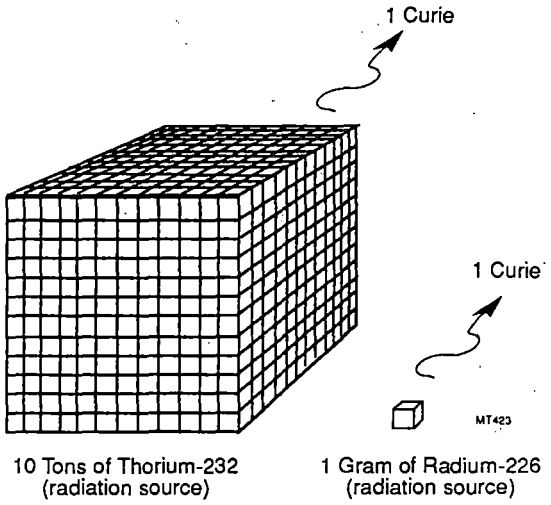


Figure 1-3: Unit Comparison

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.

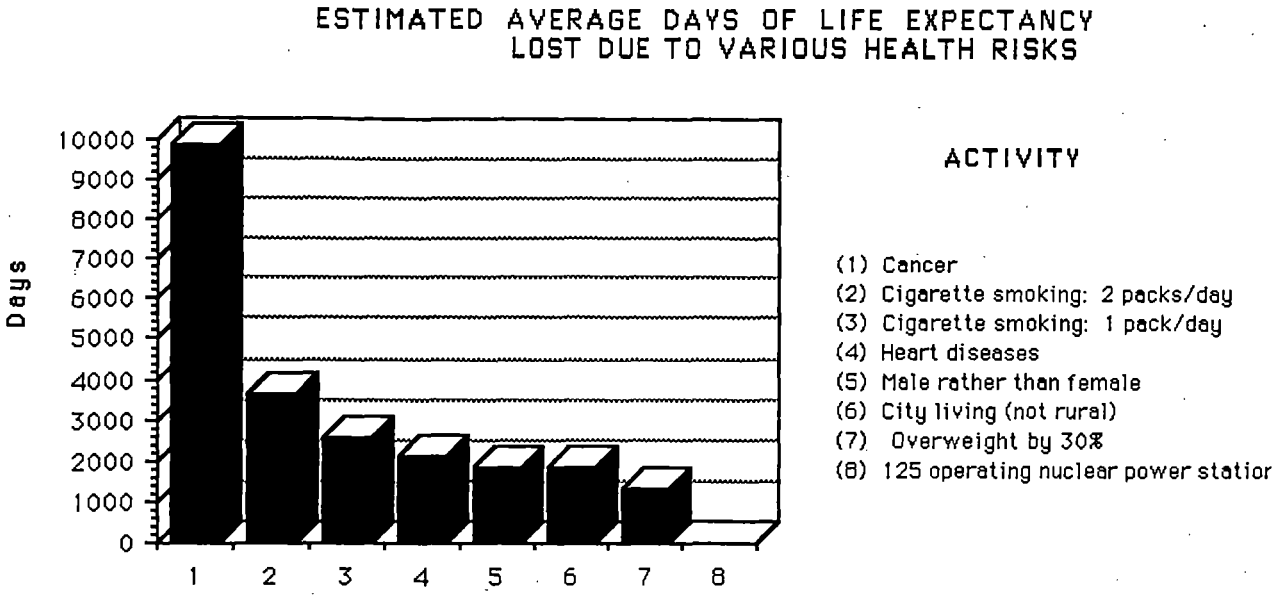


Figure 1-4: Loss of Life From Various Health Risks

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

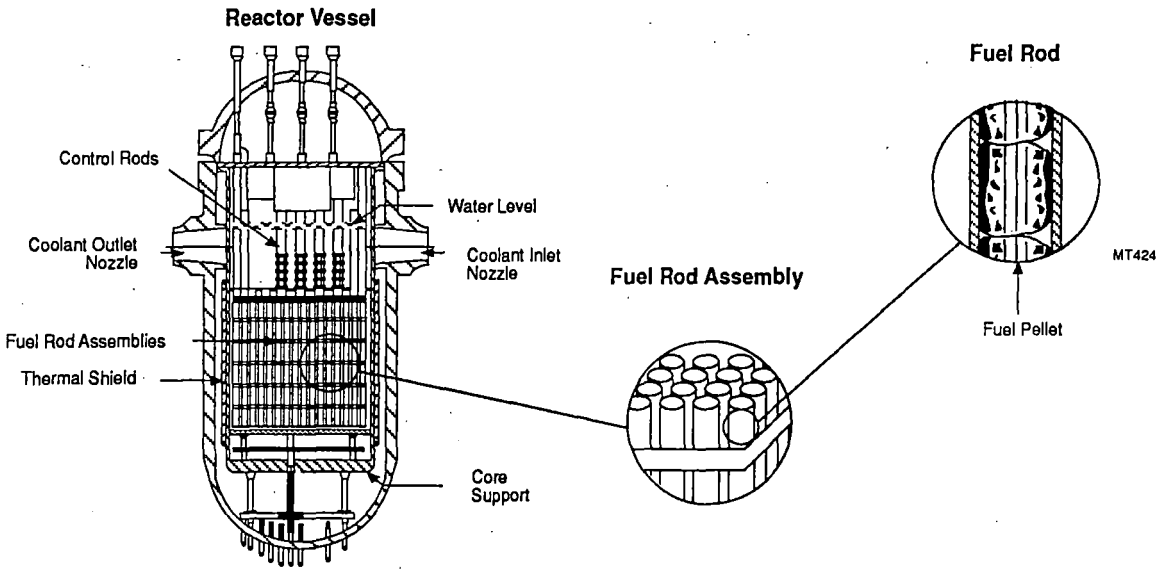
Electricity in the United States is being produced using fossil fuel, uranium, or falling water. A fossil-fueled power station burns coal, oil or natural gas in a boiler to produce energy. Nuclear power stations use uranium fuel and the heat produced from the fission process to make energy. In both cases, 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).

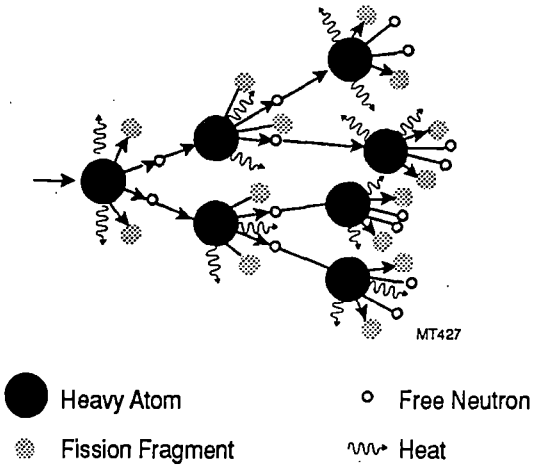


Reactor Vessel With Fuel Assemblies, Rods, and Fuel Pellets

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.

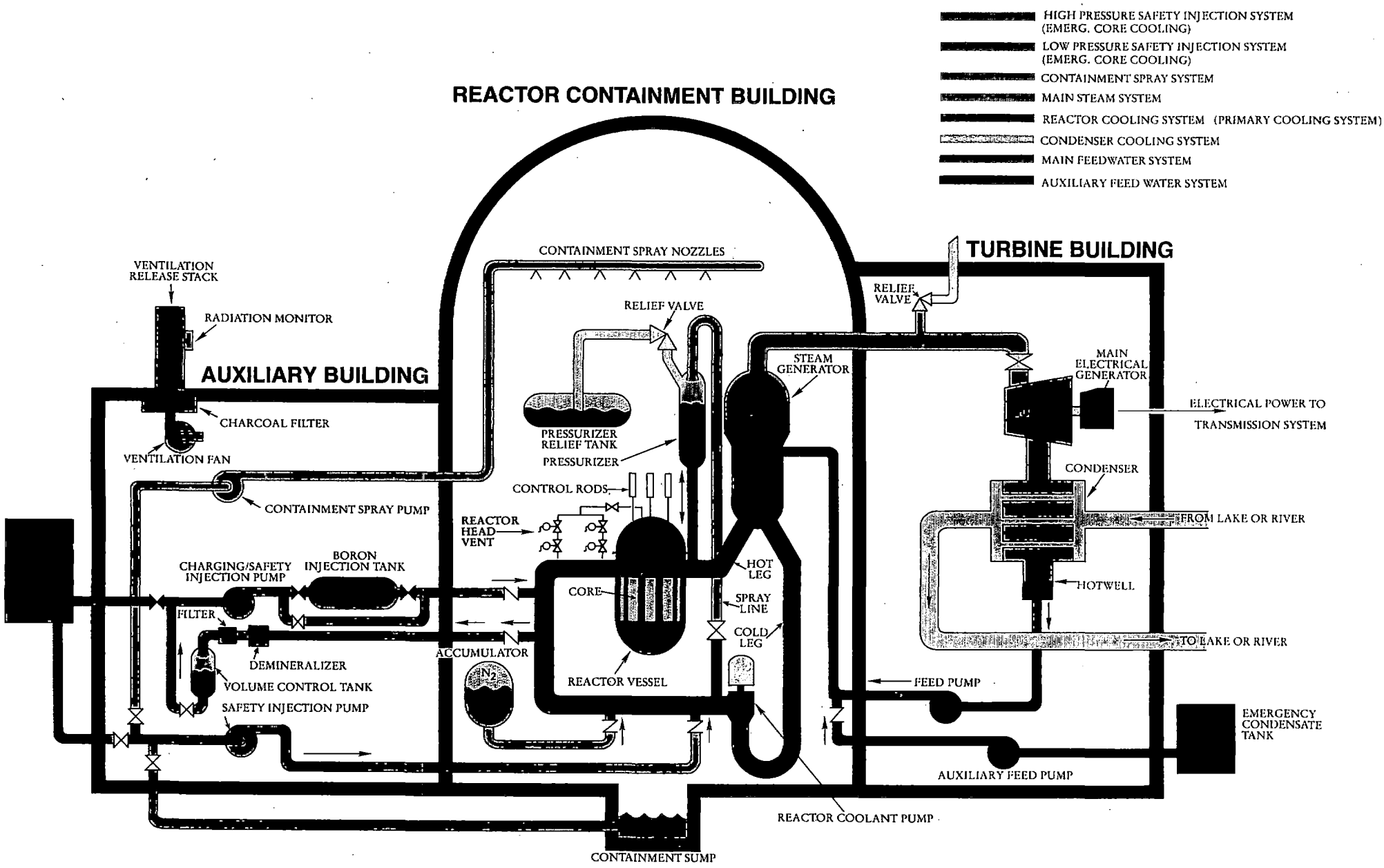
Containment

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 large 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 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 $4\frac{1}{2}$ feet thick tapering to $2\frac{1}{2}$ 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 -

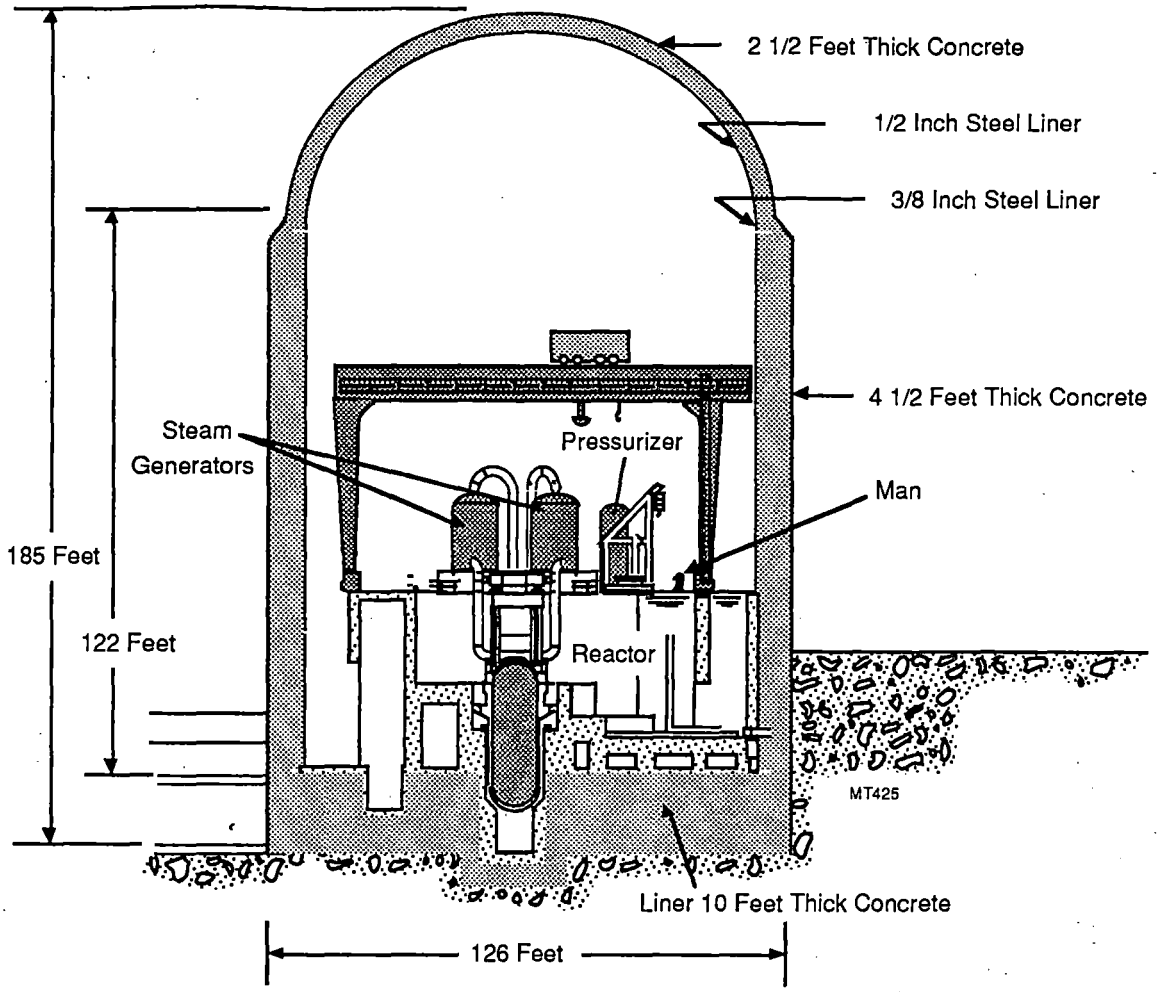


Figure 1-7: Containment Dimensions

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 chemicals 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.

Sampling And Analysis Program

III. SAMPLING AND ANALYSIS PROGRAM

A. Sampling Program

1. Table 1 summarizes the sampling program for Surry Power Station during 1990. The symbols on this table refer to the sample locations shown on Figures 1 through 3. Figure 1 indicates the locations of the land based samples while Figure 2 shows the locations of the river based samples. The small triangles in Figure 3 designate the position of environmental thermoluminescent dosimeters (TLDs) at the site boundary.

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 indicted as "co-location" samples.

3. In addition to the Radiological Environmental Monitoring Program required by Surry Technical Specifications, Virginia Electric and Power Company 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".

B. Analysis Program

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

TABLE 1

(Page 1 of 4)

SURRY - 1990

RADIOLOGICAL SAMPLING STATION

DISTANCE AND DIRECTION FROM UNIT NO. 1

Sample Media	Location	Station	Distance Miles	Direction	Degrees	Collection Frequency	Remarks	
Environmental (TLD's)	Control	(00)	-	-	-	Quarterly	Onsite*	
	West North West	(02)	0.17	WNW	292°	Quarterly	Site Boundary	
	Surry Station Discharge	(03)	0.6	NW	309°	Quarterly	Site Boundary	
Δ	North North West	(04)	0.4	NNW	330°	Quarterly	Site Boundary	
	North	(05)	0.33	N	357°	Quarterly	Site Boundary	
	North North East	(06)	0.28	NNE	22°	Quarterly	Site Boundary	
	North East	(07)	0.31	NE	45°	Quarterly	Site Boundary	
	East North East	(08)	0.43	ENE	68°	Quarterly	Site Boundary	
	East (Exclusion)	(09)	0.31	E	90°	Quarterly	Onsite	
	West	(10)	0.40	W	270°	Quarterly	Site Boundary	
	West South West	(11)	0.45	WSW	250°	Quarterly	Site Boundary	
	South West	(12)	0.30	SW	225°	Quarterly	Site Boundary	
	South South West	(13)	0.43	SSW	203°	Quarterly	Site Boundary	
	South	(14)	0.48	S	180°	Quarterly	Site Boundary	
	South South East	(15)	0.74	SSE	157°	Quarterly	Site Boundary	
	South East	(16)	1.00	SE	135°	Quarterly	Site Boundary	
	East	(17)	0.57	E	90°	Quarterly	Site Boundary	
	Station Intake	(18)	1.23	ESE	113°	Quarterly	Site Boundary	
	Hog Island Reserve	(19)	1.94	NNE	26°	Quarterly	Near Resident,	co-location
	Bacons Castle	(20)	4.45	SSW	202°	Quarterly	Apx. 5 mile TLD	co-location
	Route 633	(21)	3.5	SW	224°	Quarterly	Apx. 5 mile TLD	
	Alliance	(22)	5.1	WSW	248°	Quarterly	Apx. 5 mile TLD	co-location
	Surry	(23)	8.0	WSW	250°	Quarterly	Population Center	
	Route 636 and 637	(24)	4.0	W	270°	Quarterly	Apx. 5 mile TLD	
	Scotland Wharf	(25)	5.0	WNW	285°	Quarterly	Apx. 5 mile TLD	co-location
	Jamestown	(26)	6.3	NW	310°	Quarterly	Apx. 5 mile TLD	co-location
	Colonial Parkway	(27)	3.7	NNW	330°	Quarterly	Apx. 5 mile TLD	
	Route 617 and 618	(28)	5.2	NNW	340°	Quarterly	Apx. 5 mile TLD	
	Kingsmill	(29)	4.8	N	2°	Quarterly	Apx. 5 mile TLD	
	Williamsburg	(30)	7.8	N	0°	Quarterly	Population Center	co-location
	Kingsmill North	(31)	5.6	NNE	14°	Quarterly	Apx. 5 mile TLD	
	Budweiser	(32)	5.7	NNE	27°	Quarterly	Population Center	

* TLD stored in a lead shield in environmental building

TABLE 1

(Page 2 of 4)

SURRY - 1990

RADIOLOGICAL SAMPLING STATION

DISTANCE AND DIRECTION FROM UNIT NO. 1

Sample Media	Location	Station	Distance Miles	Direction	Degrees	Collection Frequency	Remarks	
Environmental TLD's(Cont.)	Water Plant	(33)	4.8	NE	41°	Quarterly	Apx. 5 mile TLD	
	Dow	(34)	5.1	ENE	70°	Quarterly	Apx. 5 mile TLD	
	Lee Hall	(35)	7.1	ENE	73°	Quarterly	Population Center	co-location
△	Goose Island	(36)	5.0	E	88°	Quarterly	Apx. 5 mile TLD	
	Fort Eustis	(37)	4.8	ESE	107°	Quarterly	Apx. 5 mile TLD	co-location
	Newport News	(38)	16.5	ESE	102°	Quarterly	Population Center	
	James River Bridge	(39)	14.8	SSE	147°	Quarterly	Control Location	
	Benn's Church	(40)	14.5	S	175°	Quarterly	Control Location	
	Smithfield	(41)	11.5	S	176°	Quarterly	Population Center	
	Rushmere	(42)	5.2	SSE	156°	Quarterly	Apx. 5 mile TLD	
	Rt. 628	(43)	5.0	S	177°	Quarterly	Apx. 5 mile TLD	co-location
Air Charcoal and Particulate	Surry Station	(SS)	.37	NNE	15°	Weekly	Site boundary location with Highest D/Q	
	Hog Island Reserve	(HIR)	2.0	NNE	26°	Weekly	Co-location	
□	Bacons Castle	(BC)	4.5	SSW	202°	Weekly		
	Alliance	(ALL)	5.1	WSW	248°	Weekly	Co-location	
	Colonial Parkway	(CP)	3.7	NNW	330°	Weekly		
	Dow Chemical	(DOW)	5.1	ENE	70°	Weekly		
	Fort Eustis	(FE)	4.8	ESE	107°	Weekly		
	Newport News	(NN)	16.5	ESE	122°	Weekly	Control Location	
River Water	Surry Discharge		0.17	NW	325°	Monthly	State Split	
	Scotland Wharf		5.0	WNW	285°	Monthly	Control Location/State Split	
W	Surry Station Intake		1.9	ESE	77°	Bi-monthly		
	Hog Island Point		2.4	NE	52°	Bi-monthly		
	Newport News		12.0	SE	140°	Bi-monthly		
	Chickahominy River		11.2	WNW	300°	Bi-monthly	Control Location	
	Surry Station Discharge		0.17	NW	325°	Monthly		
	Scotland Wharf		5.0	WNW	285°	Monthly		

TABLE 1

(Page 3 of 4)

SURRY - 1990

RADIOLOGICAL SAMPLING STATION

DISTANCE AND DIRECTION FROM UNIT NO. 1

Sample Media	Location	Distance Miles	Direction	Degrees	Collection Frequency	Remarks
Well Water	Surry Station	-	-	-	Quarterly	Onsite*
	Hog Island Reserve	2.0	NNE	27°	Quarterly	
W	Bacons Castle	4.5	SSW	203°	Quarterly	
	Jamestown	6.3	NW	309°	Quarterly	
Shoreline Sediment	Hog Island Reserve	0.8	N	5°	Semi-Annually	
SD	Burwell's Bay	7.76	SSE	167°	Semi-Annually	
Silt	Chickahominy River	11.2	WNW	300°	Semi-Annually	Control Location
	Surry Station Intake	1.9	ESE	77°	Semi-Annually	
S	Hog Island Point	2.4	NE	52°	Semi-Annually	
	Point of Shoals	6.4	SSE	157°	Semi-Annually	
	Newport News	12.0	SE	140°	Semi-Annually	
	Surry Station Discharge	0.5	NNW	341°	Semi-Annually	
Milk	Lee Hall	7.1	ENE	64°	Monthly	State Split
	Epps	4.8	SSW	201°	Monthly	State Split
▲	Colonial Parkway	3.7	NNW	337°	Monthly	
	Judkins	6.2	SSW	211°	Monthly	
	Williams	22.5	S	182°	Monthly	Control Location
Oysters	Deep Water Shoals	3.9	ESE	105°	Bi-Monthly	
	Point of Shoals	6.4	SSE	157°	Bi-Monthly	
O	Horsehead Shoals	4.2	ESE	137°	Bi-Monthly	State Split
	Rock Landing Shoals	7.8	SE	140°	Bi-Monthly	
	Newport News	12.0	SE	140°	Bi-Monthly	
Clams	Chickahominy River	11.2	WNW	300°	Bi-Monthly	Control Location
	Surry Station Discharge	1.3	NNW	341°	Bi-Monthly	State Split
C	Hog Island Point	2.4	NE	52°	Bi-Monthly	
	Jamestown	5.1	WNW	300°	Bi-Monthly	
	Lawnes Creek	2.4	SE	131°	Bi-Monthly	

*Well water sample taken onsite at Surry Environmental Building

TABLE 1

(Page 4 of 4)

SURRY - 1990

RADIOLOGICAL SAMPLING STATION

DISTANCE AND DIRECTION FROM UNIT NO. 1

Sample Media	Location	Distance Miles	Direction	Degrees	Collection Frequency	Remarks
Crabs CR	Surry Station Discharge	0.6	NW	312°	Annually	
Fish F	Surry Station Discharge	0.6	NW	312°	Semi-Annually	
Crops (Corn,Peanuts)	Brock's Farm	3.8	S	188°	Annually	State Split
	Slade's Farm	2.4	S	177°	Annually	State Split
Soybeans)						
(Cabbage,Kale)	Pool's Garden	2.3	S	182°	Annually	State Split
	Carter's Grove Garden	4.8	NE	56°	Annually	State Split
	Ryan's Garden	-	-	-	Annually	State Split/Control Loc. (Chester, Va.)
	Stone's Garden	-	-	-	Annually	State Split

FIGURE 1 LAND BASED SAMPLES

FIGURE 2 RIVER BASED SAMPLES

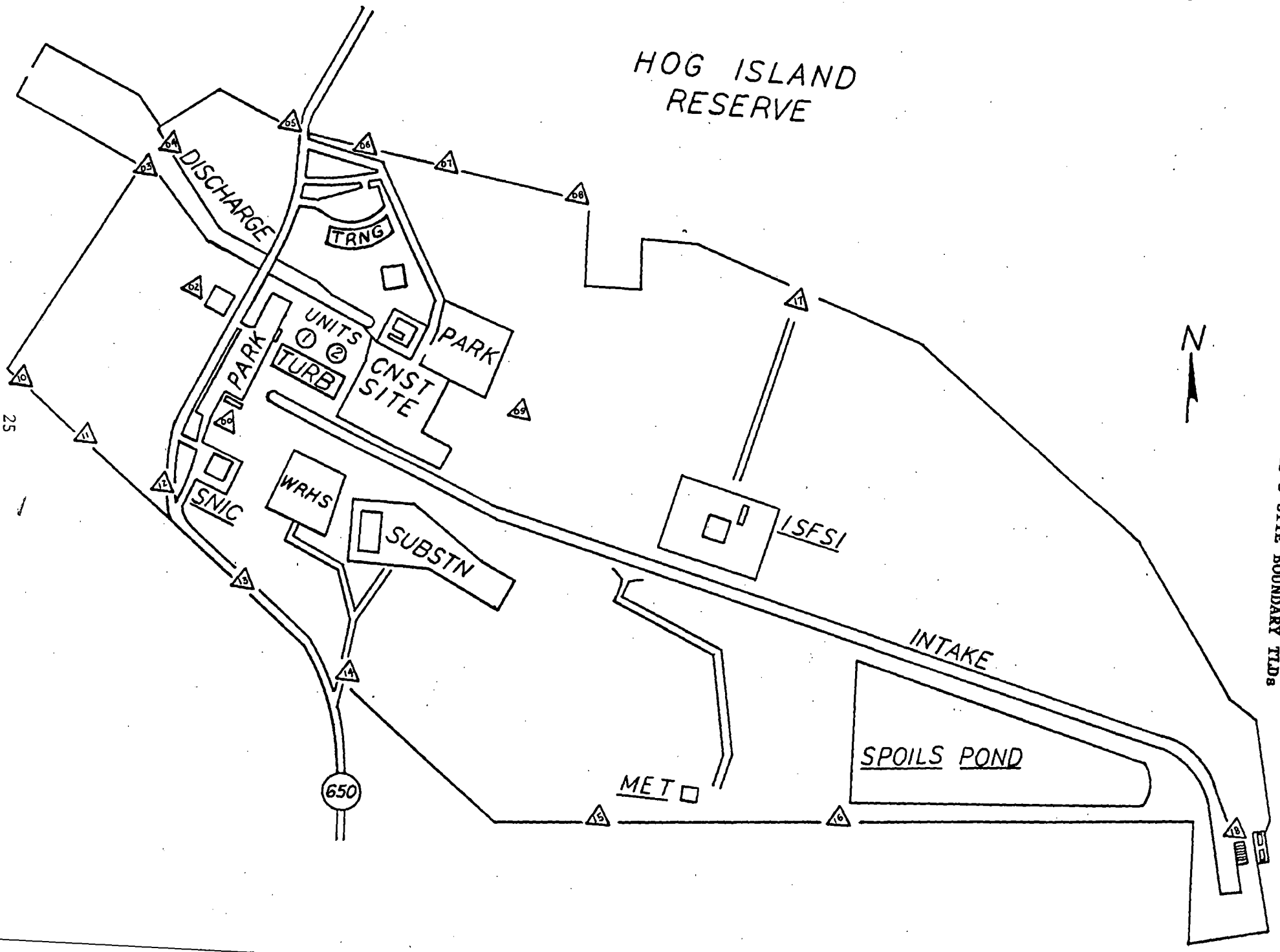


FIGURE 3 SITE BOUNDARY TLDs

TABLE 2

SURRY POWER STATION

SAMPLE ANALYSIS PROGRAM

SAMPLE MEDIA	FREQUENCY	ANALYSIS	LLD(1)	REPORT UNITS
Thermoluminescent Dosimetry (TLD)	Quarterly	Gamma Dose	1.5	mR/month
Air Iodine	Weekly	I-131	0.07	pCi/m^3
Air Particulate	Weekly	Gross Beta	0.01	pCi/m^3
	Quarterly (2)	Gamma Isotopic		pCi/m^3
		Cs-134	0.05	
		Cs-137	0.06	
River Water	Quarterly composite of monthly sample	Tritium	2000	pCi/l
	Monthly and Bi-monthly	I-131	10	pCi/l
		Gamma Isotopic		
		Mn-54	15	
		Fe-59	30	
		Co-58, 60	15	
		Zn-65	30	
		Zr-95	30	
		Nb-95	15	
		Cs-134	15	
		Cs-137	18	
		Ba-140	60	
		La-140	15	
Well Water	Quarterly	Tritium	2000	pCi/l
		I-131	1	
		Gamma Isotopic		
		Mn-54	15	
		Fe-59	30	
		Co-58, 60	15	
		Zn-65	30	
		Zr-95	30	
		Nb-95	15	
		Cs-134	15	
		Cs-137	18	
		Ba-140	60	
		La-140	15	

Footnotes located at end of table.

TABLE 2 (Cont.)

SURRY POWER STATION

SAMPLE ANALYSIS PROGRAM

SAMPLE MEDIA	FREQUENCY	ANALYSIS	LLD(1)	REPORT UNITS
Shoreline Sediment	Semi-Annual	Gamma Isotopic		pCi/kg-dry
		Cs-134	150	
		Cs-137	180	
Silt	Semi-Annual	Gamma Isotopic		pCi/kg-dry
		Cs-134	150	
		Cs-137	180	
Milk	Monthly	I-131	1	pCi/l
		Gamma Isotopic		
		Cs-134	15	
		Cs-137	18	
		Ba-140	60	
		La-140	15	
Oyster	Bi-Monthly	Gamma Isotopic		pCi/kg-wet
		Mn-54	130	
		Fe-59	260	
		Co-58, 60	130	
		Zn-65	260	
		Cs-134	130	
		Cs-137	150	
Clams	Bi-Monthly	Gamma Isotopic		pCi/kg-wet
		Mn-54	130	
		Fe-59	260	
		Co-58, 60	130	
		Zn-65	260	
		Cs-134	130	
		Cs-137	150	
Crabs	Annually	Gamma Isotopic		pCi/kg-wet
		Mn-54	130	
		Fe-59	260	
		Co-58, 60	130	
		Zn-65	260	
		Cs-134	130	
		Cs-137	150	

Footnotes located at end of table.

TABLE 2 (Cont.)

SURRY POWER STATION

SAMPLE ANALYSIS PROGRAM

SAMPLE MEDIA	FREQUENCY	ANALYSIS	LLD(1)	REPORT UNITS
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	
Crops	Annually	Gamma Isotopic		pCi/kg-wet
		I-131	60	
		Cs-134	60	
		Cs-137	80	

Footnotes:

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.

(1) LLDs indicate those levels that the environmental samples should be analyzed to, in accordance with the Surry Radiological Environmental Program. Actual analysis of the samples by Teledyne Isotopes may be lower than those listed.

(2) Quarterly composites of each location's weekly air particulate samples are analyzed for gamma emitters.

Program Exceptions

IV. PROGRAM EXCEPTIONS

REMP deviations for 1990 are listed in this chapter.

Thermoluminescent Dosimeters (TLD) were discovered missing from TLD stations No. 5 and No. 12 during the June routine monthly TLD check. For TLD station No. 5, the Company property sign on which the TLDs were attached had been removed without notification to the power station. The cause for the missing TLDs at station No. 12 could not be determined. TLD data from adjacent monitoring locations was reviewed and no unusual data was evident.

Three TLDs for the third quarter, two from station No. 17 and one form station No. 43, were inadvertently mixed in with the fourth quarter TLDs during field replacement. As a result, these three third quarter TLDs were mistakenly reinstalled in the field and the three corresponding fourth quarter TLDs were returned for analysis instead. This was rectified and the three third quarter TLDs were returned to the analytical laboratory on November 2, 1990 for analysis. Discussions were held with technicians responsible for quarterly TLD replacement, emphasizing the importance of accurate TLD replacement.

During a calendar year, 336 TLD are located in the field as part of the REMP. This year, four of the 336 TLDs were found missing. This represents only 1.2% of the total number of TLDs. The four missing TLDs are not indicative of a programmatic weakness of the REMP. The TLDs are not under constant surveillance, are located up to 16 miles from the power station, and due to the nature of the assay are subjected to nature's elements.

Due to a microorganism infestation in the lower James River (MSX/Dermo), oyster shell stock has been virtually depleted at the Newport News (Naseway Shoal) sample location. Sampling terminated at this location in 1988 and will recommence when the oyster beds revitalize as determined by the Commonwealth of Virginia. An alternative sampling location at Rock Landing Shoals was selected. The Commonwealth of Virginia also added Horsehead Shoals to the State Split sampling program for oysters. Horsehead Shoals is located between Deep Water Shoals and Rock Landing Shoals downstream of the power station. These samples will continue until the Newport News location is approved for sampling again.

REMP EXCEPTIONS FOR SCHEDULED SAMPLING AND ANALYSIS DURING 1990 - SURRY

Location	Description	Date of Sampling	Reason(s) for Loss/Exception
STA-05	Direct Radiation TLD	Second Quarter Sets 1/2	TLD missing
STA-12	Direct Radiation TLD	Second Quarter Sets 1/2	TLD missing
STA-17	Direct Radiation TLD	Third Quarter Sets 1/2	Fourth quarter TLD returned instead of third quarter TLD.
STA-43	Direct Radiation TLD	Second Quarter Set 1	Fourth quarter TLD returned instead of third quarter TLD.

Summary And Discussion Of 1990 Analytical Results

V. SUMMARY AND DISCUSSION - 1990 ANALYTICAL RESULTS

DEFINITIONS

Below are listed definitions of words and phrases for some of the common terms used in the following sections.

AVERAGE ACTIVITY

The arithmetic mean of detected radioactivity for all samples within a sampled parameter.

IMPACT

Defines the influence on people.

ISOTOPE

The radioactive element identified in a sampled pathway.

LOWER LIMIT OF DETECTION (LLD)

The LLD is used to describe the smallest amount of radioactivity that can be detected by analysis instrumentation and is statistically significant above background level.

The NRC provides Surry Power Station with LLD's that we must achieve using our analysis equipment. Many times the results of an analysis is reported as below LLD and this may sound like a contradiction. However, the LLD being referred to is the Technical Specification (NRC provided) LLD and not the actual instrument LLD. The technology in the analytical field is advancing rapidly and the LLD's achieved by current state-of-the-art equipment is in many cases less than those provided by the NRC.

PATHWAY

This is the route by which people may become exposed to man made and naturally occurring radioactivity. In this report, VEPCO and the State of Virginia sample and analyze components of many pathways; for example: air samples are obtained to analyze the exposure through the inhalation pathway and fish and other marine species are analyzed for exposure through the ingestion pathway.

PERCENT TECHNICAL SPECIFICATION (% TS) REPORTING LEVEL

This is the average level of radioactivity detected in a sample that must be reported to the NRC. VEPCO reports any activity detected in all samples.

TREND

Steady, rising or falling based on the same sampled parameter from preoperational data and previous years.

V. SUMMARY

A brief summary of the REMP radiological analyses is provided in this section.

* Based on the results of the 1990 Radiological Environmental Monitoring Program (REMP) report, Surry Power Station is operated within regulatory limits.

* All samples analyzed were either below the Technical Specifications reporting limits or below the lower limits of detection.

* Overall, the results were as expected for normal environmental samples. Naturally occurring radioactivity was observed in sample media and was within the expected activity ranges.

* Occasional samples revealed the presence of man made isotopes. The concentration of isotopes attributable to station effluents are very low and of no significant dose consequence.

AIRBORNE EXPOSURE PATHWAY

Airborne Radioiodine

Charcoal cartridges are used to collect airborne radioiodine. Once a week, the samples are collected and analyzed. The results are presented in Table B-1. All results are below the lower limit of detection with no positive activity detected. These results are similar to preoperational data and the results of samples taken prior to and after the 1986 accident in the Soviet Union at Chernobyl.

Airborne Gross Beta

Results of the weekly gross beta analysis are presented in Table B-2. A review of Table B-2 indicates that results from the station indicator compare favorably to the control location in Newport News; briefly summarized below:

Calendar Quarter	Quarterly Average All Locations	Quarterly Average Control Station
1st	15 pCi/m^3	15 pCi/m^3
2nd	14 pCi/m^3	14 pCi/m^3
3rd	15 pCi/m^3	16 pCi/m^3
4th	19 pCi/m^3	19 pCi/m^3

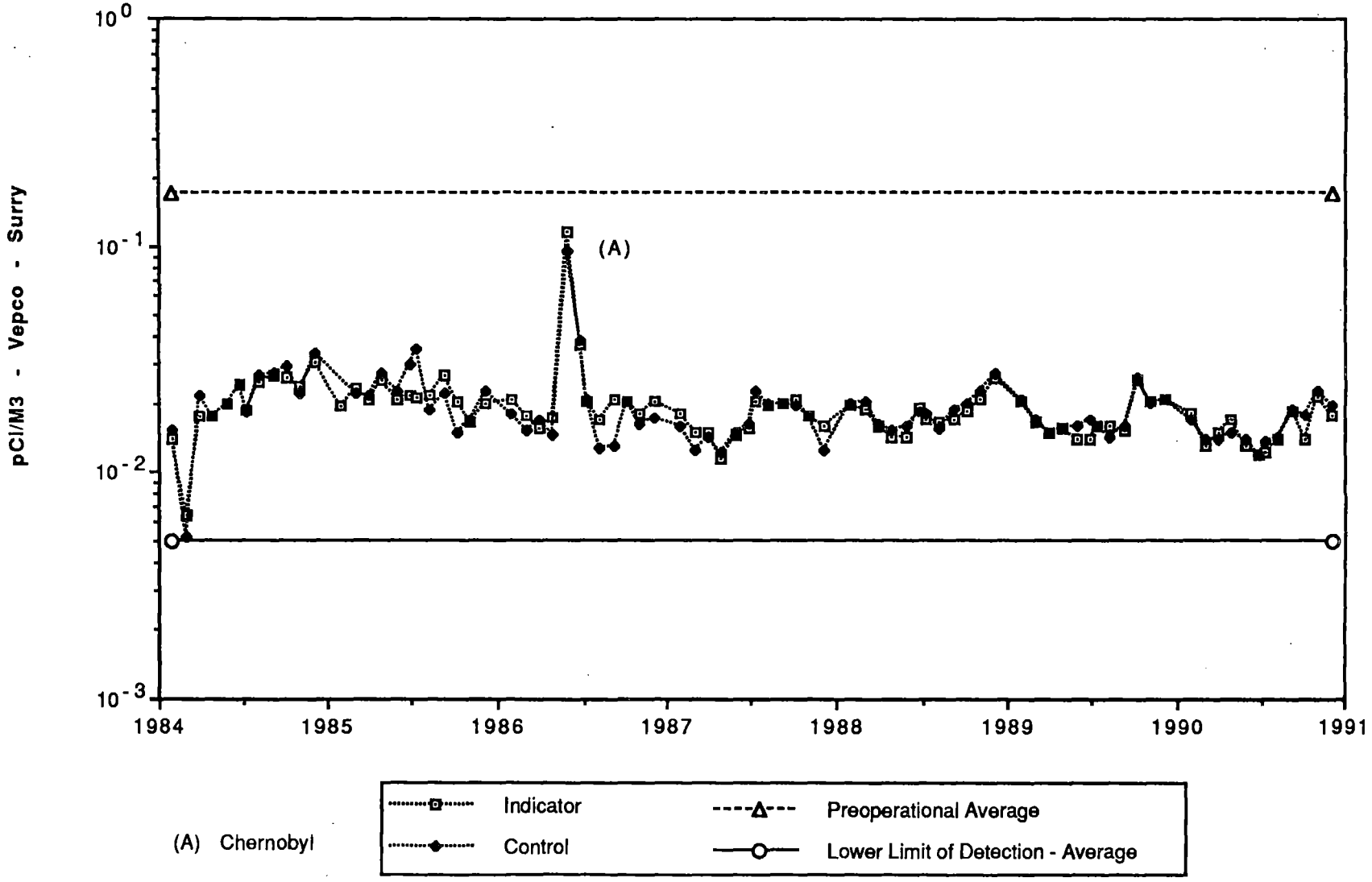
Quarterly averages are consistent with background radioactivity levels. The gross beta concentrations observed indicate a steady trend compared to levels found during the previous 5 years. Gross beta activity found during the preoperational and early operating period of Surry were higher because of nuclear weapons testing. During the past two decades nearly 740 nuclear weapons have been tested worldwide. In 1985 weapons testing ceased, and with the exception of the Chernobyl accident, airborne gross beta results have trended at stable levels.

Airborne Gamma Isotopic

Air particulate filters are analyzed for isotopes that are gamma emitters. The results of the composite analysis are listed in Table B-3. No gamma emitting radioactivity attributable to the power station was detected. However, natural background radioactivity was detected in many of the samples. The two isotopes that were identified are beryllium-7 and potassium-40. Beryllium-7 is continuously produced in the upper atmosphere by cosmic radiation. Potassium-40 is naturally present in foods, building materials and soil.

TRENDING GRAPH - 1

GROSS BETA IN AIR PARTICULATES



(A) Chernobyl

WATERBORNE EXPOSURE PATHWAY

River Water

The analysis results for the James River water sampling program are presented in Table B-4. Samples of James River water are collected as monthly grab samples at both Surry Discharge and Scotland Wharf and bi-monthly grab samples at Hog Island Point, Newport News, Chickahominy River and Surry Intake. All samples are analyzed by gamma spectroscopy and for iodine-131 by a radiochemical procedure. These samples are also composited and analyzed for tritium and on a quarterly basis.

Naturally occurring potassium-40 was measured in 11 samples with an average concentration of 100.8 pCi/liter.

All samples were analyzed for gamma emitting radioisotopes. With the exception of naturally occurring potassium-40, no other gamma emitters were detected. In particular, no iodine-131 was detected. This trend is consistent with previous years.

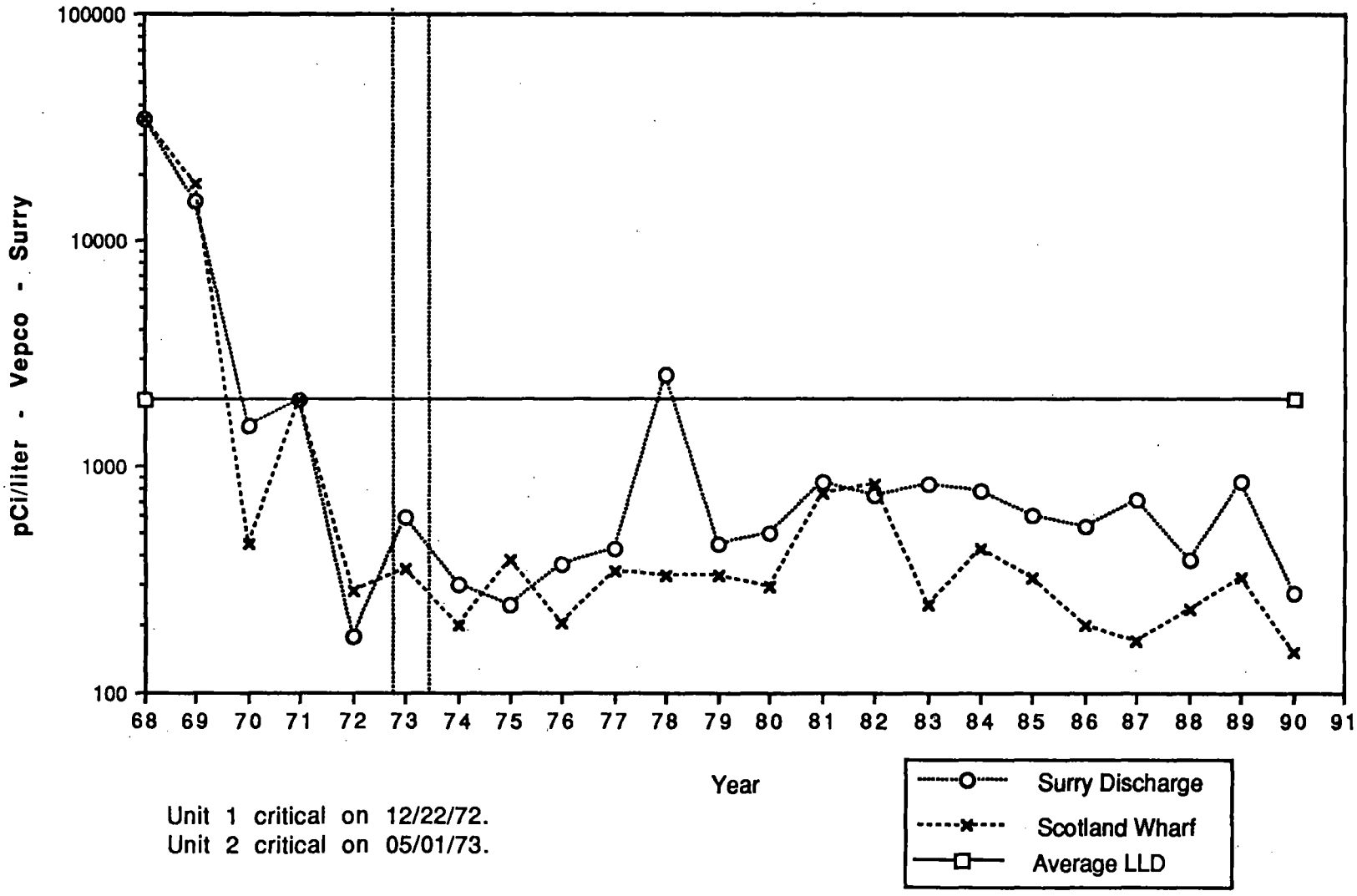
Tritium was measured in 12 of 24 quarterly composite samples. The average tritium concentration was 319 pCi/liter. Preoperational data for tritium indicated levels of activity considerably higher than current levels due, in part, to atmospheric weapons testing. This years' level is less than the average for the past 5 years. The State of Virginia samples water from the station discharge and a control site located up stream of the station Scotland Wharf. These samples are taken as part of the State Split Sample Program and analyzed independently. The results are presented in Table B-5. River water from the station discharge and control location identified tritium concentration of 835 pCi/liter and 475 pCi/liter respectively. Scotland Wharf is taken as a weekly grab sample. Station discharge is sampled by a composite sampler and collected weekly. Monthly composite samples are prepared for gamma and iodine-131 analysis and quarterly composites are prepared for tritium analysis.

In addition to the VEPCO monthly grab sample and the State Split composite sample, a VEPCO station discharge composite sampler was placed in service in May of 1989. A tritium composite from this sampler was analyzed monthly and then composited for quarterly analysis. The average tritium concentration for 1990 was 462 pCi/liter.

The attached trend graphs provide a comparison of tritium concentration measured in the downstream sample (Surry Station Discharge) and in the upstream control location (Scotland Wharf). Also, provided for comparison is the average concentration of tritium in plant effluent

TRENDING GRAPH - 2

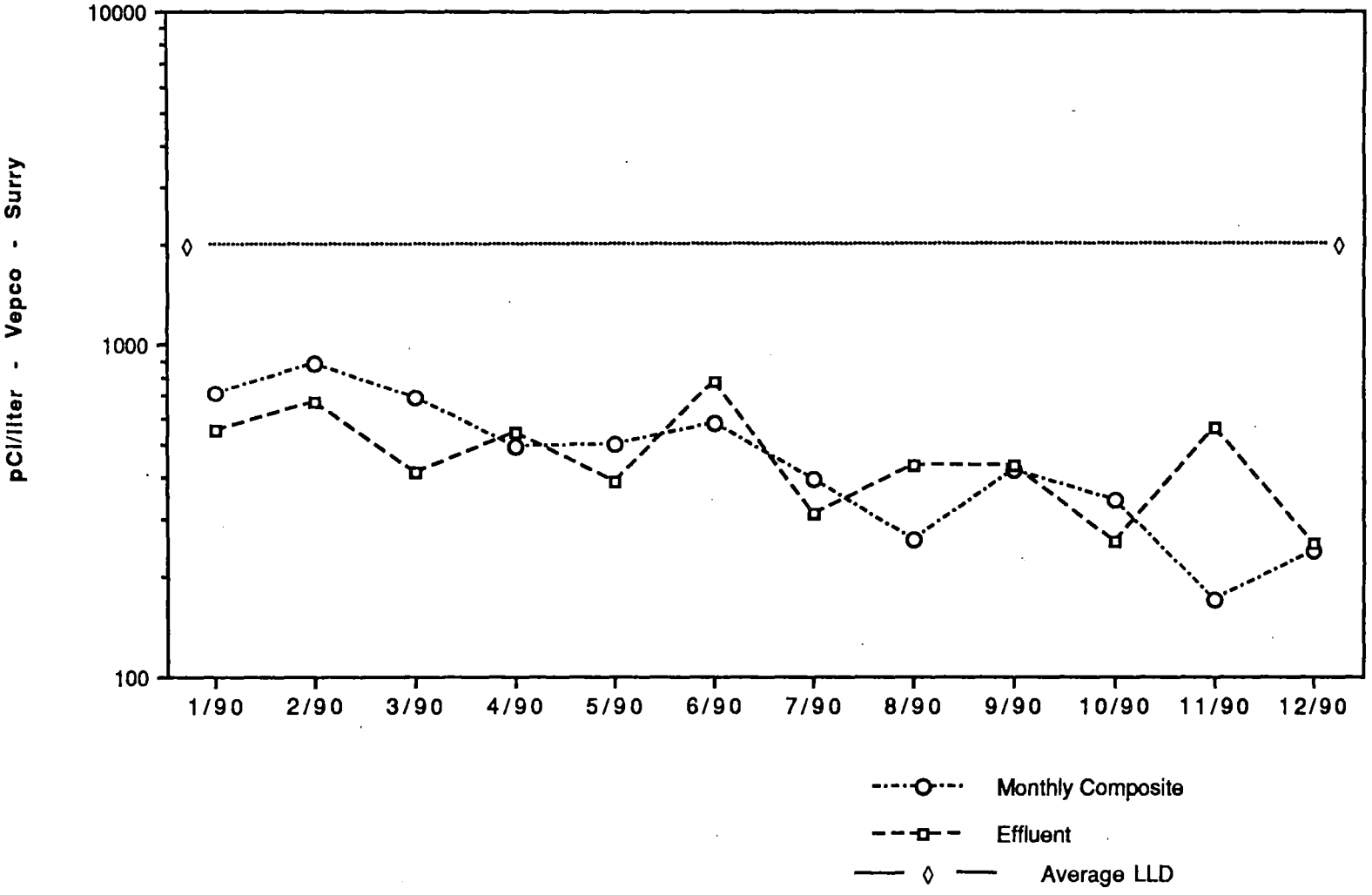
TRITIUM IN RIVER WATER



Unit 1 critical on 12/22/72.
Unit 2 critical on 05/01/73.

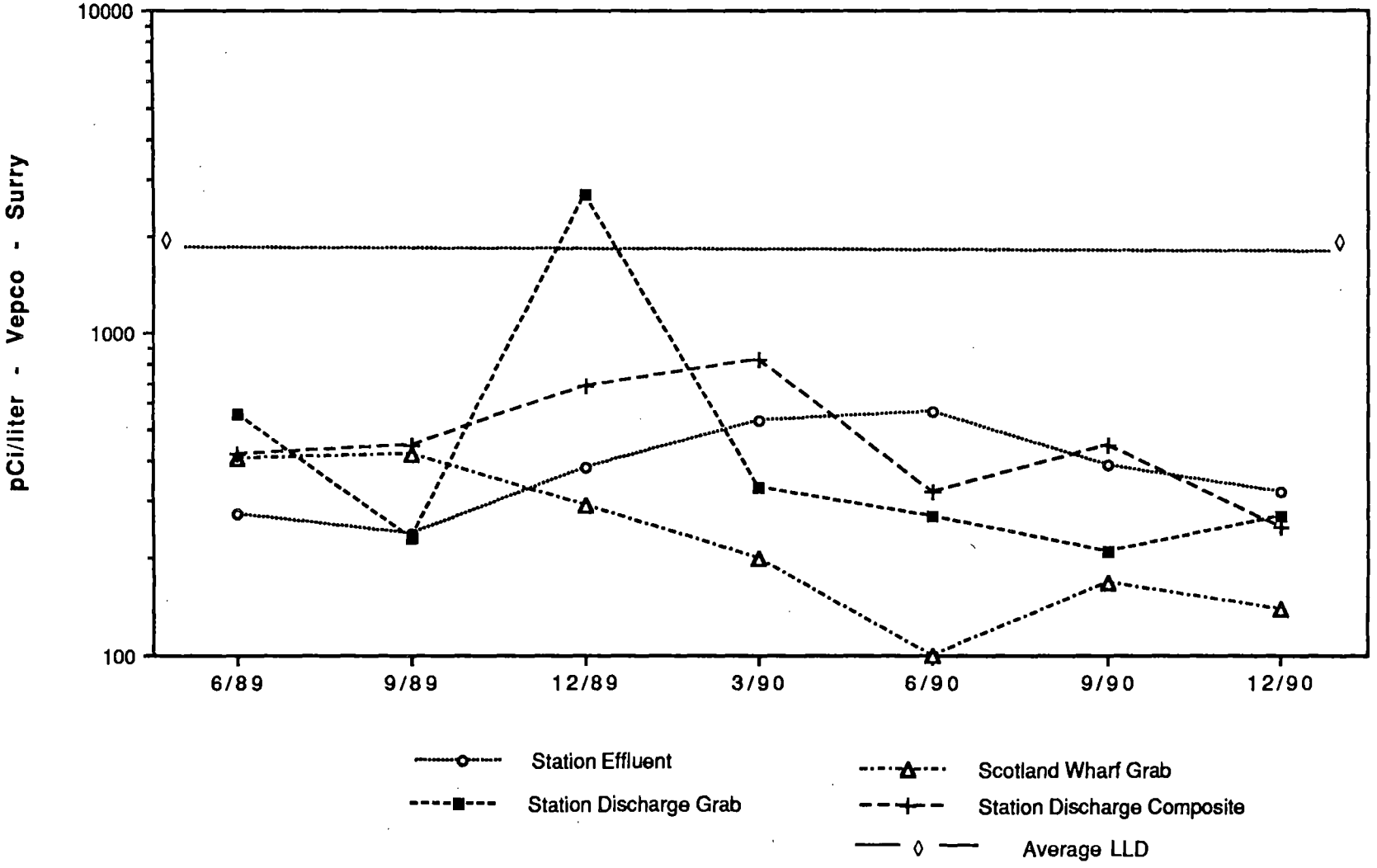
TRENDING GRAPH - 2 (Cont.)

TRITIUM
VEPCO VS. STATION DISCHARGE



TRENDING GRAPH 2 (Cont.)

RIVER WATER TRITIUM
VEPCO VS STATION EFFLUENT



samples obtained prior to release from the station. As expected, the Surry discharge samples indicated higher levels of tritium than the control location. Sampling methodology (grab sample versus composite) and frequency may cause problems in comparing results. The Station discharge composite sample taken by VEPCO personnel, however, does compare well with the station effluents. The trend follows the projected activity from samples taken prior to release. The comparison of these two data points is due to the increased frequency of sampling (hourly for the VEPCO samples versus once per six hours for the State sampler). The water in the discharge canal is further diluted by the river water beyond the discharge structure. The average tritium concentration in grab samples taken downstream of the station indicate good comparison to the State Split control concentration.

Well Water

Well water is not considered to be affected by station operations because there are no discharges made to this pathway. However, Surry does monitor well water and analyzes water samples from four indicator locations. The results of these sample analysis are presented in Table B-6.

These samples were analyzed by gamma spectroscopy and indicated that there were no man-made or naturally occurring radioisotopes present. Preoperational samples were only analyzed for gross alpha and gross beta. Gamma emitting isotopes have not been detected within the recent past and this trend is consistent throughout the operational monitoring program.

All well water samples were analyzed for tritium. No tritium was detected in any of the control or indicator samples. Preoperational samples were not analyzed for tritium however, this years results indicate a decrease from previous operating data.

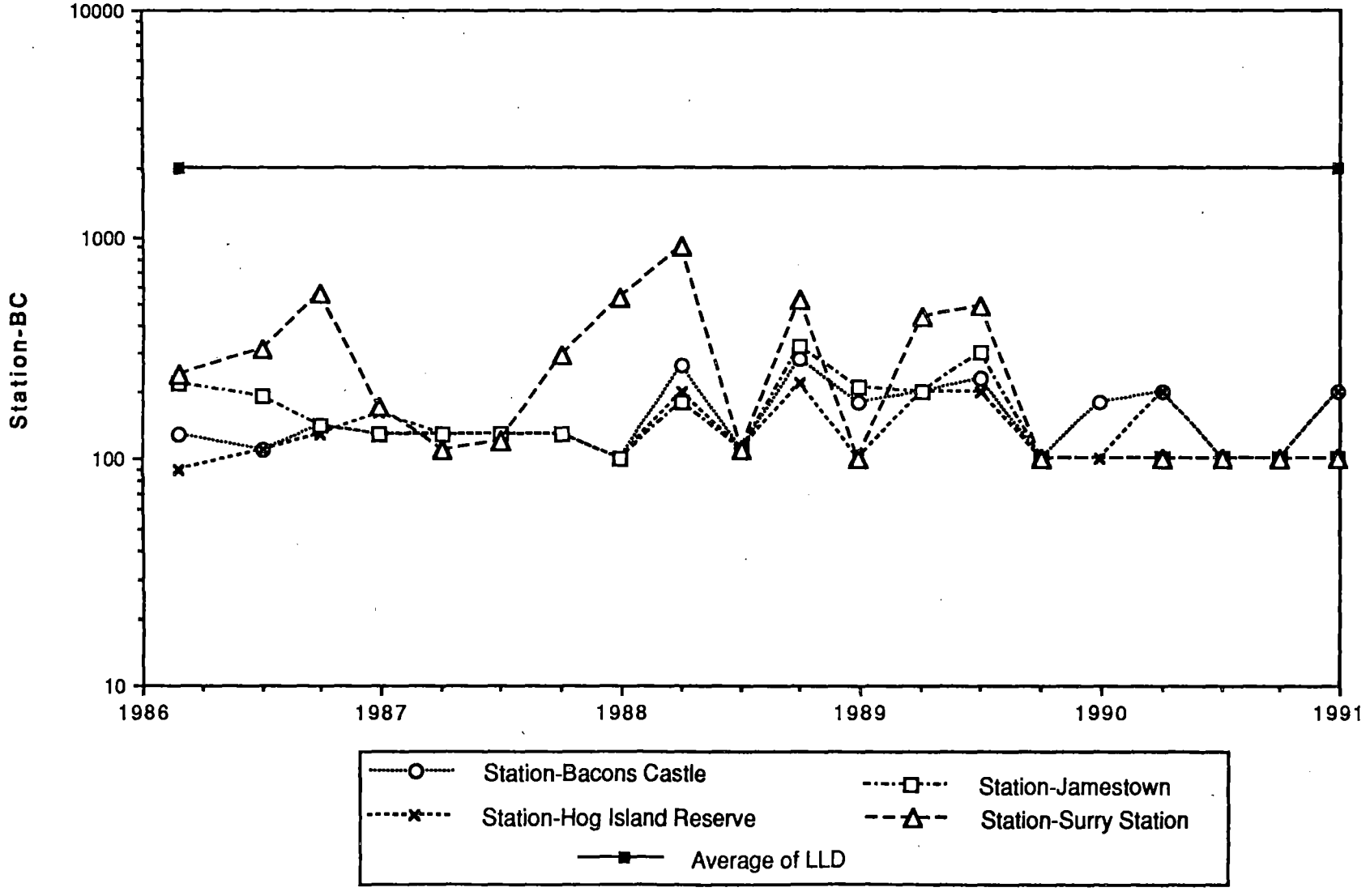
AQUATIC EXPOSURE PATHWAY

Silt

Silt samples were taken to evaluate any buildup of radionuclides in the environment due to the operation of the power station. The radioactivity in silt is a result of precipitation of radionuclides in the waste discharges and the subsequent dispersion of the material by the river current. Sampling this pathway provides a good indication of the dispersion effects of effluents to the river. Buildup of radionuclides in silt could indirectly lead to increasing radioactivity levels in clams, oysters and fish.

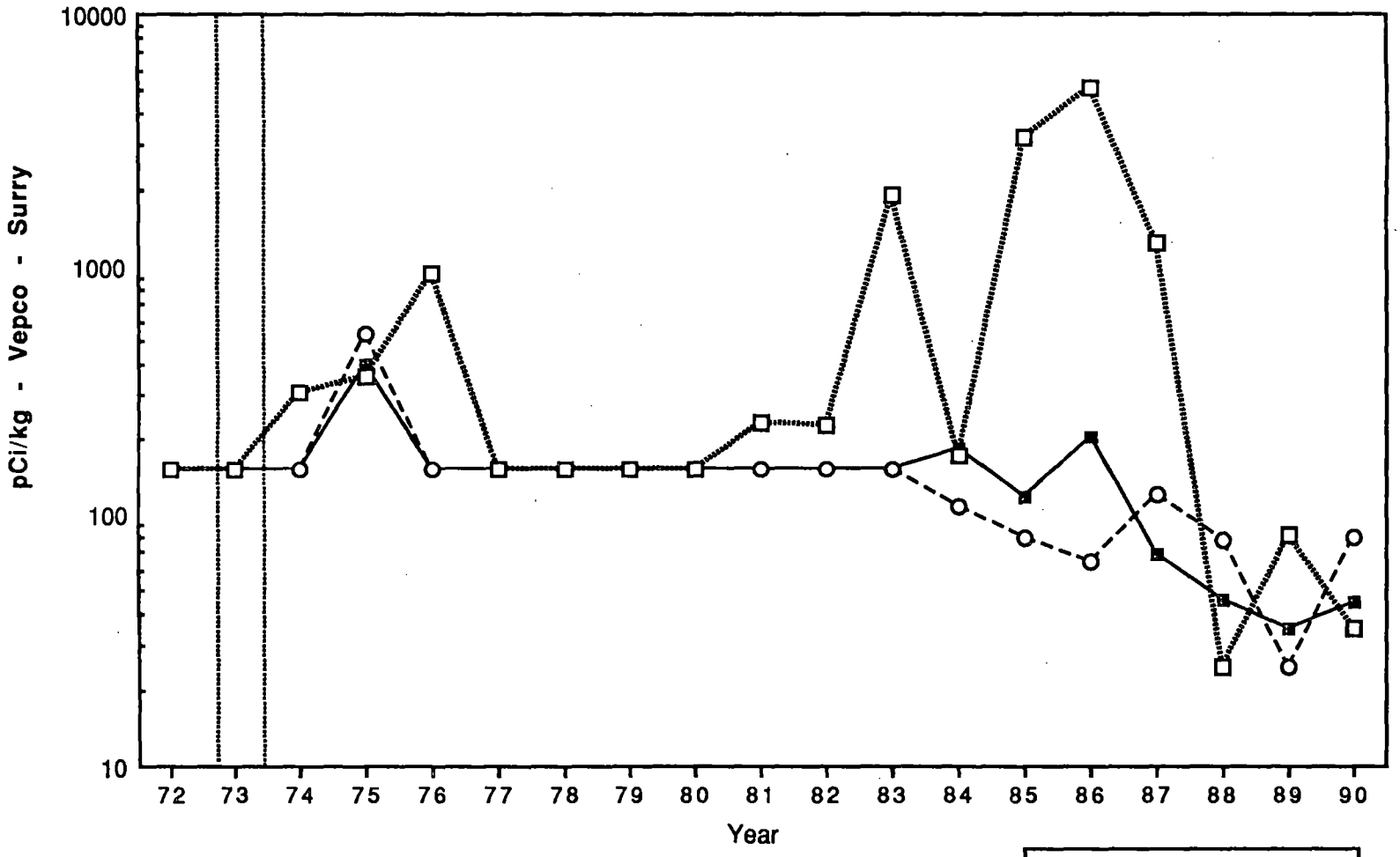
TRENDING GRAPH - 3

TRITIUM IN WELL WATER



TRENDING GRAPH - 4

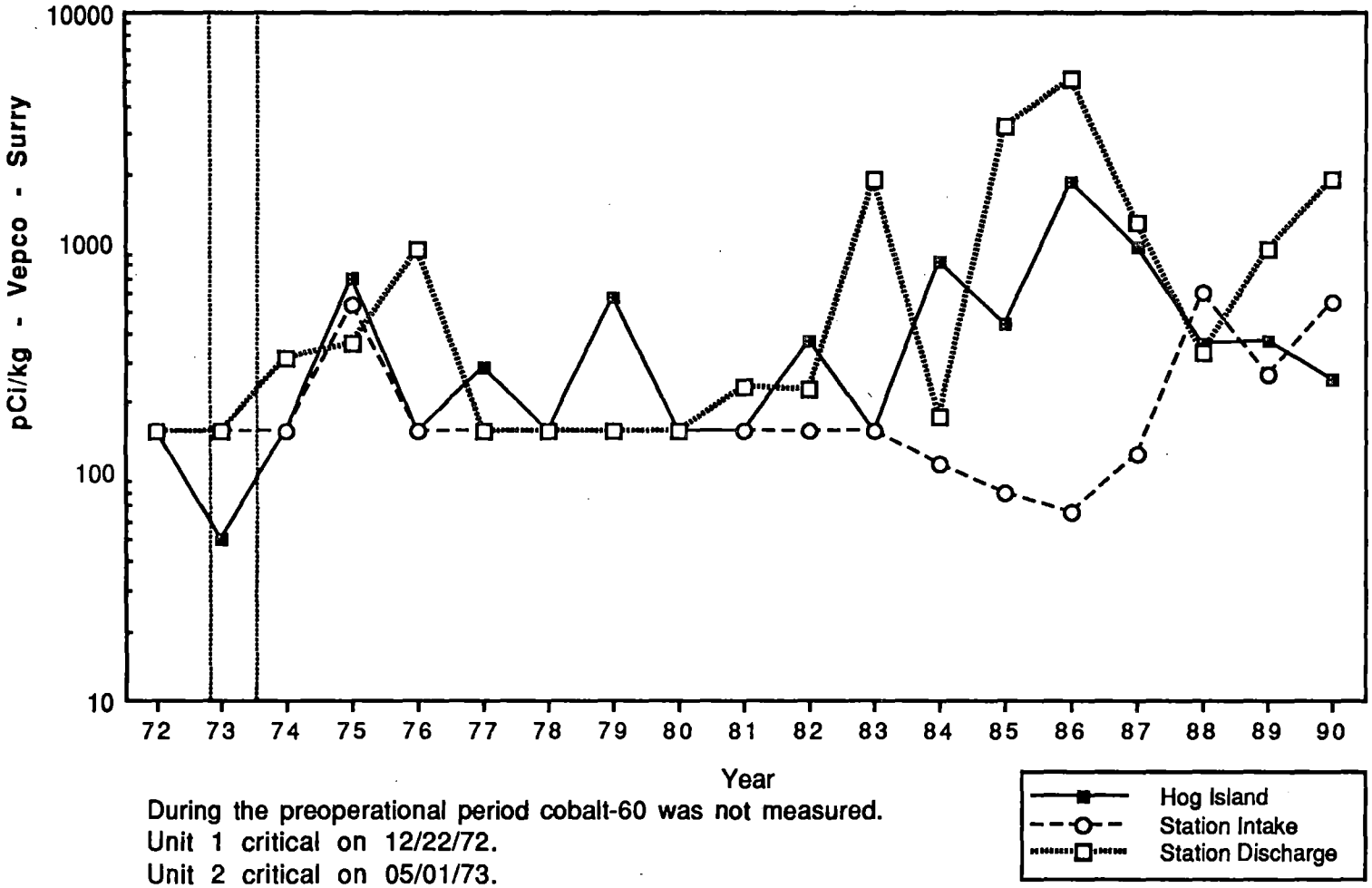
COBALT-58 IN SILT



During the preoperational period cobalt-58 was not measured.
Unit 1 critical on 12/22/72.
Unit 2 critical on 05/01/73.

TRENDING GRAPH - 5

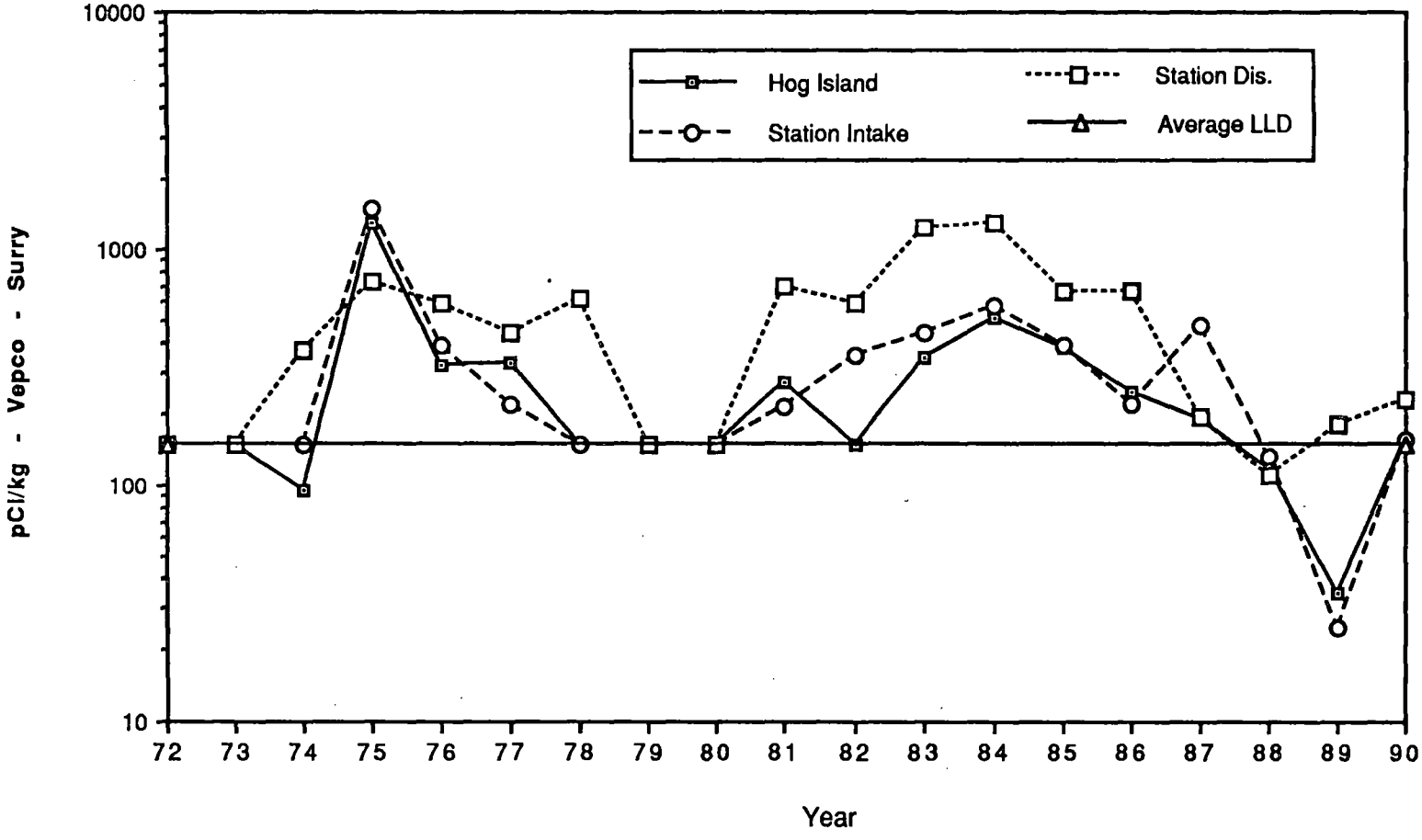
COBALT-60 IN SILT



During the preoperational period cobalt-60 was not measured.
Unit 1 critical on 12/22/72.
Unit 2 critical on 05/01/73.

TRENDING GRAPH - 6

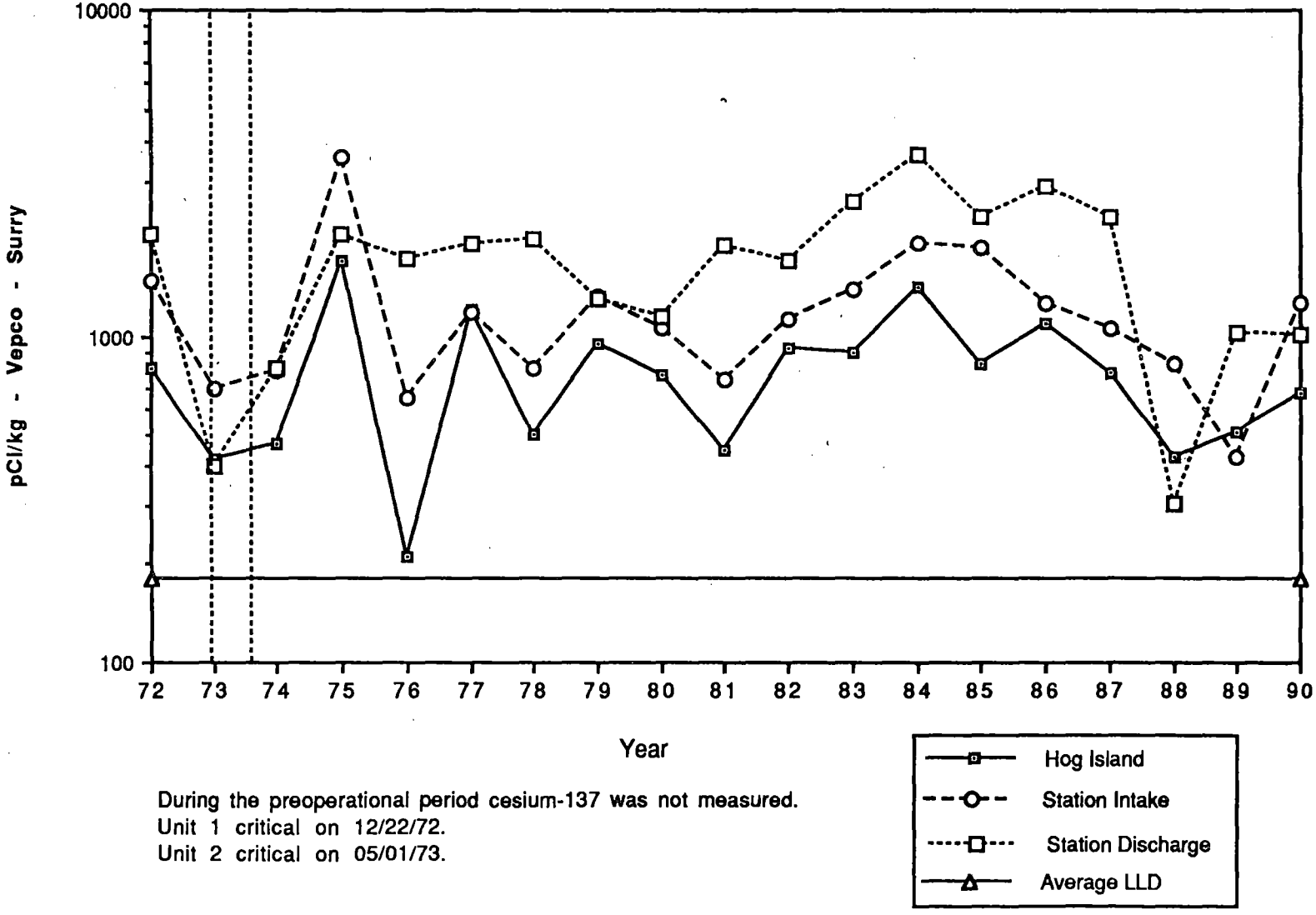
CESIUM-134 IN SILT



During the preoperational period cesium-134 was not measured.

TRENDING GRAPH - 7

CESIUM-137 IN SILT



During the preoperational period cesium-137 was not measured.
Unit 1 critical on 12/22/72.
Unit 2 critical on 05/01/73.

Silt samples are collected from six locations both up stream and down stream of the power station. These samples are analyzed for gamma emitting radioisotopes. The results of these analyses are presented in Table B-7.

The NRC does not assign reporting levels to radioisotopes measured in this pathway. Surry's Technical Specifications require that the concentrations of man-made and naturally occurring gamma emitters be monitored and trended. Preoperational analyses indicates that there were no man-made radioisotopes present in this pathway.

Cobalt-60, cesium-137 and cesium-134 average levels indicate a decrease in concentration when compared to the previous 5 year trend. During 1990 an increase in the average concentration was observed compared to 1989 and this is attributable to the continuous operation of both units at Surry Power Station.

The concentration of manmade radioisotopes in silt is not projected to continue to increase. Surry Power Station currently has under construction a Radioactive Waste Treatment Facility which will employ state of the art technologies to reduce the volume and activity of liquid effluents and reduce the impact on the environment. This facility is scheduled to go into operation in late 1991.

Shoreline Sediment

Unlike river bottom silt, shoreline sediment may provide a direct dose to humans. Buildup of radioisotopes along the shoreline may provide a source of direct exposure for those using the area for commercial and recreational uses. Samples were taken in February and August at Hog Island Point and at Burwell's Bay. The samples were analyzed by gamma spectroscopy and the results are presented in Table B-8.

This exposure pathway was not selected for analysis during the preoperational years. Nevertheless, samples analyzed over the past 5 years from this release pathway indicate a decreasing trend in the detection of gamma radioisotopes. This years analysis along with last years results indicates that no radioisotopes attributable to the operation of the power station have been detected.

Naturally occurring radioisotopes were measured in several of the samples. Potassium-40, thorium-228 and radium-226 show a steady trend over the recent past.

INGESTION EXPOSURE PATHWAY

Milk

Milk samples are an important indicator for measuring the affect of radioactive iodine, and other radioisotopes in airborne releases. The dose consequence to man is from both a direct and indirect exposure pathway. The direct exposure pathway is from the inhalation of radioactive material. The indirect exposure pathway is from the grass-cow-milk pathway. In this pathway radioactive material is deposited on the plants consumed by the dairy animals. The radioactive material is in turn passed on to man via the milk. The results of iodine-131 and other gamma analysis of milk are presented in Table B-9.

Iodine-131 has not been detected in milk prior to and since the 1986 accident at Chernobyl in the Soviet Union. The lower limit of detection was 0.5 pCi/liter for all samples.

Preoperational data shows that cesium-137 was detected in this pathway. The average activity over the past five years is consistent with the preoperational data. This year shows a significant decline in cesium-137 as none was detected in the 60 samples analyzed.

Naturally occurring potassium-40 was detected in all samples analyzed. There is a slight decrease in the average concentration of this raioisotope when compared to the previous two years and is less than the average for the past five years. The preoperational monitoring program did not analyze for this radioisotope.

Strontium-90 was detected in all of the samples collected in participation with the State Split Program. Preoperational data shows levels 5 to 6 times higher than present values. This years analysis show a decrease when compared to the previous two years and is less than the average for the past 5 years. Strontium-90 is not a part of station effluents but rather a product of weapons fallout.

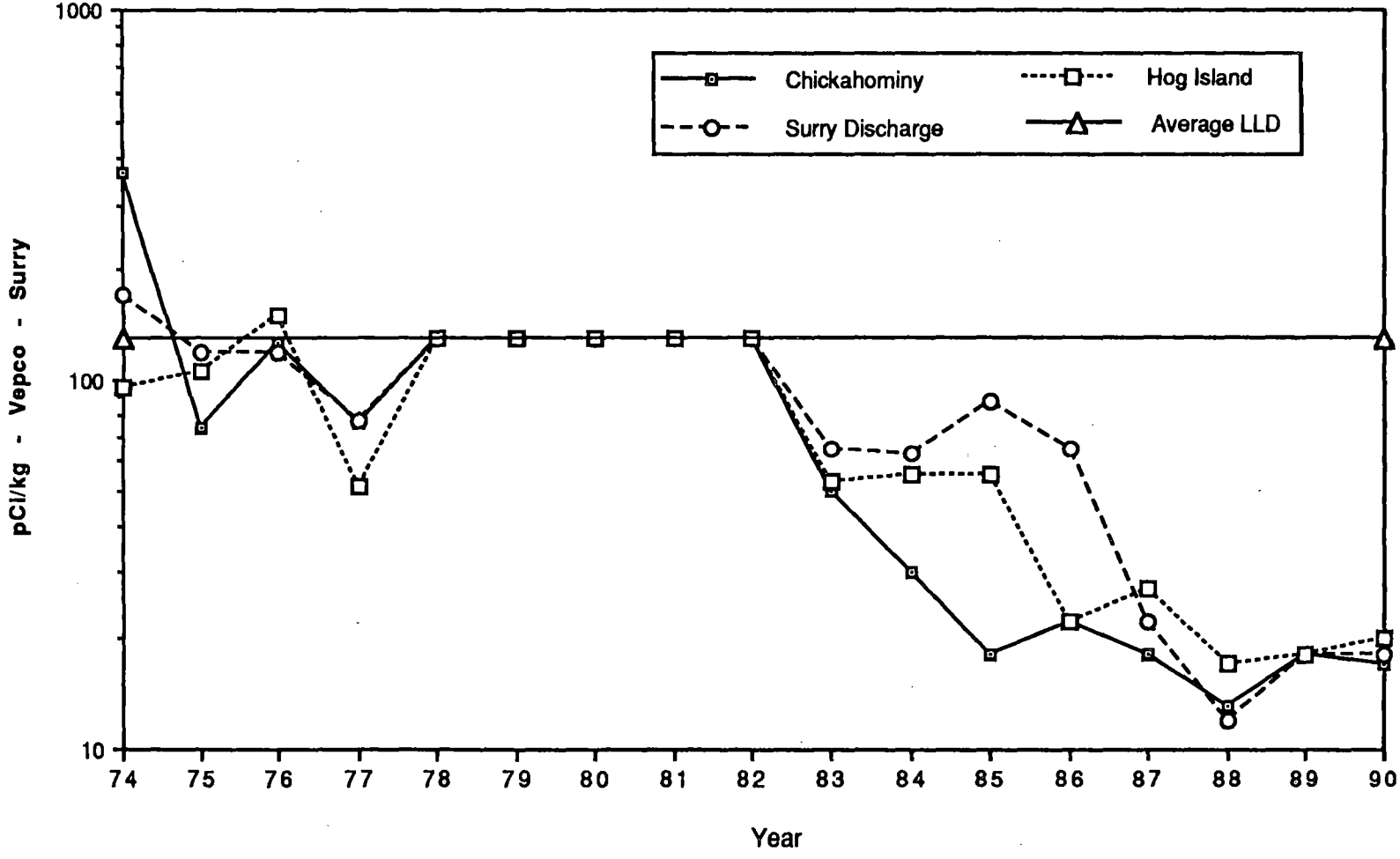
Aquatic Biota

All plants and animals have the ability to concentrate certain chemicals. Radioisotopes display the same chemical properties as their non-radioactive counter part. VEPCO samples various aquatic biota to determine the accumulation of radioisotopes in the environment. The results of the sampling program for this pathway are detailed below.

Clams were analyzed from 5 different locations. The results of the analysis is presented in Table B-10. As expected, naturally occurring potassium-40 was detected in all 18 samples. Based

TRENDING GRAPH - 8

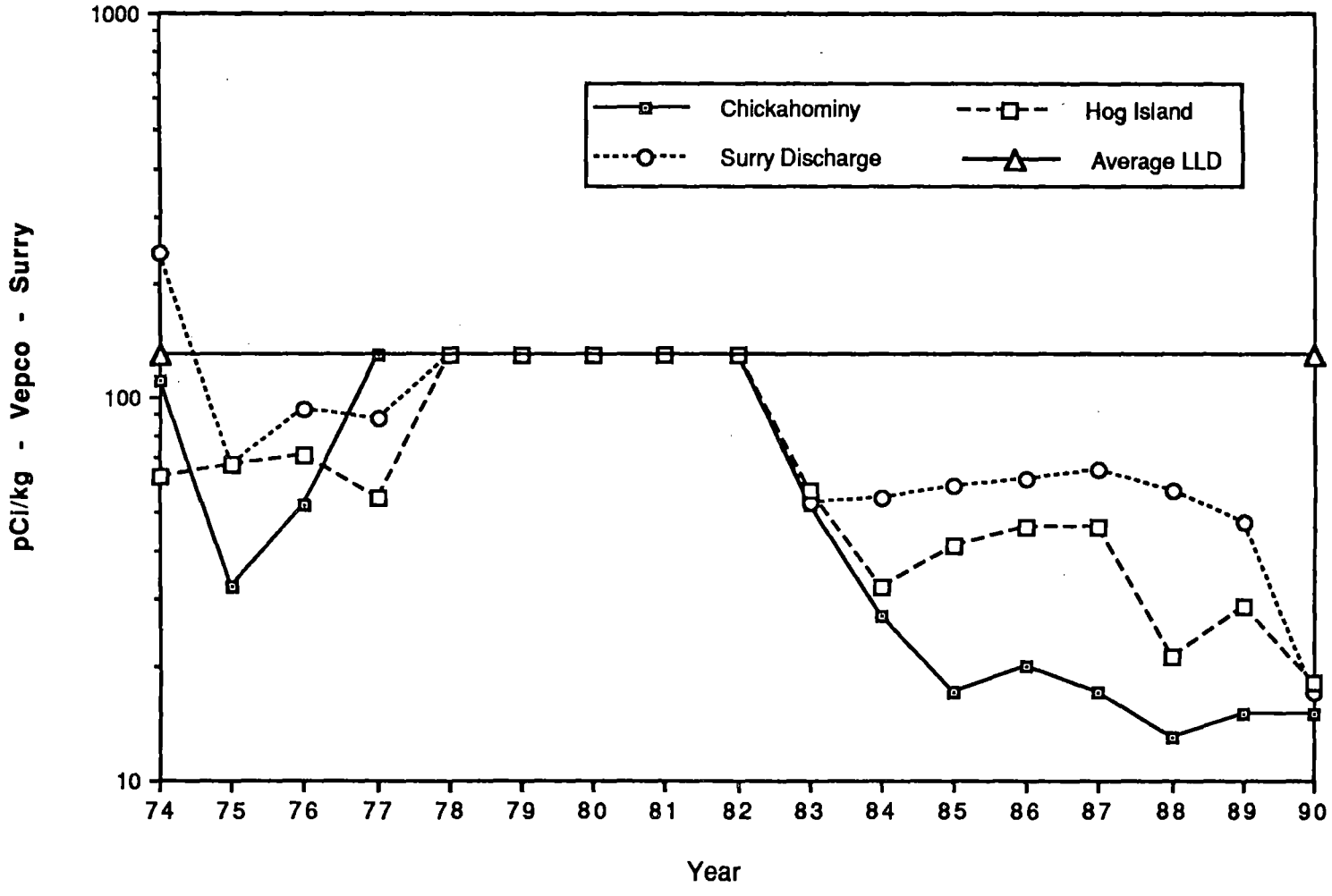
COBALT-58 IN CLAMS



During the preoperational period cobalt-58 was not measured.

TRENDING GRAPH - 9

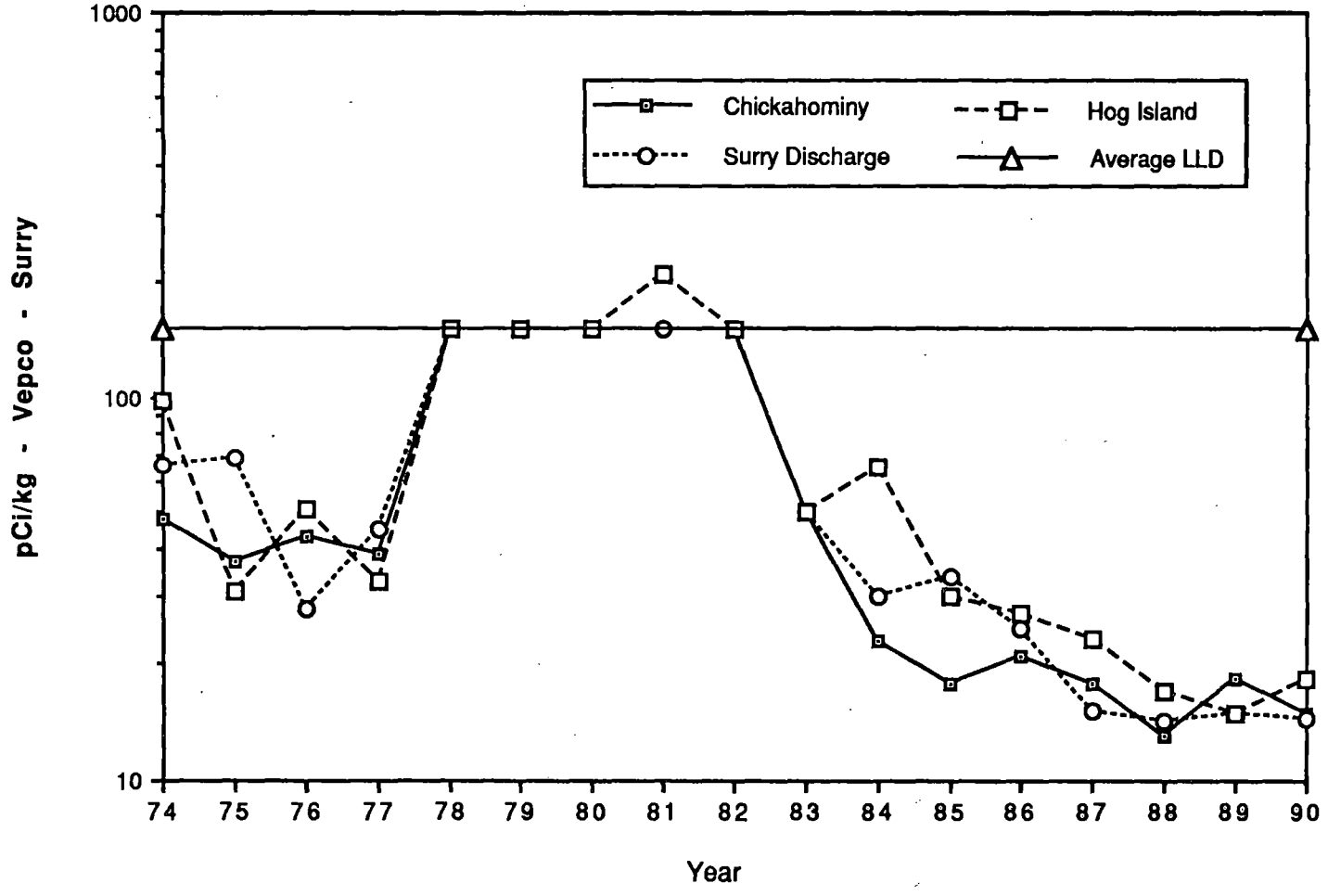
COBALT-60 IN CLAMS



During the preoperational period cobalt-60 was not measured.

TRENDING GRAPH - 10

CESIUM-137 IN CLAMS



During the preoperational period cesium-137 was not measured.

on the previous 5 years, the trend of potassium-40 in clams is decreasing. Potassium-40 is a naturally occurring radioisotope and is not a component of station effluent.

No gamma emitting radioisotopes were detected in any of the samples. This is consistent with preoperational data. The trend of gamma emitting radioisotopes in clams over the recent past continues to decrease and is well below the lower limits of detection. This marked decrease coincides with the extensive steam generator replacement project completed in 1982.

Oysters were analyzed from 5 different locations. The results of the analysis is presented in Table B-11. As expected, naturally occurring potassium-40 was detected in 21 of 24 samples. Based on the previous 5 years, the trend of potassium-40 in oysters is decreasing. The current level of potassium-40 is less than the preoperational average. No gamma emitting radioisotopes were detected in any samples. This is consistent with preoperational data and data collected since the 1986 accident at Chernobyl in the Soviet Union.

Crab samples were collected in June from the discharge canal of the station and analyzed by gamma spectroscopy. The results of this analysis is presented in Table B-12. As expected naturally occurring potassium-40 was detected. Based on the previous 5 years, the trend of potassium-40 in crabs is steady. Potassium-40 is a naturally occurring radioisotope and is not a component of station effluent. No other gamma emitting radioisotopes were detected in this sample. This is consistent with preoperational data and data collected during the past 5 years.

Four fish samples were collected in April and October from the station discharge canal and analyzed by gamma spectroscopy. The results of this analysis is presented in Table B-13. As expected naturally occurring potassium-40 was detected in all samples. Based on the previous 5 years, the trend of potassium-40 in fish is decreasing. Cesium-137 was observed in one of the fish samples with an activity of 18.7 pCi/kg. This is lower than the average of the past 5 years and indicates a decreasing trend over this time period. However, this sample is less than the lower limits of detection (150 pCi/kg) and considerably below the Technical Specification reporting level of 2,000 pCi/kg.

Food Products and Vegetation

Food products and vegetation samples were collected from four different locations and analyzed by gamma spectroscopy. The results of this analysis is presented in Table B-14. As expected naturally occurring potassium-40 was detected in all samples. Based on the previous 5 years, the trend of potassium-40 in food products and vegetation is increasing. Potassium-40 is a

naturally occurring radioisotope and is not a component of station effluent. Naturally occurring beryllium-7 was detected in one of the three samples. Based on the previous 5 years, the trend of beryllium-7 is steady. Cesium-137 was measured in two soybean samples with an average activity of 11.3 pCi/kg. This measurement is less than the average concentration over the past 5 years and indicates a slight decreasing trend. This sample is less than the lower limits of detection (80 pCi/kg) and is considerably less than the Technical Specification reporting limits of 2,000 pCi/kg.

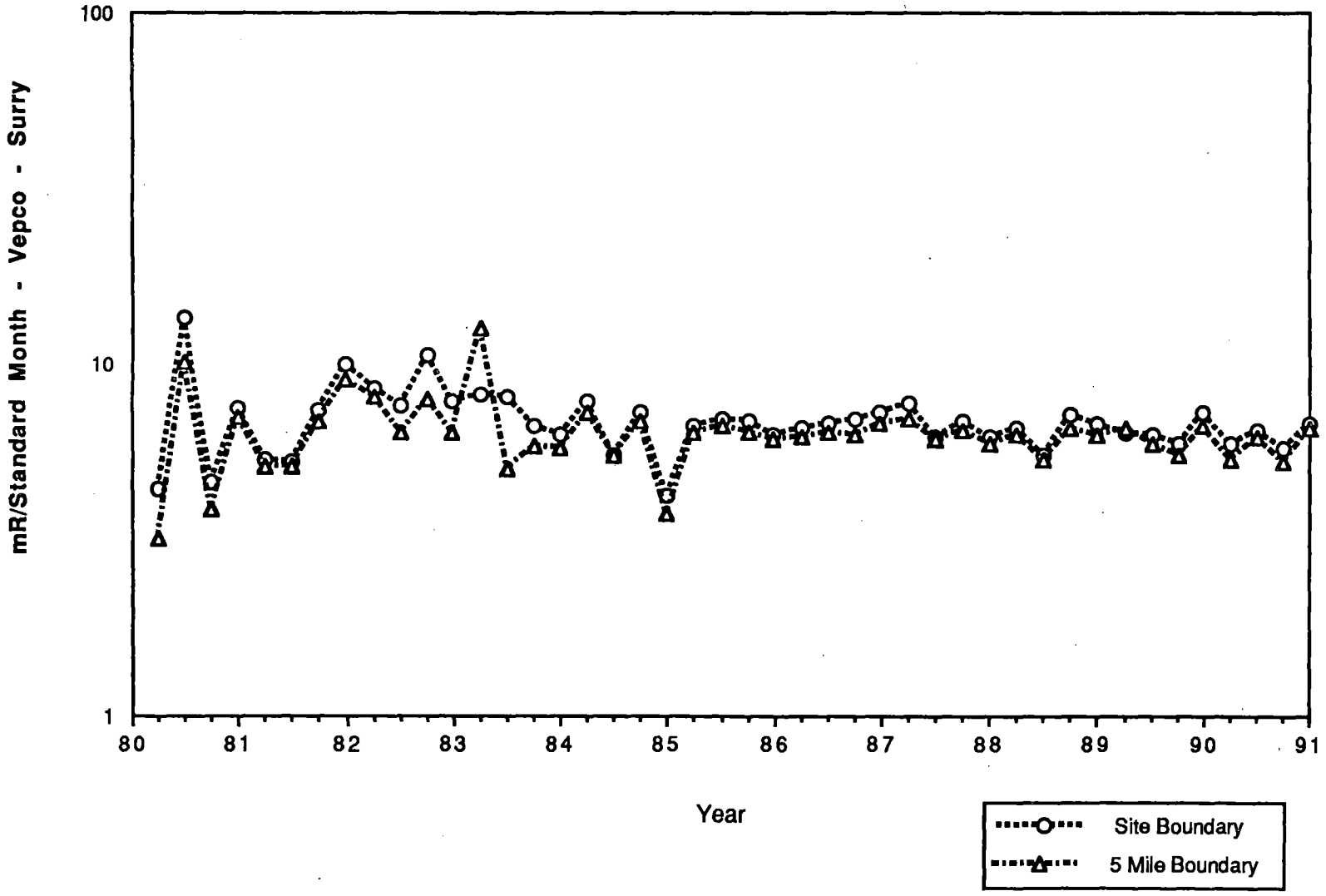
DIRECT RADIATION EXPOSURE PATHWAY

A thermoluminescent dosimeter (TLD) is an inorganic crystal used to detect ambient radiation. TLDs are placed in two concentric rings around the station at the site boundary and at approximately 5 miles. TLDs are also placed in special interest areas such as population areas and nearby residents. Several TLDs also serve as controls. These TLDs measure ambient radiation from naturally occurring radioisotopes in the air and soil, radiation from cosmic origin, fallout from nuclear weapons testing, station effluents and direct radiation from the station.

The results of this analysis is presented in Table B-15 and B-16. Control and indicator averages indicate a decreasing trend in ambient radiation levels. This years levels are slightly less than the previous five years.

TRENDING GRAPH - 11

DIRECT RADIATION MEASUREMENTS-TLD RESULTS



SUMMARY OF RESULTS - SURRY REMP PROGRAM

Isotope	Average Activity	TS Limit	Trend	% TS Reporting Level	Impact
Airborne Exposure Pathway					
Beryllium 7	0.087 pCi/m^3	Not Applicable	Steady	Not applicable. Naturally occurring isotopes do not have assigned reporting levels because they are considered to contribute to natural background radiation levels.	None; this is a naturally occurring radioisotope.
Potassium 40	0.004 pCi/m^3	Not Applicable	Decreasing	Not applicable. This is a naturally occurring radioisotope.	None; this is a naturally occurring radioisotope.
Waterborne Exposure Pathway					
River Water					
Potassium 40	101.0 pCi/l	Not Applicable	Steady	Not applicable. This is a naturally occurring isotope.	None; this is a naturally occurring radioisotope.
Tritium Average for Indicator Locations	319 pCi/l	30,000 pCi/l	Decreasing	1.06%	None; James River water is not used for a drinking water supply or crop irrigation.
Tritium Average for Control Locations	0.0 pCi/l	30,000 pCi/l	Steady	0.0%	None
Well Water					
Gross gamma emitters	No gamma emitters natural or man-made were detected	Not Applicable	Steady	0.0%	None
Tritium	0.0 pCi/l	Not Applicable	Decreasing	0.0%	None
Aquatic Exposure Pathway					
Silt					
Cesium 134	181 pCi/kg	Not Applicable	Decreasing	Not Applicable	The NRC does not assign reporting levels for radioisotopes measured in this pathway. However these radioisotopes may indirectly effect the concentration of radioactivity found in the ingestion pathway.

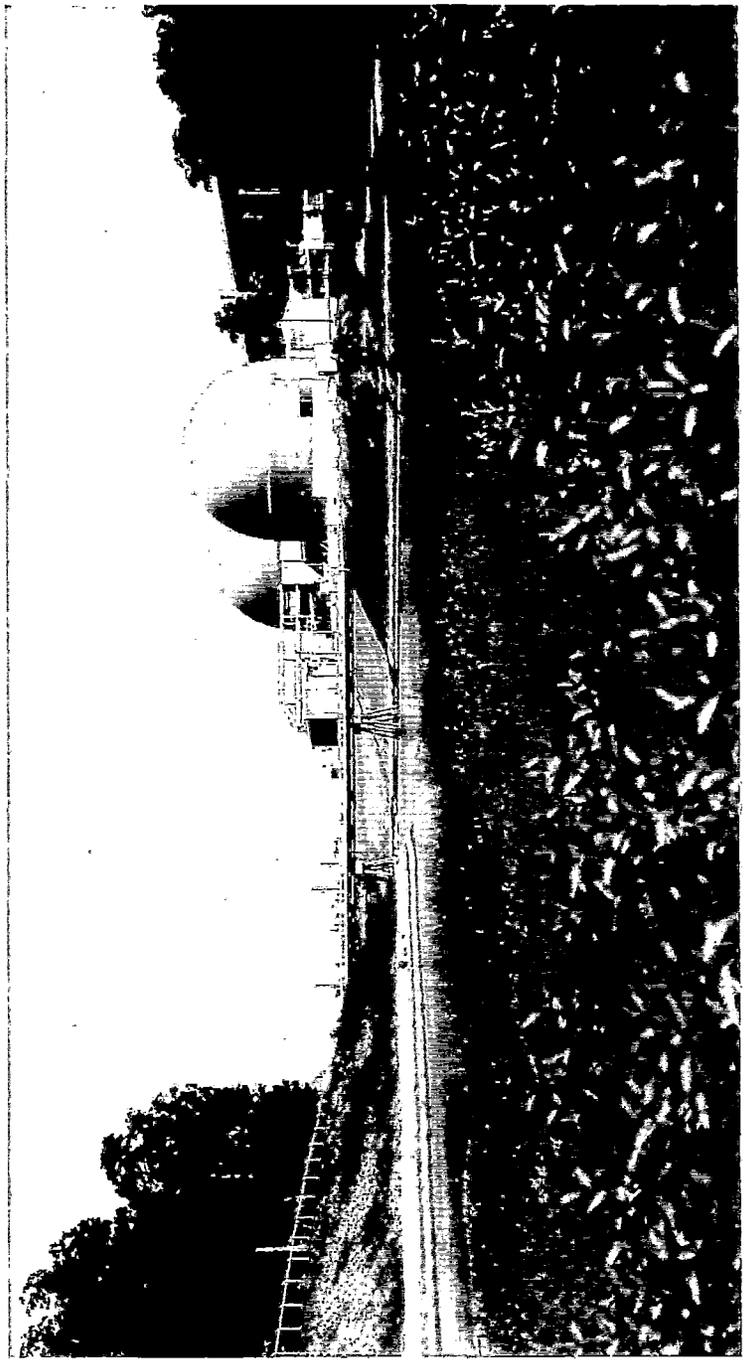
Isotope	Average Activity	TS Limit	Trend	% TS Reporting Level	Impact
Aquatic Exposure Pathway (Cont.)					
Cesium 137	771 pCi/kg	Not Applicable	Decreasing	Not Applicable	The NRC does not assign reporting levels for radioisotopes measured in this pathway. However these radioisotopes may indirectly effect the concentration of radioactivity found in the ingestion pathway.
Cobalt 60	688 pCi/kg	Not Applicable	Decreasing	Not Applicable	The NRC does not assign reporting levels for radioisotopes measured in this pathway. However, these radioisotopes may indirectly effect the concentration of radioactivity found in the ingestion pathway.
Cobalt 58	0.0 pCi/kg	Not Applicable	Decreasing	Not Applicable	The NRC does not assign reporting levels for radioisotopes measured in this pathway. However, these radioisotopes may indirectly effect the concentration of radioactivity found in the ingestion pathway.
Shoreline Sediment					
Potassium 40	4850 pCi/kg	Not Applicable	Steady	Not Applicable This is a naturally occurring isotope.	None; this is a naturally occurring radio-isotope.
Radium 226	442 pCi/kg	Not Applicable	Steady	Not Applicable. This is a naturally occurring isotope.	None; this is a naturally occurring radio-isotope.
Thorium 228	121 pCi/kg	Not Applicable	Steady	Not Applicable. This is a naturally occurring isotope.	None; this is a naturally occurring radio-isotope.
Ingestion Exposure Pathway					
Milk					
Potassium 40	1300 pCi/l	Not Applicable	Decreasing	Not Applicable. This is a naturally occurring isotope.	None; this is a naturally occurring radio-isotope.
Iodine 131	0.0 pCi/l	3.0 pCi/l	Steady	0.0%	None

Isotope	Average Activity	TS Limit	Trend	% TS Reporting Level	Impact
Ingestion Exposure Pathway (Cont.)					
Aquatic Biota					
Clam					
Potassium 40	469 pCi/kg	Not Applicable	Decreasing	Not Applicable. This is a naturally occurring isotope.	None, this is a naturally occurring radio-isotope.
Oyster					
Potassium 40	595 pCi/kg	Not Applicable	Decreasing	Not Applicable. This is a naturally occurring isotope.	None, this is a naturally occurring radio-isotope.
Crab					
Potassium 40	2430 pCi/kg	Not Applicable	Steady	Not Applicable. This is a naturally occurring isotope.	None, this is a naturally occurring radio-isotope.
Fish					
Potassium 40	1511 pCi/kg During 1990	Not Applicable	Decreasing	Not Applicable. This is a naturally occurring isotope.	None, this is a naturally occurring radio-isotope.
Cesium-137	18.7 pCi/kg	2,000 pCi/kg	Decreasing	Less than 1.0%	None; the concentration of radioactivity found in one sample this year is comparable to last year. The percent Technical Specification Reporting Level indicate an insignificant ingestion dose consequen
Food Products & Vegetation					
Potassium 40	8736 pCi/kg	Not Applicable	Increasing	Not Applicable. This is a naturally occurring isotope.	None; this is a naturally occurring radio-isotope.
Beryllium 7	220 pCi/kg	Not Applicable	Steady	Not Applicable. This is a naturally occurring isotope.	None; this is a naturally occurring radio-isotope.
Cesium-137	11.3 pCi/kg	2,000 pCi/kg	Decreasing	Less than 1.0%	None; the concentration of radioactivity found in samples this year is comparable to last year and may be attributable to worldwide fallout. The percent Technical Specification Reporting Level indicate an insignificant ingestion dose consequence.

SUMMARY OF RESULTS - SURRY REMP PROGRAM

Isotope	Average Activity	TS Limit	Trend	% TS Reporting Level	Impact
Direct Radiation Exposure Pathway					
Thermoluminescent Dosimeter					
Gross Gamma for Control Stations	5.2 mR/std mth.		Decreasing		This is the radiation level at the control site; this is "background radiation." This number should be subtracted from the average activity for the gross gamma at indicator stations to give a true ambient radiation level.
Gross Gamma for Surry Site area TLD average	6.3 mR/std mth.		Decreasing		When background (5.0 mR/standard month) is subtracted from this indicator location, the remaining TLD average 1.1 is the result of station operations.
Gross Gamma for indicator stations excluding the Surry Site area TLDs	5.8 mR/std mth.		Decreasing		When background (5.2 mR/standard month) is subtracted from this indicator location, the remaining 6 tenths of 1.0 mR is not significant when compared to the U.S. average background radiation levels of 300 mRem/year.

Conclusion



VI. CONCLUSIONS

The results of the 1990 Radiological Environmental Monitoring Program for Surry Nuclear Power Station have been presented.

- Based on the results of the REMP, Surry Power Station is operating within regulatory limits.
- All samples analyzed were either below the Technical Specifications reporting limits or below the lower limits of detection.
- Overall, the results were as expected for normal environmental samples. Naturally occurring radioactivity was observed in sample media and was within the expected activity ranges.
- Occasional samples revealed the presence of man made isotopes. The concentration of isotopes attributable to station effluents are very low and of no significant dose consequence.

As a method of referencing the measured radionuclide concentrations in sample media to the dose consequence, the data may be compared to the Reporting Level Concentrations listed in the NRC Regulatory Guide 4.8. These concentrations are based upon 25% of the annual dose commitment recommended by 10CFR50, Appendix I, to meet the criterion "As Low as is Reasonably Achievable."

Airborne Exposure

Air particulate gross beta concentrations of all the indicator locations for 1990 trend well with the control location. The gross beta concentrations indicate a steady trend when compared to the levels found during the previous 5 years. Gamma isotopic analysis of the particulate samples identified natural background radioactivity. No radioactivity attributable to the operation of the power station were identified.

River Water

All river water samples were analyzed for gamma emitting radioisotopes. With the exception of naturally occurring potassium-40, no other gamma emitters were detected. In particular, no iodine-131 was detected.

Tritium activity was measured in several samples with an average concentration of 319 pCi/liter. This value is less than the average for the past five years. The percent of Technical Specification Peporting Level is 1.06% of the VEPCO Reporting Level Concentration. Because

there is no supply of drinking water or water used for crop inrrigation, there is an insignificant dose consequence to the public from this pathway. Research of the preoperational data for tritium indicates levels of activity considerably higher than current levels due to atmospheric weapons testing.

Well Water

Well water samples were analyzed and indicated that there were no man made or naturally occurring radioisotopes present.

Silt

The NRC does not assign reporting levels to radioisotopes measured in this pathway. The average levels of man made radioisotopes in silt indicate a decrease in concentration when compared to the previous 5 year trend. During 1990 an increase in the average concentration was observed compared to 1989 and this is attributable to the continuous operation of both units at Surry Power Station.

Shoreline Sediment

Only naturally occurring radioisotopes were detected at concentrations equivalent to normal background activities. There were no radioisotopes attributable to the operation of the power station found in any sample.

Milk

Milk samples are an important indicator for measuring the affect of radioactive iodine and radioisotopes in airborne releases.

Iodine-131 was not measured in any of the 60 milk samples. Naturally occurring potassium-40 was detected at a slight decrease in average concentration when compared to the previous two years.

The concentration of strontium-90 in this years analysis shows a decrease when compared to the previous two years. Strontium-90 is not a part of station effluent, but rather a product of weapons fallout.

Aquatic Biota

Clams, Oysters and Crabs

As expected, naturally occurring potassium-40 was detected in all samples. Based on the previous 5 years, the trend of potassium in clams and oysters is decreasing (in crabs the trend is steady). No gamma emitting radioisotopes were detected in any of the samples. This trend is consistent with preoperational data.

Fish

As expected, naturally occurring potassium-40 was detected in all samples. Based on the previous 5 years, the trend of potassium-40 in fish is decreasing.

Cesium-137 was observed in one of the fish samples. The concentration in this one sample is lower than the average of the past 5 years and indicates a decreasing trend. Further, this sample is less than the lower limits of detection for the instrumentation and is considerably below the Technical Specification Reporting Limits. The percent of Technical Specification Reporting Level for this sample is calculated to be less than 1% and indicates an insignificant ingestion dose consequence.

Food Products and Vegetation

As expected, naturally occurring potassium-40 and beryllium-7 (one sample) was detected in samples collected and analyzed.

Cesium-137 was observed in two soybean samples. The concentration of radioactivity found in samples this year is comparable to last year and may be attributable to world wide fallout. The percent Technical Specification Reporting Level for this sample is calculated to be less than 1% and indicates an insignificant ingestion dose consequence.

Direct Radiation Exposure Pathway

Control and indicator averages indicate a decreasing trend in ambient radiation levels. This years levels are slightly less than the previous five years.

The direct radiation exposure that may be attributed to the station operation is 1.1 mR/standard month (0.036 mR/day). This exposure is not significant when compared to the United States average background radiation levels of 360 mRem/year (0.98 mRem/day).

References

VII. REFERENCES

1. Virginia Electric and Power Company, Surry Power Station Technical Specifications, Units 1 and 2.

2. Virginia Electric and Power Company, Station Administrative Procedure, VPAP-2103, "Offsite Dose Calculation Manual," Rev. O, May 31, 1990.

3. Title 10 Code of Federal Regulation, Part 50 (10CFR50), "Domestic Licensing of Production and Utilization Facilities."

4. United States Nuclear Regulatory Commission Regulatory Guide 1.109, Rev. 1, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR50, Appendix I," October, 1977.

5. United States Nuclear Regulatory Commission, Regulatory Guide 4.8 "Environmental Technical Specifications for Nuclear Power Plants," December, 1975.

6. USNRC Branch Technical Position, "Acceptable Radiological Environmental Monitoring Program," Rev. 1, November 1979.

7. NUREG 0472, "Radiological Effluent Technical Specifications for PWRs," Rev. 3, March 1982.

8. National Council on Radiation Protection and Measurements, Report No. 39, "Basic Radiation Protection Criteria," Washington, D.C., January 1971.

9. National Council on Radiation Protection and Measurements, Report No. 45, "Natural Background Radiation in the United States," Washington, D.C., November 1975.

10. National Council on Radiation Protection and Measurements, Report No. 95, "Radiation Exposure of the U.S. Population from Consumer Products and Miscellaneous Sources," Washington, D.C., December 1987.

11. DOE/NE-0072, "Nuclear Energy and Electricity, The Harnessed Atom," US Dept. of Energy, 1986.

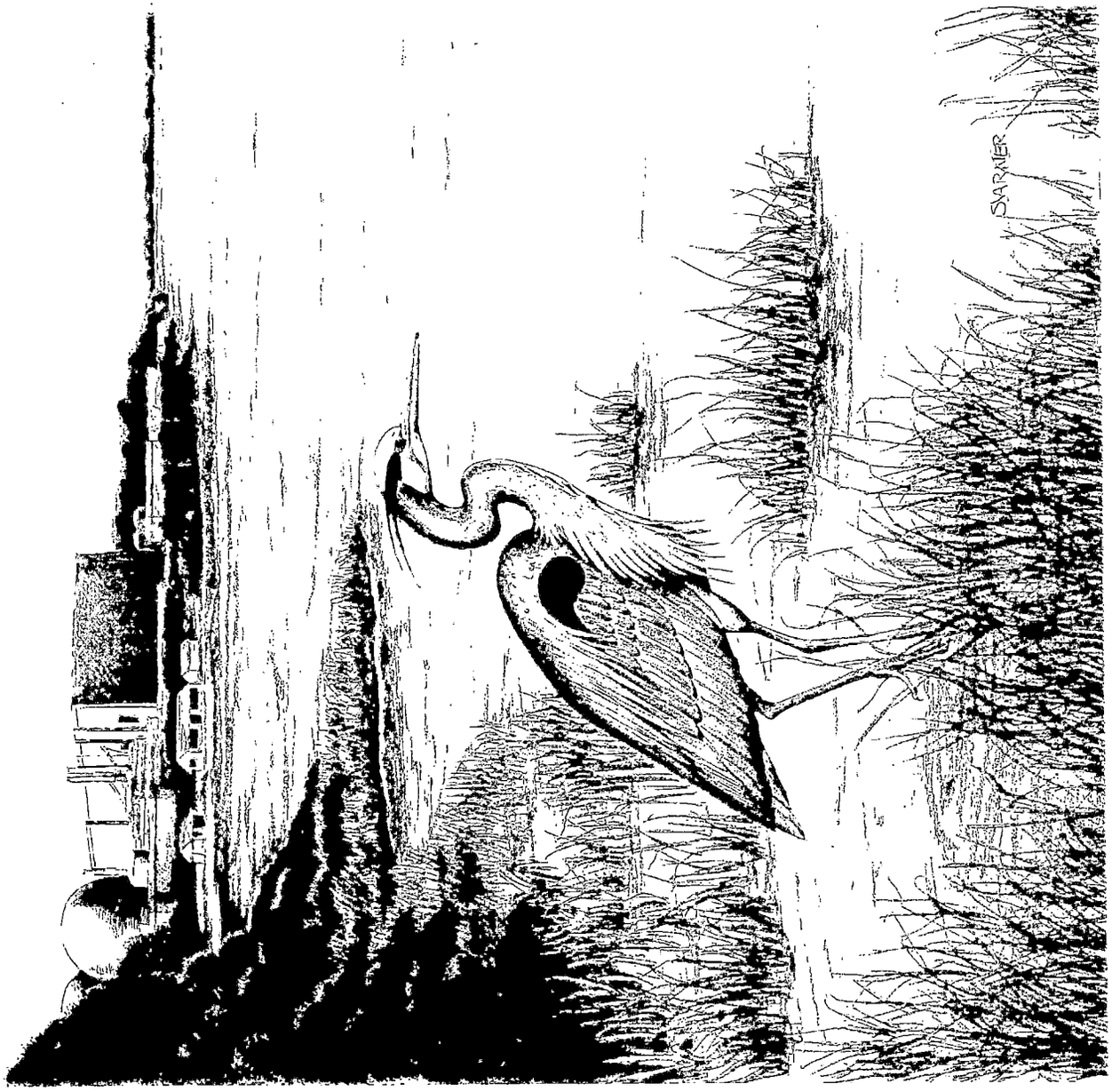
12. Eichholz, G., "Environmental Aspects of Nuclear Power," Lewis Publishers, Inc., 1985.

13. Eisenbud, M., "Environmental Radioactivity," Academy Press, Inc., Orlando, Fl, 1987.

14. Fitzgibbon, W., "Energy Skill Builders, Nuclear Reactor," Enterprise for Education, Inc., 1987.

15. Glasstone, S., and Jordan, W., "Nuclear Power and its Environmental Effects," American Nuclear Society, 1982.

Appendices



APPENDIX A
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM ANNUAL SUMMARY TABLES - 1990

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

SURRY NUCLEAR POWER STATION — DOCKET NO. 5-280-281

SURRY 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	416	0.07	-(0/364) -	N/A	N/A	-(0/52) -	0
Airborne Particulates (1E-03 pCi/m^3)	Gross Beta	416	10	15.9(364/364) (6.2-39)	ALL 5.1 mi WSW	16.8(52/52) (7.3-38)	15.8(52/52) (6.6-32)	0
	Gamma	32						
	Be-7	32	-	86.7(28/28) (46.6-130)	NN 16.5 mi ESE	96.2(4/4) (58.0-122)	96.2(4/4) (58.0-122)	0
	K-40	32	130	3.91(3/28) (3.31-5.12)	DOW 5.1 mi ENE	5.12(1/4) -	-(0/0) -	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

SURRY NUCLEAR POWER STATION — DOCKET NO. 5-280-281

SURRY 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
River Water (a) (pCi/liter)	Gamma	48						
	K-40	48	-	101(11/42) (43.6-189)	SI 12.0 mi SE	189(1/6) -	-(0/6) -	0
	Tritium (Quarterly)	24	2000	319(12/20) (140-950)	HIP 2.4 mi NE	500(3/4) (260-950)	-(0/4)	0
River Water (b) (pCi/liter - State Split)	Gamma	24						
	K-40	24	0	71.7(3/12) (61.7-79.4)	SD 0.17 mi NW	71.7(3/12) (61.7-79.4)	61.6(1/12) -	0
	Tritium (Quarterly)	24	2000	835(4/4) (270-1500)	SD 0.17 mi NW	835(4/4) (270-1500)	475(2/4) (350-600)	0
Well Water (pCi/liter)	Gamma	16						
	K-40	16	-	-(0/16) -	N/A	N/A	NONE	0
	Tritium (Quarterly)	16	2000	-(0/16) -	N/A	N/A	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

SURRY NUCLEAR POWER STATION — DOCKET NO. 5-280-281

SURRY 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
Silt pCi/kg (dry)	Gamma 12						
	Be-7 12		993(2/10) (715-1270)	SI 1.9 mi ESE	1270(1/2) -	-(0/2) -	0
	K-40 12		15678(9/10) (11800-20800)	SI 1.9 mi ESE	19100(2/2) (17400-20800)	16950(2/2 (16100-17800)	0
	Co-60 12		688(9/10) (66.9-3610)	SD 0.5 mi NNW	1911(2/2) (212-3610)	249(1/2) -	0
	Cs-134 12	150	181(3/10) (156-231)	SD 0.5 mi NNW	231(1/2) -	-(0/2) -	0
	Cs-137 12	180	771(10/10) (173-1730)	SI 1.9 mi ESE	1262(2/2) (954-1570)	615(2/2) (562-667)	0
	Ra-226 12		2164(10/10) (1540-2770)	CHIC 11.2 mi WNW	3305(2/2) (3160-3450)	3305(2/2) (3160-3450)	0
	Th-228 12		1275(10/10) (860-1680)	CHIC 11.2 mi WNW	1550(2/2) (1540-1560)	1550(2/2) (1540-1560)	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

SURRY NUCLEAR POWER STATION — DOCKET NO. 5-280-281

SURRY 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 Sediment (pCi/kg dry)	Gamma Spec	4					
	K-40	4	4850(4/4) (2910-6930)	HIR 0.8 mi N	6570(2/2) (6210-6930)	NONE	0
	Ra-226	4	442(2/4) (434-450)	HIR 0.8 mi N	450(1/2) -	NONE	0
	Th-228	4	121(2/4) (105-137)	HIR 0.8 mi N	121(2/2) (105-137)	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

SURRY NUCLEAR POWER STATION — DOCKET NO. 5-280-281

SURRY 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)	Gamma	60						
	K-40	60	-	1300(48/48) (1130-1480)	CP 3.7 mi NNW	1338(12/12) (1220-1440)	1265(12/12) (1150-1360)	0
	I-131	60	1	-(0/48) -	N/A	N/A	-(0/12) -	0
	Cs-137	60	10	-(0/48) -	N/A	N/A -	-(0/12) -	0
	Sr-89	12	-	-(0/12) -	N/A	N/A	-(0/0) -	0
	Sr-90	12	-	1.62(12/12) (0.50-3.7)	CP 3.7 mi NNW	3.40(3.3) (3.2-3.7)	-(0/0) -	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

SURRY NUCLEAR POWER STATION — DOCKET NO. 5-280-281

SURRY 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
Clams (pCi/kg wet)	Gamma Spec	30					
	K-40	-	469(21/24) (321-585)	CHIC 11.2 mi WNW	560(6/6) (192-1190)	560(6/6) (192-1190)	0
Oysters (pCi/kg wet)	Gamma Spec	24					
	K-40	-	595(21/24) (370-900)	RLS 7.8 mi SE	663(6/6) (520-900)	NONE	0
Crabs (pCi/kg wet)	Gamma Spec	1					
	K-40	-	2430(1/1) -	SD 0.6 mi NW	2430(1/1) -	NONE	0
Fish (pCi/kg wet)	Gamma Spec	4					
	K-40	-	1511(4/4) (942-2010)	SD 0.6 mi NW	1511(4/4) (942-2010)	NONE	0
	Cs-137	150	18.7(1/4) -	SD 0.6 mi NW	18.7(1/4) -	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

SURRY NUCLEAR POWER STATION — DOCKET NO. 5-280-281

SURRY 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 TLDs (mR/std. month)	Gamma	332	2	6.0(316/316) (1.1-9.0)	38 16.5 mi ESE	7.9(8/8) (7.1-9.0)	5.2(16/16) (4.2-6.3)	0
Vegetation (pCi/kg wet)	Gamma	5						
	K-40	5		8736(5/5) (4300-15200)	Brock's Garden	15200(1/1) -	NONE	0
	Be-7	5		220(1/5) -	Turner's Garden	220(1/1) -	NONE	0
	Cs-137	5		11.3(2/5) (10.2-12.4)	Slade's Garden	12.4(1/1) -	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)

SURRY - 1990

CONCENTRATIONS OF IODINE-131 IN FILTERED AIR

pCi/m3 ± 2 Sigma

STATIONS COLLECTION DATE	S S	HIR	B C	ALL	C P	DOW	F E	N N
JANUARY								
01/02/90-01/09/90	< .03	< .03	< .03	< .03	< .03	< .03	< .03	< .03
01/09/90-01/16/90	< .02	< .02	< .02	< .02	< .01	< .02	< .01	< .02
01/16/90-01/23/90	< .02	< .02	< .02	< .02	< .02	< .02	< .02	< .02
01/23/90-01/29/90	< .02	< .02	< .02	< .02	< .008	< .008	< .008	< .008
FEBRUARY								
01/29/90-02/05/90	< .02	< .02	< .02	< .02	< .02	< .02	< .02	< .02
02/05/90-02/13/90	< .01	< .01	< .01	< .01	< .01	< .01	< .01	< .01
02/13/90-02/20/90	< .02	< .02	< .02	< .02	< .01	< .01	< .01	< .01
02/20/90-02/27/90	< .01	< .01	< .01	< .01	< .02	< .02	< .02	< .02
MARCH								
02/27/90-03/06/90	< .02	< .02	< .02	< .02	< .02	< .02	< .02	< .02
03/06/90-03/13/90	< .02	< .02	< .02	< .02	< .02	< .02	< .02	< .02
03/13/90-03/20/90	< .02	< .02	< .01	< .02	< .01	< .01	< .01	< .02
03/20/90-03/28/90	< .01	< .01	< .01	< .01	< .02	< .02	< .02	< .02
03/28/90-04/03/90	< .02	< .02	< .02	< .02	< .03	< .03	< .03	< .03

TABLE B-1

(Page 2 of 4)

SURRY - 1990

CONCENTRATIONS OF IODINE-131 IN FILTERED AIR

pCi/m3 ± 2 Sigma

STATIONS COLLECTION DATE	S S	HIR	BC	ALL	CP	DOW	FE	N N
APRIL								
04/03/90-04/10/90	< .01	< .01	< .01	< .01	< .02	< .02	< .02	< .02
04/10/90-04/17/90	< .01	< .01	< .01	< .01	< .01	< .01	< .01	< .01
04/17/90-04/24/90	< .02	< .02	< .02	< .02	< .02	< .02	< .02	< .02
04/24/90-05/01/90	< .02	< .02	< .02	< .02	< .02	< .02	< .02	< .02
MAY								
05/01/90-05/08/90	< .01	< .01	< .01	< .01	< .02	< .02	< .02	< .02
05/08/90-05/15/90	< .02	< .02	< .02	< .02	< .02	< .02	< .02	< .02
05/15/90-05/22/90	< .02	< .02	< .01	< .02	< .01	< .01	< .01	< .01
05/22/90-05/29/90	< .01	< .01	< .01	< .01	< .02	< .02	< .02	< .02
JUNE								
05/29/90-06/05/90	< .02	< .02	< .02	< .02	< .02	< .02	< .02	< .02
06/05/90-06/12/90	< .01	< .01	< .01	< .01	< .02	< .02	< .02	< .02
06/12/90-06/19/90	< .02	< .02	< .02	< .02	< .02	< .02	< .02	< .02
06/19/90-06/26/90	< .02	< .02	< .02	< .02	< .02	< .02	< .02	< .01
06/26/90-07/03/90	< .01	< .02	< .01	< .01	< .03	< .02	< .03	< .02

TABLE B-1

(Page 3 of 4)

SURRY - 1990

CONCENTRATIONS OF IODINE-131 IN FILTERED AIR

pCi/m3 ± 2 Sigma

STATIONS COLLECTION DATE	SS	HIR	BC	ALL	CP	DOW	FE	NN
JULY								
07/03/90-07/10/90	< .02	< .02	< .02	< .02	< .02	< .02	< .02	< .02
07/10/90-07/17/90	< .02	< .02	< .02	< .02	< .01	< .02	< .02	< .02
07/17/90-07/24/90	< .01	< .01	< .01	< .01	< .02	< .02	< .02	< .02
07/24/90-07/31/90	< .01	< .01	< .01	< .01	< .02	< .02	< .02	< .02
AUGUST								
07/31/90-08/07/90	< .02	< .02	< .02	< .01	< .02	< .02	< .02	< .02
08/07/90-08/14/90	< .02	< .02	< .02	< .02	< .02	< .02	< .02	< .02
08/14/90-08/21/90	< .02	< .01	< .01	< .01	< .02	< .02	< .02	< .02
08/21/90-08/28/90	< .01	< .01	< .01	< .01	< .01	< .01	< .01	< .01
SEPTEMBER								
08/28/90-09/05/90	< .01	< .01	< .01	< .01	< .02	< .02	< .02	< .02
09/05/90-09/11/90	< .02	< .02	< .02	< .02	< .01	< .01	< .01	< .01
09/11/90-09/18/90	< .01	< .01	< .01	< .01	< .02	< .02	< .02	< .02
09/18/90-09/25/90	< .02	< .02	< .02	< .02	< .02	< .02	< .02	< .02
09/25/90-10/02/90	< .02	< .02	< .02	< .02	< .02	< .02	< .02	< .02

TABLE B-1

(Page 4 of 4)

SURRY - 1990

CONCENTRATIONS OF IODINE-131 IN FILTERED AIR

pCi/m3 ± 2 Sigma

STATIONS COLLECTION DATE	S S	HIR	BC	ALL	CP	DOW	FE	N N
OCTOBER								
10/02/90-10/09/90	< .02	< .02	< .02	< .02	< .02	< .02	< .02	< .02
10/09/90-10/16/90	< .02	< .02	< .02	< .02	< .02	< .02	< .02	< .02
10/16/90-10/23/90	< .02	< .02	< .02	< .02	< .01	< .01	< .01	< .01
10/23/90-10/30/90	< .02	< .02	< .02	< .02	< .02	< .02	< .02	< .02
NOVEMBER								
10/30/90-11/06/90	< .02	< .02	< .02	< .02	< .01	< .01	< .02	< .01
11/06/90-11/12/90	< .02	< .01	< .02	< .02	< .02	< .02	< .02	< .02
11/12/90-11/20/90	< .02	< .04	< .02	< .02	< .02	< .02	< .02	< .02
11/20/90-11/27/90	< .02	< .02	< .02	< .02	< .01	< .01	< .01	< .01
DECEMBER								
11/27/90-12/05/90	< .02	< .02	< .02	< .02	< .02	< .02	< .02	< .02
12/05/90-12/11/90	< .03	< .02	< .02	< .02	< .03	< .04 (a)	< .03	< .03
12/11/90-12/18/90	< .02	< .02	< .02	< .02	< .02	< .02	< .02	< .02
12/18/90-12/26/90	< .02	< .02	< .02	< .02	< .03	< .02	< .03	< .02
12/26/90-01/02/90	< .02	< .02	< .02	< .02	< .02	< .02	< .02	< .02

(a) The timer on the air sampler only indicated 96.6 hours. No reason could be detected for the short run time.

TABLE B-2

(Page 1 of 4)

SURRY - 1990

CONCENTRATIONS OF GROSS BETA IN AIR PARTICULATES

10^{-3} pCi/m3 ± 2 Sigma

STATIONS COLLECTION DATE	SS	HIR	BC	ALL	CP	DOW	FE	NN	Average ± 2 s.d.
JANUARY									
01/02/90-01/09/90	17 ± 2	18 ± 2	19 ± 2	17 ± 2	19 ± 2	19 ± 2	18 ± 2	18 ± 2	18 ± 2
01/09/90-01/16/90	15 ± 2	18 ± 2	17 ± 2	15 ± 2	15 ± 2	17 ± 2	16 ± 2	14 ± 2	16 ± 3
01/16/90-01/23/90	18 ± 2	19 ± 2	20 ± 2	21 ± 2	16 ± 2	19 ± 2	22 ± 2	19 ± 2	19 ± 4
01/23/90-01/29/90	19 ± 2	17 ± 2	19 ± 2	18 ± 2	16 ± 2	16 ± 2	18 ± 2	18 ± 2	18 ± 2
FEBRUARY									
01/29/90-02/05/90	12 ± 1	11 ± 1	14 ± 2	11 ± 1	12 ± 1	10 ± 1	12 ± 1	14 ± 2	12 ± 3
02/05/90-02/13/90	14 ± 2	16 ± 2	16 ± 2	15 ± 2	15 ± 2	15 ± 2	15 ± 2	13 ± 2	15 ± 2
02/13/90-02/20/90	15 ± 2	19 ± 2	15 ± 2	15 ± 2	12 ± 1	11 ± 1	15 ± 2	15 ± 2	15 ± 5
02/20/90-02/27/90	14 ± 2	13 ± 2	8.1 ± 1.3	13 ± 2	11 ± 1	12 ± 2	11 ± 1	12 ± 2	12 ± 4
MARCH									
02/27/90-03/06/90	18 ± 2	19 ± 2	19 ± 2	22 ± 2	20 ± 2	19 ± 2	18 ± 2	15 ± 2	19 ± 4
03/06/90-03/13/90	19 ± 2	18 ± 2	17 ± 2	20 ± 2	16 ± 2	19 ± 2	18 ± 2	18 ± 2	18 ± 3
03/13/90-03/20/90	14 ± 2	14 ± 2	14 ± 2	16 ± 2	13 ± 2	13 ± 2	15 ± 2	15 ± 2	14 ± 2
03/20/90-03/28/90	18 ± 2	17 ± 2	13 ± 1	17 ± 2	13 ± 1	16 ± 2	16 ± 2	14 ± 2	16 ± 4
03/28/90-04/03/90	6.2 ± 1.3	8.5 ± 1.5	6.7 ± 1.5	7.3 ± 1.4	8.0 ± 1.5	7.3 ± 1.4	9.5 ± 1.6	6.6 ± 1.4	8 ± 2
Quarter Average ± 2 s.d.	**15 ± 7**	**16 ± 7**	**15 ± 8**	**16 ± 8**	**14 ± 7**	**15 ± 8**	**16 ± 7**	**15 ± 7**	**15 ± 1**

TABLE B-2

(Page 2 of 4)

SURRY - 1990

CONCENTRATIONS OF GROSS BETA IN AIR PARTICULATES

10^{-3} pCi/m3 ± 2 Sigma

STATIONS COLLECTION DATE	SS	HIR	BC	ALL	CP	DOW	FE	NN	Average ± 2 s.d.
APRIL									
04/03/90-04/10/90	15 ± 2	13 ± 2	15 ± 2	14 ± 2	14 ± 2	13 ± 2	14 ± 2	14 ± 2	14 ± 2
04/10/90-04/17/90	15 ± 2	14 ± 2	15 ± 2	16 ± 2	15 ± 2	14 ± 2	15 ± 2	12 ± 2	15 ± 2
04/17/90-04/24/90	17 ± 2	16 ± 2	18 ± 2	20 ± 2	16 ± 2	18 ± 2	21 ± 2	14 ± 2	18 ± 5
04/24/90-05/01/90	19 ± 2	18 ± 2	19 ± 2	22 ± 2	18 ± 2	22 ± 2	20 ± 2	20 ± 2	20 ± 3
MAY									
05/01/90-05/08/90	16 ± 2	15 ± 2	17 ± 2	18 ± 2	15 ± 2	16 ± 2	16 ± 2	19 ± 2	17 ± 3
05/08/90-05/15/90	11 ± 2	8.8 ± 1.4	13 ± 2	14 ± 2	13 ± 2	13 ± 2	13 ± 2	11 ± 2	12 ± 3
05/15/90-05/22/90	17 ± 2	14 ± 2	17 ± 2	19 ± 2	12 ± 2	17 ± 2	16 ± 2	17 ± 2	16 ± 4
05/22/90-05/29/90	7.1 ± 1.2	7.4 ± 1.3	8.4 ± 1.3	10 ± 1	9.3 ± 1.4	7.0 ± 1.2	7.6 ± 1.3	9.5 ± 1.4	8 ± 2
JUNE									
05/29/90-06/05/90	11 ± 2	11 ± 2	10 ± 1	11 ± 2	9.2 ± 1.4	12 ± 2	12 ± 2	11 ± 2	11 ± 2
06/05/90-06/12/90	13 ± 2	12 ± 2	13 ± 2	13 ± 2	13 ± 2	11 ± 2	13 ± 2	14 ± 2	13 ± 2
06/12/90-06/19/90	10 ± 2	9.8 ± 1.5	11 ± 2	10 ± 2	11 ± 2	10 ± 2	9.8 ± 1.5	8.2 ± 1.5	10 ± 2
06/19/90-06/26/90	12 ± 2	11 ± 1	11 ± 1	13 ± 2	13 ± 2	13 ± 2	11 ± 1	13 ± 2	12 ± 2
06/26/90-07/03/90	16 ± 2	17 ± 2	16 ± 2	16 ± 2	19 ± 2	15 ± 2	15 ± 2	16 ± 2	16 ± 3
Quarter Average ± 2 s.d.	**14 ± 7**	**13 ± 6**	**14 ± 7**	**15 ± 8**	**14 ± 6**	**14 ± 8**	**14 ± 7**	**14 ± 7**	**14 ± 1**

TABLE B-2

(Page 3 of 4)

SURRY - 1990

CONCENTRATIONS OF GROSS BETA IN AIR PARTICULATES

10^{-3} pCi/m3 ± 2 Sigma

STATIONS COLLECTION DATE	SS	HIR	BC	ALL	CP	DOW	FE	NN	Average ± 2 s.d.
JULY									
07/03/90-07/10/90	13 ± 2	10 ± 2	17 ± 2	17 ± 2	13 ± 2	14 ± 2	12 ± 2	15 ± 2	14 ± 5
07/10/90-07/17/90	11 ± 2	13 ± 2	14 ± 2	14 ± 2	13 ± 2	14 ± 2	14 ± 2	14 ± 2	13 ± 2
07/17/90-07/24/90	14 ± 2	11 ± 2	13 ± 2	12 ± 2	13 ± 2	12 ± 2	15 ± 2	15 ± 2	13 ± 3
07/24/90-07/31/90	7.9 ± 1.3	8.5 ± 1.4	9.2 ± 1.4	9.1 ± 1.4	10 ± 1	8.7 ± 1.4	9.7 ± 1.5	10 ± 1	9 ± 2
AUGUST									
07/31/90-08/07/90	11 ± 2	12 ± 2	12 ± 2	14 ± 2	16 ± 2	14 ± 2	14 ± 2	14 ± 2	13 ± 3
08/07/90-08/14/90	14 ± 2	16 ± 2	16 ± 2	15 ± 2	12 ± 2	17 ± 2	17 ± 2	17 ± 2	16 ± 4
08/14/90-08/21/90	19 ± 2	16 ± 2	17 ± 2	15 ± 2	16 ± 2	15 ± 2	16 ± 2	16 ± 2	16 ± 3
08/21/90-08/28/90	12 ± 2	10 ± 2	11 ± 2	9.8 ± 1.5	11 ± 2	11 ± 2	13 ± 2	10 ± 2	11 ± 2
SEPTEMBER									
08/28/90-09/05/90	23 ± 2	22 ± 2	21 ± 2	20 ± 2	20 ± 2	20 ± 2	22 ± 2	20 ± 2	21 ± 2
09/05/90-09/11/90	21 ± 2	19 ± 2	21 ± 2	22 ± 2	19 ± 2	20 ± 2	21 ± 2	20 ± 2	20 ± 2
09/11/90-09/18/90	16 ± 2	16 ± 2	18 ± 2	16 ± 2	16 ± 2	18 ± 2	16 ± 2	17 ± 2	17 ± 2
09/18/90-09/25/90	12 ± 2	14 ± 2	14 ± 2	15 ± 2	14 ± 2	14 ± 2	15 ± 2	14 ± 2	14 ± 2
09/25/90-10/02/90	21 ± 2	19 ± 2	21 ± 2	23 ± 2	19 ± 2	18 ± 2	23 ± 2	23 ± 2	21 ± 4
Quarterly Average ± 2 s.d.	**15 ± 9**	**14 ± 8**	**16 ± 8**	**16 ± 8**	**15 ± 6**	**15 ± 7**	**16 ± 8**	**16 ± 7**	**15 ± 1**

TABLE B-2

(Page 4 of 4)

SURRY - 1990

CONCENTRATIONS OF GROSS BETA IN AIR PARTICULATES

10^{-3} pCi/m3 ± 2 Sigma

STATIONS COLLECTION DATE	SS	HIR	BC	ALL	CP	DOW	FE	NN	Average ± 2 s.d.
OCTOBER									
10/02/90-10/09/90	15 ± 2	18 ± 2	25 ± 2	19 ± 2	16 ± 2	15 ± 2	19 ± 2	17 ± 2	18 ± 7
10/09/90-10/16/90	13 ± 2	14 ± 2	15 ± 2	15 ± 2	13 ± 2	15 ± 2	13 ± 2	14 ± 2	14 ± 2
10/16/90-10/23/90	13 ± 2	17 ± 2	14 ± 2	14 ± 2	15 ± 2	15 ± 2	16 ± 2	16 ± 2	15 ± 3
10/23/90-10/30/90	14 ± 2	16 ± 2	16 ± 2	16 ± 2	13 ± 2	11 ± 1	16 ± 2	13 ± 2	14 ± 4
NOVEMBER									
10/30/90-11/06/90	33 ± 2	33 ± 2	35 ± 2	38 ± 3	30 ± 2	29 ± 2	39 ± 3	32 ± 2	34 ± 7
11/06/90-11/12/90	14 ± 2	16 ± 2	13 ± 2	16 ± 2	15 ± 2	13 ± 2	17 ± 2	15 ± 2	15 ± 3
11/12/90-11/20/90	19 ± 2	22 ± 2	23 ± 2	23 ± 2	22 ± 2	20 ± 2	19 ± 2	23 ± 2	21 ± 4
11/20/90-11/27/90	20 ± 2	24 ± 2	22 ± 2	26 ± 2	24 ± 2	23 ± 2	24 ± 2	23 ± 2	23 ± 4
DECEMBER									
11/27/90-12/05/90	17 ± 2	21 ± 2	24 ± 2	19 ± 2	18 ± 2	17 ± 2	21 ± 2	21 ± 2	20 ± 5
12/05/90-12/11/90	23 ± 2	20 ± 2	23 ± 2	25 ± 2	21 ± 2	32 ± 3 (a)	24 ± 2	23 ± 2	24 ± 7
12/11/90-12/18/90	19 ± 2	22 ± 2	22 ± 2	20 ± 2	21 ± 2	17 ± 2	23 ± 2	20 ± 2	21 ± 4
12/18/90-12/26/90	15 ± 2	17 ± 2	15 ± 2	18 ± 2	15 ± 2	17 ± 2	15 ± 2	16 ± 2	16 ± 2
12/26/90-01/02/91	15 ± 2	15 ± 2	15 ± 2	17 ± 2	13 ± 2	15 ± 2	17 ± 2	14 ± 2	15 ± 3
Qtr Average ± 2 s.d.	**18 ± 11**	**20 ± 10**	**20 ± 12**	**20 ± 13**	**18 ± 10**	**18 ± 12**	**20 ± 13**	**19 ± 11**	**19 ± 2**
Annual Average ± 2 s.d.	**15 ± 9**	**16 ± 9**	**16 ± 10**	**17 ± 10**	**15 ± 8**	**16 ± 9**	**17 ± 10**	**16 ± 9**	**16 ± 2**

(a) Timer malfunction.

TABLE B-3

(Page 1 of 2)

SURRY- 1990

CONCENTRATIONS OF GAMMA EMITTERS* IN QUARTERLY AIR PARTICULATES

10^{-3} pCi/m^3 ± 2 Sigma

STATION	NUCLIDE	FIRST QUARTER 01/02-04/03	SECOND QUARTER 04/03-07/03	THIRD QUARTER 07/03-10/02	FOURTH QUARTER 10/02-01/02	AVERAGE ± 2 s.d.
STA-SS	Be-7	98.4 ± 9.8	46.6 ± 4.7	88.9 ± 8.9	91.8 ± 9.2	81.4 ± 47.1
	K-40	< 4	< 4	3.31 ± 1.82	< 5	3.31 ± 1.82
	Co-60	< 0.2	< 0.1	< 0.3	< 0.3	-
	Cs-134	< 0.2	< 0.2	< 0.2	< 0.3	-
	Cs-137	< 0.2	< 0.2	< 0.2	< 0.3	-
	Th-228	< 0.4	< 0.3	< 0.4	< 0.5	-
STA-HIR	Be-7	109 ± 11	56.3 ± 5.6	92.8 ± 9.3	89.9 ± 9.0	87.0 ± 44.2
	K-40	< 6	< 10	< 3	< 6	-
	Co-60	< 0.3	< 0.4	< 0.2	< 0.4	-
	Cs-134	< 0.3	< 0.4	< 0.2	< 0.3	-
	Cs-137	< 0.3	< 0.3	< 0.2	< 0.3	-
	Th-228	< 0.6	< 0.6	< 0.3	< 0.5	-
STA-BC	Be-7	94.8 ± 9.5	55.8 ± 5.6	79.9 ± 8.0	91.0 ± 9.1	80.4 ± 35.1
	K-40	< 10	< 4	< 6	< 7	-
	Co-60	< 0.3	< 0.2	< 0.3	< 0.3	-
	Cs-134	< 0.3	< 0.2	< 0.3	< 0.3	-
	Cs-137	< 0.3	< 0.2	< 0.2	< 0.3	-
	Th-228	< 0.4	< 0.3	< 0.5	< 0.4	-
STA-ALL	Be-7	130 ± 13	59.2 ± 5.9	84.6 ± 8.5	101 ± 10	93.7 ± 59.4
	K-40	< 5	3.31 ± 1.32	< 6	< 4	3.31 ± 1.32
	Co-60	< 0.3	< 0.2	< 0.3	< 0.2	-
	Cs-134	< 0.3	< 0.2	< 0.3	< 0.2	-
	Cs-137	< 0.3	< 0.2	< 0.3	< 0.2	-
	Th-228	< 0.5	< 0.3	< 0.4	< 0.3	-

* All other gamma emitters were < LLD.

TABLE B-3

(Page 2 of 2)

SURRY - 1990

CONCENTRATIONS OF GAMMA EMITTERS* IN QUARTERLY AIR PARTICULATES

10^{-3} pCi/m^3 ± 2 Sigma

STATION	NUCLIDE	FIRST QUARTER 01/02-04/03	SECOND QUARTER 04/03-07/03	THIRD QUARTER 07/03-10/02	FOURTH QUARTER 10/02-01/02	AVERAGE ± 2 s.d.
STA-CP	Be-7	92.6 ± 9.3	48.1 ± 4.8	87.8 ± 8.8	102 ± 10	82.6 ± 47.5
	K-40	< 7	< 5	< 4	< 10	-
	Co-60	< 0.4	< 0.3	< 0.2	< 0.4	-
	Cs-134	< 0.4	< 0.2	< 0.2	< 0.4	-
	Cs-137	< 0.3	< 0.2	< 0.2	< 0.3	-
	Th-228	< 0.5	< 0.5	< 0.3	< 0.6	-
STA-DOW	Be-7	105 ± 10	57.4 ± 5.7	99.7 ± 10.0	92.8 ± 9.3	88.7 ± 42.9
	K-40	< 7	< 5	5.12 ± 2.57	< 4	5.12 ± 2.57
	Co-60	< 0.3	< 0.3	< 0.4	< 0.4	-
	Cs-134	< 0.3	< 0.3	< 0.3	< 0.2	-
	Cs-137	< 0.3	< 0.3	< 0.3	< 0.2	-
	Th-228	< 0.5	< 0.5	< 0.6	< 0.3	-
STA-FE	Be-7	121 ± 12	57.5 ± 5.7	99.1 ± 9.9	94.5 ± 9.4	93.0 ± 52.7
	K-40	< 5	< 10	< 5	< 3	-
	Co-60	< 0.3	< 0.4	< 0.3	< 0.3	-
	Cs-134	< 0.2	< 0.4	< 0.2	< 0.2	-
	Cs-137	< 0.2	< 0.3	< 0.2	< 0.2	-
	Th-228	< 0.4	< 0.5	< 0.4	< 0.3	-
STA-NN	Be-7	110 ± 11	58.0 ± 5.8	94.8 ± 9.5	122 ± 12	96.2 ± 55.6
	K-40	< 5	< 10	< 4	< 5	-
	Co-60	< 0.3	< 0.3	< 0.2	< 0.2	-
	Cs-134	< 0.3	< 0.3	< 0.2	< 0.2	-
	Cs-137	< 0.2	< 0.3	< 0.2	< 0.2	-
	Th-228	< 0.4	< 0.4	< 0.4	< 0.4	-

* All other gamma emitters were < LLD.

TABLE B-4

(Page 1 of 3)

SURRY - 1990

CONCENTRATIONS OF GAMMA EMITTERS* AND TRITIUM IN RIVER WATER

pCi/l ± 2 Sigma

STATION	DATE	Be-7	K-40	I-131	Cs-137	Ba-140	La-140	Th-228	H-3
JANUARY									
CHIC	01/17/90	< 30	< 60	< 0.3	< 4	< 10	< 6	< 7	
HIP	01/16/90	< 50	< 90	< 0.4	< 6	< 20	< 8	< 10	
NN	01/16/90	< 40	< 90	< 0.4	< 5	< 20	< 6	< 8	
SD	01/17/90	< 30	< 50	< 0.5	< 4	< 10	< 5	< 7	
SI	01/16/90	< 30	< 60	< 0.3	< 4	< 10	< 6	< 7	
SW	01/17/90	< 30	< 50	< 0.4	< 4	< 10	< 5	< 6	
FEBRUARY									
SD	02/20/90	< 50	< 90	< 0.4	< 5	< 20	< 8	< 10	
SW	02/20/90	< 40	< 90	< 0.3	< 5	< 20	< 7	< 8	
MARCH									
CHIC	03/13/90	< 30	< 50	< 0.1	< 3	< 10	< 6	< 6	< 100
HIP	03/12/90	< 30	< 50	< 0.2	< 3	< 10	< 6	< 6	290 ± 110
NN	03/12/90	< 50	< 200	< 0.2	< 6	< 20	< 10	< 10	< 100
SD	03/12/90	< 50	72.1 ± 37.3	< 0.2	< 6	< 20	< 9	< 10	330 ± 80
SI	03/12/90	< 30	< 70	< 0.3	< 3	< 10	< 5	< 7	< 100
SW	03/13/90	< 40	< 90	< 0.2	< 5	< 20	< 7	< 8	< 200
APRIL									
SD	04/17/90	< 30	< 60	< 0.3	< 3	< 10	< 5	< 7	
SW	04/17/90	< 30	< 60	< 0.2	< 3	< 10	< 5	< 6	

* All other gamma emitters were <LLD.

TABLE B-4

(Page 2 of 3)

SURRY - 1990

CONCENTRATIONS OF GAMMA EMITTERS* AND TRITIUM IN RIVER WATER

pCi/l ± 2 Sigma

STATION	DATE	Be-7	K-40	I-131	Cs-137	Ba-140	La-140	Th-228	H-3
MAY									
CHIC	05/17/90	< 30	< 50	< 0.2	< 3	< 20	< 7	< 6	< 100
HIP	05/17/90	< 30	< 40	< 0.2	< 3	< 10	< 6	< 5	950 ± 90 (a)
NN	05/17/90	< 30	62.3 ± 26.3	< 0.2	< 3	< 20	< 8	< 5	340 ± 90
SD	05/17/90	< 50	< 90	< 0.3	< 6	< 30	< 10	< 10	270 ± 90
SI	05/17/90	< 50	< 100	< 0.2	< 5	< 20	< 10	< 8	300 ± 90
SW	05/17/90	< 40	< 60	< 0.3	< 4	< 20	< 9	< 7	< 100
JUNE									
SD	06/19/90	< 30	< 50	< 0.1	< 3	< 10	< 5	< 5	
SW	06/19/90	< 40	< 100	< 0.2	< 4	< 20	< 6	< 8	
JULY									
CHIC	07/26/90	< 30	< 50	< 0.2	< 3	< 20	< 8	< 6	
HIP	07/26/90	< 30	43.6 ± 25.6	< 0.2	< 3	< 20	< 7	< 6	
NN	07/26/90	< 40	97.5 ± 31.6	< 0.3	< 4	< 20	< 8	< 7	
SD	07/26/90	< 30	83.6 ± 27.4	< 0.2	< 3	< 20	< 8	< 5	
SI	07/26/90	< 20	< 50	< 0.2	< 3	< 10	< 7	< 5	
SW	07/26/90	< 30	< 50	< 0.2	< 3	< 20	< 8	< 6	
AUGUST									
SD	08/21/90	< 30	91.1 ± 43.6	< 0.2	< 4	< 20	< 7	< 8	
SW	08/21/90	< 40	< 100	< 0.2	< 5	< 20	< 9	< 7	

(a) Result confirmed by a reanalysis.
* All other gamma emitters were <LLD.

TABLE B-4

(Page 3 of 3)

SURRY - 1990

CONCENTRATIONS OF GAMMA EMITTERS* AND TRITIUM IN RIVER WATER

pCi/l ± 2 Sigma

STATION	DATE	Be-7	K-40	I-131	Cs-137	Ba-140	La-140	Th-228	H-3
SEPTEMBER									
CHIC	09/25/90	< 40	< 70	< 0.2	< 4	< 30	< 8	< 8	< 100
HIP	09/24/90	< 50	< 100	< 0.2	< 5	< 30	< 10	< 8	< 100
NN	09/24/90	< 50	< 200	< 0.2	< 5	< 40	< 10	< 8	< 100
SD	09/24/90	< 40	141 ± 33	< 0.2	< 4	< 30	< 10	< 8	210 ± 90
SI	09/24/90	< 50	189 ± 38	< 0.2	< 5	< 40	< 10	< 9	< 100
SW	09/25/90	< 50	< 90	< 0.1	< 4	< 30	< 10	< 8	160 ± 80
OCTOBER									
SD	10/16/90	< 30	92.4 ± 31.9	< 0.2	< 3	< 10	< 6	< 6	
SW	10/16/90	< 30	< 60	< 0.2	< 3	< 20	< 7	< 7	
NOVEMBER									
CHIC	11/14/90	< 30	< 60	< 0.2	< 5	< 20	< 9	< 7	< 100
HIP	11/13/90	< 30	< 60	< 0.3	< 3	< 20	< 9	< 6	260 ± 120
NN	11/14/90	< 40	137 ± 40	< 0.2	< 4	< 20	< 9	< 7	< 200
SD	11/14/90	< 50	< 100	< 0.2	< 5	< 30	< 10	< 10	270 ± 110
SI	11/14/90	< 40	< 100	< 0.2	< 4	< 30	< 9	< 8	310 ± 70
SW	11/14/90	< 40	< 90	< 0.2	< 5	< 20	< 9	< 8	140 ± 80
DECEMBER									
SD	12/18/90	< 40	99.2 ± 36.1	< 0.2	< 5	< 10	< 6	< 10	
SW	12/18/90	< 30	< 80	< 0.2	< 4	< 10	< 5	< 6	

* All other gamma emitters were <LLD.

TABLE B-5

SURRY - 1990

CONCENTRATIONS OF GAMMA EMITTERS* AND TRITIUM IN RIVER WATER

pCi/l ± 2 Sigma STATE SPLIT

MONTH	COLL. DATES	Be-7	K-40	I-131	Cs-137	Ba-140	La-140	Th-228	H-3
SCOTLAND WH. (SW)									
January	01/15/90	< 50	< 50	< 2	< 4	< 80 (a)	< 30 (a)	< 7	
February	02/15/90	< 60	< 100	< 1	< 5	< 80 (a)	< 30 (a)	< 8	
March	03/15/90	< 60	< 90	< 1	< 5	< 90 (a)	< 30 (a)	< 8	600 ± 90
April	04/30/90	< 50	< 100	< 0.4	< 5	< 40	< 15	< 7	
May	05/31/90	< 50	< 90	< 0.5	< 5	< 30	< 10	< 8	
June	06/30/90	< 40	< 100	< 0.5	< 4	< 40	< 10	< 7	350 ± 90
July	07/31/90	< 60	< 100	< 0.5	< 5	< 60 (a)	< 30 (a)	< 8	
August	08/31/90	< 30	< 50	< 0.5	< 3	< 20	< 10	< 6	
September	09/30/90	< 30	61.6 ± 25.0	< 0.4	< 3	< 30	< 10	< 5	< 100
October	10/31/90	< 40	< 60	< 0.9	< 3	< 50 (a)	< 20	< 7	
November	11/30/90	< 40	< 80	< 0.4	< 4	< 30	< 10	< 7	
December	12/31/90	< 50	< 100	< 0.3	< 5	< 30	< 10	< 8	< 200
Average ± 2 s.d.			**61.6 ± 25.0**						**475 ± 354**
SURRY DIS. (SD)									
January	01/15/90	< 50	61.7 ± 34.7	< 2	< 4	< 80 (a)	< 40 (a)	< 8	
February	02/15/90	< 50	< 60	< 1	< 4	< 60	< 30 (a)	< 9	
March	03/15/90	< 70	< 90	< 1	< 6	< 100 (a)	< 50 (a)	< 10	1100 ± 100
April	04/30/90	< 40	< 80	< 0.5	< 4	< 40	< 10	< 7	
May	05/31/90	< 40	< 60	< 0.5	< 4	< 30	< 10	< 9	
June	06/30/90	< 40	< 100	< 0.5	< 3	< 30	< 10	< 5	1500 ± 100
July	07/31/90	< 50	< 200	< 0.5	< 5	< 50	< 20	< 9	
August	08/31/90	< 30	79.4 ± 24.3	< 0.5	< 3	< 20	< 10	< 6	
September	09/30/90	< 40	73.9 ± 33.6	< 0.3	< 4	< 40	< 10	< 6	470 ± 100
October	10/31/90	< 50	< 70	< 1	< 4	< 60 (a)	< 20	< 7	
November	11/30/90 (b)								
December	12/31/90	< 30	< 60	< 0.3	< 3	< 20	< 8	< 6	270 ± 140
Average ± 2 s.d.			**71.7 ± 18.1**						**835 ± 1134**

* All other gamma emitters were <LLD.
(a) LLD not met because of late receipt of sample from the State of Virginia.
(b) Sample not received at analytical laboratory.

TABLE B-6

SURRY - 1990

CONCENTRATIONS OF GAMMA EMITTERS* AND TRITIUM IN WELL WATER

pCi/l ± 2 Sigma

DATE	STATION	Be-7	K-40	I-131	Cs-137	Ba-140	La-140	Th-228	H-3
FIRST QUARTER									
03/20/90	BC	< 30	< 50	< 0.2	< 3	< 10	< 5	< 6	< 200
03/20/90	HIR	< 40	< 100	< 0.2	< 5	< 20	< 6	< 7	< 200
03/20/90	JMTN	< 50	< 200	< 0.3	< 6	< 20	< 9	< 10	< 100
03/20/90	SS	< 50	< 90	< 0.2	< 5	< 20	< 7	< 10	< 100
SECOND QUARTER									
06/19/90	BC	< 50	< 80	< 0.2	< 5	< 20	< 9	< 10	< 100
06/19/90	HIR	< 30	< 50	< 0.2	< 3	< 10	< 6	< 6	< 100
06/19/90	JMTN	< 40	< 80	< 0.1	< 4	< 20	< 7	< 7	< 100
06/19/90	SS	< 30	< 60	< 0.1	< 3	< 20	< 8	< 7	< 100
THIRD QUARTER									
09/18/90	BC	< 50	< 80	< 0.2	< 5	< 20	< 9	< 10	< 100
09/18/90	HIR	< 30	< 60	< 0.2	< 4	< 10	< 7	< 7	< 100
09/18/90	JMTN	< 30	< 50	< 0.2	< 3	< 10	< 6	< 6	< 100
09/18/90	SS	< 30	< 50	< 0.2	< 4	< 10	< 6	< 6	< 100
FOURTH QUARTER									
12/18/90	BC	< 30	< 50	< 0.2	< 3	< 10	< 4	< 6	< 200
12/18/90	HIR	< 30	< 60	< 0.2	< 4	< 10	< 4	< 8	< 200
12/18/90	JMTN	< 20	< 40	< 0.2	< 3	< 9	< 4	< 5	< 100
12/18/90	SS	< 20	< 40	< 0.2	< 3	< 9	< 4	< 5	< 100

* All other gamma emitters were <LLD.

TABLE B-7

(Page 1 of 2)

SURRY - 1990

CONCENTRATIONS OF GAMMA EMITTERS* IN SILT

pCi/kg (dry) ± 2 Sigma

STATION COLLECTION DATE	CHIC 03/12/90	HIP 03/12/90	NN 03/12/90	POS 03/12/90	SD 03/12/90	SI 03/12/90
Be-7	< 800	< 400	< 400	715 ± 480	< 400	< 2000
K-40	16100 ± 1600	11800 ± 1200	14800 ± 1500	< 2000	18100 ± 1800	20800 ± 2100
Mn-54	< 70	< 40	< 40	< 50	< 40	< 80
Co-58	< 80	< 40	< 40	< 60	< 40	< 90
Co-60	< 100	387 ± 40	147 ± 43	389 ± 53	3610 ± 360	702 ± 92
Cs-134	< 80	157 ± 34	< 40	< 60	231 ± 39	156 ± 77
Cs-137	562 ± 73	859 ± 86	421 ± 42	929 ± 93	1730 ± 170	1570 ± 160
Ra-226	3450 ± 890	1900 ± 520	1610 ± 590	2320 ± 770	2530 ± 490	2770 ± 1150
Th-228	1540 ± 150	1300 ± 130	1200 ± 120	1370 ± 140	1450 ± 140	1680 ± 170

* All other gamma emitters were <LLD.

TABLE B-7

(Page 2 of 2)

SURRY - 1990

CONCENTRATIONS OF GAMMA EMITTERS* IN SILT

pCi/kg (dry) ± 2 Sigma

STATION COLLECTION DATE	CHIC 09/25/90	HIP 09/24/90	NN 09/24/90	POS 09/24/90	SD 09/24/90	SI 09/24/90	Average ± 2 Sigma
Be-7	< 1000	< 500	< 400	< 500	< 300	1270 ±610	993 ± 785
K-40	17800 ± 1800	12200 ± 1200	15900 ± 1600	15800 ± 1600	14300 ± 1400	17400 ± 1700	15909 ± 5255
Mn-54	< 100	< 40	< 30	< 40	< 30	< 70	-
Co-58	< 100	< 50	< 40	< 50	< 30	< 70	-
Co-60	249 ± 93	280 ± 42	66.9 ± 31.4	< 50	212 ± 27	402 ± 74	644 ± 2113
Cs-134	< 100	< 50	< 40	< 50	< 30	< 70	181 ± 86
Cs-137	667 ± 143	480 ± 48	293 ± 29	173 ± 38	297 ± 30	954 ± 95	745 ± 989
Ra-226	3160 ± 1330	2260 ± 680	1540 ± 500	1970 ± 570	2090 ± 390	2650 ± 980	2354 ± 1174
Th-228	1560 ± 160	1240 ± 120	860 ± 86	1180 ± 120	1130 ± 110	1340 ± 130	1321 ± 445

* All other gamma emitters were <LLD.

TABLE B-8

SURRY - 1990

CONCENTRATIONS OF GAMMA EMITTERS* IN SHORELINE SEDIMENT

pCi/kg (dry) ± 2 Sigma

STATION COLLECTION DATE	HIR 02/27/90	BURWELL'S 02/27/90	HIR 08/28/90	BURWELL'S 08/28/90	AVERAGE ± 2 s.d.
Be-7	< 200	< 100	< 100	< 200	-
K-40	6210 ± 620	2910 ± 290	6930 ± 690	3350 ± 340	4850 ± 4031
Co-60	< 20	< 10	< 10	< 20	-
Cs-134	< 20	< 10	< 10	< 20	-
Cs-137	< 20	< 20	< 20	< 20	-
Ra-226	450 ± 236	434 ± 201	< 200	< 300	442 ± 23
Th-228	137 ± 17	< 30	105 ± 19	< 30	121 ± 45

* All other gamma emitters were <LLD.

TABLE B-9

(Page 1 of 3)

SURRY - 1990

CONCENTRATIONS OF GAMMA EMITTERS** AND STRONTIUM-89 AND-90 IN MILK

pCi/liter ± 2 Sigma

MONTH	NUCLIDE	LEE HALL	EPPS	CP	WMS	JDKS
JANUARY	Sr-89					
	Sr-90					
	K-40	1370 ± 140	1270 ± 130	1290 ± 130	1280 ± 130	1200 ± 120
	Cs-137	< 4	< 6	< 4	< 5	< 4
	I-131	< 0.2	< 0.3	< 0.4	< 0.2	< 0.4
FEBRUARY	Sr-89					
	Sr-90					
	K-40	1480 ± 150	1250 ± 130	1420 ± 140	1210 ± 120	1270 ± 130
	Cs-137	< 5	< 4	< 4	< 4	< 4
	I-131	< 0.2	< 0.1	< 0.1	< 0.2	< 0.2
MARCH	Sr-89	< 3	< 2	< 3		
	Sr-90	1.3 ± 0.4	1.1 ± 0.3	3.3 ± 0.4		
	K-40	1380 ± 140	1170 ± 120	1380 ± 140	1150 ± 120	1230 ± 120
	Cs-137	< 5	< 4	< 4	< 6	< 3
	I-131	< 0.1	< 0.1	< 0.3	< 0.2	< 0.1
APRIL	Sr-89					
	Sr-90					
	K-40	1160 ± 120	1200 ± 120	1440 ± 140	1280 ± 130	1400 ± 140
	Cs-137	< 4	< 4	< 4	< 4	< 7
	I-131	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2

(*) Strontium-89 and 90 sample analysis done on a quarterly composite of state split samples (Epps, Lee Hall) and Colonial Parkway(CP) sample at the request of the State of Virginia.
(**) All other gamma emitters were <LLD.

TABLE B-9

(Page 2 of 3)

SURRY - 1990

CONCENTRATIONS OF GAMMA EMITTERS** AND STRONTIUM-89 AND-90 IN MILK

pCi/liter ± 2 Sigma

MONTH	NUCLIDE	LEE HALL	EPPS	CP	WMS	JDKS
MAY	Sr-89					
	Sr-90					
	K-40	1290 ± 130	1260 ± 130	1320 ± 130	1200 ± 120	1190 ± 120
	Cs-137	< 4	< 4	< 4	< 4	< 5
	I-131	< 0.2	< 0.3	< 0.2	< 0.2	< 0.3
JUNE	Sr-89	< 3	< 5	< 1		
	Sr-90	1.5 ± 0.4	0.81 ± 0.24	3.2 ± 0.2		
	K-40	1360 ± 140	1330 ± 130	1420 ± 140	1300 ± 130	1220 ± 120
	Cs-137	< 5	< 4	< 4	< 4	< 4
	I-131	< 0.2	< 0.2	< 0.1	< 0.1	< 0.2
JULY	Sr-89					
	Sr-90					
	K-40	1440 ± 140	1160 ± 120	1360 ± 140	1240 ± 120	1470 ± 150
	Cs-137	< 3	< 4	< 4	< 4	< 6
	I-131	< 0.3	< 0.4	< 0.2	< 0.3	< 0.4
AUGUST	Sr-89					
	Sr-90					
	K-40	1370 ± 140	1280 ± 130	1220 ± 120	1350 ± 130	1230 ± 120
	Cs-137	< 4	< 4	< 4	< 4	< 4
	I-131	< 0.3	< 0.4	< 0.2	< 0.2	< 0.2

(*) Strontium-89 and 90 sample analysis done on a quarterly composite of state split samples (Epps, Lee Hall) and Colonial Parkway(CP) sample at the request of the State of Virginia.
(**) All other gamma emitters were <LLD.

TABLE B-9

(Page 3 of 3)

SURRY - 1990

CONCENTRATIONS OF GAMMA EMITTERS** AND STRONTIUM-89 AND-90 IN MILK

pCi/liter ± 2 Sigma

MONTH	NUCLIDE	LEE HALL	EPPS	CP	WMS	JDKS
SEPTEMBER	Sr-89	< 4	< 4	< 5		
	Sr-90	0.76 ± 0.55	0.70 ± 0.24	3.7 ± 0.4		
	K-40	1330 ± 130	1340 ± 130	1270 ± 130	1190 ± 120	1320 ± 130
	Cs-137	< 4	< 4	< 4	< 4	< 4
	I-131	< 0.2	< 0.2	< 0.2	< 0.2	< 0.3
OCTOBER	Sr-89					
	Sr-90					
	K-40	1330 ± 130	1280 ± 130	1400 ± 140	1350 ± 140	1240 ± 120
	Cs-137	< 5	< 4	< 4	< 5	< 6
	I-131	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
NOVEMBER	Sr-89					
	Sr-90					
	K-40	1250 ± 120	1320 ± 130	1280 ± 130	1270 ± 130	1370 ± 140
	Cs-137	< 4	< 4	< 4	< 4	< 4
	I-131	< 0.1	< 0.1	< 0.2	< 0.2	< 0.2
DECEMBER	Sr-89	< 4	< 5			< 4 (a)
	Sr-90	0.50 ± 0.14	0.61 ± 0.20			1.9 ± 0.2
	K-40	1130 ± 110	1280 ± 130	1260 ± 130	1360 ± 140	1190 ± 120
	Cs-137	< 5	< 10	< 4	< 4	< 5
	I-131	< 0.4	< 0.4	< 0.2	< 0.2	< 0.2

(*) Strontium-89 and 90 sample analysis done on a quarterly composite of state split samples (Epps, Lee Hall) and Colonial Parkway(CP) samples at the request of the State of Virginia.
(**) All other gamma emitters were <LLD.
(a) Sample not received in original shipment. Replacement received 12/20/90.

TABLE B-10

SURRY - 1990

CONCENTRATIONS OF GAMMA EMITTERS* IN CLAMS

pCi/kg (wet) ± 2 Sigma

STATION	DATE	TYPE	Be-7	K-40	Co-58	Co-60	Cs-137	Ra-226	Th-228
CHIC	01/17/90	Clams	< 100	359 ± 87	< 10	< 9	< 9	< 200	< 20
	03/13/90	Clams	< 100	1190 ± 120	< 10	< 10	< 10	< 300	< 20
	05/17/90	Clams	< 300	595 ± 197	< 30	< 20	< 30	< 500	< 50
	07/26/90	Clams	< 200	653 ± 129	< 20	< 20	< 20	< 300	< 30
	09/25/90	Clams	< 100	372 ± 91	< 10	< 9	< 10	< 200	< 20
	11/14/90	Clams	< 200	192 ± 101	< 20	< 10	< 10	< 300	< 30
JMTN	01/16/90	Clams	< 100	321 ± 100	< 10	< 10	< 9	< 200	< 20
	03/12/90	Clams	< 100	425 ± 98	< 10	< 10	< 10	< 200	< 20
	05/17/90	Clams	< 100	454 ± 90	< 10	< 10	< 10	< 200	< 20
	07/26/90	Clams	< 100	382 ± 94	< 10	< 10	< 10	< 200	< 20
	09/25/90	Clams	< 100	397 ± 88	< 10	< 10	< 9	< 200	< 20
	11/13/90	Clams	< 200	445 ± 111	< 20	< 10	< 20	< 300	< 30
SD	01/17/90**	Clams	< 300	372 ± 180	< 30	< 30	< 20	< 400	< 40
	03/01/90**	Clams	< 100	431 ± 82	< 10	< 9	< 8	< 200	< 20
	05/03/90**	Clams	< 200	529 ± 103	< 10	< 10	< 10	< 300	< 20
	06/28/90**	Clams	< 200	573 ± 150	< 20	< 10	< 10	< 200	< 20
	09/18/90**	Clams	< 200	484 ± 124	< 20	< 20	< 20	< 300	< 30
	11/02/90**	Clams	< 300	< 500	< 20	< 20	< 20	< 300	< 30
HIP	01/16/90	Clams	< 200	435 ± 117	< 20	< 10	< 10	< 300	< 30
	03/12/90	Clams	< 200	< 600	< 20	< 20	< 20	< 300	< 30
	05/17/90	Clams	< 200	569 ± 125	< 20	< 20	< 20	< 300	< 30
	07/26/90	Clams	< 200	335 ± 110	< 20	< 20	< 20	< 300	< 30
	09/24/90	Clams	< 200	< 500	< 20	< 20	< 20	< 300	< 30
	11/13/90	Clams	< 200	573 ± 145	< 20	< 20	< 20	< 300	< 30
LC	01/16/90	Clams	< 200	566 ± 112	< 20	< 10	< 10	< 300	< 20
	03/12/90	Clams	< 200	561 ± 106	< 20	< 20	< 20	< 300	< 30
	05/17/90	Clams	< 100	442 ± 120	< 10	< 10	< 10	< 300	< 30
	07/26/90	Clams	< 100	502 ± 148	< 10	< 10	< 10	< 300	< 30
	09/24/90	Clams	< 100	585 ± 97	< 10	< 10	< 10	< 200	< 20
	11/13/90	Clams	< 200	565 ± 158	< 20	< 20	< 20	< 300	< 30
Average ± 2 s.d.				**493 ± 350**					

* All other gamma emitters were <LLD.

** State Split

TABLE B-11

SURRY - 1990

CONCENTRATIONS OF GAMMA EMITTERS* IN OYSTERS

pCi/kg (wet) ± 2 Sigma

STATION	DATE	TYPE	Be-7	K-40	Co-58	Co-60	Cs-137	Ra-226	Th-228
RLS	01/16/90	Oysters	< 200	524 ± 103	< 20	< 10	< 10	< 200	< 30
	03/12/90	Oysters	< 100	621 ± 133	< 10	< 20	< 10	< 300	< 30
	05/17/90	Oysters	< 100	520 ± 104	< 10	< 10	< 10	< 200	< 20
	07/26/90	Oysters	< 100	900 ± 149	< 10	< 10	< 10	< 300	< 30
	09/24/90	Oysters	< 100	851 ± 125	< 10	< 10	< 10	< 200	< 20
	11/13/90	Oysters	< 200	564 ± 116	< 20	< 10	< 20	< 300	< 30
DWS	01/16/90	Oysters	< 200	405 ± 117	< 20	< 10	< 10	< 300	< 20
	03/12/90	Oysters	< 100	508 ± 132	< 10	< 10	< 10	< 300	< 20
	05/17/90	Oysters	< 200	430 ± 142	< 20	< 10	< 10	< 300	< 30
	07/26/90	Oysters	< 200	557 ± 116	< 20	< 10	< 20	< 300	< 30
	09/24/90	Oysters	< 300	< 700	< 30	< 20	< 20	< 400	< 40
	11/13/90	Oysters	< 200	595 ± 167	< 20	< 20	< 20	< 400	< 40
POS	01/16/90	Oysters	< 200	836 ± 116	< 20	< 10	< 10	< 200	< 20
	03/12/90	Oysters	< 200	< 400	< 20	< 20	< 20	< 400	< 50
	05/02/90**	Oysters	< 100	409 ± 122	< 10	< 10	< 10	< 300	< 30
	05/17/90	Oysters	< 200	370 ± 101	< 20	< 10	< 10	< 300	< 30
	06/29/90**	Oysters	< 200	740 ± 110	< 10	< 10	< 10	< 200	< 20
	07/26/90	Oysters	< 200	558 ± 131	< 20	< 20	< 20	< 400	< 30
	09/13/90**	Oysters	< 100	849 ± 117	< 10	< 9	< 10	< 200	< 20
	09/24/90	Oysters	< 100	777 ± 109	< 10	< 9	< 10	< 200	< 20
	11/01/90**	Oysters	< 300	< 500	< 20	< 20	< 8	< 300	< 30
	11/13/90	Oysters	< 200	636 ± 128	< 10	< 10	< 10	< 300	< 20
HHS	01/16/90**	Oysters	< 100	436 ± 92	< 10	< 10	< 9	< 200	< 20
	02/27/90**	Oysters	< 100	418 ± 113	< 10	< 10	< 10	< 200	< 20
Average ± 2 s.d.				**595 ± 336**					

* All other gamma emitters were <LLD.
** State Split

TABLE B-12

SURRY - 1990

CONCENTRATIONS OF GAMMA EMITTERS* IN CRABS

pCi/kg (wet) ± 2 Sigma

STATION	DATE	TYPE	Be-7	K-40	Co-58	Co-60	Cs-137	Ra-226	Th-228
SD	06/07/90	Crabs	< 200	2430 ± 240	< 20	< 20	< 20	< 300	< 30

* All other gamma emitters were <LLD.

TABLE B-13

SURRY - 1990

CONCENTRATIONS OF GAMMA EMITTERS* IN FISH

pCi/kg (wet) ± 2 Sigma

COLL. DATE	STATION	SAMPLE TYPE	K-40	Co-58	Cs-134	Cs-137
04/03/90	SD	CATFISH	942 ± 111	< 8	< 8	< 10
04/04/90	SD	WHITE PERCH	1140 ± 160	< 10	< 10	< 10
10/05/90	SD	WHITE PERCH	2010 ± 240	< 30	< 30	18.7 ± 1.04
10/05/90	SD	CATFISH	1950 ± 300	< 20	< 20	< 20
Average ± 2 s.d.			**1511 ± 1097**			**18.7 ± 1.04**

* All other gamma emitters were below <LLD.

TABLE B-14

SURRY - 1990

CONCENTRATIONS OF GAMMA EMITTERS* IN VEGETATION

pCi/kg (wet) ± 2 Sigma

STATION	SAMPLE TYPE	COLLECTION DATE	Be-7	K-40	I-131	Cs-134	Cs-137
Poole's Garden**	Kale	06/05/90	< 200	5680 ± 570	< 50	< 20	< 20
Ryan's Garden**	Kale	06/05/90	< 200	4900 ± 490	< 50	< 20	< 20
Turner's Garden**	Cabbage	07/15/90	220 ± 82	4300 ± 430	< 20	< 10	< 10
Brock"s Garden	Soybeans	11/27/90	< 60	15200 ± 1500	< 30	< 7	10.2 ± 4.9 (a)
Slade's Garden**	Soybeans	12/06/90	< 60	13600 ± 1400	< 10	< 8	12.4 ± 6.4 (a)
Average ± 2 s.d.			**220 ± 82**	**8736 ± 10449**			**11.3 ± 3.1**

* All other gamma emitters were below <LLD
** State Split
(a) Confirmed by reanalysis.

TABLE B-15

(Page 1 of 2)

SURRY - 1990

DIRECT RADIATION MEASUREMENTS - QUARTERLY TLD RESULTS

mR/month ± 2 Sigma - Set 1 - 098

STATION NUMBER	FIRST QUARTER	SECOND QUARTER	THIRD QUARTER	FOURTH QUARTER	AVERAGE ± 2 s.d.
02	7.1 ± 0.6	7.7 ± 0.8	6.6 ± 0.3	8.0 ± 0.6	7.4 ± 1.2
03	7.0 ± 0.4	8.0 ± 0.5	7.3 ± 0.9	8.5 ± 0.7	7.7 ± 1.4
04	6.0 ± 0.4	7.3 ± 1.0	5.8 ± 0.4	6.9 ± 1.2	6.5 ± 1.4
05	5.7 ± 0.2	(a)	4.9 ± 0.2	6.6 ± 0.2	5.7 ± 1.7
06	6.1 ± 0.3	6.9 ± 0.5	5.9 ± 0.4	7.6 ± 0.5	6.6 ± 1.6
07	5.7 ± 0.5	6.7 ± 0.4	5.8 ± 0.3	7.1 ± 0.6	6.3 ± 1.4
08	5.8 ± 0.4	6.7 ± 0.7	5.7 ± 0.4	7.0 ± 0.6	6.3 ± 1.3
09	5.4 ± 1.0	6.8 ± 1.1	5.8 ± 0.3	6.9 ± 0.3	6.2 ± 1.5
10	5.3 ± 0.2	6.5 ± 0.6	5.5 ± 0.4	6.8 ± 0.6	6.0 ± 1.5
11	5.8 ± 0.3	6.5 ± 0.8	5.7 ± 0.7	6.8 ± 0.5	6.2 ± 1.1
12	5.7 ± 0.2	(a)	5.8 ± 0.5	7.0 ± 0.4	6.2 ± 1.4
13	5.9 ± 0.3	6.2 ± 0.4	5.9 ± 0.3	7.0 ± 0.4	6.3 ± 1.0
14	6.5 ± 0.4	7.0 ± 0.5	6.2 ± 0.5	7.3 ± 0.6	6.8 ± 1.0
15	5.3 ± 0.3	6.1 ± 0.6	5.4 ± 0.3	6.2 ± 0.3	5.8 ± 0.9
16	5.7 ± 0.4	5.6 ± 0.7	5.7 ± 0.3	6.5 ± 0.7	5.9 ± 0.8
17	5.2 ± 0.5	5.7 ± 0.4	4.6 ± 0.4 (b)	1.1 ± 1.9 (c)	4.2 ± 4.2
18	4.3 ± 0.2	5.4 ± 0.7	4.3 ± 0.3	5.3 ± 0.3	4.8 ± 1.2
19	4.9 ± 0.5	5.8 ± 0.5	5.0 ± 0.2	6.1 ± 0.2	5.5 ± 1.2
20	4.8 ± 0.4	5.6 ± 0.6	4.6 ± 0.3	5.8 ± 0.3	5.2 ± 1.2
21	5.0 ± 0.2	5.7 ± 0.5	5.2 ± 0.4	6.4 ± 0.4	5.6 ± 1.2
22	4.7 ± 0.1	5.5 ± 0.8	4.6 ± 0.3	5.9 ± 0.2	5.2 ± 1.3

(a) TLD missing
(b) Third quarter TLD inadvertantly rehung when placing fourth quarter TLD in field. Third quarter TLD received 11/02/90.
(c) TLD was apparently irridiated in transit to the vendor laboratory.

TABLE B-15

(Page 2 of 2)

SURRY - 1990

DIRECT RADIATION MEASUREMENTS - QUARTERLY TLD RESULTS

mR/month ± 2 Sigma - **Set 1 - 098**

STATION NUMBER	FIRST QUARTER	SECOND QUARTER	THIRD QUARTER	FOURTH QUARTER	AVERAGE ± 2 s.d.
23	6.0 ± 0.3	6.7 ± 0.6	5.6 ± 0.3	6.8 ± 0.3	6.3 ± 1.1
24	5.2 ± 0.3	6.1 ± 0.6	5.1 ± 0.3	6.3 ± 0.3	5.7 ± 1.2
25	5.5 ± 0.2	5.7 ± 0.6	5.5 ± 0.3	6.4 ± 0.1	5.8 ± 0.9
26	5.1 ± 0.2	6.0 ± 0.1	5.3 ± 0.4	7.0 ± 0.4	5.9 ± 1.7
27	4.7 ± 0.3	5.7 ± 0.2	4.8 ± 0.2	6.2 ± 1.0	5.4 ± 1.4
28	5.6 ± 0.3	6.2 ± 0.5	5.2 ± 0.3	6.8 ± 0.7	6.0 ± 1.4
29	4.6 ± 0.3	5.7 ± 0.4	4.6 ± 0.4	6.0 ± 0.4	5.2 ± 1.5
30	5.0 ± 0.1	6.0 ± 0.3	4.8 ± 0.3	6.2 ± 0.3	5.5 ± 1.4
31	4.5 ± 0.3	5.3 ± 0.3	4.5 ± 0.2	5.4 ± 0.2	4.9 ± 1.0
32	5.2 ± 0.3	5.7 ± 0.1	5.1 ± 0.4	7.0 ± 1.1	5.8 ± 1.7
33	5.7 ± 0.2	6.9 ± 0.7	5.4 ± 0.5	7.0 ± 0.4	6.3 ± 1.6
34	5.8 ± 0.4	6.3 ± 0.3	5.6 ± 0.3	6.9 ± 0.3	6.2 ± 1.2
35	6.3 ± 0.4	7.2 ± 0.4	6.0 ± 0.4	7.2 ± 0.5	6.7 ± 1.2
36	6.3 ± 0.4	7.4 ± 0.9	6.1 ± 0.5	7.0 ± 0.4	6.7 ± 1.2
37	5.6 ± 0.3	6.4 ± 0.7	5.3 ± 0.5	6.9 ± 0.3	6.1 ± 1.5
38	7.5 ± 0.5	7.7 ± 0.7	7.1 ± 0.5	9.0 ± 0.8	7.8 ± 1.6
39	5.3 ± 0.2	5.9 ± 0.2	5.3 ± 0.3	6.2 ± 0.3	5.7 ± 0.9
40	4.3 ± 0.1	4.8 ± 0.3	4.3 ± 0.1	5.4 ± 0.3	4.7 ± 1.0
41	6.0 ± 0.2	6.3 ± 0.3	5.8 ± 0.4	7.5 ± 0.3	6.4 ± 1.5
42	5.3 ± 0.2	5.7 ± 0.4	5.3 ± 0.4	6.7 ± 0.7	5.8 ± 1.3
43	5.4 ± 0.4	5.4 ± 0.1	4.6 ± 0.3 (a)	4.4 ± 3.6 (b)	5.0 ± 1.1
Average ± 2 s.d.	**5.5 ± 1.4**	**6.3 ± 1.5**	**5.4 ± 1.4**	**6.6 ± 2.4**	**6.0 ± 1.2**

(a) Third quarter TLD inadvertantly rehung when placing fourth quarter TLD in field. Third quarter TLD received 11/02/90.
(b) TLD was apparently irridiated in transit to the vendor laboratory.

TABLE B-16

(Page 1 of 2)

SURRY - 1990

DIRECT RADIATION MEASUREMENTS - QUARTERLY TLD RESULTS

mR/month ± 2 Sigma - Set 2 - 099

STATION NUMBER	FIRST QUARTER	SECOND QUARTER	THIRD QUARTER	FOURTH QUARTER	AVERAGE ± 2 s.d.
02	7.3 ± 0.3	7.4 ± 0.6	7.1 ± 0.4	8.1 ± 0.5	7.5 ± 0.9
03	7.6 ± 0.5	7.3 ± 0.5	7.4 ± 0.6	8.6 ± 0.7	7.7 ± 1.2
04	6.1 ± 0.3	6.1 ± 0.9	5.8 ± 0.3	7.4 ± 0.4	6.4 ± 1.4
05	5.7 ± 0.1	(a)	5.2 ± 0.2	6.8 ± 0.2	5.9 ± 1.6
06	6.4 ± 0.3	7.0 ± 0.4	6.3 ± 0.4	7.4 ± 0.4	6.8 ± 1.0
07	5.7 ± 0.2	5.7 ± 0.5	5.7 ± 0.3	7.0 ± 0.2	6.0 ± 1.3
08	5.9 ± 0.3	6.4 ± 0.9	5.8 ± 0.4	6.8 ± 0.4	6.2 ± 0.9
09	6.2 ± 0.2	6.0 ± 0.6	5.9 ± 0.4	7.0 ± 0.7	6.3 ± 1.0
10	5.5 ± 0.4	6.6 ± 0.6	5.6 ± 0.2	7.1 ± 0.6	6.2 ± 1.6
11	5.8 ± 0.3	6.0 ± 0.7	5.9 ± 0.2	7.0 ± 0.8	6.2 ± 1.1
12	6.1 ± 0.2	(a)	5.9 ± 0.4	7.1 ± 0.6	6.4 ± 1.3
13	6.0 ± 0.2	6.3 ± 0.3	5.9 ± 0.3	7.3 ± 0.2	6.4 ± 1.3
14	6.6 ± 0.2	7.3 ± 0.2	6.3 ± 0.5	7.1 ± 0.6	6.8 ± 0.9
15	5.7 ± 0.3	5.7 ± 0.5	5.5 ± 0.2	6.9 ± 0.6	6.0 ± 1.3
16	5.7 ± 0.1	6.5 ± 1.3	5.4 ± 0.5	6.7 ± 0.4	6.1 ± 1.2
17	5.4 ± 0.3	6.0 ± 0.6	4.6 ± 0.4 (b)	2.2 ± 2.5 (c)	4.6 ± 3.3
18	4.7 ± 0.2	5.2 ± 0.6	4.3 ± 0.2	5.7 ± 0.2	5.0 ± 1.2
19	5.1 ± 0.1	6.1 ± 0.3	5.0 ± 0.5	6.6 ± 0.4	5.7 ± 1.6
20	4.9 ± 0.2	5.7 ± 0.3	4.7 ± 0.2	6.3 ± 0.4	5.4 ± 1.5
21	5.6 ± 0.7	6.6 ± 1.6	5.1 ± 0.2	6.2 ± 0.5	5.9 ± 1.3
22	5.1 ± 0.1	5.5 ± 0.5	4.6 ± 0.3	5.8 ± 0.3	5.3 ± 1.0

(a) TLD missing
(b) Third quarter TLD inadvertantly rehung when placing fourth quarter TLD in field. Third quarter TLD received 11/02/90.
(c) TLD was apparently irridiated in transit to the vendor laboratory.

TABLE B-16

(Page 2 of 2)

SURRY - 1990

DIRECT RADIATION MEASUREMENTS - QUARTERLY TLD RESULTS

mR/month ± 2 Sigma - **Set 2 - 099**

STATION NUMBER	FIRST QUARTER	SECOND QUARTER	THIRD QUARTER	FOURTH QUARTER	AVERAGE ± 2 s.d.
23	6.0 ± 0.2	6.7 ± 0.6	5.6 ± 0.3	7.2 ± 0.2	6.4 ± 1.4
24	5.7 ± 0.3	6.3 ± 0.4	5.2 ± 0.2	6.2 ± 0.6	5.9 ± 1.0
25	5.8 ± 0.2	5.9 ± 0.3	5.2 ± 0.3	6.1 ± 0.2	5.8 ± 0.8
26	5.2 ± 0.2	5.9 ± 0.7	5.3 ± 0.2	5.6 ± 0.9	5.5 ± 0.6
27	4.8 ± 0.3	5.9 ± 0.5	4.5 ± 0.2	6.4 ± 0.4	5.4 ± 1.8
28	5.4 ± 0.0	6.4 ± 0.5	5.3 ± 0.3	6.7 ± 0.4	6.0 ± 1.4
29	4.7 ± 0.2	5.3 ± 0.4	4.6 ± 0.2	5.5 ± 0.5	5.0 ± 0.9
30	5.1 ± 0.2	6.3 ± 0.6	5.0 ± 0.5	6.2 ± 0.3	5.7 ± 1.4
31	4.6 ± 0.1	5.6 ± 0.8	4.5 ± 0.2	6.0 ± 0.7	5.2 ± 1.5
32	5.2 ± 0.2	6.1 ± 0.4	5.0 ± 0.2	6.5 ± 0.6	5.7 ± 1.4
33	5.6 ± 0.2	6.8 ± 0.6	5.4 ± 0.3	7.2 ± 0.7	6.3 ± 1.8
34	5.7 ± 0.2	6.2 ± 0.5	5.4 ± 0.4	7.2 ± 1.0	6.1 ± 1.6
35	5.8 ± 0.2	6.8 ± 0.4	5.9 ± 0.3	7.1 ± 0.6	6.4 ± 1.3
36	6.3 ± 0.5	7.3 ± 0.3	6.1 ± 0.5	7.5 ± 0.7	6.8 ± 1.4
37	5.2 ± 0.4	6.3 ± 0.6	5.2 ± 0.2	6.5 ± 0.4	5.8 ± 1.4
38	7.2 ± 0.4	8.4 ± 1.4	7.2 ± 0.5	9.0 ± 1.1	8.0 ± 1.8
39	5.3 ± 0.2	6.1 ± 0.6	5.2 ± 0.5	6.3 ± 0.5	5.7 ± 1.1
40	4.2 ± 0.2	5.3 ± 0.9	4.2 ± 0.2	5.7 ± 0.6	4.9 ± 1.5
41	5.7 ± 0.4	6.4 ± 0.4	5.9 ± 0.9	7.2 ± 0.8	6.3 ± 1.3
42	5.4 ± 0.3	6.0 ± 0.6	5.6 ± 0.6	6.3 ± 0.6	5.8 ± 0.8
43	5.1 ± 0.3	6.1 ± 0.4	5.5 ± 0.7	6.3 ± 0.4	5.8 ± 1.1
Average ± 2 s.d.	**5.7 ± 1.4**	**6.3 ± 1.3**	**5.5 ± 1.4**	**6.7 ± 1.4**	**6.1 ± 1.1**

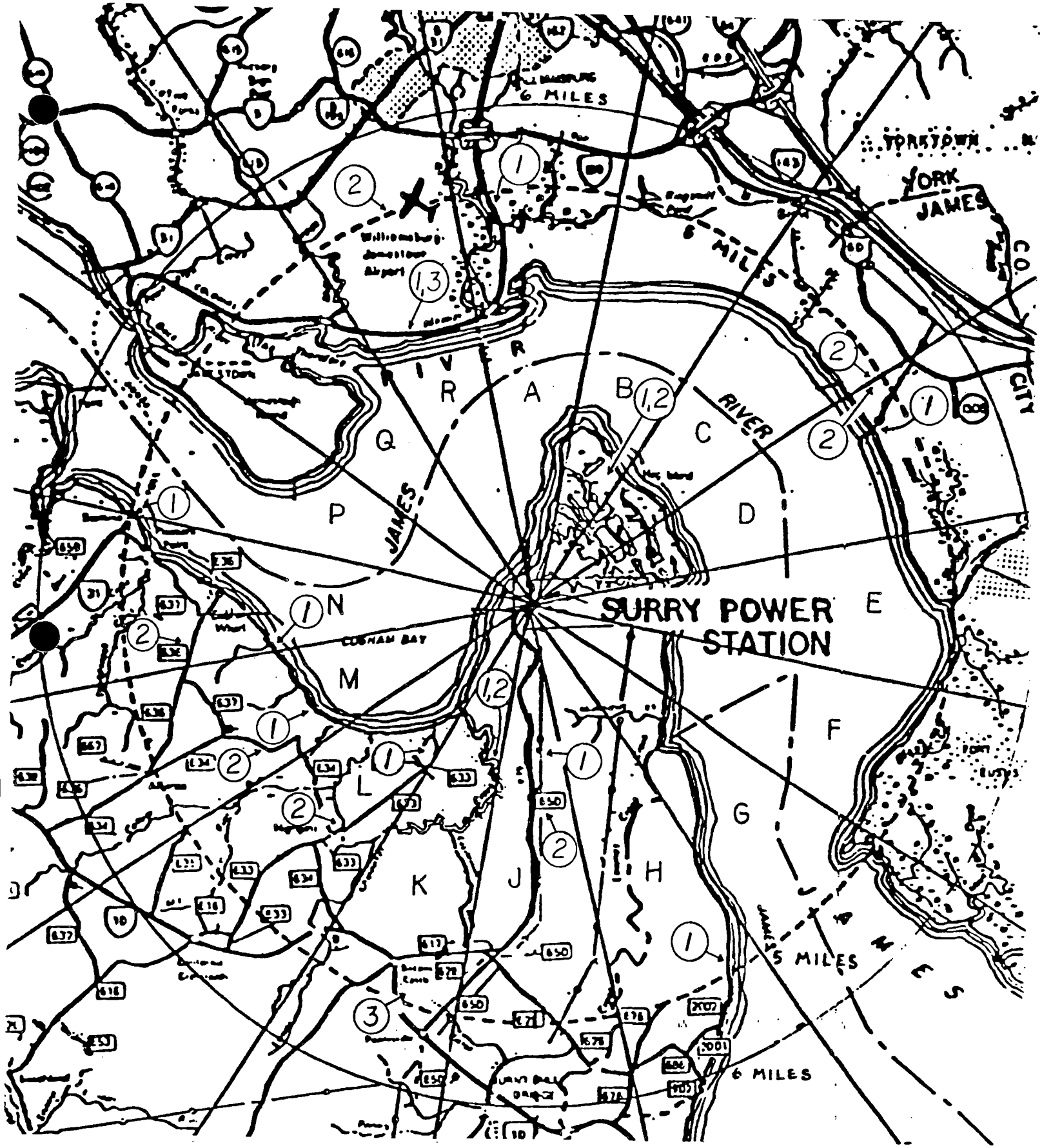
APPENDIX C
LAND USE CENSUS - 1990

ANNUAL RADIOLOGICAL ENVIRONMENTAL

LAND USE CENSUS FOR SURRY POWER STATION - 1990

Sector	Nearest Resident	Nearest Garden	Nearest Cow	Nearest Goat
A-(N)	4.72 @ 357°	*	*	*
B-(NNE)	1.90 @ 34°	1.90 @ 34°	*	*
C-(NE)	*	4.91 @ 56°	*	*
D-(ENE)	4.73 @ 63°	4.91 @ 56°	*	*
E-(E)	*	*	*	*
F-(ESE)	*	*	*	*
G-(SE)	*	*	*	*
H-(SSE)	4.75 @ 152°	*	*	*
J-(S)	1.82 @ 182°	2.01 @ 182°	*	*
K-(SSW)	1.87 @ 193°	1.87 @ 193°	4.84 @ 201°	*
L-(SW)	2.28 @ 222°	3.65 @ 224°	*	*
M-(WSW)	2.82 @ 243°	3.52 @ 246°	*	*
N-(W)	3.15 @ 260°	4.12 @ 267°	*	*
P-(WNW)	4.79 @ 281°	*	*	*
Q-(NW)	*	*	*	*
R-(NNW)	3.73 @ 339°	4.89 @ 340°	3.65 @ 337°	*

* None
All distances are in statute miles.



1990 LAND USE CENSUS LOCATION MAP

1 = NEAREST RESIDENT 2 = NEAREST GARDEN 3 = NEAREST COW 4 = NEAREST GOAT

APPENDIX D
SYNOPSIS OF ANALYTICAL PROCEDURES

ANALYTICAL PROCEDURES SYNOPSIS

Appendix D is a synopsis of the analytical procedures performed on samples collected for the Surry 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.

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:

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

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

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 $SrN0_3$ 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 $SrC0_3$ 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.

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 $Sr(N0_3)_2$ 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 radio-chemical 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 $CaS0_4$: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

SURRY - 1990

US EPA INTERLABORATORY COMPARISON PROGRAM 1990

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.

SURRY - 1990

US EPA INTERLABORATORY COMPARISON PROGRAM 1990

(Page 2 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
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.

SURRY - 1990

US EPA INTERLABORATORY COMPARISON PROGRAM 1990

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.

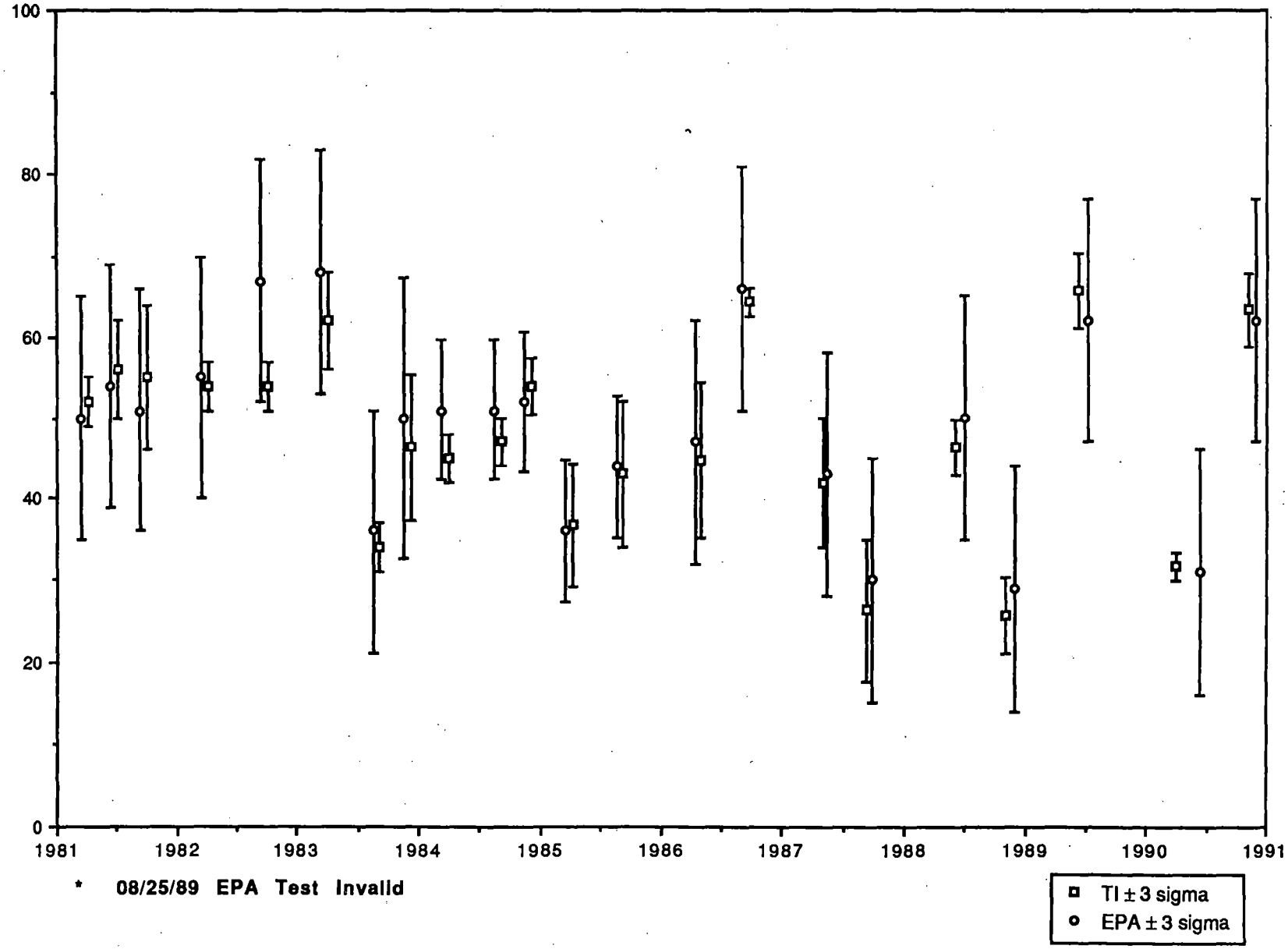
(e) Incomplete removal of calcium, lead to erroneously high strontium yields. More care is being taken in the strontium nitrate and strontium sulfate precipitation steps to ensure a final volume of at least 20 ml in the strontium sulfate step. Reanalysis of internal QC samples produced good results after 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 - 12

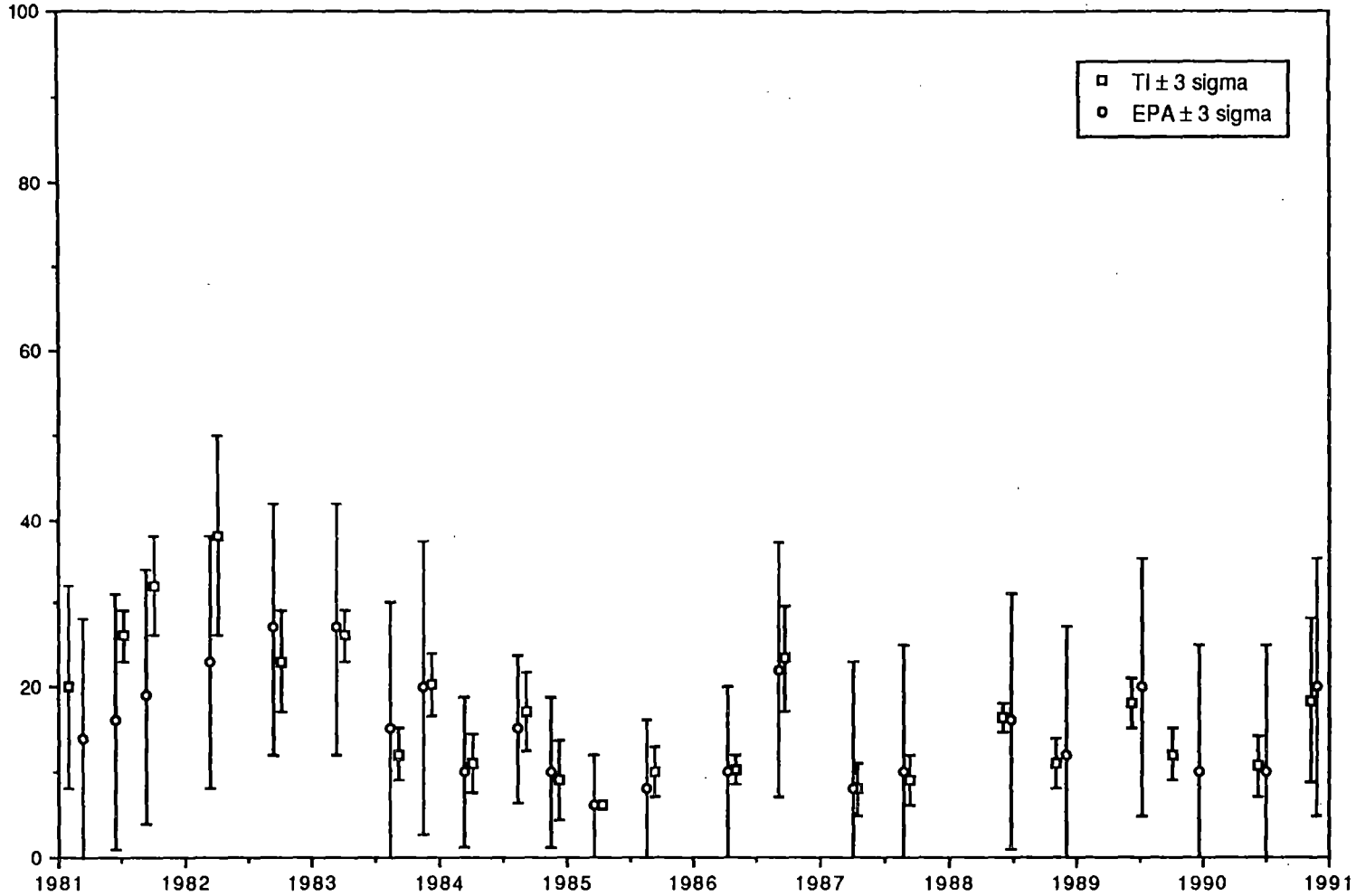
US EPA CROSS CHECK PROGRAM

GROSS BETA IN AIR PARTICULATES



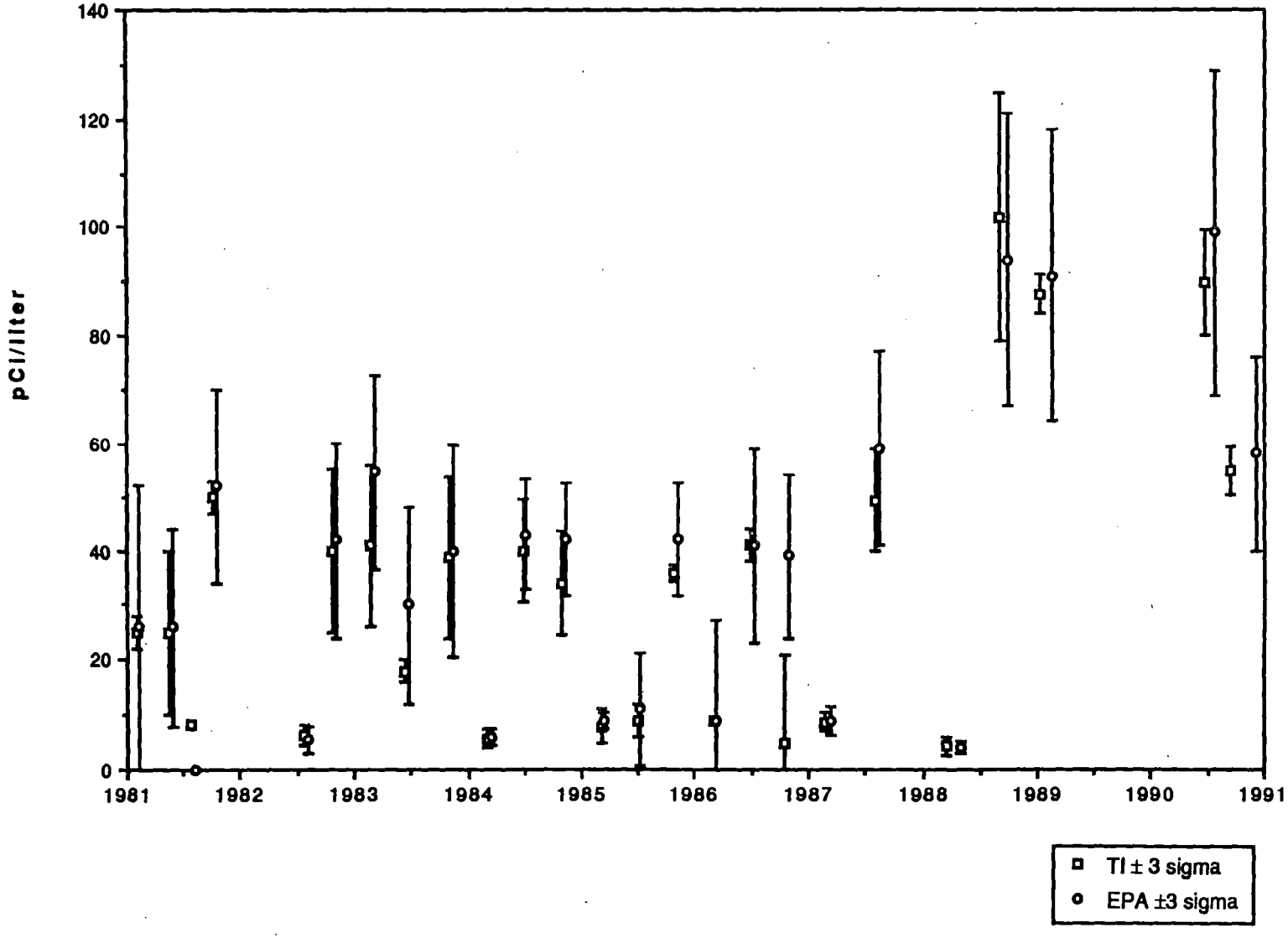
US EPA CROSS CHECK PROGRAM

CESIUM-137 IN AIR PARTICULATES



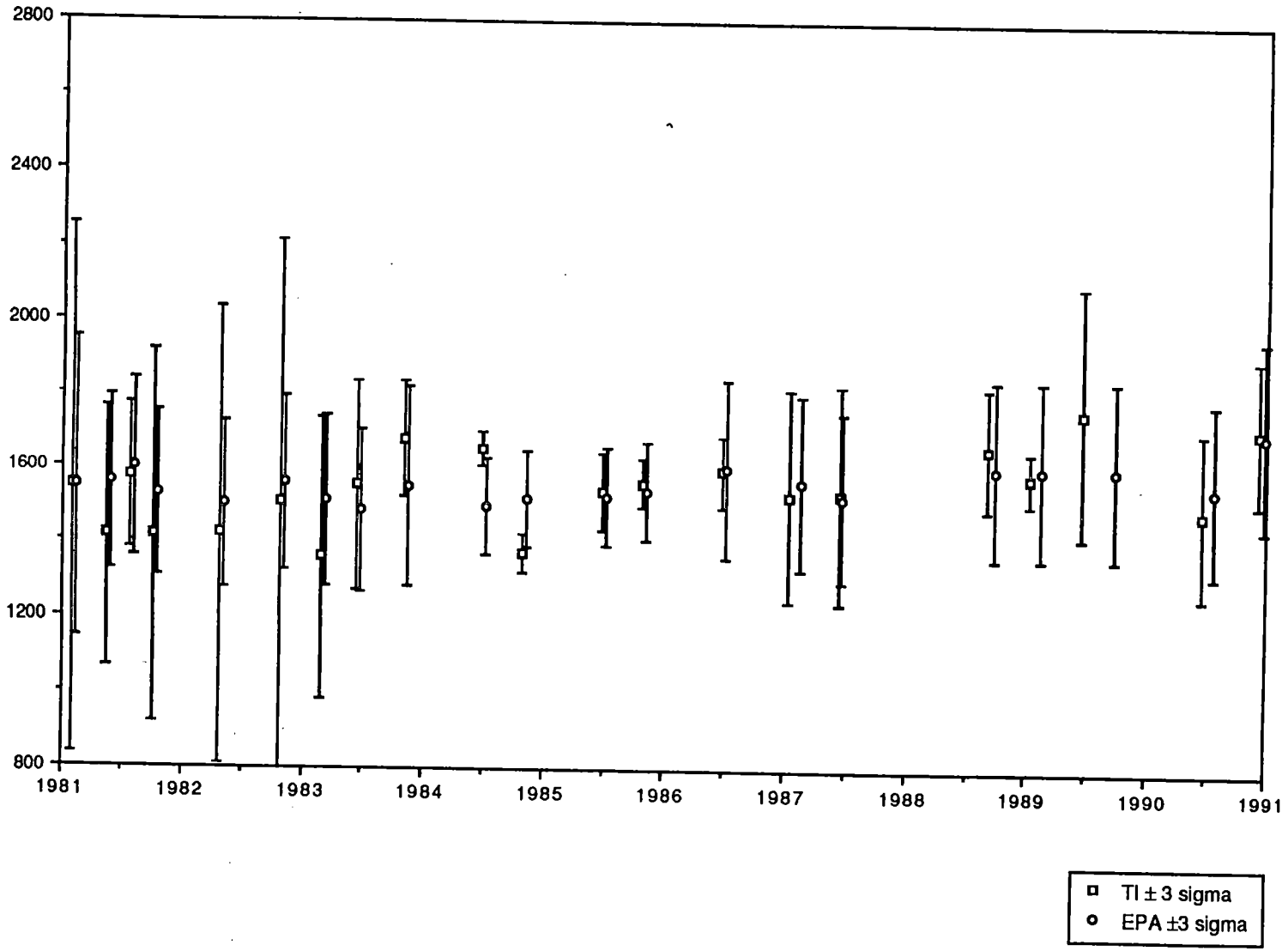
US EPA CROSS CHECK PROGRAM

IODINE-131 IN MILK



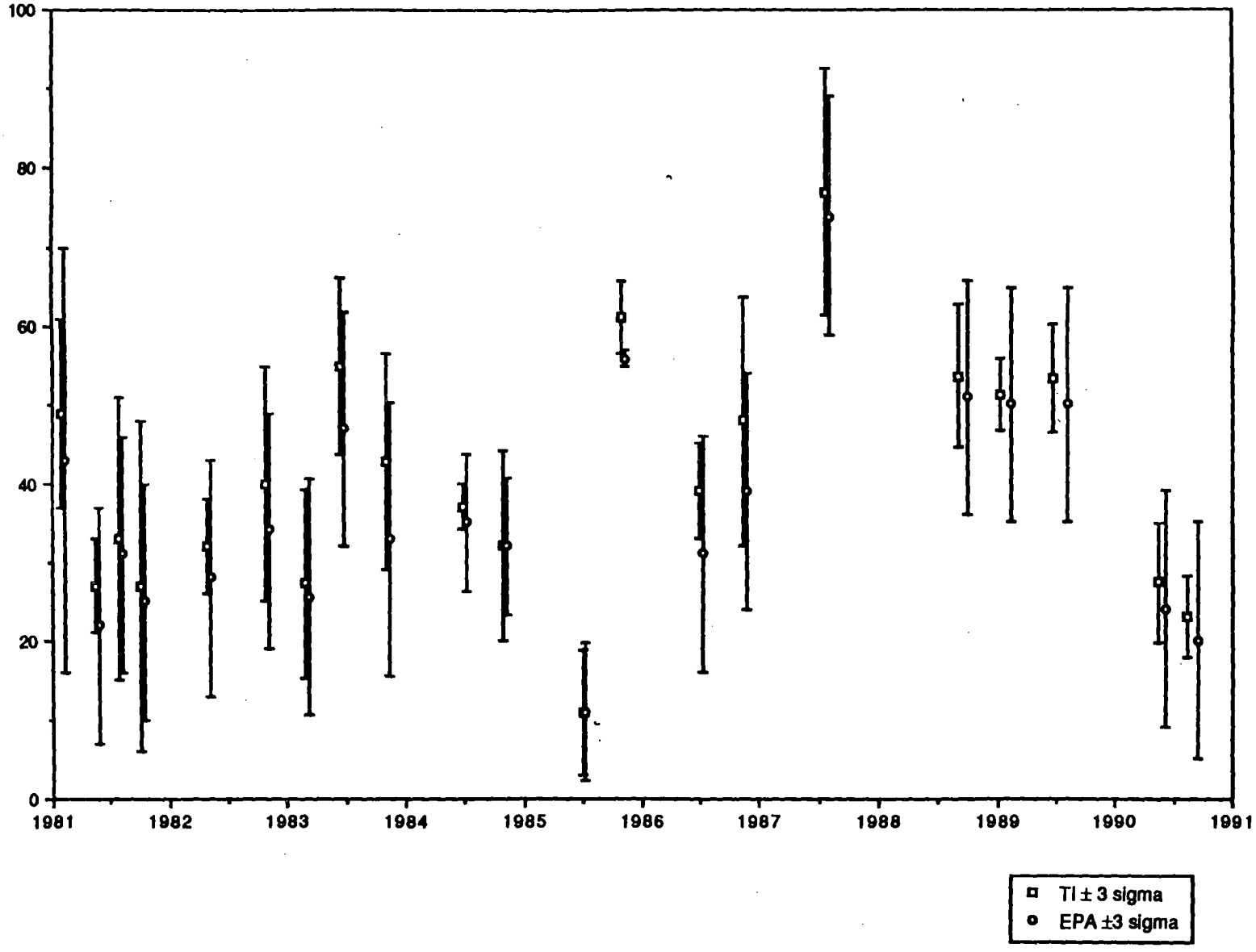
US EPA CROSS CHECK PROGRAM

POTASSIUM-40 IN MILK



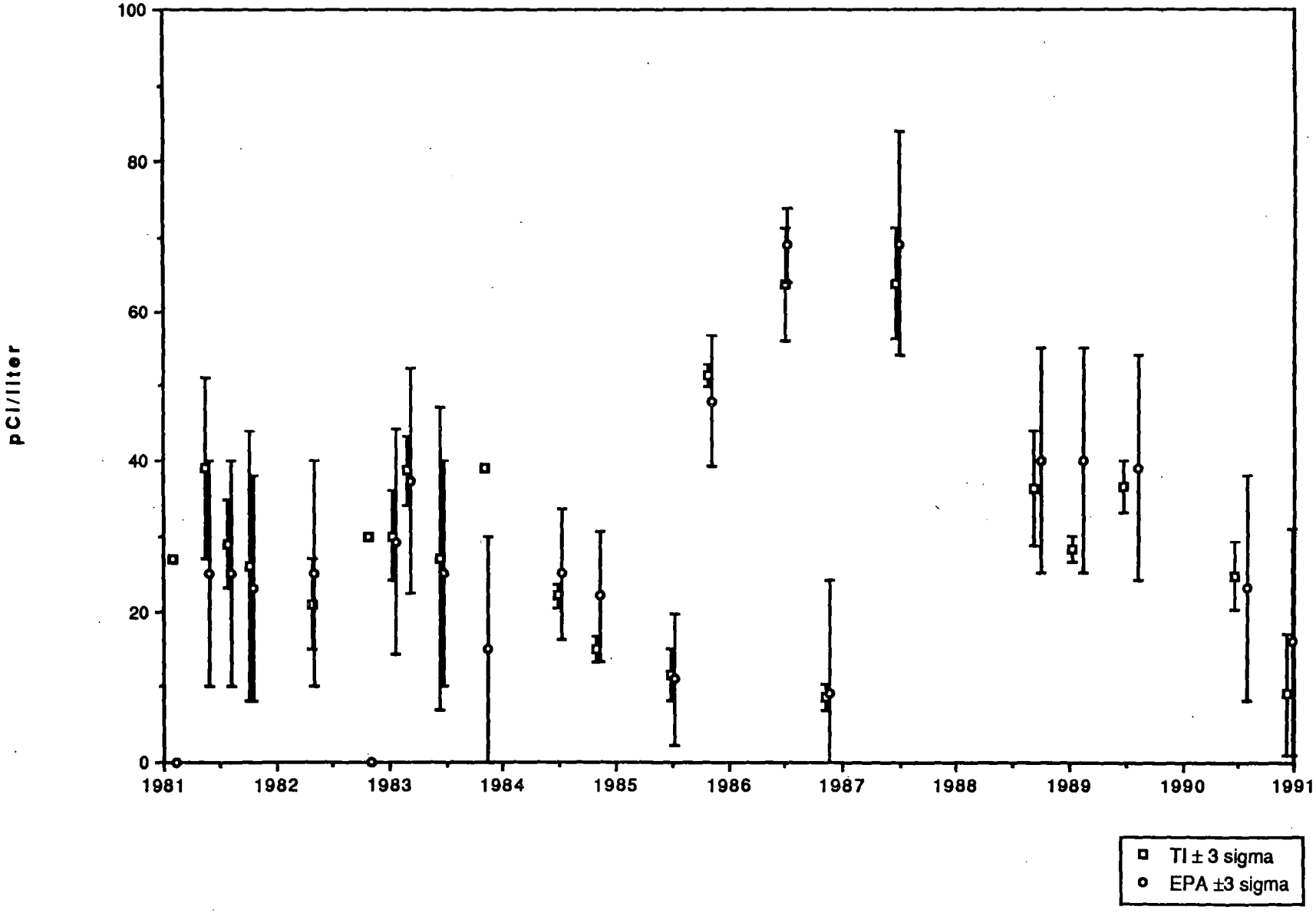
US EPA CROSS CHECK PROGRAM

CESIUM-137 IN MILK



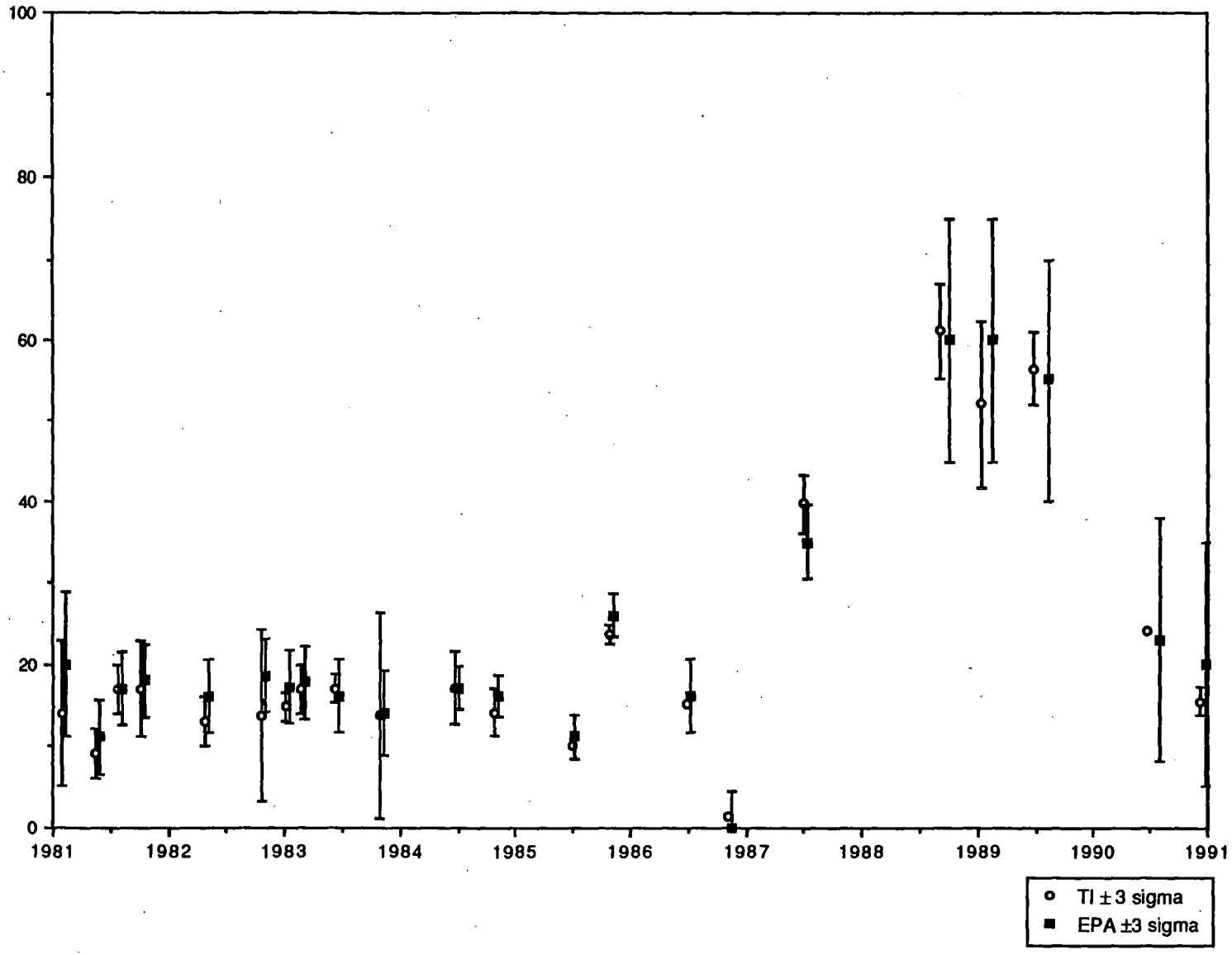
US EPA CROSS CHECK PROGRAM

STRONTIUM 89 IN MILK



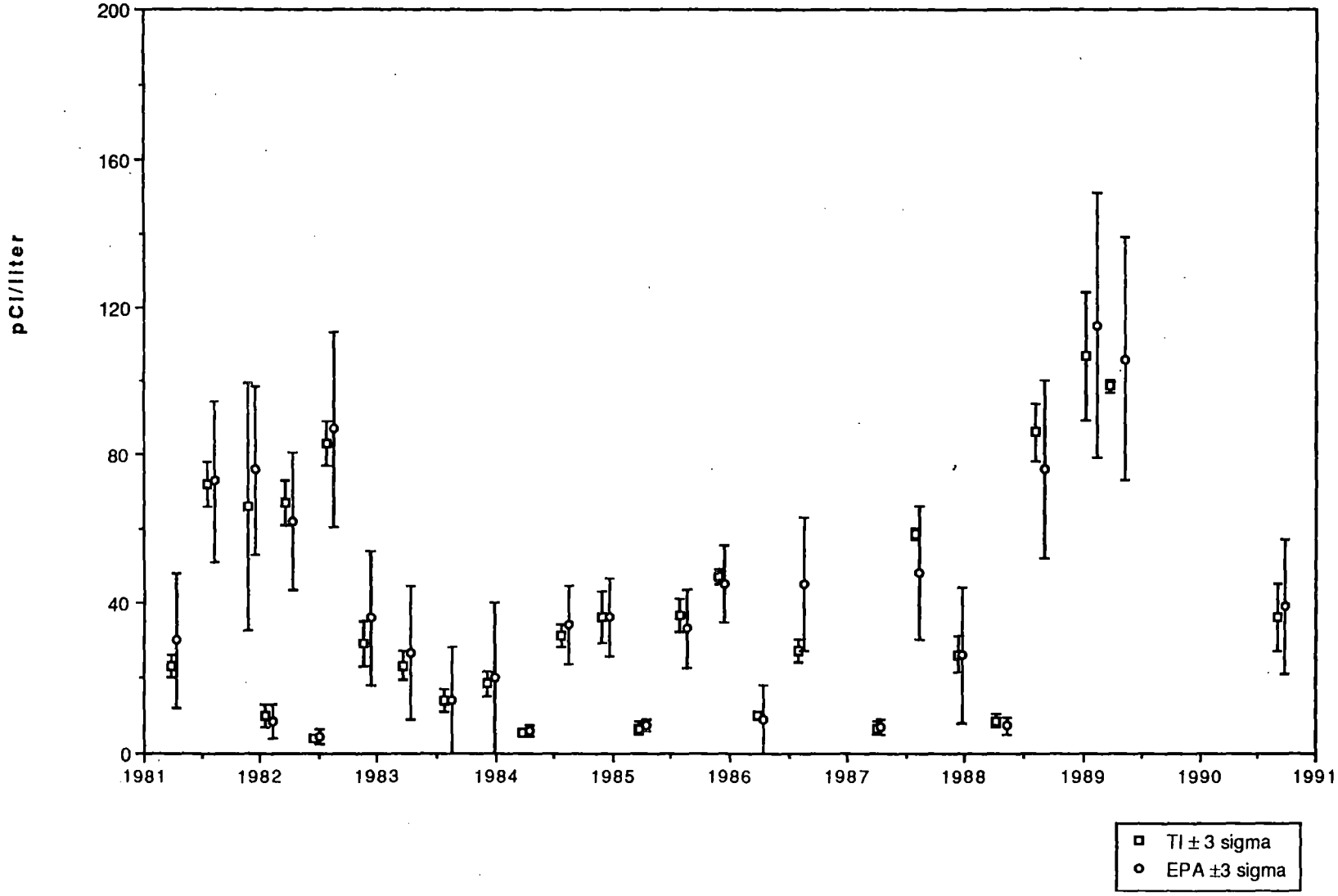
US EPA CROSS CHECK PROGRAM

STRONTIUM-90 IN MILK



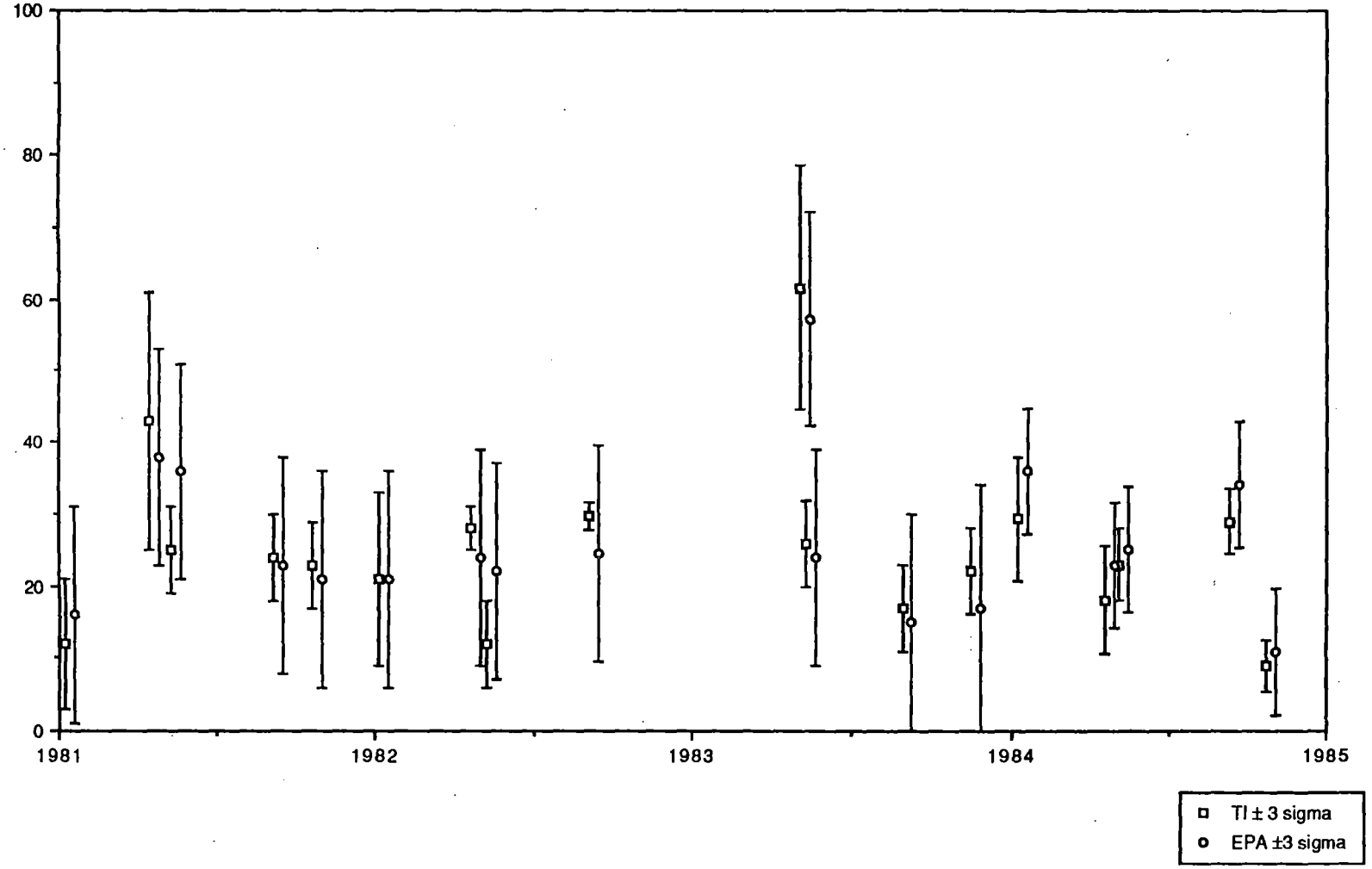
US EPA CROSS CHECK PROGRAM

IODINE-131 IN WATER



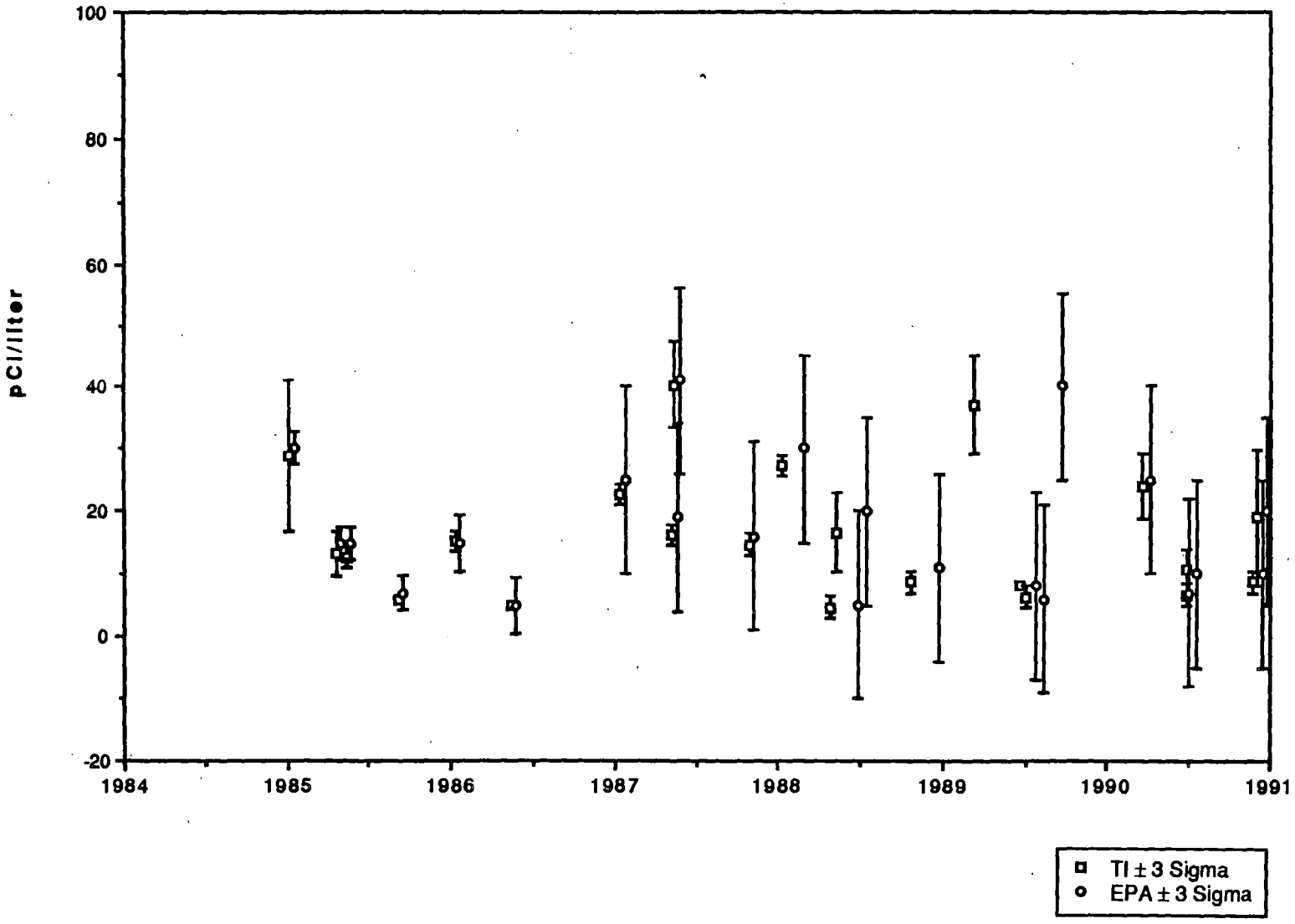
US EPA CROSS CHECK PROGRAM

STRONTIUM-89 IN WATER (pg. 1)



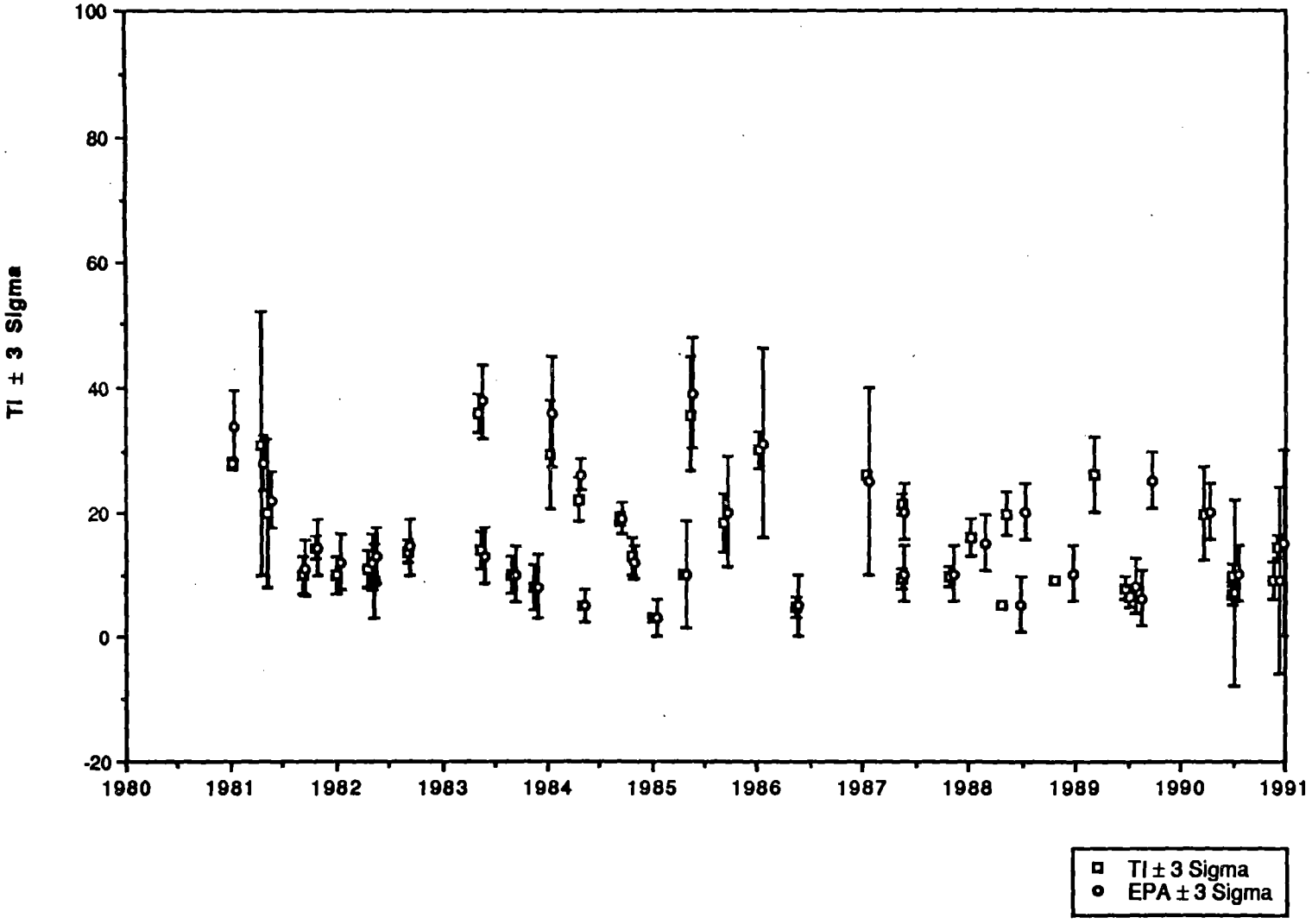
US EPA CROSS CHECK PROGRAM

STRONTIUM-89 IN WATER (pg. 2)



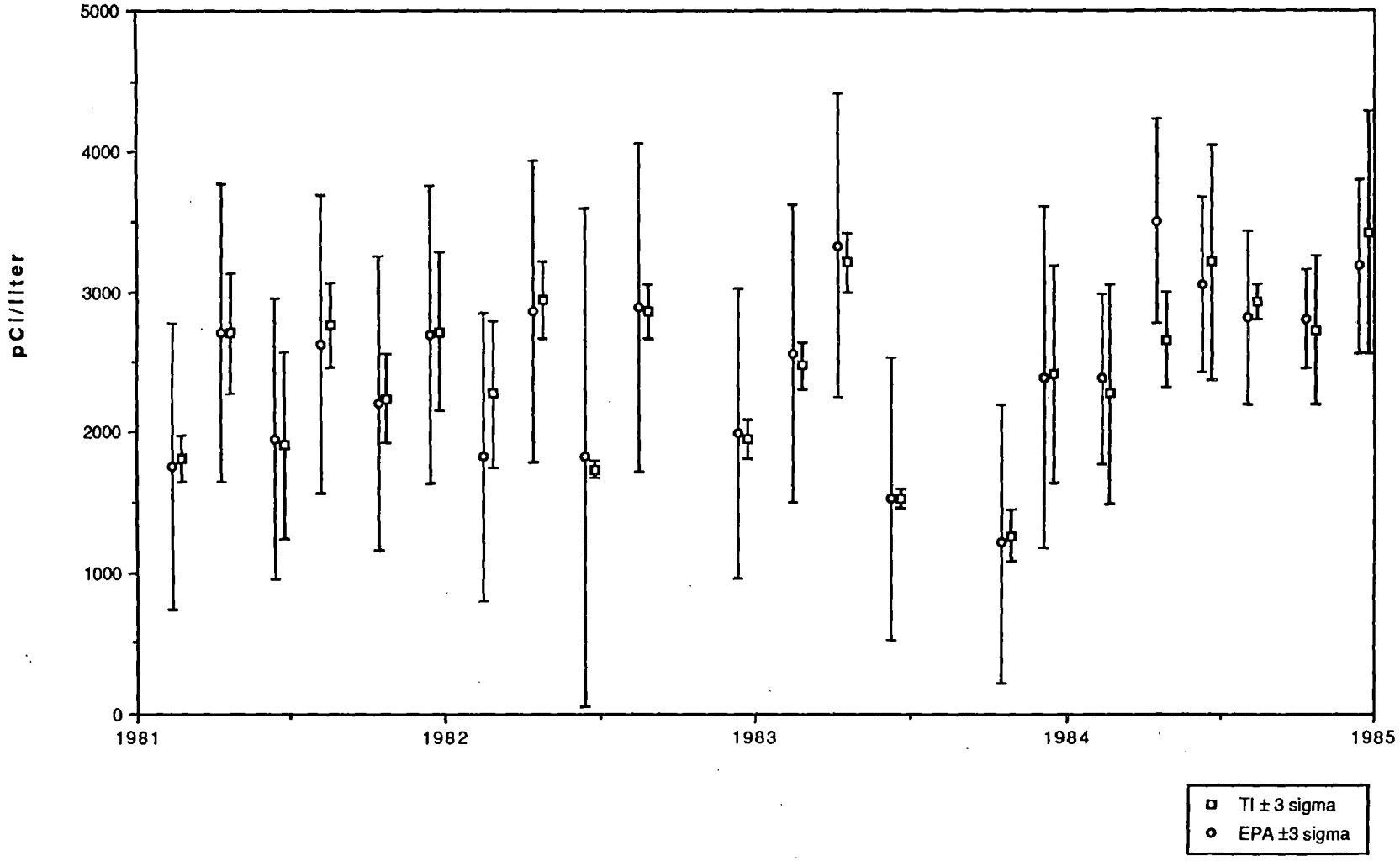
US EPA CROSS CHECK PROGRAM

STRONTIUM-90 IN WATER



US EPA CROSS CHECK PROGRAM

TRITIUM IN WATER (pg. 1)



US EPA CROSS CHECK PROGRAM

TRITIUM IN WATER (pg. 2)