

# **ARTIFICIAL ISLAND RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM**

**For**

**Salem Generating Station, Unit 1: Docket No. 50-272**

**Salem Generating Station, Unit 2: Docket No. 50-311**

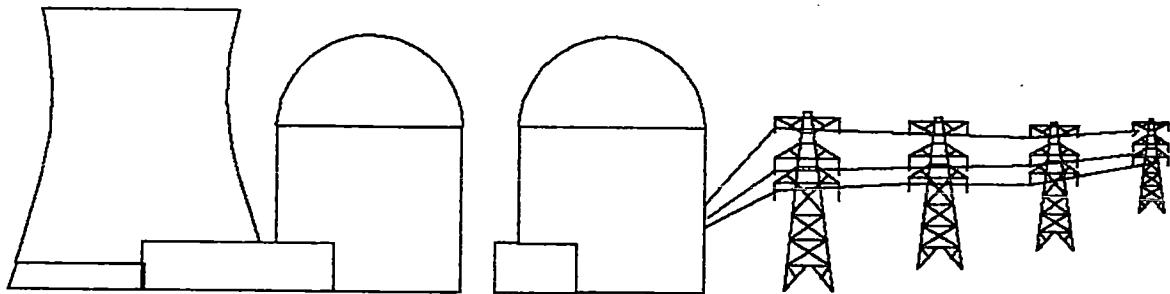
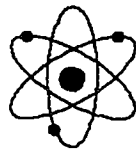
**Hope Creek Generating Station: Docket No. 50-354**

**1993 ANNUAL RADIOLOGICAL  
ENVIRONMENTAL OPERATING REPORT  
JANUARY 1 TO DECEMBER 31, 1993**

**Prepared By  
PUBLIC SERVICE ELECTRIC AND GAS COMPANY  
RESEARCH AND TESTING LABORATORY**

**APRIL 1994**

# **ARTIFICIAL ISLAND RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM**



## **SALEM & HOPE CREEK**

### **GENERATING STATIONS**

**1993 ANNUAL RADIOLOGICAL  
ENVIRONMENTAL OPERATING REPORT  
JANUARY 1 TO DECEMBER 31, 1993**

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## SUMMARY

During normal operations of a nuclear power generating station there are releases of small amounts of radioactive material to the environment. To monitor and determine the effects of these releases a radiological environmental monitoring program (REMP) has been established for the environment around Artificial Island where the Salem Units 1 and 2 (SGS) and Hope Creek (HCGS) Generating Stations are located. The results of the REMP are published annually, providing a summary and interpretation of the data collected. Additional data relating to the releases of radioactive materials to the environment can be obtained in the Radiological Effluent Release Report (RERR) which is published and submitted to the Nuclear Regulatory Commission on a semiannual frequency.

The PSE&G Research and Testing Laboratory (RTL) has been responsible for the collection and analysis of environmental samples during the period of January 1, 1993, through December 31, 1993, and the results are discussed in this report.

Most of the radioactive materials noted in this report are normally present in the environment, either naturally, such as potassium-40, or as a result of non-nuclear generating station activity such as nuclear bomb testing. Measurements made in the vicinity of Artificial Island were compared to background or control measurements and the preoperational REMP study performed before Salem Unit 1 became operational. Samples of air particulates, air iodine, precipitation, milk, surface, ground and drinking water, vegetables, beef, game, fodder crops, soil, fish, crabs, and sediment were collected and analyzed. External radiation dose measurements were also made in the vicinity of Artificial Island using thermoluminescent dosimeters.

To demonstrate compliance with Technical Specifications (Section 3/4.12.1), most samples were analyzed for gamma emitting isotopes, tritium (H-3), strontium-89 (Sr-89) and 90 (Sr-90), iodine-131 (I-131), gross beta and gross alpha. The results of these analyses were used to assess the environmental impact of SGS and HCGS operations, thereby demonstrating compliance with Technical Specifications (Section 3/4.11) and applicable Federal and State regulations, and to verify the adequacy of radioactive effluent control systems. The results provided in this report are summarized below:

- There were a total of 1738 analyses on 946 environmental samples during 1993. Direct radiation dose measurements were also made using 411 thermoluminescent dosimeters (TLDs).

- In addition to the detection of naturally-occurring isotopes (i. e. Be-7, K-40, Ra-226 and Th-232), low levels of Sr-90, and Cs-137 were also detected in various media. The detection of these radionuclides may be attributed to residual fallout from atmospheric weapons testing. Trace levels of Mn-54, Co-58, Co-60, Sr-89, Cs-134, and Cs-137 were also detected. The concentrations of these nuclides were well below the Technical Specification reporting limit.
- Dose measurements made with quarterly TLDs at 31 offsite locations around Artificial Island averaged 64 millirads for the year 1993. An average of the control locations (background) for this time was 60 millirads for the year. This was comparable to the preoperational phase of the program which had an average of 55 millirads per year for 1973 to 1976.

## INTRODUCTION

This section gives a brief description of the characteristics, effects, and sources of radiation and the operation of a nuclear generating station, both a boiling water reactor and a pressurized water reactor.

## RADIATION CHARACTERISTICS

The word "radioactive" describes the state of the nucleus of an atom containing an excess of energy. The excessive energy is usually due to an imbalance in the number of electrons, protons, and/or neutrons which make up the atom. To release this excess energy the atom emits electromagnetic or particulate radiation to become stable (non-radioactive). This process is called radioactive decay. Part of the electromagnetic spectrum consists of gamma-rays and x-rays, which are similar in nature to light and microwaves. Particulate radiation may be in the form of electrically charged particles such as alpha (2 protons plus 2 neutrons) and beta (1 electron) particles, or have no charge at all (neutron).

Radioactive decay is measured in terms of "half-life". The half-life may be defined as the amount of time it takes for a radioactive material to decay to half of its original activity. The half-life of a radionuclide depends on the radionuclide and can range anywhere from a fraction of a second to as long as several million years. Each radionuclide also has a unique decay characteristic, both in terms of the energy of its radiation and the types of its radiation. Radionuclides may decay directly into a stable element or go through a series of decays (becoming several different radioisotopes) before eventually becoming a stable element.

Radioactivity is measured by the number of nuclear disintegrations (decays) of the source of radiation per unit of time. The unit of this measurement is called the curie. One curie equates to  $2.2 \times 10^{12}$  disintegrations per minute. For the purpose of quantifying the effluents of a nuclear power reactor this unit is broken down into a microcurie and a picocurie. The microcurie is one millionth of a curie and represents  $2.2 \times 10^6$  decays per minute, while the picocurie is one millionth of a microcurie and represents 2.2 decays per minute.



## RADIATION EFFECTS

Radiation effects are measured in terms of the amount of biological damage produced. Biological damage from electromagnetic and particulate radiation is produced by ionizing an atom, breaking a chemical bond, or altering the chemistry of a living cell. To assess biological damage, the type, energy, and amount of radiation must be considered.

There are essentially two types of exposure to radiation: external and internal. External exposure can involve the total body, thereby implying exposure to all organs, or parts of the body, such as the arm, foot, or head. Internal exposure, meaning the uptake of radioactive elements by inhalation, ingestion, or by means of a cut, can involve a single selective organ or several organs.

An example of the selectivity of internal exposure is the uptake of a radioiodine which concentrates in the thyroid gland, versus the uptake of a radiocesium which will collect in the muscle and liver. The quantity of the radionuclide and duration of time a radionuclide remains in the body directly influences the total exposure or dose to an organ. The duration of time depends on the amount of radioactive decay and the length of time it takes to remove the radionuclide from the body (biological decay). It should be noted that the biological effect of radiation is independent of the source (internal or external) and dependent on the dose.

The measurement of dose to man is expressed in terms of a unit called the rem. A better unit of dose, the millirem (mrem;  $1 \text{ mrem} = 1/1000 \text{ rem}$ ) is most often used because the typical dose is usually on the order of thousandths of a rem. Another term used is the collective dose to a population, called a person-rem. A person-rem is calculated by adding up each individual dose to a population (e.g. 0.0001 rem to each person of a population of 10,000 persons = 1 person-rem).

## SOURCES OF RADIATION EXPOSURE

Radioactive elements have existed on our planet (and on everything that has emerged from it) since its formation, including our own bodies. Every second over 7000 atoms undergo radioactive decay in the body of the average adult (or roughly 420,000 disintegrations per minute) from natural background.

Many sources of radiation exist today and, of them, the most universal and least controllable is background radiation from terrestrial radioactivity and cosmic rays. Terrestrial radioactivity originates from such radionuclides as potassium-40 (K-40), uranium-238 (U-238), thorium-232 (Th-232), radium-226 (Ra-226), and radon-222 (Rn-222). Some of these radionuclides have half-lives of millions of years and are introduced into the water, soil, and air by such means as volcanoes, weathering, erosion, diffusion, and radioactive decay.

One naturally-occurring terrestrial radionuclide is a significant source of radiation exposure to the general public---radon gas. Radon gas (Rn-222) is an inert gas produced in the ground from the radioactive decay of radium (from the decay of uranium and thorium) and emitted into the air. Because of the use of lime and gypsum (which would contain radium) in its production, building materials such as cinder block, sheet rock, and concrete are also radon gas sources. Concentrations of radon gas are dependent on the concentrations of radium (uranium and thorium) in the soil, altitude, soil permeability, temperature, pressure, soil moisture, rainfall, snow cover, atmospheric conditions, and season. The gas can move through cracks and openings into basements of buildings, become trapped in a small air volume indoors and result in higher concentrations than found outdoors. Radon can also be dissolved in well water and contribute to airborne radon in houses when released through showers or washing.

Since radon gas is radioactive, it, too, continues to produce, by decay, other radioactive materials referred to as radon daughters. These daughters are solid particles which can stick to surfaces such as dust particles in the air. The dust containing the radon daughter particles can be inhaled and deposited in the lungs. Radon daughters emit high energy alpha particles which results in an average dose to the lungs of 300 mrem (0.3 rem to a 10 year old) in the United States. In areas such as New Jersey and Pennsylvania, over a geological formation known as the Reading Prong, doses much higher than 300 mrem/yr have been recorded due to natural deposits of uranium. Doses due to radon gas and its daughters are the highest dose contributor to individuals from all natural sources.

Cosmic rays are high energy electromagnetic rays which originate from outer space. About 300 cosmic rays pass through each person every second. Cosmic rays also interact with atoms in the earth's atmosphere and produce radioactive substances such as carbon-14 (C-14), sodium-22 (Na-22), beryllium-7 (Be-7), and tritium (H-3). Some of these radionuclides become deposited on land and water while the rest remain suspended in the atmosphere.

Other naturally-occurring sources of radiation which contribute to doses to the human body are trace amounts of uranium and radium in drinking water and radioactive potassium in milk. Sources of naturally-occurring radiation and their average dose contribution are summarized in Table 1.

TABLE 1

## COMMON SOURCES OF RADIATION\*

<u>Natural Sources</u>	<u>Approximate Dose (mrem/year)</u>	<u>Manmade Sources</u>	<u>Approximate Dose (mrem/year)</u>
Cosmic Rays	42	Medical radiation	90
Building Materials	35	Television and	
Internal	28	consumer products	1-5
Ground	11	Weapons Fallout	2-5
		Nuclear Power Plants	1
APPROXIMATE TOTAL	100		100

\* Reference: NUREG-0558 and EPA Report ORP/SID 72-1

The average individual in the United States receives approximately 100 mrem per year from natural sources. In some areas the dose from natural radiation is significantly higher. Residents of Colorado receive an additional 80 mrem per year due to the increase in cosmic (higher elevation) and terrestrial radiation levels. Transcontinental and intercontinental airline pilots receive 1000 mrem/yr due to the high elevation and length of these flights and resultant higher cosmic radiation levels. In several locations around the world high concentrations of mineral deposits give natural background radiation levels of several thousand mrem per year.

The average individual is also exposed to radiation from a number of man-made sources. The single largest of these sources comes from medical diagnostic tools such as X-rays, CAT-scans, fluoroscopic examinations and radio-pharmaceuticals. Approximately 160 million people in the United States are exposed to medical or dental X-rays in any given year. The annual dose to an individual from such medical irradiation averages 90 mrem which is approximately equal to the annual sum of natural radiation. Smaller doses from man-made sources come from consumer products (television, smoke detectors, fertilizer), fallout from prior nuclear weapons tests, and production of nuclear power and its associated fuel cycle.

There are approximately 200 radionuclides produced in the nuclear weapons detonation process; a number of these are detected in fallout. Fallout commonly refers to the radioactive debris that settles to the surface of the earth following the detonation of nuclear weapons. Fallout can be washed down to the earth's surface by rain or snow and is dispersed throughout the environment. The radionuclides found in fallout which produce most of the fallout radiation exposures to man are I-131, Sr-89, Sr-90, and Cs-137. There have been no atmospheric weapons tests in this country since 1964.

## NUCLEAR POWER REACTORS

After World War II and during the development of atomic weapons, an understanding of the great energy potential from atomic chain reactions was realized and put to peaceful use. Among the most successfully developed peaceful uses were nuclear power reactors. It was known that the fission reactions in an atomic weapon detonation generated large amounts of energy and heat. If that energy and heat could be harnessed, electricity could be produced. As a comparison, one pound of uranium-235 (the fuel of a nuclear reactor) could produce the heat of 1,500 tons of coal. So, at the University of Chicago, under the direction of Enrico Fermi, the world's first nuclear reactor began operation (went critical) on December 2, 1942.

It wasn't until 1957 that the nuclear reactor was first used to commercially produce electricity in Shippingport, Pennsylvania. Today there are over 100 reactors for public power generation of electricity in this country and 300 in the world.

The function of a nuclear reactor is to generate heat to produce electricity. The generation of heat is accomplished by permitting self-sustaining, controlled nuclear fissions. Nuclear fission is the splitting of an atom when hit by a neutron, which, in turn, produces two entirely different atoms, as well as generating a lot of heat. When one fission occurs more neutrons are given off which leads to more atoms to fission, producing more neutrons etc., thus giving rise to a chain reaction. The atom bomb, using large masses of fissionable material, is a chain reaction uncontrolled. Nuclear reactors, on the other hand, use small masses of fissionable material (thus making it impossible for a nuclear explosion), and are therefore able to sustain a controlled chain reaction.

The best known and most widely used material for the fission reaction is uranium-235. Most uranium exists in the form U-238 (238 refers to the atomic mass, i.e., the number of protons and neutrons combined). However, it also exists in the form of uranium-235 which is in a proportion of one atom per 140 atoms of U-238. Uranium-235 becomes very unstable when its nucleus is struck by a neutron. To overcome the instability, the uranium atoms split (fission) and become two fission products (e.g. Iodine 131 and Xenon 133). When the fission occurs, some neutrons are released to initiate another fission and start a chain reaction.

There are several different ways to control the rate of a chain reaction. Some of these means are the use of moderators, varying the size of a reactor vessel, and using neutron absorbing materials (such as cadmium) as control rods.

There are three major types of nuclear reactors in operation in the world: the pressurized light-water reactor (PWR), boiling light-water reactor (BWR), and the gas-cooled reactor. The nuclear reactors built and operating on Artificial Island are the BWR (Hope Creek) and the PWR (Salem Units 1 and 2).

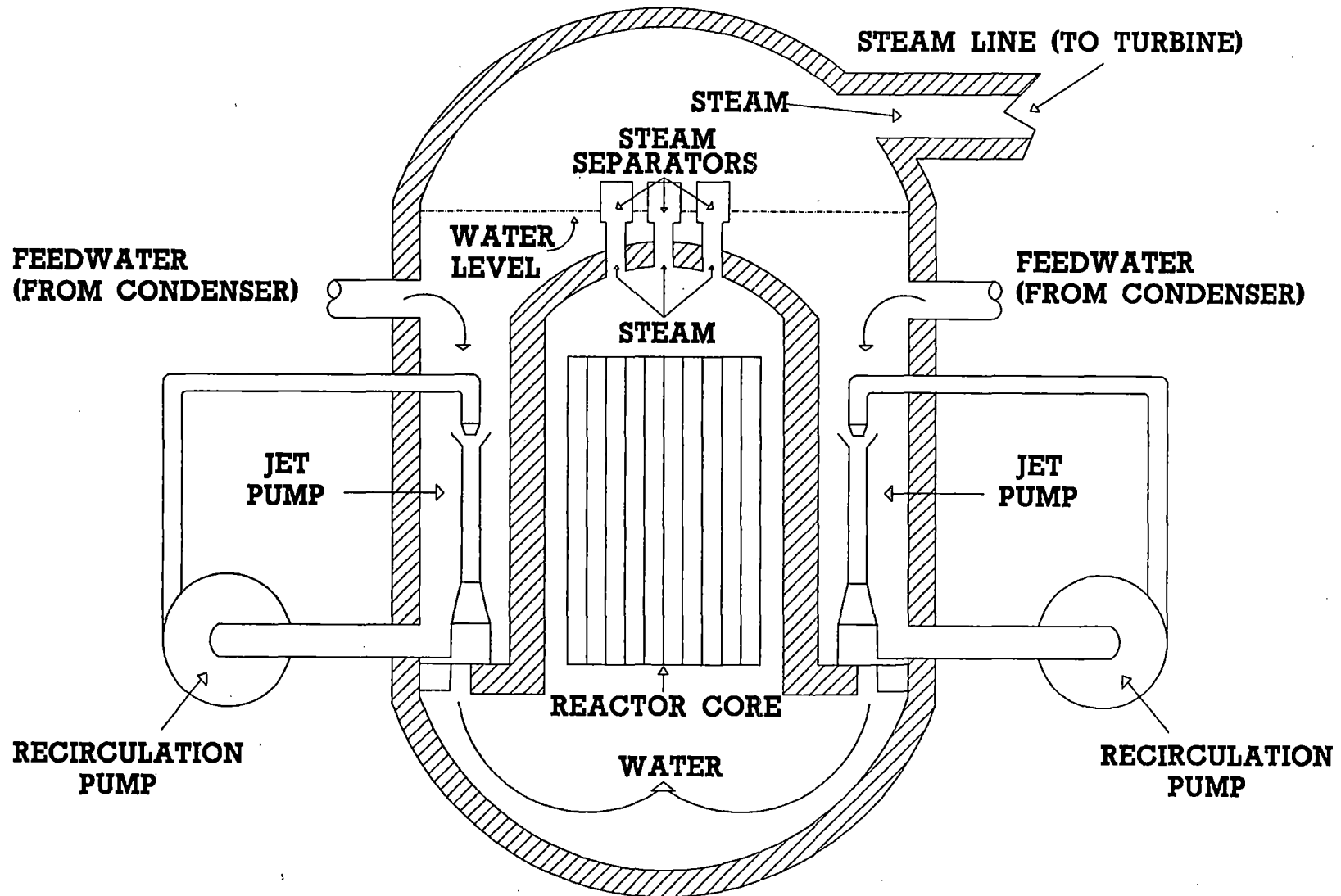
Of the two types of light-water reactors (LWR), the BWR has a simpler design. In a BWR the steam desired to generate electricity is produced in the core itself. Here is how the BWR works (refer to Figures 1 and 2):

1. Water enters the reactor vessel through the reactor core which consists of 764 fuel assemblies. Each assembly consists of 64 zirconium alloy fuel rods about 13 feet long. Sixty-two of these rods contain uranium fuel pellets. The fuel pellets have been enriched so that the U-235-to-U-238 ratio is now one atom of U-235 to every 20 to 40 atoms of U-238. The core is contained in a 6" thick steel reactor vessel about 75 feet high and weighing 624 tons.
2. The water flows along the fuel rods. Then, when the 185 control rods (containing cadmium) are withdrawn, the fissioning process in the fuel rods generates heat that causes the water passing through the core to boil into steam in the reactor vessel.
3. The steam flows through the steam lines at the top of the reactor directly into a turbine generator (see Figure 2).
4. In the turbine, the force of the steam striking the blades attached to a shaft causes the shaft to spin.
5. The shaft spins inside a generator, causing a magnetic field to move through coils of wire to produce electricity.
6. A second separate water system, carrying cooling water from an outside source (e.g. the cooling tower located on Artificial Island), condenses the steam back to water.
7. The condensed water is then pumped back into the reactor vessel to start the entire cycle again.

The fission chain reaction is controlled by the 185 control rods located between the fuel assemblies. These control rods contain material which absorbs neutrons and controls the rate of fissioning. By moving the control rods up or down, the reactor can sustain a chain reaction at desired power levels. By inserting them all the way into the reactor core, fissioning can be completely stopped.

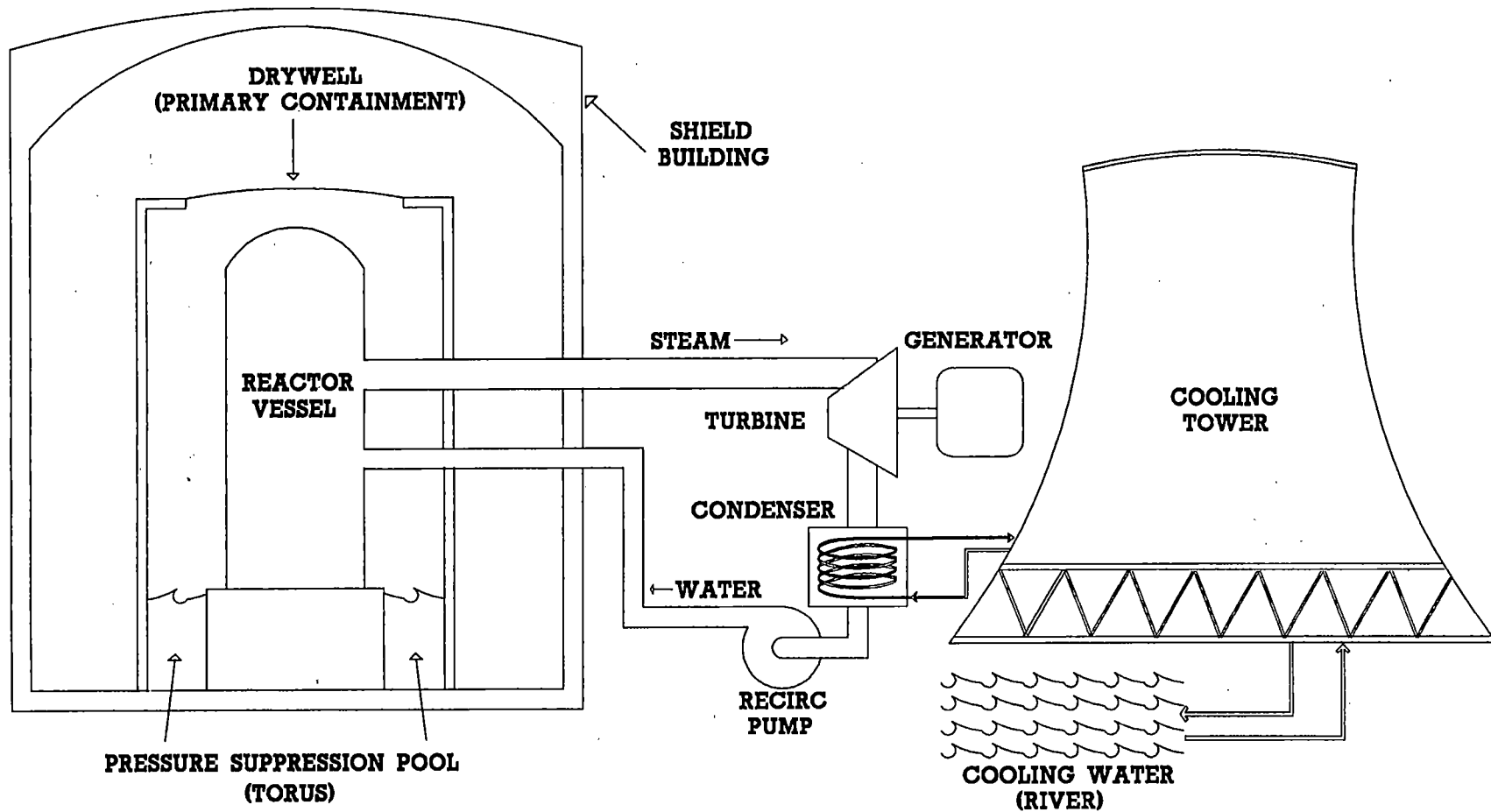
**FIGURE 1**

## BWR VESSEL & CORE



**FIGURE 2**

**SCHEMATIC OF BWR POWER PLANT**



A PWR differs from a BWR in that water inside the reactor vessel system is pressurized to prevent boiling (steam) when heated. This pressurized hot water is used to heat a second source of water, at lower pressure, which will produce steam to turn the turbines. The following outline indicates how the PWR works (see Figure 3):

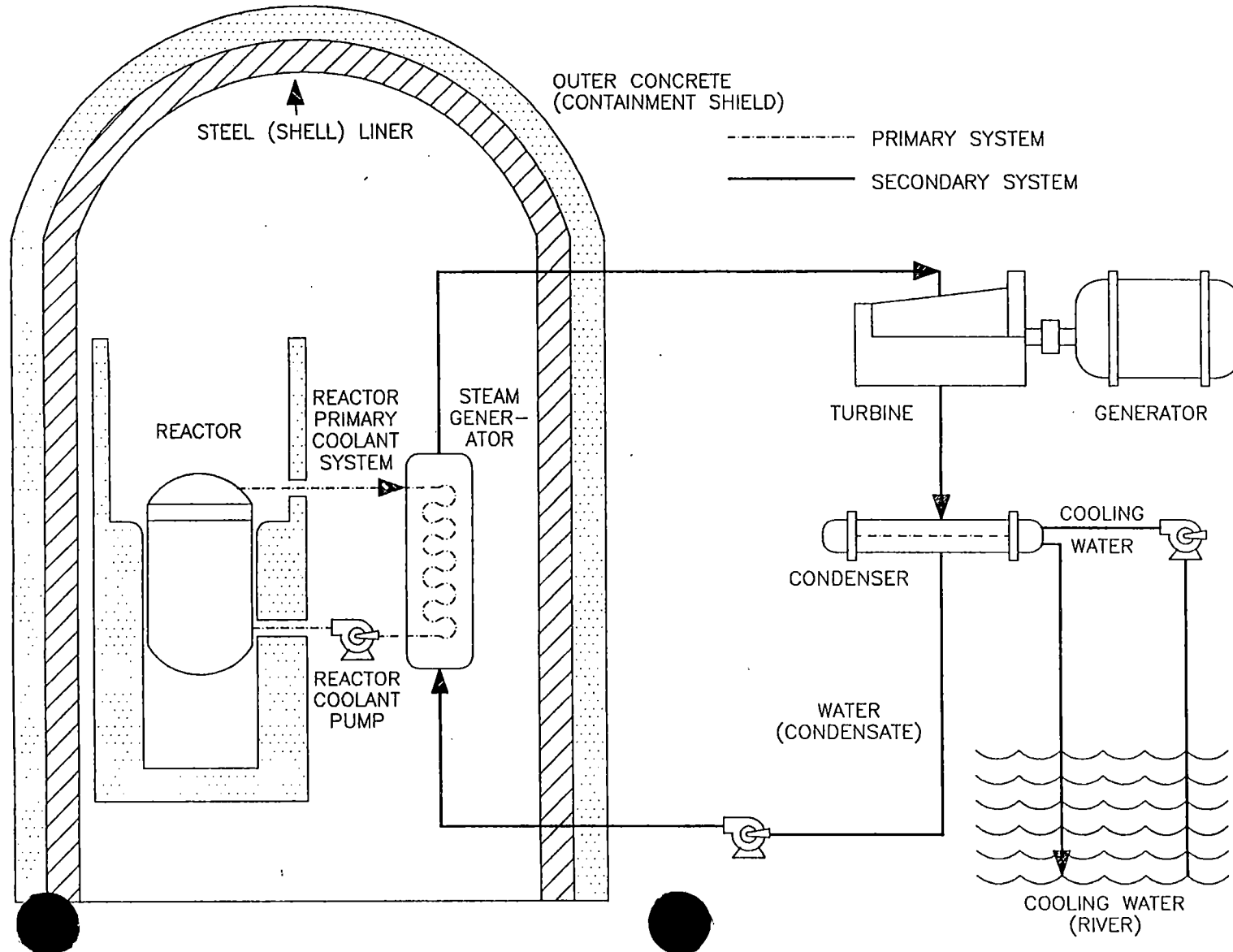
1. Within the 424-ton reactor vessel at SGS, water flows across 193 fuel assemblies in the reactor core. Each assembly consists of 264 fuel rods, each about 15 feet long.
2. The water flows along the fuel rods. When the 53 control rods are raised, the fissioning process begins and the water is heated to about 600°F by the nuclear fission process. This water is referred to as the primary coolant. The primary coolant is maintained at about 2000 psi of pressure to keep the water from boiling, hence a pressurized water system.
3. The primary coolant flows from the reactor as a hot liquid to tubes in the steam generators where the water gives up its heat (cooled) to the water in the steam generator. The water in the steam generator is called secondary coolant. The primary water, after giving up its heat, is returned to the reactor core to start the process over.
4. The secondary coolant in the steam generator is not under high pressure and turns to steam because of the primary coolant heat-up. This steam is sent through steam lines to the turbine generator to generate electricity in the same method as outlined in the BWR description above.
5. The exhausted steam from the turbine is channeled into the condenser below the turbine, cooled back into water and returned to the steam generators. The cooling action of the condenser is provided by a third (tertiary coolant) system of circulating water drawn from a river, ocean, or lake (at SGS, this is the Delaware River).

About 65 percent of the nuclear power plants in the United States are PWRs and 35 percent are BWRs. The PWR is also used in nuclear submarines and other naval vessels.



**FIGURE 3**

SCHEMATIC OF PWR POWER PLANT



## CONTAINMENT OF RADIOACTIVITY

The radioactivity present in a nuclear reactor is not just derived from U-235 fuel and the fission products generated from the chain reaction. Other radioactive substances are generated by means of activation. Activation products are corrosion materials, from component and structural surfaces in the coolant water, that become radioactive. The materials become radioactive or activated when hit by neutrons from the fission reaction.

There are a series of several barriers to contain the radioactivity present in a light water reactor. The first of these is the nuclear fuel itself. The fission products are trapped inside the ceramic fuel pellets that are designed to retain them. The fission products that are gaseous or volatile migrate out of the fuel.

Encasing the fuel pellets are metal fuel rods (known as fuel cladding) designed to retain the fuel pellets. The small fraction of fission products that might leave the fuel pellets (such as the gaseous products) are collected here in small gaps between the fuel pellets and cladding.

The next barrier level is the cooling water which is circulated around the fuel rods. The fission and activation products (such as radioiodines, strontiums, and cesiums) are soluble and are retained in the coolant. These materials can be removed by filter and purification systems used for the coolant.

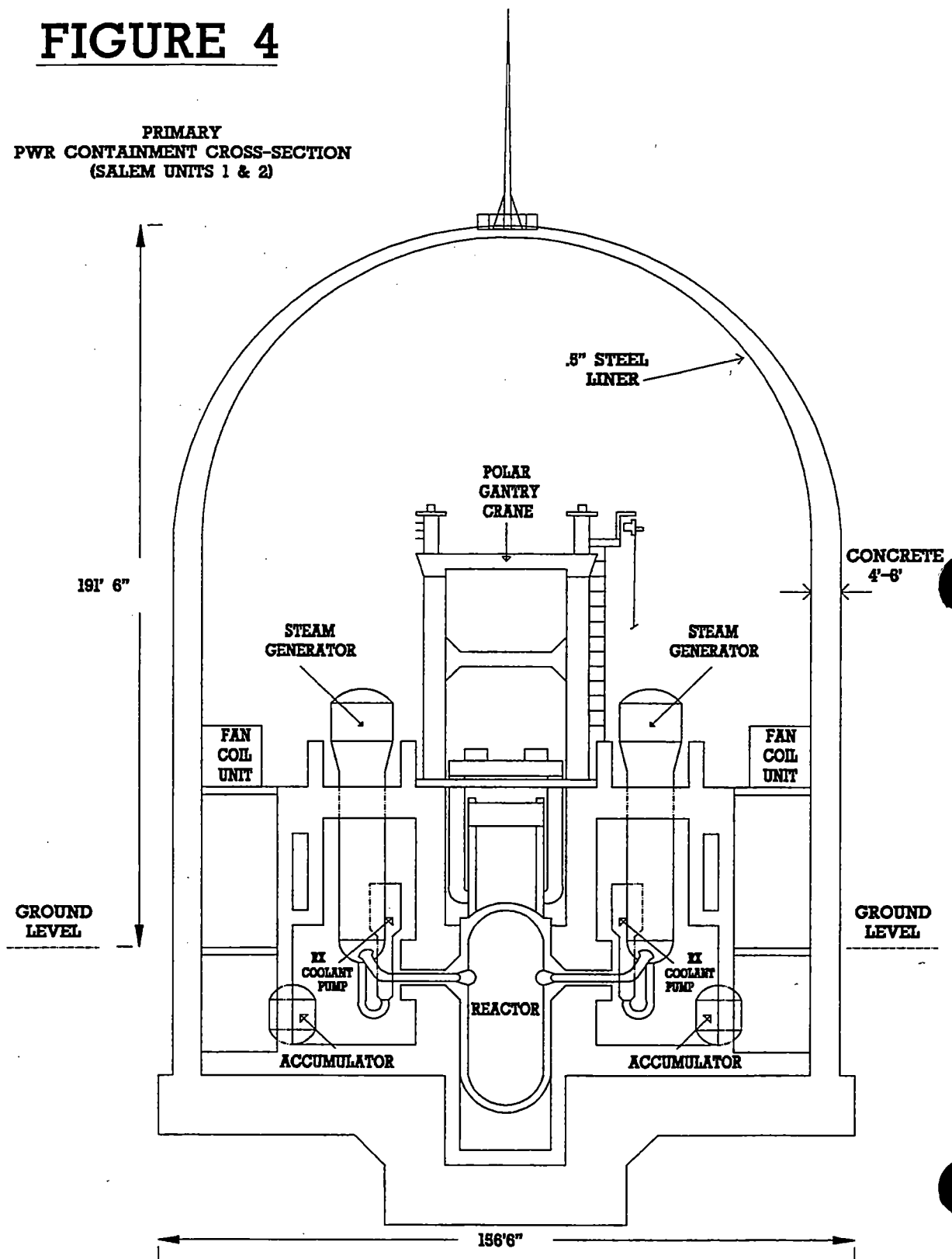
The next level is the reactor vessel. The reactor vessel is a steel structure (6 to 8 inches thick) which contains the fuel rods and coolant. The vessel and its coolant systems provide containment for all radionuclides in the coolant.

From here the PWR and BWR differ in structure. The next barrier around a PWR reactor vessel is the containment building which is a four-foot thick, steel-reinforced (Salem Units 1 and 2 also include a steel liner) concrete structure (see Figure 4). It is designed to contain water and gases which may accidentally escape the above barriers. The containment is also designed to withstand tornadoes, floods, and earthquakes.

In a BWR, the reactor vessel is contained in a drywell and pressure suppression chamber (see Figure 5). This system is designed to reduce the pressure and water build-up that may occur during a break in the steam piping. The walls of the drywell (which are two feet thick) consist of concrete with a steel containment shield over the reactor vessel top. The reactor vessel and drywell system is surrounded by a steel reinforced reactor building structure (see Figure 2).

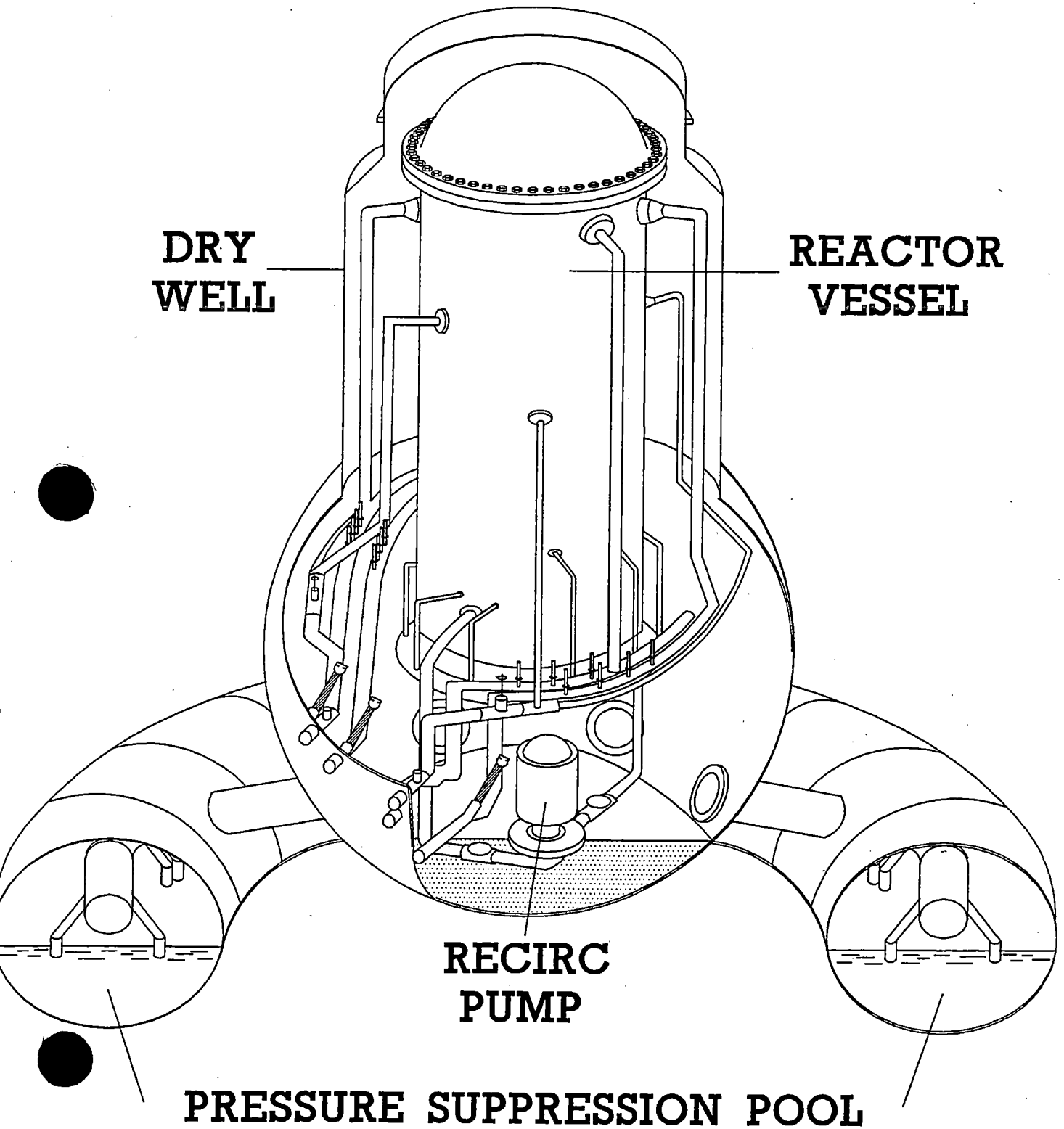
# FIGURE 4

PRIMARY  
PWR CONTAINMENT CROSS-SECTION  
(SALEM UNITS 1 & 2)



# **FIGURE 5**

**BWR MARK I  
PRIMARY CONTAINMENT CROSS-SECTION  
(HOPE CREEK)**



## SOURCES OF RADIOACTIVE LIQUID AND GASEOUS EFFLUENTS

Under normal operating conditions for nuclear power plants most of the fission products are retained within the fuel and fuel cladding. However, small amounts of radioactive fission products are able to diffuse or migrate through the fuel cladding and into the primary coolant. Trace quantities of the component and structure surfaces, which have been activated, also get into the primary coolant water. Many of the soluble fission and activation products, such as radioactive iodines, strontiums, cobalts, and cesiums are removed by demineralizers in the purification system of the primary coolant. The noble gas fission products have a very low solubility in the primary coolant and therefore cannot be removed by the demineralizers.

Instead, they are released as a gas when the primary coolant is depressurized and are collected by a system designed for gas collection and decay. This represents the principal source of gaseous effluents.

Small releases of radioactive liquids from valves, piping, or equipment associated with the primary coolant system may occur in the reactor, auxiliary, and fuel handling buildings. The noble gases become part of the gaseous wastes, while the remaining radioactive liquids are collected in floor and equipment drains and sumps and are processed prior to release. Processed primary coolant water that does meet chemical specifications for reuse may also become waste water. These represent the principal sources of liquid effluents.

## RADIOACTIVITY REMOVAL FROM LIQUID AND GASEOUS WASTES

In a nuclear power plant, radioactive liquid and gaseous wastes are collected, stored, and processed through processing systems to remove or reduce most of the radioactivity (exclusive of tritium) prior to reuse within the plant or discharge to the environment. These primary systems are required by Technical Specifications to be installed and operable and help to ensure that all releases of radioactive liquid and gaseous effluents are as-low-as-reasonably-achievable (ALARA).

At both SGS and HCGS, liquid waste is routed through demineralizers and filters which clean the water for recycling. If the demineralized water does not meet the requirements for reuse, the water is stored in tanks for sampling and then analyzed for radioactivity and chemical content before being discharged to the Delaware River. All concentrates produced from the demineralizers are packaged as solid waste for shipment and burial at an offsite burial facility.

At Salem, the circulating water system provides an additional minimum of 185,000 gallons per minute dilution flow for liquid releases. At Hope Creek, the cooling tower provides an additional 29,000 gallons per minute dilution flow prior to discharge to the Delaware River. The average flow rate of the Delaware River is five million gallons per minute and provides additional dilution.

In SGS, the waste gases collected by the vent header system are first routed to the gas compressors which compress the gases into waste gas decay tanks. After a waste gas decay tank is filled, the tank contents may be stored for a period up to 90 days (generally) to allow for decay of the shorter-lived radionuclides. In HCGS, the waste gases from the main condenser air ejectors are collected and delayed from release in the offgas system. The discharge of all waste gases at HCGS and SGS is made through high efficiency particulate air (HEPA) filters and charcoal filters prior to release. The filters are rated to be 95% efficient for iodines and greater than 99% efficient for removal of particulates. Noble gases, however, cannot be removed by these filters. Gaseous effluents are discharged through elevated vents which enhances atmospheric dispersion and dilution.

Radioactive effluent releases are limited and controlled by release concentrations and dose limits, per Technical Specifications and the U.S. Nuclear Regulatory Commission's regulation in Title 10 of the Code of Federal Regulations, Part 20 (10 CFR 20). These regulations are based on recommendations of the International Commission on Radiological Protection (ICRP), the National Council on Radiation Protection and Measurements (NCRP) and the Federal Radiation Council (FRC) for basic radiation protection standards and guidance. The operations of the Hope Creek and Salem Generating Stations (Units 1 and 2), and their associated effluent releases, were well within the 10 CFR 20 limits and maintained ALARA.

## THE RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Artificial Island is the site of Salem and Hope Creek Generating Stations. The Salem Generating Station (SGS) consists of two operating pressurized water nuclear power reactors. Salem Unit One has a net rating of 1115 MWe (3411 MWt), and Salem Unit Two has the same rating at 1115 MWe (3411 MWt). The Hope Creek Generating Station (HCGS) is a boiling water nuclear power reactor which has a net rating of 1067 MWe (3293 MWt).

Artificial Island is a man-made peninsula on the east bank of the Delaware River and was created by the deposition of hydraulic fill from dredging operations. It is located in Lower Alloways Creek Township, Salem County, New Jersey. The environment surrounding Artificial Island is characterized mainly by the Delaware River and Bay, extensive tidal marshlands, and low-lying meadowlands. These land types make up approximately 85% of the land area within five miles of the site. Most of the remaining land is used for agriculture [5,6]. More specific information on the demography, hydrology, meteorology, and land use of the area may be found in the Environmental Reports [5,6], Environmental Statements [7,8], and the Updated Final Safety Analysis Report for SGS [9] and the Final Safety Analysis Report for HCGS [10].

Since 1968, an off-site Radiological Environmental Monitoring Program (REMP) has been conducted at the Artificial Island Site. Starting in December, 1972, more extensive radiological monitoring programs were initiated. The operational REMP was initiated in December, 1976, when Salem Unit 1 achieved criticality. The PSE&G Research and Testing Laboratory (RTL), has been involved in the REMP since its inception. The RTL is responsible for the collection of all radiological environmental samples, and, from 1973, through June, 1983, conducted a quality assurance program in which duplicates of a portion of those samples analyzed by the primary laboratory were also analyzed by the RTL.

From January, 1973, through June, 1983, Radiation Management Corporation (RMC) had primary responsibility for the analysis of all samples under the Artificial Island REMP and the annual reporting of results. RMC reports for the preoperational and operational phase of the program are referenced in this report [1-3]. On July 1, 1983, the RTL assumed primary responsibility for the analysis of all samples (except TLDs) and the reporting of results. Teledyne Isotopes (TI), Westwood, NJ, at that time, took over responsibility for third-party QA analyses and TLDs. An additional vendor, Controls for Environmental Pollution Inc., had been retained to provide third-party QA analyses and certain non-routine analyses from May 1988 up until June 1, 1992. At this time, TI is our sole QA vendor. RTL reports for the operational phase from 1983 to 1992 are referenced in this report [4].

An overview of the 1993 Program is provided in Table 2.

Radioanalytical data from samples collected under this program were compared with results from the preoperational phase. Differences between these periods were examined statistically, where applicable, to determine the effects, if any, of station operations. This report summarizes the results from January 1 through December 31, 1993, for the Artificial Island Radiological Environmental Monitoring Program.

## OBJECTIVES

The objectives of the Operational Radiological Environmental Monitoring Program are:

- To fulfill the obligations of the Radiological Surveillance sections of the Technical Specifications for the Salem Generating Station (SGS) and the Hope Creek Generating Station (HCGS).
- To determine whether any significant increase occurs in the concentration of radionuclides in critical pathways.
- To determine if SGS or HCGS has caused an increase in the radioactive inventory of long-lived radionuclides.
- To detect any change in ambient gamma radiation levels.
- To verify that SGS and HCGS operations have no detrimental effects on the health and safety of the public or on the environment.

This report, as required by Section 6.9.1.10 of the Salem Technical Specifications, and Section 6.9.1.7 of the Hope Creek Technical Specifications, summarizes the findings of the 1993 REMP. Results of the four-year preoperational program which was conducted prior to the operation of any reactors on the Artificial Island have been summarized for purposes of comparison with subsequent operational reports [2].

In order to meet the stated objectives, an appropriate operational REMP was developed. Samples of various media were selected to obtain data for the evaluation of the radiation dose to man and other organisms. The selection of sample types was based on: (1), established critical pathways for the transfer of radionuclides through the environment to man, and, (2), experience gained during the preoperational phase. Sampling locations were determined from site meteorology, Delaware estuarine hydrology, local demography, and land uses.



Sampling locations were divided into two classes, indicator and control. Indicator stations are those which are expected to manifest station effects, if any exist. Control samples are collected at locations which are believed to be unaffected by station operations, usually at 15 to 30 kilometers distance. Fluctuations in the levels of radionuclides and direct radiation at indicator stations are evaluated with respect to analogous fluctuations at control stations. Indicator and control station data are also evaluated relative to preoperational data. Appendix A describes and summarizes, in accordance with Section 6.9.1.10 of the Salem TS and Section 6.9.1.7 of the Hope Creek TS, the entire operational program as performed in 1993. Appendix B describes the coding system which identifies sample type and location. Table B-1 lists the sampling stations and the types of samples collected at each station. These sampling stations are indicated on maps B-1 and B-2.

#### DATA INTERPRETATION

Results of all analyses were grouped according to the analysis performed for each type of sample and are presented in the data tables in Appendix C. All results above the lower limit of detection (LLD) are at a confidence level of 2 sigma. This represents the range of values into which 95% of repeated analyses of the same sample should fall. As defined in Regulatory Guide 4, LLD is the smallest concentration of radioactive material in a sample that will yield a net count (above system background) that will be detected with 95% probability, with only 5% probability of falsely concluding that a blank observation represents a "real signal". LLD is normally calculated as 4.66 times one standard deviation of the background count, or of the blank sample count, as appropriate.

The grouped data were averaged and standard deviations calculated in accordance with Appendix B of Reference 16. Thus, the 2 sigma deviations of the averaged data represent sample and not analytical variability. For reporting and calculation of averages, any result occurring at or below the lower limit of detection is considered to be at that limit. When a group of data was composed of 50% or more LLD values, averages were not calculated.

Grab sampling is a useful and acceptable procedure for taking environmental samples of a medium in which the concentration of radionuclides is expected to vary slowly with time or where intermittent sampling is deemed sufficient to establish the radiological characteristics of the medium. This method, however, is only representative of the sampled medium for that specific location and instant of time.

As a result, variation in the radionuclide concentrations of the samples will normally occur. Since these variations will tend to counterbalance one another, the extraction of averages based upon repetitive grab samples is considered valid.

#### QUALITY ASSURANCE PROGRAM

The PSE&G Research and Testing Laboratory (RTL), has a quality assurance program designed to maximize confidence in the analytical procedures used. Approximately 20% of the total analytical effort is spent on quality control, including process quality control, instrument quality control, interlaboratory cross-check analyses, and data review. The analytical methods utilized in this program are summarized in Appendix D.

The quality of the results obtained by the RTL is ensured by the implementation of the Quality Assurance Program as described in the Environmental Division Quality Assurance Plan [17] and the Environmental and Chemical Services Division Procedures Manual [18]. The internal quality control activity of the Laboratory includes the quality control of instrumentation, equipment and reagents; the use of reference standards in calibration, documentation of established procedures and computer programs, and analysis of duplicate and spiked samples. The external quality control activity is implemented through participation in the USEPA Laboratory Intercomparison Studies Program. These results are listed in Tables E-1 through E-5 in Appendix E.

#### RESULTS AND DISCUSSION

The analytical results of the 1993 REMP samples are divided into categories based on exposure pathways: atmospheric, direct, terrestrial, and aquatic. The analytical results for the 1993 REMP are summarized in Appendix A. The data for individual samples are presented in Appendix C. The data collected demonstrates that SGS Units 1 and 2 and HCGS were operated in compliance with Technical Specifications.

The REMP for the Artificial Island Site has historically included samples and analyses not specifically required by the Salem and Hope Creek Generating Stations Technical Specifications. PSE&G continues to collect and analyze these samples in order to maintain personnel proficiency in performing these non-routine analyses. These analyses are referenced throughout the report as Management Audit samples. The summary tables in this report include these additional samples and analyses.

#### ATMOSPHERIC

Particulates were collected on Schleicher-Schuell No. 25 glass fiber filters with low-volume air samplers. Iodine was collected from the air by adsorption on triethylenediamine (TEDA) impregnated

charcoal cartridges connected in series after the air particulate filters. Air sample volumes were measured with calibrated dry-gas meters and were corrected to standard temperature and pressure.

Precipitation was collected in a Wong Laboratory Automatic Precipitation Collector having a 95 square inch collection area, until June 28, 1993. This collector was automatically covered during periods of no precipitation to exclude fallout resulting from dry deposition. Samples were collected monthly and transferred to new polyethylene containers. The collector was rinsed with distilled water to include residual particulates in the precipitation samples. Tritium results were corrected for the tritium content of the distilled water. As of June 28th, a modified rain collector was fabricated to include the same 95 square inch collection area inside a cylindrical tank with a tapered bottom which drains directly into a 2.5 gallon container inside a refrigerator. No rinsing is required because the taper on the tank bottom allows for constant for gravimetric transfer of the entire rainfall sample into the container. No tritium correction is necessary because the distilled water rinse is not longer used.

#### Air Particulates (Tables C-1, C-2, C-3)

Air particulate samples were collected at six locations. Each of the 304 weekly samples collected were analyzed for gross alpha (management audit analysis) and gross beta. Quarterly composites of the weekly samples from each station were analyzed for specific gamma emitters and a single quarterly composite sample was analyzed for Sr-89 and Sr-90 as a management audit analysis. Total data recovery for the six sampling stations during 1993 was 97.9 percent.

- Gross alpha activity was detected in 229 of the indicator station samples at concentrations ranging from  $0.7 \times 10^{-3}$  to  $4.3 \times 10^{-3}$  pCi/m<sup>3</sup>. Gross alpha activity was detected in 50 control station samples at levels ranging from  $0.9 \times 10^{-3}$  to  $4.3 \times 10^{-3}$  pCi/m<sup>3</sup>. LLD sensitivities for the remaining 25 indicator and control station samples ranged from  $<0.7 \times 10^{-3}$  to  $<2.0 \times 10^{-3}$  pCi/m<sup>3</sup>. The grand average was  $2.0 \times 10^{-3}$ . The maximum preoperational level detected was  $7.8 \times 10^{-3}$  pCi/m<sup>3</sup>.
- Gross beta activity was detected in 253 of the indicator station samples at concentrations ranging from  $8.4 \times 10^{-3}$  to  $88 \times 10^{-3}$  pCi/m<sup>3</sup> and in 51 control station samples from  $7.6 \times 10^{-3}$  to  $43 \times 10^{-3}$  pCi/m<sup>3</sup>. The average for both indicator and control station samples was  $23 \times 10^{-3}$  pCi/m<sup>3</sup>. The maximum pre-operational level detected was  $920 \times 10^{-3}$  pCi/m<sup>3</sup>, with an average of  $74 \times 10^{-3}$  pCi/m<sup>3</sup>.
- Gamma spectrometric analysis performed on each of the 24 quarterly composite samples analyzed, indicated the presence of the naturally-occurring radionuclide Be-7, and the radionuclide Co-58. All other gamma emitters searched for were below the Lower Limit of Detection.

- Beryllium-7, attributed to cosmic ray activity in the atmosphere, was detected in all twenty indicator station composites that were analyzed, at concentrations ranging from  $42 \times 10^{-3}$  to  $90 \times 10^{-3}$  pCi/m<sup>3</sup> and in the four control station composites from  $47 \times 10^{-3}$  to  $92 \times 10^{-3}$  pCi/m<sup>3</sup>. The maximum preoperational level detected was  $330 \times 10^{-3}$  pCi/m<sup>3</sup>, with an average of  $109 \times 10^{-3}$  pCi/m<sup>3</sup>.
- Cobalt-58 was detected in one of the indicator stations' composites at a concentration of  $1.2 \times 10^{-3}$ . It was not detected in any of the control station samples. LLD sensitivities for both the indicator and control station samples ranged from  $<0.1$  to  $<0.5$  pCi/m<sup>3</sup>. No preoperational data is available for comparison.
- Strontium-89 and strontium-90 analyses were performed on five indicator station composites and one control station composite from the first quarter composites as management audit analyses.
  - Strontium-89 was not detected in any of the indicator or the control composites analyzed. LLD sensitivities for both the indicator and control station samples ranged from  $<0.3 \times 10^{-3}$  to  $<1.0 \times 10^{-3}$  pCi/m<sup>3</sup>. The maximum preoperational level detected was  $4.7 \times 10^{-3}$  pCi/m<sup>3</sup>.
  - Strontium-90 was not detected in any of the indicator or control station composites analyzed. LLD sensitivities for both the indicator and control station samples were  $<0.2 \times 10^{-3}$  to  $<0.3 \times 10^{-3}$  pCi/m<sup>3</sup>. The maximum preoperational level detected was  $3.0 \times 10^{-3}$  pCi/m<sup>3</sup>.

#### Air Iodine (Table C-4)

Iodine in filtered air samples was collected at six locations. Each of the 304 weekly samples collected was analyzed for I-131.

- Iodine-131 was not detected in any of the 304 weekly samples analyzed. LLD sensitivities for the 253 indicator station samples ranged from  $<1.4 \times 10^{-3}$  to  $<30 \times 10^{-3}$  pCi/m<sup>3</sup>. LLD sensitivities for the 51 control station samples ranged from  $<2.1 \times 10^{-3}$  to  $<12 \times 10^{-3}$  pCi/m<sup>3</sup>. The maximum preoperational level detected was  $42 \times 10^{-3}$  pCi/m<sup>3</sup>.

#### Precipitation (Table C-6)

Although not required by the SGS or HCGS Technical Specifications, monthly precipitation samples were collected at a location in the town of Salem as management audit samples. Each of the ten monthly samples collected were analyzed for gross alpha, gross beta, tritium gamma emitters.

- Gross alpha activity was detected in two of the ten samples collected at a concentration of 0.7 and 2.6 pCi/L. LLD sensitivities for the remaining eight samples ranged from <0.9 to <4.3 pCi/L. The maximum preoperational level detected was 4.7 pCi/L.
- Gross beta activity was detected in nine samples at concentrations ranging from 0.5 to 4.5 pCi/L, with an average of 1.8 pCi/L. The LLD value of the remaining sample was <0.9 pCi/L. The maximum preoperational level detected was 71 pCi/L, with an average of 19 pCi/L.
- Tritium activity was detected in only one of the ten samples, at a value of 130 pCi/L. LLD sensitivities for the remaining nine samples ranged from <110 to <190 pCi/L. The maximum preoperational level detected was 610 pCi/L, with an average of 216 pCi/L.
- Gamma spectrometric analysis was performed on all ten of the monthly samples. Analysis indicated the presence of the naturally-occurring radionuclides Be-7, K-40 and Radium. All other gamma emitters searched for were below the Lower Limit of Detection.
  - Beryllium-7, attributed to cosmic ray activity, was detected in seven of the ten samples at concentrations ranging from 39 to 120 pCi/L, with an average of 50 pCi/L. The maximum preoperational level detected was 79 pCi/L, with an average of 29 pCi/L. The increase in the naturally-occurring Be-7 activity over preoperational levels is most likely due to spallation reactions in the upper atmosphere.
  - Potassium-40 activity was detected in two samples at concentrations of 56 and 60 pCi/L. The maximum preoperational level detected was 18 pCi/L. This increase over preoperational levels is most likely due to the sampling stations relatively close proximity to an estuarian environment.
  - Radium activity was detected in two of the samples at 7.3 and 8.3 pCi/L. The LLD sensitivities measured throughout the year for the remaining eight samples ranged from <1.8 to <11 pCi/L. No preoperational data is available for comparison. However, the presence of Radium is not attributable to the operations of SGS or HCGS.

## DIRECT RADIATION

Ambient radiation levels in the environs were measured with energy-compensated  $\text{CaSO}_4$  (Dy) thermoluminescent dosimeters (TLDs) supplied and read by Teledyne Isotopes. Packets for monthly and quarterly exposure were placed on and around the Artificial Island Site at various distances.

## Direct Radiation (Tables C-7, C-8)

total of 43 locations were monitored for direct radiation during 1993, including 6 on-site locations, 29 off-site locations within the 10 mile zone, and 6 control locations beyond 10 miles. Monthly and quarterly measurements were made at the 6 on-site stations, 15 off-site indicator stations and 3 control stations. An additional 14 quarterly measurements were taken at schools and population centers, with 3 additional controls beyond the 10 mile zone in Delaware.

■ Four readings for each TLD at each location were taken in order to obtain a more statistically valid result. For these measurements, the rad is considered equivalent to the rem, in accordance with 10CFR20.4.

- The average dose rate for the 15 monthly off-site indicator TLDs was 6.0 millirads per standard month, and the corresponding average control dose rate was 6.5 millirads per standard month. The preoperational average monthly TLD readings was 4.6 millirads per standard month.
- The averages for the quarterly TLD's were based on only the first three quarters of 1993. The fourth quarter results were invalidated by Teledyne Isotopes (See Program Deviations). The average dose rate for the 29 quarterly off-site indicator TLDs was 5.3 millirads per standard month, and the average control rate was 5.0 millirads per standard month. The preoperational average quarterly TLD readings was 4.4 millirads per standard month.

In Figure 7, the quarterly average radiation levels of the offsite indicator stations versus the control stations, are plotted for the year period from 1974 through 1993.

## TERRESTRIAL

Milk samples were taken semi-monthly when cows were on pasture and monthly when cows were not grazing on open pasture. Samples were collected in new polyethylene containers and transported in ice chests with no preservatives added.

Well water samples were collected monthly by PSE&G personnel. Separate raw and treated potable water samples were composited daily by personnel of the City of Salem water treatment plant. All samples were collected in new polyethylene containers.

Locally grown vegetable and fodder crops are collected once a year time of harvest. Such samples are weighed in the field at time pickup and then packed in plastic bags. Grass or green chop is collected from grazing areas, where possible.

Game (muskrat) is collected annually (time of year dependent on weather conditions, which affect pelt thickness) from local farms after being trapped, stripped of their pelts and gutted. The carcasses are packed in plastic bags and kept chilled in ice chests during transport.

#### Milk (Tables C-9, C-10)

Milk samples were collected at four local dairy farms. Samples were collected semi-monthly when cows were on pasture and monthly when cows were not on pasture. Animals are considered on pasture from April to November of each year. Each sample was analyzed for I-131 and gamma emitters. In addition, although not specifically required by the SGS and HCGS Technical Specifications, one sample from each location was analyzed for Sr-89 and Sr-90 in order to maintain the data base developed in prior years.

- Iodine-131 was not detected in any of the 80 samples analyzed. LLD sensitivities for the 60 indicator station samples ranged from  $<0.1$  to  $<0.8$  pCi/L and for the 20 control station samples from  $<0.2$  to  $<0.8$  pCi/L. The maximum preoperational level detected was 65 pCi/L which occurred following a period of atmospheric nuclear weapons tests.
- Gamma spectrometric analysis performed on each of the 80 samples indicated the presence of the naturally-occurring radionuclide K-40. All other gamma emitters searched for were below the Lower Limit of Detection.
  - Potassium-40 was detected in all 80 samples. Concentrations for the 60 indicator station samples ranged from 930 to 1500 pCi/L, with an average of 1350 pCi/L. The 20 control station sample concentrations ranged from 1200 to 1400 pCi/L, with an average of 1300 pCi/L. The maximum preoperational level detected was 2000 pCi/L, with an average of 1437 pCi/L.
- Strontium-89 and strontium-90 analyses were performed on three indicator station samples and one control station sample from the first sampling period in July, as management audit samples.
  - Strontium-89 was not detected in any of the three indicator samples analyzed nor in the control station sample. LLD sensitivities for the indicator samples ranged from  $<0.8$  to  $<1.4$  pCi/L and for the control station at  $<1.1$  pCi/L. The maximum preoperational level detected was 14 pCi/L.
  - Strontium-90 was detected in all of the three indicator samples analyzed. Average concentrations for the indicator station samples was 2.5 pCi/L and for the control station sample at 2.2 pCi/L. The average concentration for all samples was 2.5 pCi/L.

The maximum preoperational level detected was 12 pCi/L, with an average of 3.5 pCi/L. The presence of Sr-90 in the samples can be attributed to fallout from previous nuclear weapons testing.

#### Well Water (Ground Water) (Tables C-11, C-12, C-13)

Although wells in the vicinity of the Salem and Hope Creek Generating Station are not directly affected by plant operations, water samples were collected monthly from one indicator well and one control well during January through December of the year. Each sample was analyzed for gross alpha, gross beta, potassium-40, tritium, I-131 and gamma emitters. Quarterly composites were analyzed for Sr-89 and Sr-90.

- Gross alpha activity was detected in one of the indicator station samples at a concentration of 5.9 pCi/L. Activity was detected in two of the control station samples at concentrations of 1.7 and 1.8 pCi/L. LLD values ranged from <0.4 to <4.7 pCi/L for both the indicator and control station samples. The maximum preoperational level detected was 9.6 pCi/L.
- Gross beta activity was detected in all 24 samples. Concentrations for the 12 indicator station samples ranged from 2.7 to 4.4 pCi/L, with an average of 3.3 pCi/L. Concentrations for the 12 control station samples ranged from 8.8 to 11 pCi/L, with an average concentration of 10 pCi/L. The combined average for both stations was 6.7 pCi/L. The maximum preoperational level detected was 38 pCi/L, with an average of 9 pCi/L.
- Potassium-40 activity (determined by atomic absorption) was detected in all 24 samples. Concentrations for the 12 indicator station samples ranged from 3.0 to 3.6 pCi/L, with an average of 3.4 pCi/L. Concentrations for the 12 control station samples ranged from 6.5 to 12 pCi/L, with an average of 9.8 pCi/L. The average concentration detected for all samples was 6.6 pCi/L. The maximum preoperational level detected was 19 pCi/L, with an average of 7.8 pCi/L.
- Tritium activity was detected in three of the indicator station samples at concentrations ranging from 140 to 350 pCi/L. There was no Tritium activity detected in any of the control station samples. The LLD sensitivities for the remaining 21 samples ranged from <110 to <210 pCi/L. The maximum preoperational level detected was 380 pCi/L.
- Gamma spectrometric analysis performed on each of the 12 indicator station and 12 control station water samples indicated the presence of the naturally-occurring radionuclides K-40 and Radium. All other gamma emitters searched for were below the Lower Limit of Detection.



- Radium was detected in ten of the indicator station samples at concentrations ranging from 9.3 to 150 pCi/L and in all twelve control station samples from 56 to 160 pCi/L. LLD sensitivities for the remaining two samples were <4.5 and <7.4 pCi/L. The maximum preoperational level detected was 2.0 pCi/L.

These values are similar to those found last year. However, as with the 1989 through 1992 results, they are higher values than found in the preoperational program. We believe that results are higher due to a procedural change in which the samples are no longer boiled down to a 100 ml standard geometry. This change results in less removal of radon (and its daughters) from the sample. Since Ra-226 is an alpha emitter, its identification by gamma isotopic analysis is obtained by counting the gamma rays from Pb-214, one of its daughter products. We believe that values currently being observed are typical for this geographical area.

- Potassium-40 was detected in only one of the indicator station samples with a concentration of 64 pCi/L, and not detected in any of the control station samples. LLD values for both stations ranged from <8.9 to <60 pCi/L. The maximum preoperational level detected was 30 pCi/L.

■ Strontium-89 and strontium-90 analyses were performed on quarterly composites of the monthly well water samples.

- Strontium-89 was not detected in any of the four indicator station or four control station composites. LLD sensitivities for the indicator samples ranged from <0.6 to <1.1 pCi/L and for the control samples from <0.5 to <0.8 pCi/L. The maximum preoperational level detected was <2.1 pCi/L.
- Strontium-90 was not detected in any of the four indicator station or four control station composites. LLD sensitivities for indicator samples ranged from <0.5 to <0.8 pCi/L and for the control samples from <0.4 to <0.5 pCi/L. The maximum preoperational level detected was 0.87 pCi/L.

■ Iodine-131 was not detected in any of the twelve indicator station samples or control station samples. LLD sensitivities for all the stations, indicator and control, ranged from <0.1 to <0.4 pCi/L.

#### Potable Water (Drinking Water) (Tables C-14, C-15, C-16)

Both raw and treated potable water samples were collected from the Salem water treatment plant. Each consisted of daily aliquots composited into a monthly sample. The raw water source for this plant is Laurel Lake and adjacent wells.

Each of the 24 individual samples was analyzed for gross alpha, gross beta, K-40, tritium, iodine-131 and gamma emitters. Quarterly composites of monthly raw and treated water samples were analyzed for Sr-89 and Sr-90.

- Gross alpha activity was detected in five raw water samples at concentrations of 0.8 to 3.2 pCi/L and in three treated water samples at 0.9 to 1.5 pCi/L. The averages for both raw and treated water samples was 1.4 pCi/L. The maximum pre-operational level detected was 2.7 pCi/L.
- Gross beta activity was detected in all 24 samples at concentrations ranging from 1.9 to 4.4 pCi/L for the raw water and from 2.1 to 4.0 pCi/L for treated water. The average concentration for both raw and treated was 3.0 pCi/L. The maximum preoperational level detected was 9.0 pCi/L, with an average of 4.2 pCi/L.
- Potassium-40 activity (determined by atomic absorption) was detected in all 24 samples at concentrations ranging from 1.4 to 2.9 pCi/L for the raw water and from 1.6 to 3.1 pCi/L for treated water. The average concentration for both raw and treated was 2.0 pCi/L. The maximum preoperational level detected was 10 pCi/L, with an average of 1.7 pCi/L.
- Tritium activity was only detected in four raw water samples at concentrations of 150 to 240 pCi/L, and not in any of the treated water samples. LLD sensitivities for the remaining 20 samples ranged from <110 to <200 pCi/L. The maximum preoperational level detected was 350 pCi/L, with an average of 179 pCi/L.
- Iodine-131 measurements to a sensitivity of 1.0 pCi/L were performed. Since the receiving water body (Delaware River) is brackish, the water is not used for human consumption. Drinking water supplies are not affected by discharges from the site. Iodine-131 measurements for all 24 samples were below the LLD sensitivities. The LLD sensitivities ranged from <0.1 to <0.6 pCi/L.
- Gamma spectrometric analysis performed on each of the 24 monthly water samples indicated the presence of the naturally-occurring radionuclide Radium. All other gamma emitters searched for were below the Lower Limit of Detection.
- The radionuclide K-40 was not detected in any of the potable water samples. Since gamma analyses does not require the water samples to be concentrated down to a volume of 100mL, K-40 results obtained through gamma analyses, are not as sensitive as the results obtained from atomic absorption. The minimum detection value for K-40 analyses as indicated by the LLD, ranged from <12 to <45 pCi/L. No preoperational data is available for comparison.

- Radium was only detected in one potable raw sample at a concentration of 27 pCi/L. It was detected in two treated samples at concentrations of 5.2 and 6.8 pCi/L. LLD sensitivities for both raw and treated waters ranged from <1.3 to <6.3 pCi/L. The maximum preoperational level detected was 1.4 pCi/L.
- Strontium-89 and strontium-90 analyses were performed on quarterly composites of the daily raw and treated water samples.
  - Strontium-89 was not detected in any of the four raw or treated water composites. LLD sensitivities for the raw water sample composites ranged from <0.6 to <0.8 pCi/L and for the treated water sample composites from <0.5 to <0.8 pCi/L. The maximum preoperational level detected was 1.1 pCi/L.
  - Strontium-90 was not detected in any of the four raw or treated water sample composites. LLD sensitivities for the four treated water sample composites ranged from <0.5 to <0.6 pCi/L and for the raw water sample composites from <0.5 to <0.6 pCi/L. The maximum preoperational level detected was 2.1 pCi/L.

#### Vegetables (Table C-17)

Although vegetables in the region are not irrigated with water in which liquid plant effluents have been discharged, a variety of food products grown in the area for human consumption were sampled at four indicator stations (8 samples) and four control stations (9 samples). The vegetables collected as management audit samples are analyzed for gamma emitters and included asparagus, cabbage, sweet corn, peppers and tomatoes.

- Gamma spectrometric analysis performed on each of the seventeen samples indicated the presence of the naturally occurring radionuclide K-40. All other gamma emitters searched for were below the Lower Limit of Detection.
- Potassium-40 was detected in all seventeen samples. Concentrations for the eight indicator station samples ranged from 1300 to 2600 pCi/kg-wet and for the nine control station samples from 1000 to 2800 pCi/kg-wet. The average concentration detected for all samples was 1980 pCi/kg-wet. The maximum preoperational level detected was 4800 pCi/kg-wet, with an average of 2140 pCi/kg-wet.

#### Game (Table C-18)

Although not required by the SGS or HCGS Technical Specifications, samples of muskrats, inhabiting the marshlands surrounding the site, are collected.

This game is consumed by local residents. The samples, when available, are collected from two locations once a year as management audit samples and analyzed for gamma emitters. Samples from two locations were collected during the months of January and February to satisfy this requirement.

- Gamma spectrometric analysis of the flesh indicated the presence of the naturally-occurring radionuclide K-40. All other gamma emitters searched for were below the Lower Limit of Detection.

- Potassium-40 was detected in the indicator station sample at a concentration of 2000 pCi/kg-wet and the control station sample at 2300 pCi/kg-wet. The average for both muskrat samples was 2150 pCi/kg-wet. The maximum preoperational level detected was 27000 pCi/kg-wet, with an average of 4400 pCi/kg-wet.

#### BEEF (Table C-18)

Although not required by the SGS or HCGS Technical Specifications, beef samples are collected, when available, as management audit samples and analyzed for gamma emitters. One beef sample from the first half of the year was collected.

- Gamma spectrometric analysis of the flesh indicated the presence of the naturally-occurring radionuclide K-40. All other gamma emitters searched for were below the Lower Limit of Detection.

- Potassium-40 was detected in the one beef sample at a concentration of 2600 pCi/kg-wet. The maximum pre-operational level detected was 4800 pCi/kg-wet.

#### Fodder Crops (Table C-19)

Although not required by the SGS or HCGS Technical Specifications, eight samples of crops normally used as cattle feed were collected from three indicator stations (6 samples) and one control station (2 samples). It was determined that these products may be a significant element in the food-chain pathway. Fodder crops are collected as management audit samples and analyzed for gamma emitters. Four of the locations from which samples were collected are milk sampling stations. Samples collected for wet gamma analysis included silage and soybeans.

- Gamma spectrometric analysis performed on each of the eight samples indicated the presence of the naturally-occurring radionuclides Be-7, K-40, and Radium. All other gamma emitters searched for were below the Lower Limit of Detection.

- Beryllium-7, attributed to cosmic ray activity in the atmosphere, was detected in the three silage samples from the indicator stations at concentrations ranging from 530 to 1100 pCi/kg-wet, with an average of 800 pCi/kg-wet. It was detected in the control station silage sample at 940 pCi/kg-wet. The maximum preoperational level detected for silage was 4700 pCi/kg-wet, with an average of 2000 pCi/kg-wet. LLD sensitivities for the remaining three indicator soybean samples ranged from <48 to <150 pCi/kg-wet. The control station soybean sample was <43 pCi/kg-wet. The maximum preoperational level detected for soybean samples was 9300 pCi/kg-dry.
- Potassium-40 was detected in all eight samples. Concentrations for the six indicator station samples ranged from 2800 to 17000 pCi/kg-wet and for the two control station samples from 6500 to 12000 pCi/kg-wet. The average concentration detected for the corn silage samples was 5100 pCi/kg-wet which was comparable to preoperational results which averaged 7000 pCi/kg-wet. Although the Research and Testing Laboratory no longer reports results based upon the dry weight of the sample, soybean results were comparable to preoperational studies. Results averaged 14750 pCi/kg-wet which was comparable to preoperational results of 22000 pCi/kg-dry.

## AQUATIC

All aquatic samples were collected by Environmental Consulting Services, Inc. and delivered by PSE&G personnel. Surface water samples were collected in new polyethylene containers which were rinsed twice with the sample medium prior to collection. Edible fish and crabs are taken by net and then processed. In processing, the flesh is separated from the bone and shell and placed in sealed polyethylene containers and frozen before being transported in ice chests.

Sediment samples were taken with a bottom grab sampler and frozen in sealed polyethylene containers before being transported in ice chests.

### Surface Water (Tables C-20, C-21, C-22, C-23)

Surface water samples were collected monthly at four indicator stations and one control station in the Delaware estuary. One location is at the outfall area (which is the area where liquid radioactive effluents from the Salem Station are allowed to be discharged into the Delaware River), another is downstream from the outfall area, and another is directly west of the outfall area at the mouth of the Appoquinimink River. Two upstream locations are on the Delaware River and at the mouth of the Chesapeake and Delaware Canal, the latter being sampled when the flow is from the Canal into the river.

Station 12C1, at the mouth of the Appoquinimink River, serves as the operational control. All surface water samples were analyzed monthly for gross alpha, gross beta, and gamma emitters. Quarterly composites were analyzed for tritium.

- Gross alpha activity was detected in 15 samples from the 48 indicator stations at concentrations ranging from 1.4 to 4.7 pCi/L and in three control station samples from 2.0 to 2.8 pCi/L. These values are within the variations of the LLD sensitivities for the remaining samples which ranged from <1.3 to <3.7 pCi/L. The maximum preoperational level detected was 27 pCi/L.
- Gross beta activity was detected in 46 of the 48 indicator station samples ranging from 4 to 120 pCi/L, with an average of 53 pCi/L. Beta activity was detected in 11 of the control station samples with concentrations ranging from 6 to 90 pCi/L, with an average of 52 pCi/L. The maximum preoperational level detected was 110 pCi/L, with an average of 32 pCi/L.
- Tritium activity was detected in three samples from the sixteen indicator station composites at concentrations from 130 to 460 pCi/L, with an average of 330 pCi/L. There was no tritium detected in any of the four control station composites. LLD sensitivities for the remaining composites, both indicator and control, ranged from <110 to <200 pCi/L. The maximum preoperational level detected was 600 pCi/L, with an average of 210 pCi/L.
- Gamma spectrometric analysis performed on each of the 48 indicator station and 12 control station surface water samples indicated the presence of Co-58, Co-60, Cs-137 and the naturally-occurring radionuclides K-40 and Radium. All other gamma emitters searched for were below the Lower Limit of Detection.
- Potassium-40 was detected in 31 samples from the indicator station samples at concentrations ranging from 30 to 150 pCi/L and in seven of the control station samples ranging from 48 to 130 pCi/L. The average for the indicator station locations was 85 pCi/L, while the average for the control station locations was 81 pCi/L. LLD sensitivities measured throughout the year for the remaining samples ranged from <11 to <42 pCi/L. The maximum preoperational level detected was 200 pCi/L, with an average of 48 pCi/L.
- Radium was detected in four samples out of the 48 indicator stations, at an average concentration of 8.5 pCi/L. It was only detected in one of the control station samples at a concentration of 7 pCi/L. The LLD sensitivities for all remaining samples measured throughout the year ranged from <0.6 to <6.8 pCi/L. The maximum preoperational level detected was 4.0 pCi/L.

- Cobalt-58 was detected in one indicator station sample at a concentration of 5.5 pCi/L. LLD sensitivities for the remaining indicator and the control station samples measured throughout the year ranged from <0.3 to <4.2 pCi/L. The presence of Co-58 in this sample can be attributed to sampling during a radioactive liquid effluent release.
- Cobalt-60 was detected in one indicator station sample at a concentration of 4.0 pCi/L. LLD sensitivities for the remaining indicator and the control station samples ranged from <0.3 to <3.2 pCi/L. The presence of Co-60 in this sample can be attributed to sampling during a radioactive liquid effluent release.
- Cesium-137 was also detected in the one indicator station sample at a concentration of 5.4 pCi/L. LLD sensitivities for the remaining indicator and the control station samples ranged from <0.2 to <3.0 pCi/L. The presence of Cs-137 in this sample can be attributed to sampling during a radioactive liquid effluent release.

#### Fish (Table C-24)

Edible species of fish were collected semi-annually at three locations and analyzed for tritium (aqueous), gamma emitters (flesh), and for Sr-89 and Sr-90 (bones & flesh). Samples included catfish, weakfish, white perch and striped bass.

- Tritium analysis was performed on the aqueous fraction of the flesh portions of each of the four samples from the two indicator stations and the two samples from the control station as management audit analyses. Tritium activity was detected in one of the four indicator station samples at a concentration of 170 pCi/kg-wet, and in one of the two control station samples at a concentration of 150 pCi/kg-wet. LLD sensitivities for the remaining indicator and control station samples ranged from <90 to <100 pCi/kg-wet.
- Gamma spectrometric analysis performed on each of the four indicator station samples and two control station samples indicated the presence of the naturally-occurring radionuclide K-40. All other gamma emitters searched for were below the Lower Limit of Detection.
- Potassium-40 was detected in all four samples from the two indicator stations at concentrations ranging from 2600 to 3100 pCi/kg-wet for an average of 2900 pCi/kg-wet. K-40 was detected in both samples from the control station samples at 2700 and 3500 pCi/kg-wet. The average for the control samples was 3100 pCi/kg-wet. The maximum preoperational level detected was 13000 pCi/kg-wet, with an average of 2 pCi/kg-wet.

■ Strontium-89 and strontium-90 analyses were performed on each of the four indicator station and two control station samples. These are management audit analyses analyzed in recognition of the high bioaccumulation factor of strontium in bone.

- Strontium-89 was not detected in any of the indicator or control station bone samples. LLD sensitivities for the samples, both indicator and control, ranged from <16 to <70 pCi/kg-dry. The maximum preoperational level detected was 100 pCi/kg-dry.
- Strontium-90 was detected in all four indicator station bone samples and in both control station bone samples. Concentrations in the indicator samples averaged 120 pCi/kg-dry. The concentrations in the control samples was 105 pCi/kg-dry. The average for all samples was 115 pCi/kg-dry. The maximum preoperational level detected was 940 pCi/kg-dry, with an average of 335 pCi/kg-dry. The presence of Sr-90 in the samples can be attributed to fallout from previous nuclear weapons testing.
- Strontium-89 of the flesh was not detected in any of the six indicator and control station samples. LLD sensitivities for the six samples, indicator and control, ranged from <25 to <42 pCi/kg-wet. The preoperational level ranged from <4.1 to <100 pCi/kg-wet.
- Strontium-90 of the flesh was not detected in any of the six indicator and control station samples. LLD sensitivities for the six samples, indicator and control, ranged from <18 to <29 pCi/kg-wet. The maximum preoperational level detected was 67 pCi/kg-wet.

#### Blue Crab (Table C-25)

Blue crab samples were collected semi-annually at two locations, one indicator and one control, and the edible portions were analyzed for gamma emitters, Sr-89 and Sr-90, while the aqueous fraction was analyzed for tritium. The crab shells were also analyzed for Sr-89 and Sr-90.

■ Tritium analysis was performed on the aqueous fraction of the flesh portions of each of the two indicator samples and two control samples as management audit analysis. No tritium activity was detected in any of the four station or control samples analyzed. LLD sensitivities for the four samples, indicator and control, ranged between <90 to <100 pCi/kg-wet. The maximum preoperational level detected was 320 pCi/kg-wet.

■ Gamma spectrometric analysis on the flesh of each of the two indicator station samples and two control station samples indicated the presence of the naturally-occurring radionuclides Radium and K-40. All other gamma emitters searched for were below the Lower Limit of Detection.



- Potassium-40 was detected in both indicator station samples at concentrations of 2700 and 2900 pCi/kg-wet and in both of the control station samples at 2200 and 2500 pCi/kg-wet. The average for both the indicator and control station samples was 2600 pCi/kg-wet. The maximum preoperational level detected was 12000 pCi/kg-wet, with an average of 2835 pCi/kg-wet.

■ Strontium-89 and strontium-90 analyses were performed on the flesh and shell of each of the indicator station and control station samples, as management audit analyses. Strontium analysis of the shell is performed because of the reconcentration factor of strontium in crab shells.

- Strontium-89 of the flesh was not detected in any of the four samples, indicator nor control. LLD sensitivities for all the samples ranged from <24 to <31 pCi/kg-wet. The maximum preoperational level detected was <51 pCi/kg-wet.
- Strontium-89 of the shell was not detected in any of the four samples, indicator nor control. LLD sensitivities for all the samples, indicator and control, ranged from <37 to <72 pCi/kg-dry. The maximum preoperational level detected was 210 pCi/kg-dry.
- Strontium-90 of the flesh was not detected in any of the four, indicator or control samples. LLD sensitivities for these station samples ranged from <15 to <20 pCi/kg-wet. The maximum preoperational level detected was <150 pCi/kg-wet.
- Strontium-90 of the shell was detected in both indicator station samples at 180 and 200 pCi/kg-dry and in both of the control station samples at 140 and 200 pCi/kg-dry. The average for both indicator and control station samples was 180 pCi/kg-dry. The maximum preoperational level detected was 990 pCi/kg-dry, with an average of 614 pCi/kg-dry. The presence of Sr-90 can be attributed to fallout from weapons testing or fallout from the Chernobyl accident.

#### Sediment (Table C-26)

Sediment samples were collected semi-annually from six locations, five indicator stations and one control station. Each of the twelve samples was analyzed for Sr-90 (management audit analysis) and gamma emitters. Although trace levels of man-made nuclides were detected in some sediment samples, these levels were expected and well within the acceptable levels specified in section 3/4.12.1 of the Technical Specifications.

- Strontium-90 was detected in one of the ten indicator station samples, at a concentration of 48 pCi/kg-dry, but was not detected in any of the control station samples.

LLD sensitivities for those remaining samples, both indicator and control, ranged from <22 to <76 pCi/kg-dry. The maximum preoperational level detected was 320 pCi/kg-dry.

Gamma spectrometric analysis was performed on each of the ten indicator station samples and two control station samples. In addition to the detection of the naturally-occurring radionuclides Radium, K-40 and Th-232, low levels of Mn-54, Co-58, Co-60, Cs-134 and Cs-137 were also detected. All other gamma emitters searched for were <LLD.

- Manganese-54 was detected in three of the ten indicator stations at concentrations ranging from 23 to 41 pCi/kg-dry, with an average of 31 pCi/kg-dry. It was not detected in either of the two control station samples. LLD sensitivities for the other nine samples, both indicator and control, ranged from <7.5 to <26 pCi/kg-dry. No preoperational data is available for comparison.
- Cobalt-58 was detected in six indicator station samples at concentrations ranging from 45 to 83 pCi/kg-dry. The LLD sensitivities for the other six samples, indicator and control, ranged from <7.9 to <21 pCi/kg-dry. No preoperational data is available for comparison.
- Cobalt-60 was detected in six of the ten indicator stations at concentrations ranging from 34 to 140 pCi/kg-dry, with an average of 87 pCi/kg-dry. It was not detected at either of the two control stations. LLD sensitivities for the other six samples, indicator and control, ranged from <10 to <38 pCi/kg-dry. No preoperational data is available for comparison.
- Cesium-134 was detected in four indicator station samples at concentrations ranging from 46 to 70 pCi/kg-dry, with an average of 59 pCi/kg-dry. It was detected in one control station sample at a concentration of 49 pCi/kg-dry. LLD sensitivities for the other seven samples, indicator and control, ranged from <5.2 to <36 pCi/kg-dry. No preoperational data is available for comparison.
- Cesium-137 was detected in six indicator station samples at concentrations ranging from 33 to 180 pCi/kg-dry, but was not detected in either control station sample. The LLD sensitivities for the other six samples, both indicator and control, ranged from <4.8 to <16 pCi/kg-dry. The maximum preoperational level detected was 400 pCi/kg-dry.
- Potassium-40 was detected in all ten indicator station samples at concentrations ranging from 3200 to 18000 pCi/kg-dry, with an average of 10770 pCi/kg-dry. Concentrations detected in both of the control station samples were at 13000 and 16000 pCi/kg-dry.

The average for both the indicator and control station samples was 11400 pCi/kg-dry. The maximum preoperational level detected was 21000 pCi/kg-dry, with an average of 15000 pCi/kg-dry.

- Radium was detected in all ten indicator station samples at concentrations ranging from 290 to 1900 pCi/kg-dry, with an average of 786 pCi/kg-dry. Concentrations detected in both of the control station samples were at 590 and 860 pCi/kg-dry, with an average of 725 pCi/kg-dry. The average for both the indicator and control station samples was 780 pCi/kg-dry. The maximum preoperational level detected was 1200 pCi/kg-dry, with an average of 760 pCi/kg-dry.
- Thorium-232 was detected in all ten indicator station samples at concentrations ranging from 430 to 1600 pCi/kg-dry, with an average of 852 pCi/kg-dry. Concentrations detected in both of the control station samples were at 790 and 830 pCi/kg-dry, with an average of 810 pCi/kg-dry. The average for both the indicator and control station samples was 845 pCi/kg-dry. The maximum preoperational level detected was 1300 pCi/kg-dry, with an average of 840 pCi/kg-dry.

## PROGRAM DEVIATIONS

Air Particulate and iodine sampler location 3H3, which is located on the roof of the Research and Testing Laboratory, was operational for only 3 1/4 days out of a 7 day sampling period (for the week beginning March 1). This unscheduled power outage was due to severe storm conditions.

Air particulate and iodine sampler location 5S1 experienced an extended power outage beginning on June 12th and lasting until June 25th. This outage was due to Atlantic City Electric Company's Station Feed Transformer experiencing a failure and being replaced. The duration of this outage was 192 hours, resulting in two weeks of data not being included in any averages.

On several occasions during October and November, the air sampler at location 2F2 experienced several power interruptions. The air sampler was removed, returned to the Research and Testing Laboratory and serviced. During servicing a faulty neutral connection was identified. The poor ground connection resulted in intermittent faults in the power supply outlet circuit. A new ground connection was made and the problem with recurring breaker trips ceased. This problem resulted in four weeks of data not being included in any averages. Although the data from location 2F2 was not available for the periods discussed above, a review of the data from the adjacent air sampling locations collected during this period indicated no unusual results. Data recovery for air particulate and air iodine results for all stations was 97.9%.

Air particulate and iodine sampler location 16E1 experienced an equipment malfunction shortly after servicing for the week beginning on November 29th. The defective breaker was replaced the following week.

The fourth quarter TLD results were invalidated by Teledyne Brown Engineering - Environmental Services Corporation (formerly Teledyne Isotopes). The problem was due to a faulty TLD reader which yielded irregular exposure in the different areas of the TLDs. The data from the fourth quarter could not be salvaged. To prevent reoccurrence, PSE&G has installed an additional set of quarterly TLDs at all locations to be held, in reserve and not normally read. In the event that any set of TLDs exhibit erratic exposures, the reserve set of TLDs will be read. Results from the monthly TLD's collected and analyzed during this quarter were reviewed and did not vary significantly from the other three quarters.

## CONCLUSIONS

The Radiological Environmental Monitoring Program for Artificial Island was conducted during 1993 in accordance with the SGS and H Technical Specifications. The Lower Limit of Detection (LLD) values required by the Technical Specifications were achieved for this reporting period. The objectives of the program were also met during this period. The data collected assists in demonstrating that SGS Units One and Two and HCGS were operated in compliance with Technical Specifications.

From the results obtained, it can be concluded that the levels and fluctuations of radioactivity in environmental samples were as expected for an estuarine environment. No unusual radiological characteristics were observed in the environs of Artificial Island during this reporting period. Since these results were comparable to the results obtained during the preoperational phase of the program which ran from 1973 to 1976, we can conclude that the operation of SGS Units One and Two and HCGS had no significant impact on the radiological characteristics of the environs of Artificial Island.

TABLE 2

## ARTIFICIAL ISLAND RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

MEDIUM	STATION CODE					COLLECTION FREQUENCY	TYPE/FREQUENCY* OF ANALYSIS
	INDICATOR				CONTROL		
<u>I. ATMOSPHERIC ENVIRONMENT</u>							
a. Air Particulate	5S1 2F2	5D1	16E1	1F1	3H3	Weekly	Gross alpha/weekly Gross beta/weekly Sr-89 & Sr-90/first quarter** Gamma scan/quarterly
b. Air Iodine	5S1 2F2	5D1	16E1	1F1	3H3	Weekly	Iodine-131/weekly
c. Precipitation	2F2					Monthly	Gross alpha/monthly Gross beta/monthly Tritium/monthly Gamma scan/monthly
<u>II. DIRECT RADIATION</u>							
a. Thermoluminescent Dosimeters	2S2 5S1 6S2 7S1 10S1	5D1 10D1 14D1 16E1 11F1	2E1 3E1 13E1 5F1 13F4	1F1 2F2 2F6 6F1	3G1 3H1 3H3 7F1	Monthly	Gamma dose/monthly
b. Thermoluminescent Dosimeters	2S2 5S1 6S2 7S1 10S1 4D2 11E2 4F2 13F3	5D1 10D1 14D1 16E1 7F1 9E1 15D1 10F2 14F2	2E1 3E1 13E1 5F1 11F1 2F5 12E1 12F1 15F3	1F1 2F2 2F6 6F1 13F4 3F2 3F3 13F2 16F2	3G1 3H1 3H3 1G1 10G1 16G1	Quarterly	Gamma dose/quarterly

TABLE 2 (cont'd)

## ARTIFICIAL ISLAND RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

MEDIUM	STATION CODE		COLLECTION FREQUENCY	TYPE/FREQUENCY* OF ANALYSIS
	INDICATOR	CONTROL		
<u>III. Terrestrial Environment</u>				
a. Milk	2F7 11F3 14F4	3G1	Monthly (when animals are on pasture) Semi-monthly (when animals are on pasture)	Iodine-131/monthly Gamma scan/monthly  Iodine-131/semi-monthly Gamma scan/semi-monthly Sr-89 & Sr-90/July, first collection
b. Well Water	2S3 3E1		Monthly	Gross alpha/monthly Gross beta/monthly Potassium-40/monthly Tritium/monthly Gamma scan/monthly Sr-89 & Sr-90/quarterly
c. Potable Water (Raw & Treated)	2F3		Monthly (composited daily)	Gross alpha/monthly Gross beta/monthly Potassium-40/monthly Tritium/monthly Gamma scan/monthly Sr-89 & Sr-90/quarterly
d. Vegetables	3E1 2F4 3E3 1G1 3H5 4F2 5F3 14F3 2G1 2G2		Annually (at harvest)	Gamma scan/on collection

TABLE 2 (cont'd)

## ARTIFICIAL ISLAND RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

MEDIUM	STATION CODE		COLLECTION FREQUENCY	TYPE/FREQUENCY* OF ANALYSIS
	INDICATOR	CONTROL		
e. Beef	3E1		Semi- annually	Gamma scan/on collection
f. Game (Muskrat)	11D1 3E1		Semi- annually	Gamma scan/on collection
g. Fodder Crops	3E1 2F7 11F3 14F4 3G1		Annually	Gamma scan/on collection
h. Soil	6S1 10D1 16E1 1F1 3G1 2F4 2F7 5F1 11F3 14F4		Collect from each location once every three years	Sr-90/on collection Gamma scan/on collection
<u>IV. AQUATIC ENVIRONMENT</u>				
a. Surface Water	11A1 7E1 1F2 12C1 16F1		Monthly	Gross alpha/monthly Gross beta/monthly Gamma scan/monthly Tritium/quarterly



TABLE 2 (cont'd)

## ARTIFICIAL ISLAND RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

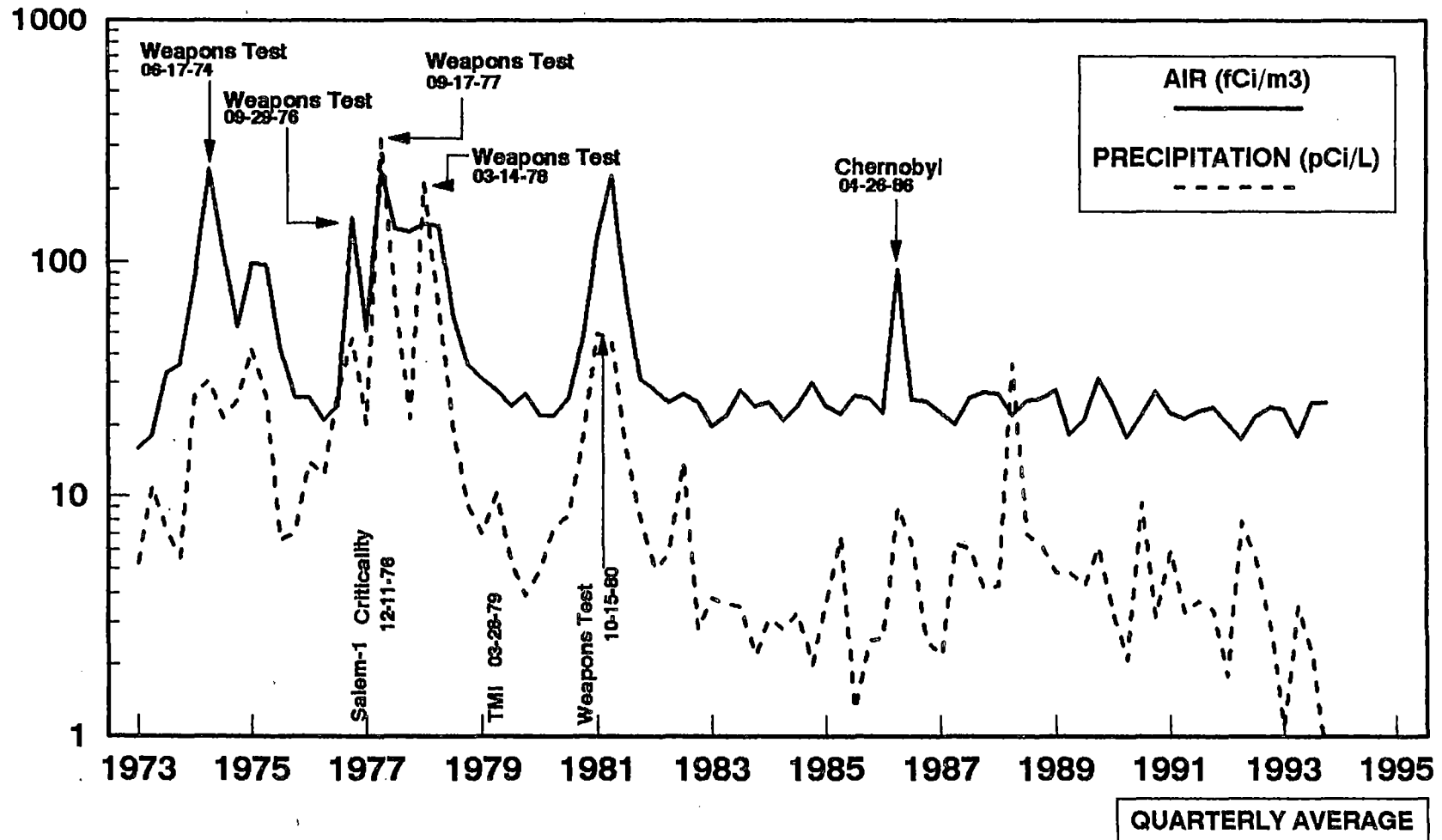
MEDIUM	STATION CODE			COLLECTION FREQUENCY	TYPE/FREQUENCY* OF ANALYSIS
	INDICATOR	CONTROL			
b. Edible Fish	11A1	7E1	12C1	Semi- annually	Tritium (flesh) Aqueous fraction/on collection** Sr-89 & Sr-90 (bones)/on collection** Sr-89 & Sr-90 (flesh/on collection** Gamma scan (flesh)/on collection
c. Blue Crabs	11A1	16F1	12C1	Semi- annually	Tritium (flesh) Aqueous fraction/on collection** Sr-89 & Sr-90 (flesh)/on collection Sr-89 & Sr-90 (shell)/on collection Gamma scan (flesh)/on collection
d. Sediment	11A1 15A1 16A1	7E1	16F1 12C1	Semi- annually	Sr-90/on collection Gamma scan/on collection

\* Except for Tlds, the quarterly analysis is performed on a composite of individual samples collected during the quarter.

\*\* Management audit analyses, not required by Technical Specifications or by specific commitments to local officials.

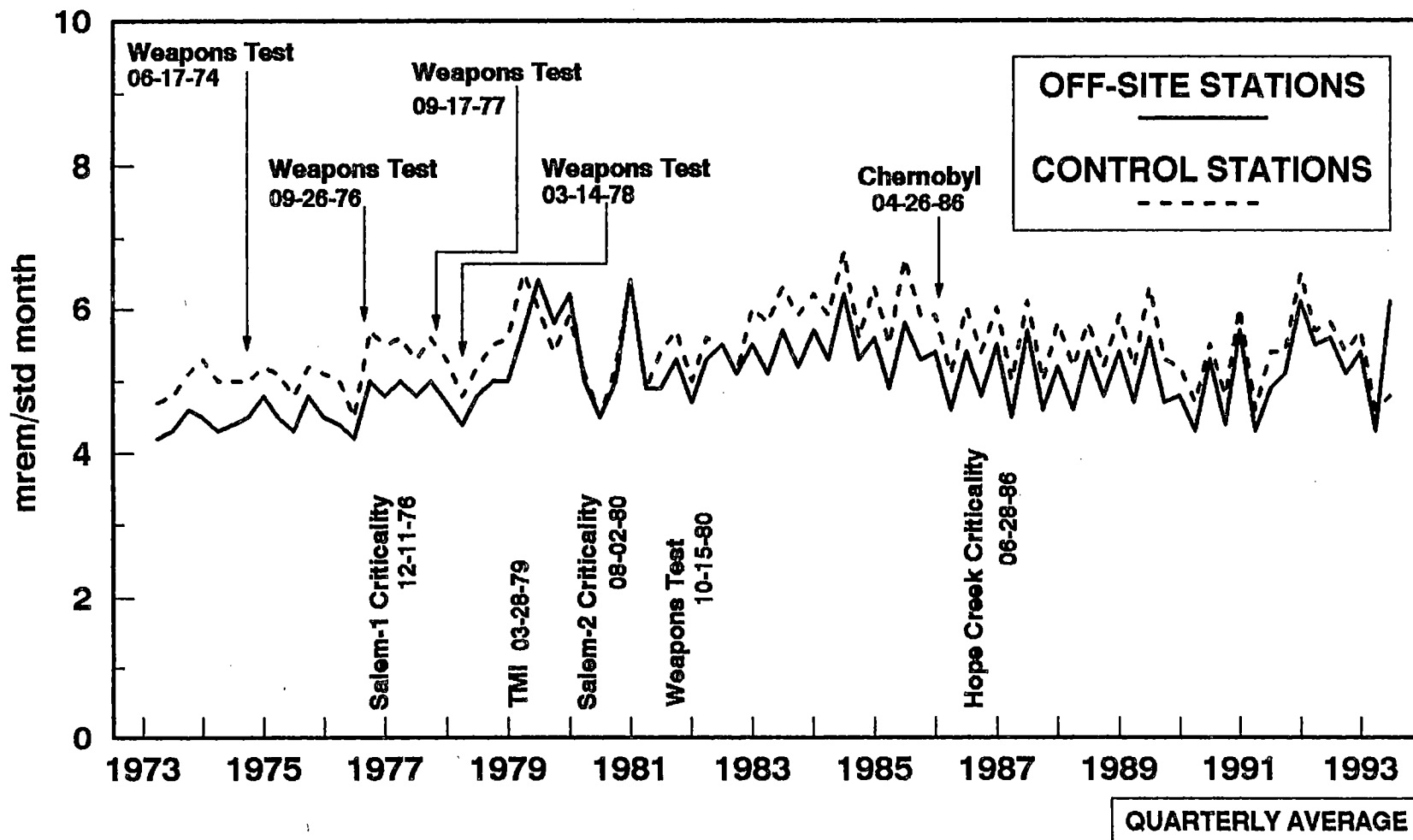
FIGURE 6

# BETA IN PRECIPITATION AND AIR PARTICULATE 1973 THROUGH 1993



**FIGURE 7**  
**AMBIENT RADIATION - OFFSITE vs CONTROL STATION**  
**1973 THROUGH 1993**

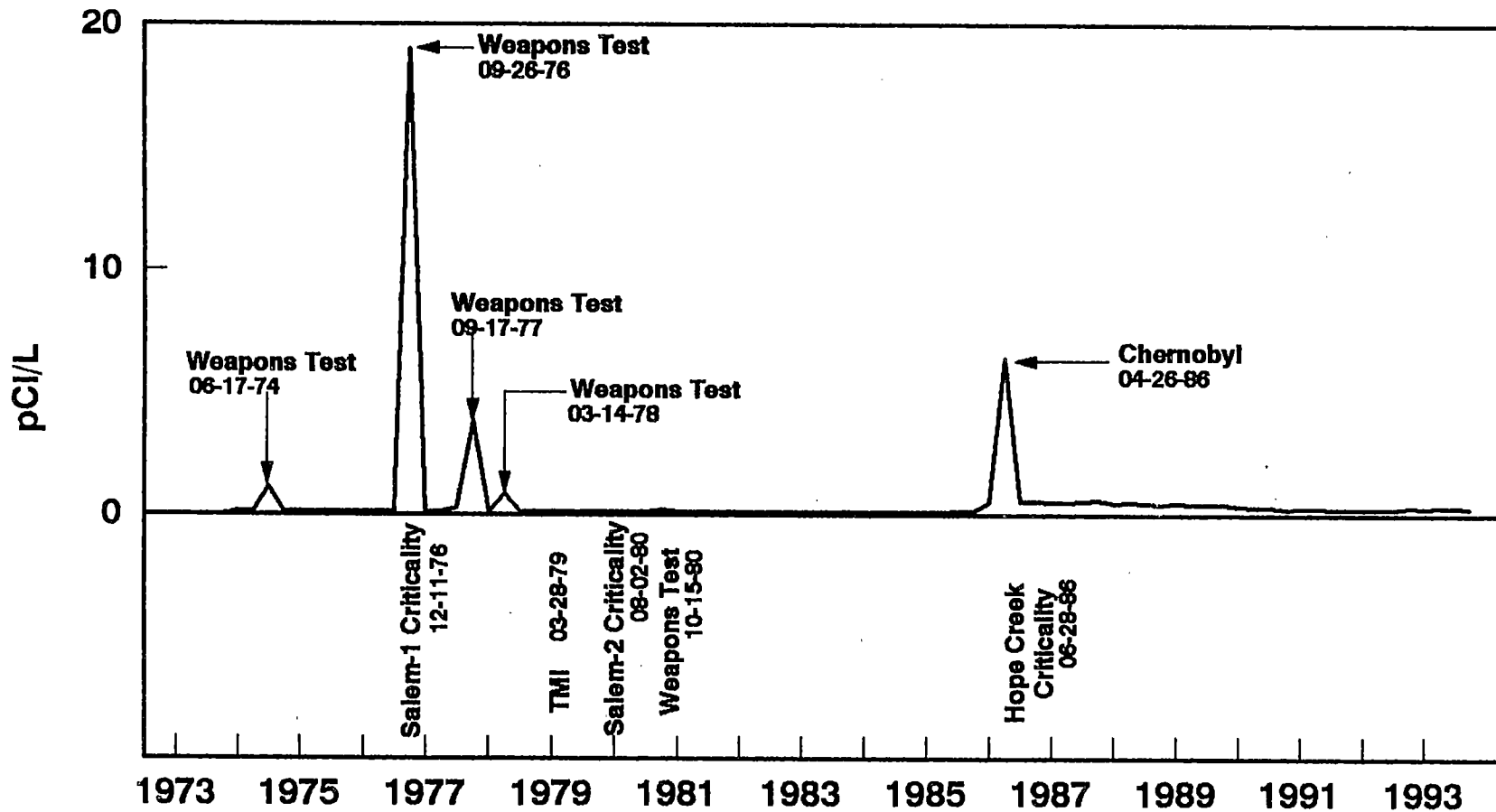
94



# FIGURE 8

## IODINE-131 ACTIVITY IN MILK

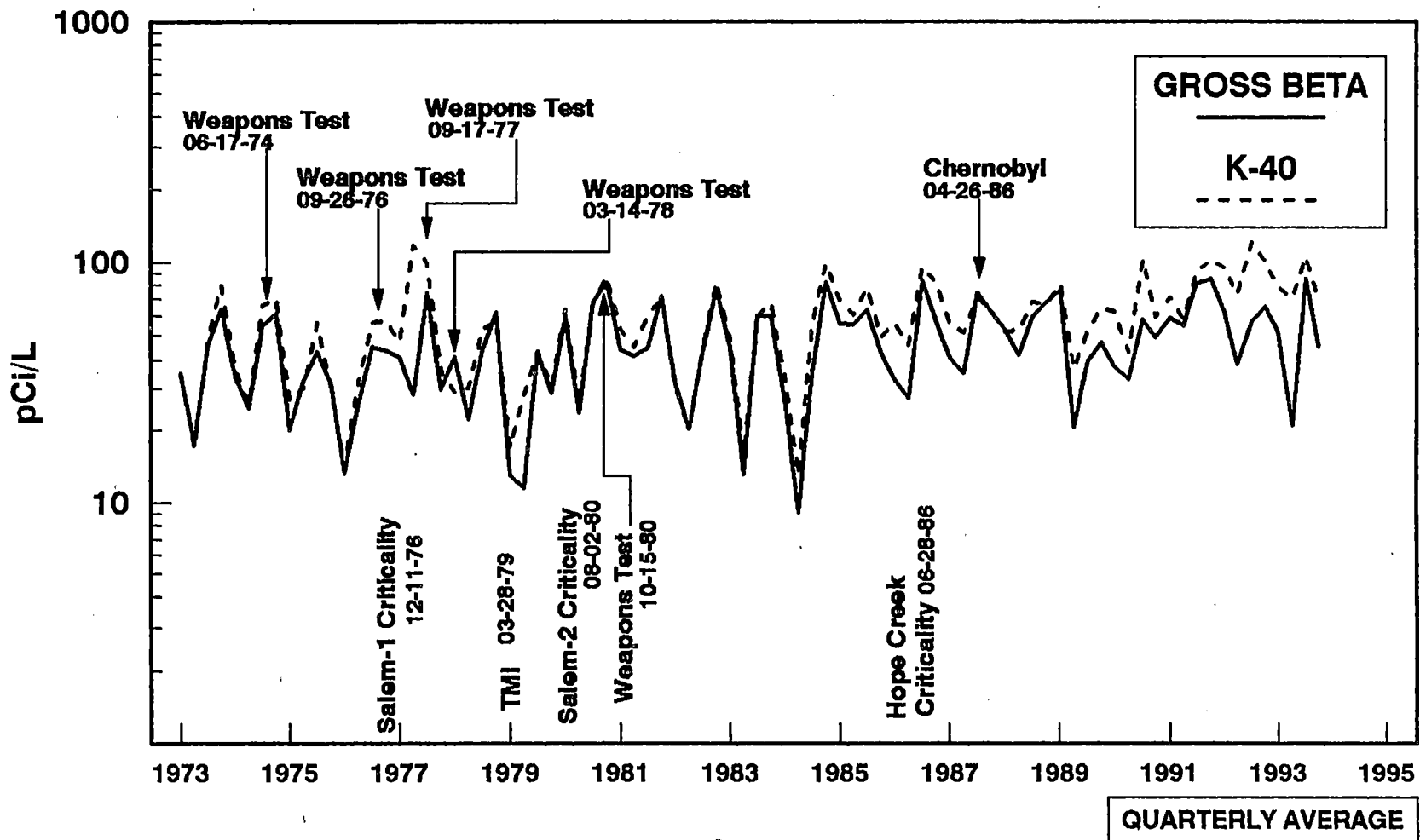
### 1973 THROUGH 1993



NOTE: Analysis method for milk was changed on 1/1/86. Reported values for Iodine-131 since this change have all been below the lower limit of detection (1 pCi/L) for this method.

QUARTERLY AVERAGE

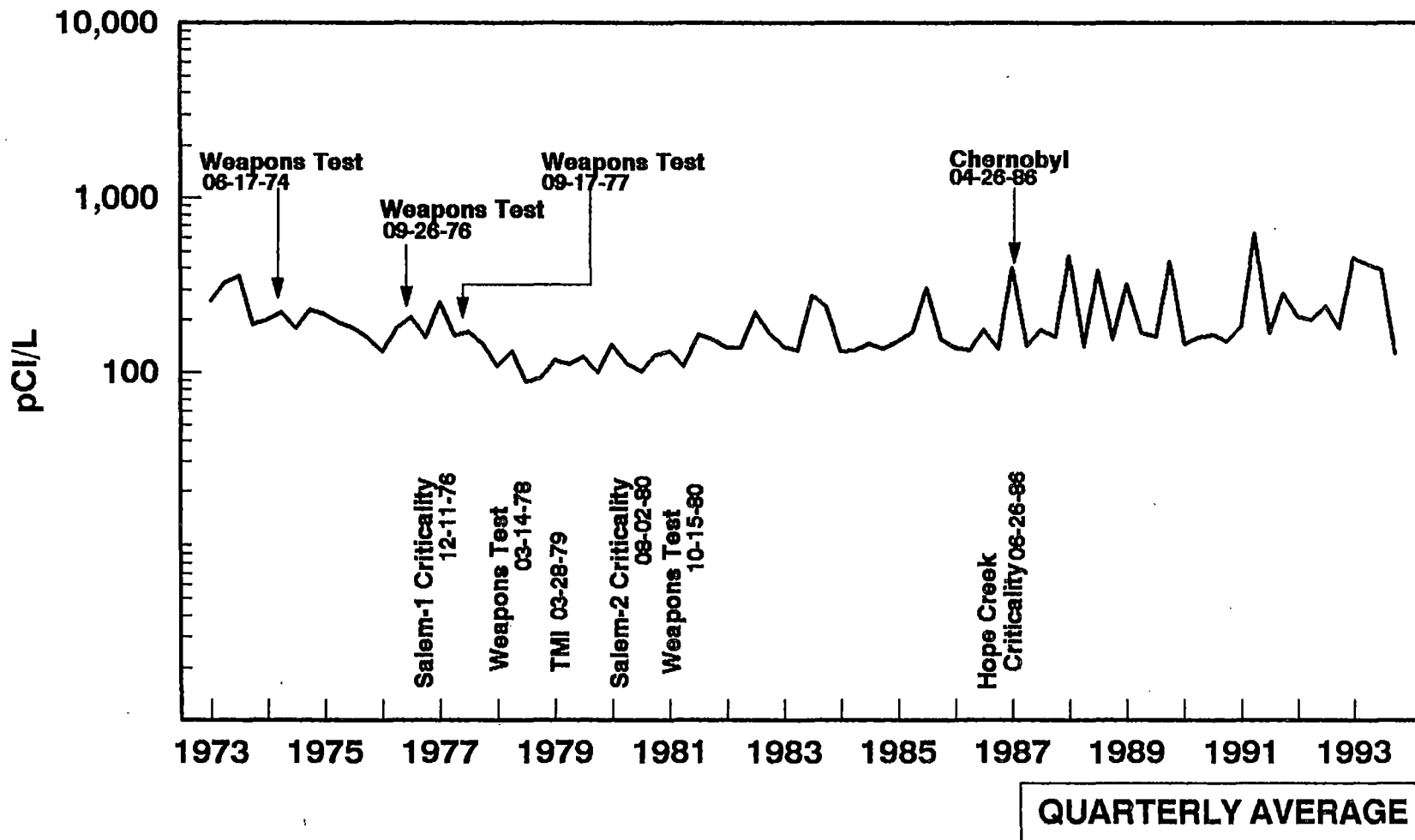
**FIGURE 9**  
**GROSS BETA & K-40 ACTIVITY IN SURFACE WATER**  
**1973 THROUGH 1993**



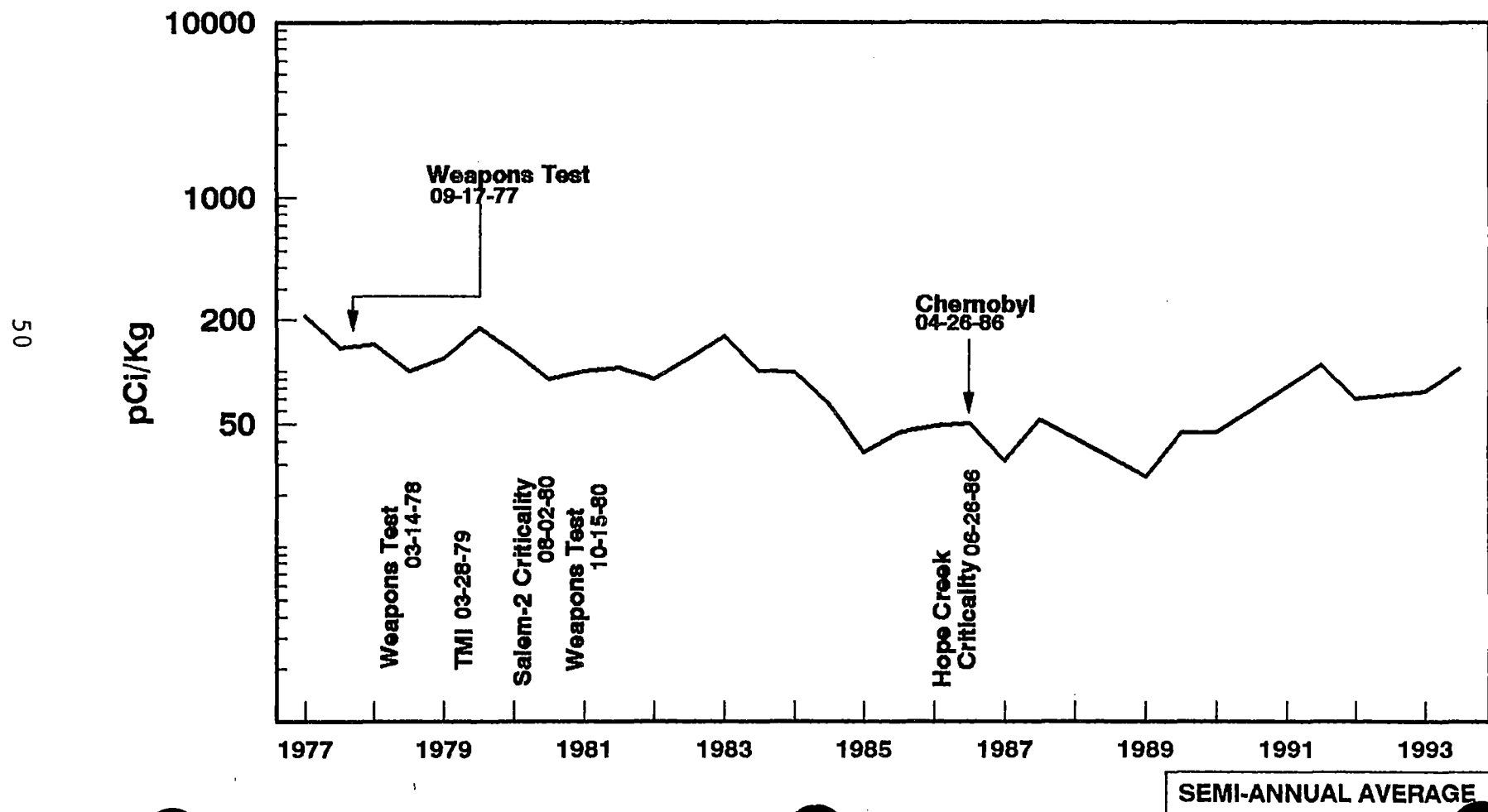
# FIGURE 10

## TRITIUM ACTIVITY IN SURFACE WATER

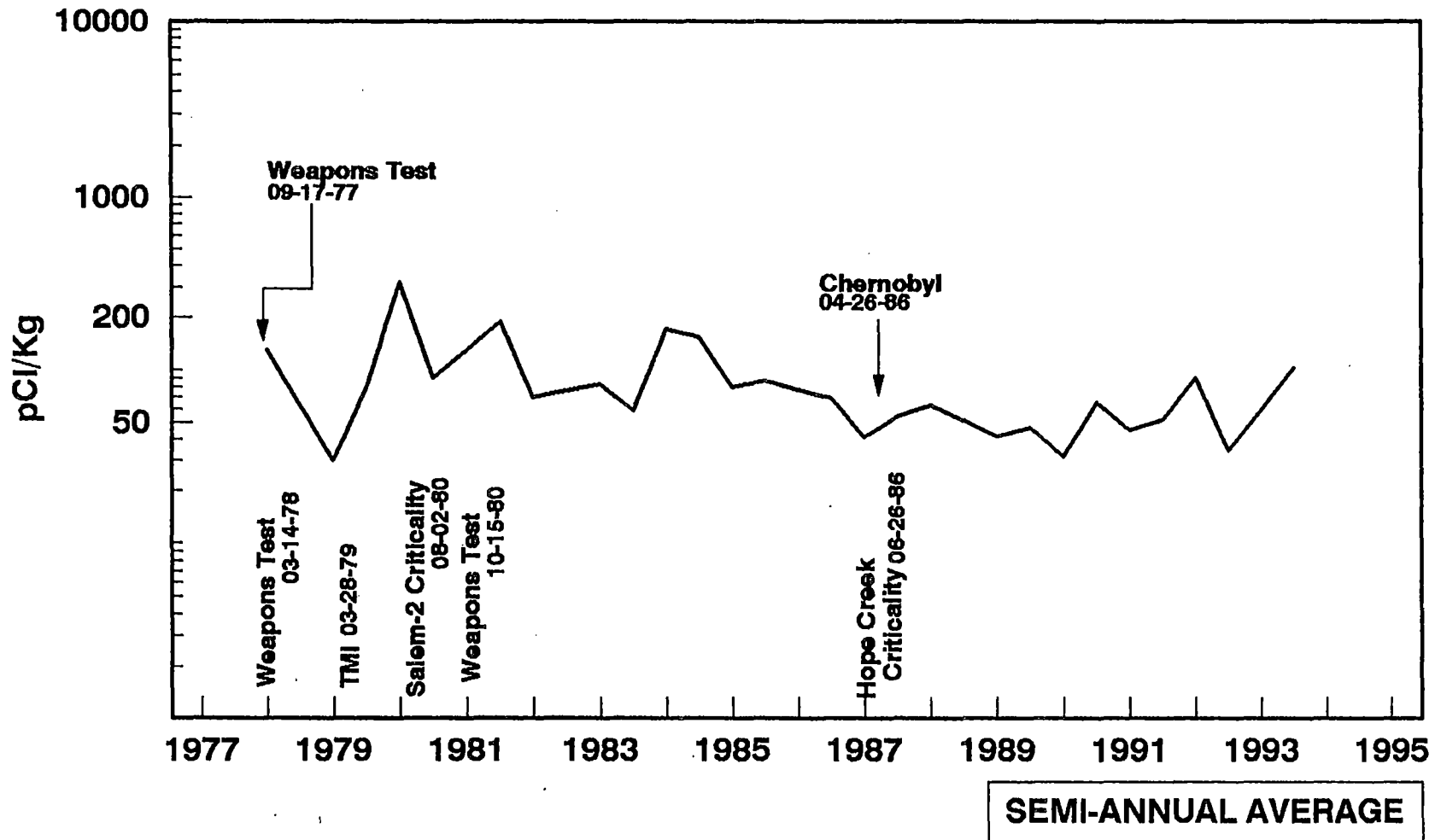
### 1973 THROUGH 1993



**FIGURE 11A**  
**CESIUM - 137 IN WATER SEDIMENT**  
**1977 THROUGH 1993**



**FIGURE 11B**  
**COBALT-60 IN WATER SEDIMENT**  
**1977 THROUGH 1993**





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## APPENDIX A

### PROGRAM SUMMARY

## ARTIFICIAL ISLAND RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

SALEM GENERATING STATION  
HOPE CREEK GENERATING STATIONDOCKET NOS. 50-272/-311  
DOCKET NO. 50-353

SALEM COUNTY, NEW JERSEY

JANUARY 1, 1993 to DECEMBER 31, 1993

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	ANALYSIS AND TOTAL NUMBER OF ANALYSES PERFORMED		LOWER LIMIT OF DETECTION (LLD)*	ALL INDICATOR LOCATIONS MEAN** (RANGE)	LOCATION WITH HIGHEST MEAN		CONTROL LOCATION MEAN (RANGE)	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
					NAME DISTANCE AND DIRECTION	MEAN (RANGE)		
I AIRBORNE Air particulates (10 <sup>-3</sup> pCi/m <sup>3</sup> )	Alpha	304	1.0	2.1 (229/253) (0.7-4.3)	5D1 3.5 mi E	2.2 (38/52) (1.0-3.9)	2.0 (50/51) (0.9-4.3)	0
					1F1 5.8 mi N	2.2 (51/52) (0.9-4.3)		
					2F2 8.7 mi NNE	2.2 (45/48) (1.1-3.6)		
	Beta	304	6.0	23 (253/253) (8.4-88)	16E1 4.1 mi NNW	24 (51/51) (8.7-88)	22 (51/51) (7.6-43)	0
	Sr-89	6	0.4	<LLD	-	<LLD	<LLD	0
	Sr-90	6	0.3	<LLD	-	<LLD	<LLD	0
	Gamma Be-7	24	6.8	67 (20/20) (42-90)	5D1 3.5 mi E	84 (4/4) (73-90)	69 (4/4) (47-92)	0
	Co-58	24	0.3	1.2 (1/20) (1.2)	5S1 1.0 mi E	1.2 (1/4) (1.2)	<LLD	0
	Air Iodine (10 <sup>-3</sup> pCi/m <sup>3</sup> )	I-131	304	<LLD	-	<LLD	<LLD	0
	Precipitation (pCi/L)	Alpha	10	1.7 (2/10) (0.7-2.6)	2F2 8.7 mi NNE	1.7 (2/10) (0.7-2.6)	No Control Location	0
		Beta	10	2.0*** 1.9 (9/10) (0.5-4.5)	2F2 8.7 mi NNE	1.9 (9/10) (0.5-4.5)	No Control Location	0

## ARTIFICIAL ISLAND RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

SALEM GENERATING STATION  
HOPE CREEK GENERATING STATIONDOCKET NOS. 50-272/-311  
DOCKET NO. 50-353

SALEM COUNTY, NEW JERSEY

JANUARY 1, 1993 to DECEMBER 31, 1993

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	ANALYSIS AND TOTAL NUMBER OF ANALYSES PERFORMED		LOWER LIMIT OF DETECTION (LLD)*	ALL INDICATOR LOCATIONS MEAN** (RANGE)	LOCATION WITH HIGHEST MEAN		CONTROL LOCATION MEAN (RANGE)	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
					NAME DISTANCE AND DIRECTION	MEAN (RANGE)		
I AIRBORNE (Cont'd) PRECIPITATION (pCi/L)	H-3	10	150	130 (1/10) (130)	2F2 8.7 mi NNE	130 (1/10) (130)	No Control Location	0
	Gamma Be-7	10	15	66 (7/10) (39-120)	2F2 8.7 mi NNE	66 (7/10) (39-120)	No Control Location	0
	K-40	10		58 (2/10) (56-60)	2F2 8.7 mi NNE	58 (2/10) (56-60)	No Control Location	0
	RA-NAT	10		7.8 (2/10) (7.3-8.3)	2F2 8.7 mi NNE	7.8 (2/10) (7.3-8.3)	No Control Location	
II Direct Direct Radiation (mrad/std. month)	Gamma 288 Dose monthly		-	6.2 (252/252) (3.8-11)	11S1 0.09 mi SW	8.1 (12/12) (5.9-11)	6.5 (36/36) (5.1-8.1)	
	Gamma 123(1) Dose qtrly.		-	5.4 (105/105) (3.0-9.8)	7S1 0.12 mi SE	6.5 (3/3) (5.6-6.9)	5.0 (18/18) (4.1-6.4)	0
III TERRESTRIAL MILK (pCi/L)	I-131	80	0.4	<LLD	-	<LLD	<LLD	0
	Sr-89	4	1.1	<LLD	-	<LLD	<LLD	0
	Sr-90	4	0.9	2.5 (3/3) (1.1-4.7)	2F7 5.7 mi NNE	4.7 (1/1) (4.7)	2.2 (1/1) (2.2)	0
	Gamma K-40	80	120	1350 (60/60) (930-1500)	11F3 5.3 mi SW	1400 (20/20) (1300-1500)	1300 (20/20) (1200-1400)	0

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SALEM COUNTY, NEW JERSEY

JANUARY 1, 1993 to DECEMBER 31, 1993

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	ANALYSIS AND TOTAL NUMBER OF ANALYSES PERFORMED		LOWER LIMIT OF DETECTION (LLD)*	ALL INDICATOR LOCATIONS MEAN** (RANGE)	LOCATION WITH HIGHEST MEAN		CONTROL LOCATION MEAN (RANGE)	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
					NAME DISTANCE AND DIRECTION	MEAN (RANGE)		
III TERRESTRIAL (Cont'd) Well Water (pCi/L)	Alpha	24	1.2	5.9 (1/12) (5.9)	2S3 700 ft. NNE	5.9 (1/12) (5.9)	1.8 (2/12) (1.7-1.8)	0
	Beta	24	1.0***	3.3 (12/12) (2.7-4.4)	3E1 4.1 mi NE	10 (12/12) (8.8-11)	10.0 (12/12) (8.8-11.0)	0
	K-40	24	-	3.4 (12/12) (3.0-3.6)	3E1 4.1 mi NE	9.8 (12/12) (6.5-12)	9.8 (12/12) (6.5-12)	0
	H-3	24	150	260 (3/12) (140-350)	2S3 700 ft. NNE	<LLD	<LLD	0
	Sr-89	8	1.0	<LLD	-	<LLD	<LLD	0
	Sr-90	8	0.6	<LLD	-	<LLD	<LLD	0
	Gamma K-40	24	35	64 (1/12) (64)	2S3 700 ft NNE	64 (1/12) (64)	<LLD	0
	I-131	24	0.6	<LLD	-	<LLD	<LLD	0
	RA-NAT	24	7.4	56 (10/12) (9.3-150)	3E1 4.1 mi NE	107 (12/12) (56-160)	107 (12/12) (56-160)	0
	Potable Water Raw-Treated (pCi/L)							
	Alpha	24	1.0	1.4 (8/24) (0.8-3.2)	2F3 8.0 mi NNE	1.4 (8/24) (0.8-3.2)	No Control Location	0
	Beta	24	1.0***	3.0 (24/24) (1.9-4.4)	2F3 8.0 mi NNE	3.0 (24/24) (1.9-4.4)	No Control Location	0

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DOCKET NO. 50-353

SALEM COUNTY, NEW JERSEY

JANUARY 1, 1993 to DECEMBER 31, 1993

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	ANALYSIS AND TOTAL NUMBER OF ANALYSES PERFORMED		LOWER LIMIT OF DETECTION (LLD)*	ALL INDICATOR LOCATIONS MEAN** (RANGE)	LOCATION WITH HIGHEST MEAN		CONTROL LOCATION MEAN (RANGE)	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
					NAME DISTANCE AND DIRECTION	MEAN (RANGE)		
III TERRESTRIAL (Cont'd) Potable Water Raw-Treated (pCi/L)	K-40	24	-	2.0 (24/24) (1.4-3.1)	2F3 8.0 mi NNE	2.0 (24/24) (1.4-3.1)	No Control Location	0
	H-3	24	150	190 (4/24) (150-240)	2F3 8.0 mi NNE	190 (4/24) (150-240)	No Control Location	0
	Sr-89	8	1.0	<LLD	-	<LLD	No Control Location	0
	Sr-90	8	0.8	<LLD	-	<LLD	No Control Location	0
	1-131	24	0.6	<LLD	-	<LLD	No Control Location	0
	Gamma K-40	24	35	<LLD	-	<LLD)	No Control Location	0
	RA-NAT	24	7.4	13 (3/24) (5.2-27)	2F3 8.0 mi NNE	13 (3/24) (5.2-27)	No Control Location	0
Fruits & Vegetables (pCi/kg-wet)	Gamma K-40	17	70	2000 (8/8) (1300-2600)	3H5 25 mi NE	1900 (4/4) (1000-2800)	1900 (9/9) (1000-2800)	0
Game (pCi/kg-wet)	Gamma K-40	2	70	2000 (1/1) (2000)	11D1 3.5 mi SW	2300 (1/1) (2300)	2300(1/1) (2300)	0
Beef (pCi/Kg-wet)	Gamma K-40	1	70	2600 (1/1) (2600)	3E1 4.1 mi NE	2600 (1/1) (2600)	No Control Location	0

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SALEM COUNTY, NEW JERSEY

JANUARY 1, 1993 to DECEMBER 31, 1993

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	ANALYSIS AND TOTAL NUMBER OF ANALYSES PERFORMED		LOWER LIMIT OF DETECTION (LLD)*	ALL INDICATOR LOCATIONS MEAN** (RANGE)	LOCATION WITH HIGHEST MEAN NAME DISTANCE AND DIRECTION MEAN (RANGE)		CONTROL LOCATION MEAN (RANGE)	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
III TERRESTRIAL (Cont'd)								
Fodder Crops (pCi/kg-wet)	Gamma Be-7	8	150	800 (3/8) (530-1100)	14F4 7.6 mi WNW	1100 (1/2) (1100)	940 (1/2) (940)	0
	K-40	8	85	10000 (6/6) (2800-17000)	14F4 7.6 mi WNW	11000 (2/2) (5800-17000)	9200 (2/2) (6500-12000)	0
	RA-NAT	8	48	47 (2/6) (35-59)	14F4 7.6 mi WNW	59 (1/2) (59)	<LLD	0
IV AQUATIC								
Surface Water (pCi/L)	Alpha	60	2.0	2.6 (15/48) (1.4-4.7)	16F1 6.9 mi NNW	3.3 (4/12) (2.8-4.1)	2.3 (3/12) (2.0-2.8)	0
	Beta	60	3.8***	53 (48/48) (4-120)	7E1 4.5 mi SE	86 (12/12) (22-120)	52 (11/12) (6-90)	0
	H-3	20	150	330 (3/16) (130-460)	11A1 0.2 mi SW	330 (3/4) (130-460)	<LLD	0
	Gamma K-40	60	35	85 (31/48) (30-150)	7E1 4.5 mi SE	100 (11/12) (45-150)	81 (7/12) (48-130)	0
	RA-NAT	60	7.4	8.5 (4/48) (5-15)	11A1 0.2 mi SW	9 (3/12) (5-15)	7 (1/12) (7)	0
	Co-58	60	1.6	5.5 (1/48) (5.5)	11A1 0.2 mi SW	5.5 (1/12) (5.5)	<LLD	0
	Co-60	60	2.1	4.0 (1/48) (4.0)	11A1 0.2 mi SW	4.0 (1/12) (4.0)	<LLD	0
Cs-137	60	1.6	5.4 (1/48)	11A1 0.2 mi SW	5.4 (1/12) (5.4)	<LLD	0	



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SALEM COUNTY, NEW JERSEY

JANUARY 1, 1993 to DECEMBER 31, 1993

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	ANALYSIS AND TOTAL NUMBER OF ANALYSES PERFORMED		LOWER LIMIT OF DETECTION (LLD)*	ALL INDICATOR LOCATIONS	LOCATION WITH HIGHEST MEAN		CONTROL LOCATION	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
				MEAN** (RANGE)	NAME DISTANCE AND DIRECTION	MEAN (RANGE)	MEAN (RANGE)	
IV AQUATIC (Cont'd) Blue Crabs (pCi/kg-dry)	Sr-89	4	60	<LLD	-	<LLD	<LLD	0
	(shells)							
	Sr-90	4	-	190 (2/2) (180-200)	11A1 0.2 mi SW	190 (2/2) (180-200)	170 (2/2) (140-200)	0
	(shells)							
	(pCi/kg-wet)							
Blue Crabs (pCi/kg-wet)	H-3	4	100	<LLD	-	<LLD	<LLD	0
	(aqueous)							
	Sr-89	4	100	<LLD	-	<LLD	<LLD	0
	(flesh)							
	Sr-90	4	40	<LLD	-	<LLD	<LLD	0
Edible Fish (pCi/kg-dry)	(flesh)							
	Gamma K-40	4	70	2800 (2/2) (2700-2900)	11A1 0.2 mi SW	2800 (2/2) (2700-2900)	2400 (2/2) (2200-2500)	0
	Sr-89	6	75	<LLD	-	<LLD	<LLD	0
	(bones)							
	Sr-90	6	25	120 (4/4) (41-290)	11A1 0.2 mi SW	170 (2/2) (41-290)	100 (2/2) (30-180)	0
(pCi/kg-wet)	(bones)							
	H-3	6	100	170 (1/4) (170)	7E1 4.5 mi SE	170 (1/4) (170)	150 (1/2) (150)	0
	(aqueous)							
	Sr-89	6	100	<LLD	-	<LLD	<LLD	0
	(flesh)							
Gamma K-40	Sr-90	6	40	<LLD	-	<LLD	<LLD	0
	(flesh)							
	Gamma K-40	6	70	2900 (4/4) (2600-3100)	12C1 2.5 mi WSW	3100 (2/2) (2700-3500)	3100 (2/2) (2700-3500)	0

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SALEM COUNTY, NEW JERSEY

JANUARY 1, 1993 to DECEMBER 31, 1993

MEDIUM OR PATHWAY SAMPLED (UNIT OF MEASUREMENT)	ANALYSIS AND TOTAL NUMBER OF ANALYSES PERFORMED		LOWER LIMIT OF DETECTION (LLD)*	ALL INDICATOR LOCATIONS MEAN** (RANGE)	LOCATION WITH HIGHEST MEAN		CONTROL LOCATION MEAN (RANGE)	NUMBER OF NONROUTINE REPORTED MEASUREMENTS
					NAME DISTANCE AND DIRECTION	MEAN (RANGE)		
IV AQUATIC (Cont'd) Sediment (pCi/kg-dry)	Sr-90	12	25	48 (1/10) (48)	16A1 0.7 mi NNW	48 (1/10) (48)	<LLD	0
	Gamma K-40	12	70	11000 (10/10) (3200-18000)	16F1 6.9 mi NNW	18000 (2/2) (17000-18000)	14000 (2/2) (13000-16000)	0
	Mn-54	12	28	31 (3/10) (23-41)	16A1 0.7 mi NNW	35 (2/2) (29-41)	<LLD	0
	Co-58	12	15	61 (6/10) (45-83)	7E1 4.5 mi SE	83 (1/2) (83)	<LLD	0
	Co-60	12	32	87 (6/10) (34-140)	16A1 0.7 mi NNW	120 (2/2) (110-140)	<LLD	0
	Cs-134	12	22	59 (4/10) (46-70)	16A1 0.7 mi NNW	70 (1/2) (70)	49 (1/2) (49)	0
	Cs-137	12	20	95 (6/10) (33-180)	15A1 0.3 mi NW	180 (1/2) (180)	<LLD	0
	RA-NAT	12	40	790 (10/10) (290-1900)	16A1 0.7 mi NNW	1600 (2/2) (1200-1900)	720 (2/2) (590-860)	0
	Th-232	12	110	850 (10/10) (430-1600)	16A1 0.7 mi NNW	1250 (2/2) (900-1600)	810 (2/2) (790-830)	0

\* LLD listed is the lower limit of detection which we endeavored to achieve during this reporting period. In some instances nuclides were detected at concentrations above the LLD values shown.

\*\* Mean calculated using values above LLD only. Fraction of measurements above LLD are in parentheses.

\*\*\* Typical LLD value.

(1) TLD results for the 4th Quarter were invalidated by T.I. (See Program Deviations).

**APPENDIX B**

**SAMPLE DESIGNATION  
AND  
LOCATIONS**

## APPENDIX B

### SAMPLE DESIGNATION

The PSE&G Research And Testing Laboratory identifies samples by a three part code. The first two letters are the power station identification code, in this case "SA". The next three letters are for the media sampled.

AIO = Air Iodine	IDM = Immersion Dose (TLD)
APT = Air Particulates	MLK = Milk
ECH = Hard Shell Blue Crab	PWR = Potable Water (Raw)
ESF = Edible Fish	PWT = Potable Water (Treated)
ESS = Sediment	RWA = Rain Water (Precipitation)
FPB = Beef	SOL = Soil
FPL = Green Leafy Vegetables	SWA = Surface Water
FPV = Vegetables (Various)	VGT = Fodder Crops (Various)
GAM = Game (Muskrat)	WWA = Well Water

The last four symbols are a location code based on direction and distance from the site. Of these, the first two represent each of sixteen angular sectors of 22.5 degrees centered about the reactor site. Sector one is divided evenly by the north axis and other sectors are numbered in a clockwise direction; i.e., 2=NNE, 3=NE, 4=ENE, etc. The next digit is a letter which represents the radial distance from the plant:

S = On-site location	E = 4-5 miles off-site
A = 0-1 miles off-site	F = 5-10 miles off-site
B = 1-2 miles off-site	G = 10-20 miles off-site
C = 2-3 miles off-site	H = >20 miles off-site
D = 3-4 miles off-site	

The last number is the station numerical designation within each sector and zone; e.g., 1,2,3,... For example, the designation SA-WWA-3E1 would indicate a sample in the SGS program (SA), consisting of well water (WWA), which had been collected in sector number 3, centered at 45° (north east) with respect to the reactor site at a radial distance of 4 to 5 miles off-site, (therefore, radial distance E). The number 1 indicates that this is sampling station #1 in that particular sector.

## SAMPLING LOCATIONS

All of the sampling locations and specific information about the individual locations are given in Table B-1. Maps B-1 and B-2 show the locations of sampling stations with respect to the site.

TABLE B-1

STATION CODE	STATION LOCATION	SAMPLE TYPES
2S2	0.4 mi. NNE of vent	IDM
2S3	700 ft. NNE of vent; fresh water holding tank	WWA
5S1	1.0 mi. E of vent; site access road	AIO, APT, IDM
6S2	0.2 mi. ESE of vent; observation building	IDM, SOL
7S1	0.12 mi. SE of vent; station personnel gate	IDM
10S1	0.14 mi. SSW of vent; inlet cooling water bldg.	IDM
11S1	0.09 mi. SW of vent; service water inlet bldg.	IDM
11A1	0.2 mi. SW of vent; outfall area	ECH, ESF, ESS, SW
15A1	0.3 mi. NW of vent; cooling tower blowdown discharge line outfall	ESS
16A1	0.7 mi. NNW of vent; south storm drain discharge line	ESS
12C1	2.5 mi. WSW of vent; west bank of Delaware River	ECH, ESF, ESS, SWA
4D2	3.7 mi. ENE of vent; Alloway Creek Neck Road	IDM, VGT
5D1	3.5 mi. E of vent; local farm	AIO, APT, IDM
10D1	3.9 mi. SSW of vent; Taylor's Bridge Spur	IDM, SOL
11D1	3.5 mi. SW of vent	GAM
14D1	3.4 mi. WNW of vent; Bay View, Delaware	IDM
15D1	3.8 mi. NW of vent; Rt. 9, Augustine Beach	IDM
2E1	4.4 mi. NNE of vent; local farm	IDM
3E1	4.1 mi. NE of vent; local farm	FPB, GAM, IDM, VGT WWA
3E2	5.7 mi. NE of vent; local farm	FPV

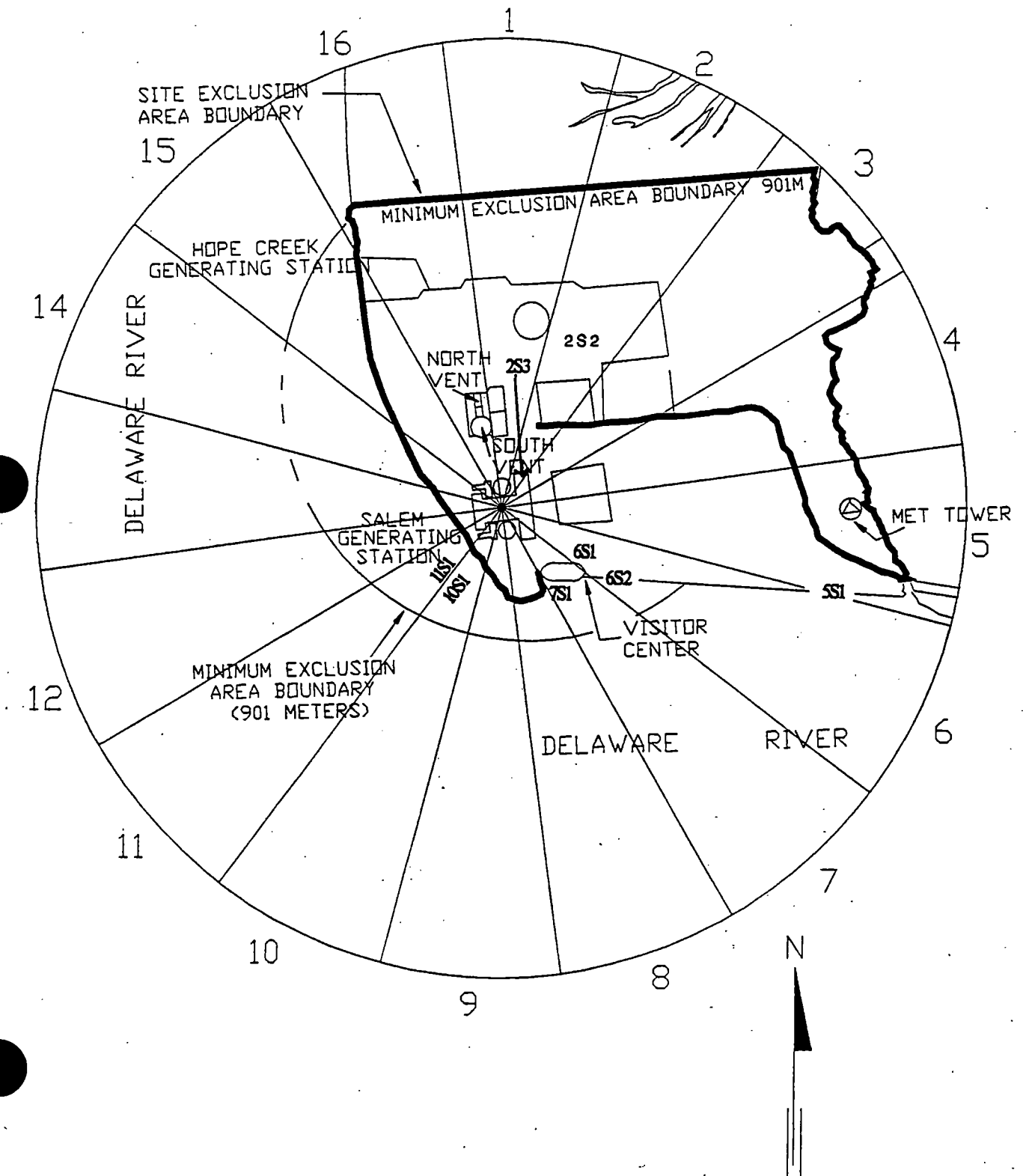
TABLE B-1 (cont'd)

STATION ID	STATION LOCATION	SAMPLE TYPES
3E3	5.6 mi. NE of vent; local farm	FPV
7E1	4.5 mi. SE of vent; 1 mi. W of Mad Horse Creek	ESF, ESS, SWA
9E1	4.2 mi. S of vent	IDM
11E2	5.0 mi. SW of vent; Rt. 9	IDM
12E1	4.4 mi. WSW of vent; Thomas Landing	IDM
13E1	4.2 mi. W of vent; Diehl House Lab	IDM
16E1	4.1 mi. NNW of vent; Port Penn	AIO, APT, IDM, SOL
1F1	5.8 mi. N of vent; Fort Elfsborg	AIO, APT, IDM, SOL
1F2	7.1 mi. N of vent; midpoint of Delaware River	SWA
2F2	8.7 mi. NNE of vent; Salem Substation	AIO, APT, IDM, RWA
2F3	8.0 mi. NNE of vent; Salem Water Company	PWR, PWT
2F4	6.3 mi. NNE of vent; local farm	FPV, FPL, SOL
2F5	7.4 mi. NNE of vent; Salem High School	IDM
2F6	7.3 mi. NNE of vent; Southern Training Center	IDM
2F7	5.7 mi. NNE of vent; local farm	MLK, VGT, SOL
3F2	5.1 mi. NE of vent; Hancocks Bridge Municipal Building	IDM
3F3	8.6 mi. NE of vent; Quinton Township School	IDM
4F2	6.0 mi. ENE of vent; Mays Lane, Harmersville	IDM
5F1	6.5 mi. E of vent; Canton	FPV, IDM, SOL
5F3	6.4 mi. E of vent; local farm	FPL
6F1	6.4 mi. ESE of vent; Stow Neck Road	IDM
7F2	9.1 mi. SE of vent; Bayside, New Jersey	IDM
10F2	5.8 mi. SSW of vent; Rt. 9	IDM
11F1	6.2 mi. SW of vent; Taylor's Bridge Delaware	IDM

TABLE B-1 (cont'd)

STATION CODE	STATION LOCATION	SAMPLE TYPES
11F3	5.3 mi. SW of vent; Townsend, Delaware	MLK,VGT,SOL
12F1	9.4 mi. WSW of vent; Townsend Elementary School	IDM
13F2	6.5 mi. W of vent; Odessa, Delaware	IDM
13F3	9.3 mi. W of vent; Redding Middle School, Middletown, Delaware	IDM
13F4	9.8 mi. W of vent; Middletown, Delaware	IDM
14F2	6.6 mi. WNW of vent; Boyds Corner	IDM
14F3	5.4 mi. WNW of vent; local farm	FPV
14F4	7.6 mi. WNW of vent; local farm	MLK,VGT,SOL
15F3	5.4 mi. NW of vent	IDM
16F1	6.9 mi. NNW of vent; C&D Canal	ESS,SWA
16F2	8.1 mi. NNW of vent; Delaware City Public School	IDM
1G1	10.3 mi. N of vent; local farm	FPV
1G3	19 mi. N of vent; N. Church St. Wilmington, Delaware	IDM
2G1	12 mi. NNE of vent; Mannington Township, NJ	FPV
2G2	13.5 mi. NNE of vent; local farm	FPV
3G1	17 mi. NE of vent; local farm	IDM,MLK,VGT,SOL
10G1	12 mi. SSW of vent; Smyrna, Delaware	IDM
16G1	15 mi. NNW of vent; Greater Wilmington Airport	IDM
3H1	32 mi. NE of vent; National Park, New Jersey	IDM
3H3	110 mi. NE of vent; Research and Testing Laboratory	AIO,APT,IDM
3H5	25 mi. NE of vent; local farm	FPL,FPV

# **MAP B-1** **ON-SITE SAMPLING LOCATIONS** **ARTIFICIAL ISLAND**





This map shows the Salem Generating Station area in New Jersey, centered around the Delaware River. The station is located at the intersection of the river and the Atlantic Ocean. The map includes a grid with latitude and longitude coordinates, a scale bar, and a north arrow. Key features include:

- Geographic Features:** Delaware River, Killcohook National Wildlife Refuge, Red Lion Hundred, Saint Georges Hundred, Apquimink Hundred, Blackbird Hundred, Duck Creek Hundred, Bombay Hook National Wildlife Refuge, Lower Alloways Creek, Stow Creek, Hopewell, Greenwich, Bayside Tract, and the State of New Jersey.
- Towns and Settlements:** Lower Penns Neck, Mannington, Elsinboro, Middletown, Saint Georges Hundred, Apquimink Hundred, Smyrna, and Fairfield.
- Infrastructure:** Major roads (e.g., 40, 13, 71, 18, 16, 12, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779

## APPENDIX C

### DATA TABLES

# APPENDIX C

## DATA TABLES

Appendix C presents the analytical results of the 1993 Artificial Island Radiological Environmental Monitoring Program for the period of January 1 to December 31, 1993.

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TABLE C-1  
1993 CONCENTRATIONS OF GROSS ALPHA EMITTERS IN AIR PARTICULATES  
Results in Units of  $10^{-3}$  pCi/m<sup>3</sup>  $\pm$  2 sigma

<----- STATION ID ----->							
* MONTH	SA-APT-5S1	** SA-APT-5D1	SA-APT-16E1	SA-APT-1F1	SA-APT-2F2	SA-APT-3H3 (Control)	AVERAGE
JANUARY	1.6 $\pm$ 0.7	2.3 $\pm$ 1.3	1.8 $\pm$ 0.7	1.5 $\pm$ 0.8	2.1 $\pm$ 0.8	1.1 $\pm$ 0.6	1.7 $\pm$ 0.9
	1.9 $\pm$ 0.8	1.7 $\pm$ 1.4	2.7 $\pm$ 1.0	1.5 $\pm$ 1.0	2.5 $\pm$ 0.9	2.2 $\pm$ 0.9	2.1 $\pm$ 0.9
	2.6 $\pm$ 0.8	2.6 $\pm$ 1.3	2.7 $\pm$ 0.9	1.6 $\pm$ 0.6	2.1 $\pm$ 0.8	2.1 $\pm$ 0.7	2.3 $\pm$ 0.9
	1.8 $\pm$ 0.7	2.3 $\pm$ 1.1	1.6 $\pm$ 0.7	2.3 $\pm$ 0.7	2.0 $\pm$ 0.7	2.3 $\pm$ 0.8	2.1 $\pm$ 0.6
	3.2 $\pm$ 0.8	2.7 $\pm$ 1.2	2.6 $\pm$ 0.8	1.9 $\pm$ 0.7	2.2 $\pm$ 0.8	1.7 $\pm$ 0.6	2.4 $\pm$ 1.1
FEBRUARY	1.8 $\pm$ 0.7	3.9 $\pm$ 1.5	2.9 $\pm$ 0.9	2.5 $\pm$ 0.8	2.2 $\pm$ 0.8	2.6 $\pm$ 0.8	2.7 $\pm$ 1.4
	2.1 $\pm$ 0.7	<1.0	1.8 $\pm$ 0.8	1.1 $\pm$ 0.6	2.2 $\pm$ 0.8	2.0 $\pm$ 0.7	1.7 $\pm$ 1.0
	1.9 $\pm$ 0.8	1.7 $\pm$ 1.1	2.9 $\pm$ 1.0	1.7 $\pm$ 0.8	1.6 $\pm$ 0.8	2.8 $\pm$ 0.9	2.1 $\pm$ 1.2
	2.4 $\pm$ 0.8	2.4 $\pm$ 1.3	3.4 $\pm$ 0.9	3.0 $\pm$ 0.8	2.8 $\pm$ 0.8	3.0 $\pm$ 0.8	2.8 $\pm$ 0.8
MARCH	1.2 $\pm$ 0.7	1.2 $\pm$ 0.9	2.1 $\pm$ 0.9	2.1 $\pm$ 0.8	1.3 $\pm$ 0.8	(1)	1.6 $\pm$ 1.0
	2.0 $\pm$ 0.7	1.6 $\pm$ 1.2	0.9 $\pm$ 0.6	1.2 $\pm$ 0.6	1.1 $\pm$ 0.6	0.9 $\pm$ 0.5	1.3 $\pm$ 0.9
	2.6 $\pm$ 0.8	3.3 $\pm$ 1.4	2.4 $\pm$ 0.9	2.6 $\pm$ 0.8	2.2 $\pm$ 0.8	1.9 $\pm$ 0.7	2.5 $\pm$ 0.9
	<0.8	<0.9	<0.9	<0.8	1.1 $\pm$ 0.7	1.0 $\pm$ 0.6	0.9 $\pm$ 0.2
APRIL	<0.7	1.5 $\pm$ 1.0	1.3 $\pm$ 0.7	0.9 $\pm$ 0.6	<0.8	1.0 $\pm$ 0.6	1.0 $\pm$ 0.6
	1.2 $\pm$ 0.6	1.3 $\pm$ 1.1	1.0 $\pm$ 0.7	1.3 $\pm$ 0.6	<0.8	1.6 $\pm$ 0.7	1.2 $\pm$ 0.6
	1.0 $\pm$ 0.5	<1.0	1.3 $\pm$ 0.7	2.0 $\pm$ 0.7	2.0 $\pm$ 0.7	1.5 $\pm$ 0.6	1.5 $\pm$ 0.9
	1.8 $\pm$ 0.7	<0.9	2.2 $\pm$ 0.8	2.5 $\pm$ 0.8	2.3 $\pm$ 0.8	2.3 $\pm$ 0.8	2.0 $\pm$ 1.2
MAY	1.8 $\pm$ 0.7	2.5 $\pm$ 1.4	1.8 $\pm$ 0.9	2.6 $\pm$ 0.8	2.0 $\pm$ 0.8	2.6 $\pm$ 0.8	2.2 $\pm$ 0.8
	1.4 $\pm$ 0.6	2.4 $\pm$ 1.4	1.7 $\pm$ 0.8	1.9 $\pm$ 0.7	2.6 $\pm$ 0.9	1.4 $\pm$ 0.7	1.9 $\pm$ 1.0
	2.3 $\pm$ 0.7	2.5 $\pm$ 1.6	2.6 $\pm$ 0.8	2.9 $\pm$ 0.8	2.4 $\pm$ 0.8	2.4 $\pm$ 0.8	2.5 $\pm$ 0.4
	2.0 $\pm$ 0.7	2.0 $\pm$ 1.3	2.1 $\pm$ 0.8	1.8 $\pm$ 0.7	2.1 $\pm$ 0.7	1.2 $\pm$ 0.6	1.9 $\pm$ 0.7
	1.7 $\pm$ 0.7	<1.0	1.2 $\pm$ 0.7	1.2 $\pm$ 0.7	3.1 $\pm$ 0.9	2.5 $\pm$ 0.8	1.8 $\pm$ 1.7
JUNE	2.9 $\pm$ 1.0	<2.0	2.6 $\pm$ 1.1	4.2 $\pm$ 1.1	3.0 $\pm$ 1.1	<1.1	2.6 $\pm$ 2.1
	2.4 $\pm$ 0.9	<1.0	2.4 $\pm$ 0.9	2.0 $\pm$ 0.7	1.8 $\pm$ 0.8	2.6 $\pm$ 0.8	2.0 $\pm$ 1.2
	(2)	2.2 $\pm$ 1.1	2.1 $\pm$ 0.7	2.0 $\pm$ 0.7	2.3 $\pm$ 0.7	1.7 $\pm$ 0.7	2.1 $\pm$ 0.5
	(2)	2.7 $\pm$ 1.8	1.7 $\pm$ 1.0	1.8 $\pm$ 0.9	2.3 $\pm$ 1.0	2.0 $\pm$ 0.8	2.1 $\pm$ 0.8

TABLE C-5 (cont'd)  
1993 CONCENTRATIONS OF GROSS ALPHA EMITTERS IN AIR PARTICULATES  
Results in Units of  $10^{-3}$  pCi/m<sup>3</sup>  $\pm$  2 sigma

<----- STATION ID ----->							
* MONTH	SA-APT-5S1	** SA-APT-5D1	SA-APT-16E1	SA-APT-1F1	SA-APT-2F2	SA-APT-3H3 (Control)	AVERAGE
JULY	2.0 $\pm$ 0.7	<2.0	2.3 $\pm$ 0.8	3.5 $\pm$ 0.9	2.3 $\pm$ 0.8	1.6 $\pm$ 0.6	2.3 $\pm$ 1.3
	3.4 $\pm$ 1.0	3.9 $\pm$ 1.8	2.9 $\pm$ 1.0	3.4 $\pm$ 1.0	2.8 $\pm$ 1.0	3.8 $\pm$ 1.1	3.4 $\pm$ 0.9
	<1.0	1.6 $\pm$ 1.2	<1.2	1.5 $\pm$ 0.8	1.3 $\pm$ 0.8	1.2 $\pm$ 0.8	1.3 $\pm$ 0.4
	2.5 $\pm$ 0.7	2.3 $\pm$ 1.2	1.7 $\pm$ 0.7	2.8 $\pm$ 0.8	2.3 $\pm$ 0.7	1.5 $\pm$ 0.6	2.2 $\pm$ 1.0
AUGUST	2.1 $\pm$ 0.7	1.7 $\pm$ 1.2	1.8 $\pm$ 0.7	2.4 $\pm$ 0.7	1.6 $\pm$ 0.6	1.8 $\pm$ 0.6	1.9 $\pm$ 0.6
	1.8 $\pm$ 0.6	1.3 $\pm$ 1.0	1.4 $\pm$ 0.7	3.4 $\pm$ 0.8	3.2 $\pm$ 0.9	1.9 $\pm$ 0.7	2.2 $\pm$ 1.8
	2.0 $\pm$ 0.8	1.7 $\pm$ 1.4	2.2 $\pm$ 1.1	2.3 $\pm$ 0.9	2.5 $\pm$ 0.9	2.6 $\pm$ 0.8	2.2 $\pm$ 0.7
	1.7 $\pm$ 0.8	<1.0	2.1 $\pm$ 0.8	3.9 $\pm$ 1.0	1.6 $\pm$ 0.7	1.7 $\pm$ 0.7	2.0 $\pm$ 2.0
	2.4 $\pm$ 0.7	2.3 $\pm$ 1.3	2.0 $\pm$ 0.8	2.4 $\pm$ 0.8	2.3 $\pm$ 0.8	3.1 $\pm$ 0.8	2.4 $\pm$ 0.7
SEPTEMBER	2.8 $\pm$ 0.8	1.8 $\pm$ 1.1	2.7 $\pm$ 0.9	2.6 $\pm$ 0.8	3.6 $\pm$ 0.9	2.8 $\pm$ 0.8	2.7 $\pm$ 1.1
	2.2 $\pm$ 0.8	<2.0	2.4 $\pm$ 1.0	1.9 $\pm$ 0.8	1.6 $\pm$ 0.8	2.0 $\pm$ 0.8	2.0 $\pm$ 0.5
	1.7 $\pm$ 0.7	2.1 $\pm$ 1.3	<0.9	1.4 $\pm$ 0.7	1.2 $\pm$ 0.7	1.6 $\pm$ 0.7	1.5 $\pm$ 0.8
	1.1 $\pm$ 0.6	<1.0	1.9 $\pm$ 0.8	1.6 $\pm$ 0.7	1.4 $\pm$ 0.7	1.1 $\pm$ 0.6	1.4 $\pm$ 0.7
OCTOBER	1.6 $\pm$ 0.7	1.0 $\pm$ 0.9	1.3 $\pm$ 0.7	1.8 $\pm$ 0.8	1.2 $\pm$ 0.7	1.7 $\pm$ 0.7	1.4 $\pm$ 0.6
	0.7 $\pm$ 0.4	1.1 $\pm$ 0.9	1.2 $\pm$ 0.5	1.7 $\pm$ 0.6	(3)	2.5 $\pm$ 0.7	1.4 $\pm$ 1.4
	1.1 $\pm$ 0.8	2.6 $\pm$ 1.7	1.0 $\pm$ 0.7	1.7 $\pm$ 0.8	<1.0	1.8 $\pm$ 0.9	1.5 $\pm$ 1.3
	1.9 $\pm$ 0.6	2.7 $\pm$ 1.3	2.4 $\pm$ 0.7	2.5 $\pm$ 0.7	3.2 $\pm$ 0.8	2.5 $\pm$ 0.7	2.5 $\pm$ 0.8
	1.3 $\pm$ 0.6	2.6 $\pm$ 1.5	1.9 $\pm$ 0.7	1.8 $\pm$ 0.7	(3)	1.3 $\pm$ 0.7	1.8 $\pm$ 1.1
NOVEMBER	1.9 $\pm$ 0.7	1.0 $\pm$ 0.8	2.7 $\pm$ 0.7	1.0 $\pm$ 0.6	1.4 $\pm$ 0.6	1.3 $\pm$ 0.6	1.6 $\pm$ 1.3
	3.4 $\pm$ 0.9	3.6 $\pm$ 1.5	3.6 $\pm$ 0.9	4.3 $\pm$ 1.0	(3)	4.3 $\pm$ 1.0	3.8 $\pm$ 0.9
	2.0 $\pm$ 0.7	<2.0	2.8 $\pm$ 0.7	1.4 $\pm$ 0.6	1.6 $\pm$ 0.8	1.9 $\pm$ 0.7	2.0 $\pm$ 1.0
	1.6 $\pm$ 0.8	<2.0	2.3 $\pm$ 0.9	1.9 $\pm$ 0.8	(3)	1.9 $\pm$ 0.8	1.9 $\pm$ 0.5
DECEMBER	1.9 $\pm$ 0.7	<1.0	(3)	2.3 $\pm$ 0.8	2.3 $\pm$ 0.8	2.3 $\pm$ 0.8	2.0 $\pm$ 1.1
	2.4 $\pm$ 0.8	2.1 $\pm$ 1.2	2.8 $\pm$ 0.8	2.4 $\pm$ 0.8	2.6 $\pm$ 0.8	1.9 $\pm$ 0.8	2.4 $\pm$ 0.7
	2.2 $\pm$ 0.7	3.0 $\pm$ 1.3	1.5 $\pm$ 0.6	2.4 $\pm$ 0.8	2.7 $\pm$ 0.8	2.3 $\pm$ 0.7	2.4 $\pm$ 1.0
	1.9 $\pm$ 0.7	1.9 $\pm$ 1.1	2.6 $\pm$ 0.8	2.1 $\pm$ 0.8	3.2 $\pm$ 0.9	2.6 $\pm$ 0.8	2.4 $\pm$ 1.0
AVERAGE	1.9 $\pm$ 1.3	2.0 $\pm$ 1.6	2.0 $\pm$ 1.3	2.1 $\pm$ 1.6	2.1 $\pm$ 1.4	2.0 $\pm$ 1.4	
GRAND AVERAGE							2.0 $\pm$ 1.4

\* Sampling dates can be found in Table C-5

\*\* Results reported by the QC lab, Teledyne Isotopes Inc.

- (1) Power interruption to the sampler, caused by storm. Results not included in any averages.  
 (2) Extended power outage due to Transformer failure. Results not included in any averages.  
 (3) Equipment malfunction. Results not included in any averages.

TABLE C-2  
1993 CONCENTRATIONS OF GROSS BETA EMITTERS IN AIR PARTICULATES  
Results in Units of  $10^{-3}$  pCi/m<sup>3</sup>  $\pm$  2 sigma

<----- STATION ID ----->							
* MONTH	SA-APT-5S1	** SA-APT-5D1	SA-APT-16E1	SA-APT-1F1	SA-APT-2F2	SA-APT-3H3 (Control)	AVERAGE
JANUARY	18 $\pm$ 2 28 $\pm$ 2 28 $\pm$ 3 22 $\pm$ 2 22 $\pm$ 2	22 $\pm$ 3 33 $\pm$ 3 23 $\pm$ 3 18 $\pm$ 2 22 $\pm$ 2	19 $\pm$ 2 35 $\pm$ 3 27 $\pm$ 3 21 $\pm$ 2 23 $\pm$ 2	19 $\pm$ 3 34 $\pm$ 3 26 $\pm$ 2 21 $\pm$ 2 23 $\pm$ 2	22 $\pm$ 2 31 $\pm$ 3 28 $\pm$ 3 21 $\pm$ 2 23 $\pm$ 2	18 $\pm$ 2 29 $\pm$ 3 27 $\pm$ 2 23 $\pm$ 2 22 $\pm$ 2	20 $\pm$ 4 32 $\pm$ 6 27 $\pm$ 4 21 $\pm$ 3 23 $\pm$ 1
FEBRUARY	28 $\pm$ 2 18 $\pm$ 2 24 $\pm$ 3 28 $\pm$ 2	24 $\pm$ 3 17 $\pm$ 2 8.7 $\pm$ 2.0 26 $\pm$ 3	24 $\pm$ 2 20 $\pm$ 2 88 $\pm$ 5 28 $\pm$ 3	27 $\pm$ 2 12 $\pm$ 2 22 $\pm$ 2 28 $\pm$ 2	28 $\pm$ 2 21 $\pm$ 2 16 $\pm$ 2 29 $\pm$ 3	28 $\pm$ 2 16 $\pm$ 2 27 $\pm$ 3 28 $\pm$ 2	27 $\pm$ 4 17 $\pm$ 6 31 $\pm$ 57 28 $\pm$ 2
MARCH	22 $\pm$ 2 18 $\pm$ 2 30 $\pm$ 2 9.3 $\pm$ 1.8	32 $\pm$ 3 17 $\pm$ 2 25 $\pm$ 3 12 $\pm$ 2	26 $\pm$ 3 18 $\pm$ 2 30 $\pm$ 3 10 $\pm$ 2	30 $\pm$ 2 17 $\pm$ 2 29 $\pm$ 2 10 $\pm$ 2	19 $\pm$ 3 13 $\pm$ 2 25 $\pm$ 2 11 $\pm$ 2	(1) 16 $\pm$ 2 28 $\pm$ 2 7.6 $\pm$ 1.8	26 $\pm$ 11 17 $\pm$ 4 28 $\pm$ 5 10 $\pm$ 3
APRIL	9.0 $\pm$ 1.8 12 $\pm$ 2 15 $\pm$ 2 22 $\pm$ 2	11 $\pm$ 2 16 $\pm$ 2 13 $\pm$ 3 23 $\pm$ 3	8.7 $\pm$ 2.0 11 $\pm$ 2 18 $\pm$ 2 20 $\pm$ 2	8.8 $\pm$ 1.7 10 $\pm$ 2 16 $\pm$ 2 22 $\pm$ 2	8.4 $\pm$ 1.9 14 $\pm$ 2 10 $\pm$ 2 24 $\pm$ 3	9.7 $\pm$ 1.8 14 $\pm$ 2 15 $\pm$ 2 19 $\pm$ 2	9 $\pm$ 2 13 $\pm$ 4 15 $\pm$ 5 22 $\pm$ 4
MAY	21 $\pm$ 2 18 $\pm$ 2 24 $\pm$ 2 15 $\pm$ 2 19 $\pm$ 2	20 $\pm$ 3 14 $\pm$ 2 20 $\pm$ 3 16 $\pm$ 3 20 $\pm$ 3	21 $\pm$ 3 13 $\pm$ 2 23 $\pm$ 2 17 $\pm$ 2 13 $\pm$ 2	20 $\pm$ 2 15 $\pm$ 2 23 $\pm$ 2 15 $\pm$ 2 21 $\pm$ 2	23 $\pm$ 2 17 $\pm$ 2 25 $\pm$ 3 16 $\pm$ 2 22 $\pm$ 2	24 $\pm$ 2 16 $\pm$ 2 22 $\pm$ 2 15 $\pm$ 2 20 $\pm$ 2	22 $\pm$ 3 16 $\pm$ 4 23 $\pm$ 3 16 $\pm$ 2 19 $\pm$ 6
JUNE	19 $\pm$ 2 22 $\pm$ 3 (2) (2)	18 $\pm$ 3 19 $\pm$ 3 21 $\pm$ 3 22 $\pm$ 3	26 $\pm$ 3 22 $\pm$ 3 18 $\pm$ 2 21 $\pm$ 3	22 $\pm$ 3 21 $\pm$ 2 22 $\pm$ 2 20 $\pm$ 3	21 $\pm$ 3 20 $\pm$ 3 21 $\pm$ 2 24 $\pm$ 3	14 $\pm$ 2 20 $\pm$ 2 21 $\pm$ 2 22 $\pm$ 2	20 $\pm$ 8 21 $\pm$ 2 21 $\pm$ 3 22 $\pm$ 3



TABLE C- (cont'd)  
1993 CONCENTRATIONS OF GROSS BETA EMITTERS IN AIR PARTICULATES  
Results in Units of  $10^{-3}$  pCi/m<sup>3</sup>  $\pm$  2 sigma

<----- STATION ID ----->							
* MONTH	SA-APT-5S1	** SA-APT-5D1	SA-APT-16E1	SA-APT-1F1	SA-APT-2F2	SA-APT-3H3 (Control)	AVERAGE
JULY	25 $\pm$ 2 33 $\pm$ 3 19 $\pm$ 2 20 $\pm$ 2	23 $\pm$ 3 32 $\pm$ 4 18 $\pm$ 3 20 $\pm$ 3	26 $\pm$ 2 36 $\pm$ 3 20 $\pm$ 3 22 $\pm$ 2	28 $\pm$ 2 32 $\pm$ 3 18 $\pm$ 2 20 $\pm$ 2	26 $\pm$ 2 33 $\pm$ 3 18 $\pm$ 2 21 $\pm$ 2	19 $\pm$ 2 36 $\pm$ 3 17 $\pm$ 2 16 $\pm$ 2	25 $\pm$ 6 34 $\pm$ 4 18 $\pm$ 2 20 $\pm$ 4
AUGUST	21 $\pm$ 2 26 $\pm$ 2 17 $\pm$ 2 26 $\pm$ 3 28 $\pm$ 2	18 $\pm$ 3 25 $\pm$ 3 27 $\pm$ 3 23 $\pm$ 3 32 $\pm$ 4	21 $\pm$ 3 35 $\pm$ 3 24 $\pm$ 4 27 $\pm$ 3 39 $\pm$ 3	20 $\pm$ 2 28 $\pm$ 2 24 $\pm$ 3 33 $\pm$ 3 32 $\pm$ 3	18 $\pm$ 2 29 $\pm$ 2 26 $\pm$ 3 27 $\pm$ 2 39 $\pm$ 3	17 $\pm$ 2 27 $\pm$ 2 26 $\pm$ 3 28 $\pm$ 2 38 $\pm$ 3	19 $\pm$ 3 28 $\pm$ 7 24 $\pm$ 7 27 $\pm$ 7 35 $\pm$ 9
SEPTEMBER	26 $\pm$ 2 33 $\pm$ 3 19 $\pm$ 2 18 $\pm$ 2	32 $\pm$ 3 24 $\pm$ 3 17 $\pm$ 3 31 $\pm$ 3	28 $\pm$ 3 24 $\pm$ 3 18 $\pm$ 2 21 $\pm$ 3	29 $\pm$ 2 23 $\pm$ 3 19 $\pm$ 2 25 $\pm$ 2	26 $\pm$ 2 26 $\pm$ 3 18 $\pm$ 2 23 $\pm$ 2	24 $\pm$ 2 20 $\pm$ 3 19 $\pm$ 2 23 $\pm$ 2	28 $\pm$ 6 25 $\pm$ 9 18 $\pm$ 2 24 $\pm$ 9
OCTOBER	22 $\pm$ 2 8.5 $\pm$ 1.6 26 $\pm$ 3 20 $\pm$ 2 18 $\pm$ 2	23 $\pm$ 3 20 $\pm$ 3 28 $\pm$ 4 26 $\pm$ 3 26 $\pm$ 3	21 $\pm$ 2 19 $\pm$ 2 25 $\pm$ 2 17 $\pm$ 2 23 $\pm$ 2	20 $\pm$ 2 17 $\pm$ 2 28 $\pm$ 3 21 $\pm$ 2 17 $\pm$ 2	21 $\pm$ 2 (3) 28 $\pm$ 3 24 $\pm$ 2 (3)	20 $\pm$ 2 22 $\pm$ 2 24 $\pm$ 3 20 $\pm$ 2 17 $\pm$ 2	21 $\pm$ 2 17 $\pm$ 10 27 $\pm$ 4 21 $\pm$ 6 20 $\pm$ 8
NOVEMBER	24 $\pm$ 2 38 $\pm$ 3 23 $\pm$ 2 20 $\pm$ 2	19 $\pm$ 3 39 $\pm$ 4 25 $\pm$ 3 24 $\pm$ 3	21 $\pm$ 2 43 $\pm$ 3 24 $\pm$ 2 27 $\pm$ 3	16 $\pm$ 2 41 $\pm$ 3 23 $\pm$ 2 29 $\pm$ 3	24 $\pm$ 2 (3) 25 $\pm$ 2 (3)	23 $\pm$ 2 43 $\pm$ 3 24 $\pm$ 2 26 $\pm$ 2	21 $\pm$ 6 41 $\pm$ 5 24 $\pm$ 2 25 $\pm$ 7
DECEMBER	22 $\pm$ 2 36 $\pm$ 3 18 $\pm$ 2 28 $\pm$ 2	32 $\pm$ 4 35 $\pm$ 3 19 $\pm$ 3 25 $\pm$ 3	(3) 36 $\pm$ 3 18 $\pm$ 2 26 $\pm$ 2	28 $\pm$ 3 40 $\pm$ 3 20 $\pm$ 2 24 $\pm$ 2	23 $\pm$ 2 35 $\pm$ 3 22 $\pm$ 2 27 $\pm$ 3	30 $\pm$ 3 32 $\pm$ 3 19 $\pm$ 2 23 $\pm$ 2	27 $\pm$ 9 36 $\pm$ 5 19 $\pm$ 3 26 $\pm$ 4
AVERAGE	22 $\pm$ 13	23 $\pm$ 13	24 $\pm$ 23	23 $\pm$ 14	23 $\pm$ 12	22 $\pm$ 13	

GRAND AVERAGE      23 $\pm$ 15

\* Sampling dates can be found in Table C-5

\*\* Results reported by the QC lab, Teledyne Isotopes Inc.

- (1) Power interruption to the sampler, caused by a storm. Results not included in any averages.
- (2) Extended power outage due to Transformer failure. Results not included in any averages.
- (3) Equipment malfunction. Results not included in any averages.

TABLE C-3

1993 CONCENTRATIONS OF STRONTIUM-89\* AND STRONTIUM-90\* AND GAMMA EMITTERS\*\*  
IN QUARTERLY COMPOSITES OF AIR PARTICULATEResults in Units of  $10^{-3}$  pCi/m<sup>3</sup>  $\pm$  2 sigma

STATION ID	*** SAMPLING PERIOD	<-- STRONTIUM -->		<-- GAMMA EMITTERS -->	
		SR-89	SR-90	BE-7	CO-58
SA-APT-5S1	12-29-92 to 03-29-93	<0.3	<0.2	57±5	<0.1
SA-APT-5D1 (1)	12-29-92 to 03-29-93	<1.0	<0.2	62±6	<0.3
SA-APT-16E1	12-28-92 to 03-29-93	<0.3	<0.2	56±4	<0.3
SA-APT-1F1	12-29-92 to 03-29-93	<0.3	<0.2	55±4	<0.1
SA-APT-2F2	12-29-92 to 03-29-93	<0.4	<0.3	53±4	<0.2
SA-APT-3H3 (C)	12-28-92 to 03-29-93	<0.4	<0.3	60±5	<0.2
SA-APT-5S1	03-29-93 to 06-28-93			71±5	<0.1
SA-APT-5D1 (1)	03-29-93 to 06-28-93			90±9	<0.5
SA-APT-16E1	03-29-93 to 06-28-93			78±6	<0.1
SA-APT-1F1	03-29-93 to 06-28-93			80±5	<0.2
SA-APT-2F2	03-29-93 to 06-28-93			82±5	<0.1
SA-APT-3H3 (C)	03-29-93 to 06-28-93			92±5	<0.1
SA-APT-5S1	06-28-93 to 09-27-93			68±5	<0.2
SA-APT-5D1 (1)	06-28-93 to 09-27-93			90±9	<0.5
SA-APT-16E1	06-28-93 to 09-28-93			75±6	<0.3
SA-APT-1F1	06-28-93 to 09-27-93			76±5	<0.1
SA-APT-2F2	06-28-93 to 09-27-93			74±5	<0.2
SA-APT-3H3 (C)	06-28-93 to 09-27-93			75±5	<0.1
SA-APT-5S1	09-27-93 to 12-27-93			48±4	1.2±0.3
SA-APT-5D1 (1)	09-27-93 to 12-27-93			73±7	<0.3
SA-APT-16E1	09-28-93 to 12-27-93			52±4	<0.2
SA-APT-1F1	09-27-93 to 12-27-93			57±3	<0.1
SA-APT-2F2	09-27-93 to 12-27-93			42±4	<0.2
SA-APT-3H3 (C)	09-27-93 to 12-27-93			47±4	<0.1
AVERAGE				67±29	

\* Strontium results are corrected for decay to sample stop date.

\*\* All other gamma emitters searched for were &lt;LLD; typical LLDs are given in Table C-27

\*\*\* Management audit analyses, not required by Technical Specifications or by specific commitments to local officials.

(C) Control Station

(1) Results by Teledyne Isotopes, Inc.

1993 CONCENTRATIONS OF IODINE-131\* IN FILTERED AIR  
Results in Units of  $10^{-3}$  pCi/m<sup>3</sup>

----- STATION ID -----						
* MONTH	SA-AIO-5S1	** SA-AIO-5D1	SA-AIO-16E1	SA-AIO-1F1	SA-AIO-2F2	SA-AIO-3H3 (Control)
JANUARY	<12 <8.8 <8.1 <5.8 <7.1	<20 <20 <10 <10 <20	<7.4 <2.8 <8.0 <4.0 <4.9	<10 <9.1 <4.0 <3.2 <4.1	<3.4 <4.1 <11 <11 <13	<4.4 <7.6 <2.7 <9.1 <4.1
FEBRUARY	<8.8 <6.3 <5.0 <8.2	<20 <8.0 <10 <9.0	<7.7 <7.7 <11 <8.7	<4.4 <3.4 <7.6 <4.2	<8.7 <7.5 <8.4 <12	<5.3 <2.8 <4.7 <6.2
MARCH	<9.6 <8.7 <7.9 <7.1	<10 <20 <9.0 <9.0	<6.3 <9.2 <6.4 <5.0	<11 <8.6 <7.2 <3.5	<5.1 <8.9 <8.8 <8.1	(1) <3.2 <6.8 <5.6
APRIL	<6.4 <6.0 <10 <5.6	<10 <20 <10 <10	<11 <4.8 <5.8 <4.8	<6.0 <4.4 <3.2 <5.7	<2.2 <11 <5.8 <12	<12 <3.3 <8.3 <4.7
MAY	<6.3 <11 <4.4 <3.8 <4.6	<20 <10 <20 <20 <20	<3.1 <5.3 <9.2 <4.7 <4.9	<4.5 <3.5 <9.8 <9.6 <12	<7.9 <4.5 <7.1 <5.6 <9.3	<4.9 <9.4 <3.6 <9.6 <4.7
JUNE	<6.6 <5.2 (2) (2)	<20 <20 <10 <30	<14 <5.0 <3.8 <5.8	<3.3 <5.4 <8.0 <5.5	<27 <4.6 <3.6 <10	<8.0 <2.2 <5.7 <6.2

TABLE C-4 (Cont'd)  
1993 CONCENTRATIONS OF IODINE-131\* IN FILTERED AIR  
Results in Units of  $10^{-3}$  pCi/m<sup>3</sup>

<----- STATION ID ----->						
* MONTH	SA-AIO-5S1	** SA-AIO-5D1	SA-AIO-16E1	SA-AIO-1F1	SA-AIO-2F2	SA-AIO-3H3 (Control)
JULY	<4.8	<9.0	<4.8	<8.6	<8.2	<6.2
	<9.2	<10	<4.3	<5.8	<10	<3.8
	<8.3	<10	<6.1	<7.8	<6.3	<4.9
	<12	<20	<11	<2.6	<8.2	<8.4
AUGUST	<3.9	<10	<5.6	<6.6	<8.7	<8.2
	<3.9	<20	<11	<6.5	<5.9	<6.9
	<13	<10	<10	<4.5	<8.5	<6.0
	<3.8	<10	<3.6	<11	<16	<2.1
SEPTEMBER	<8.4	<20	<8.1	<6.9	<3.1	<10
	<6.7	<7.0	<16	<4.1	<1.9	<4.8
	<6.5	<30	<6.0	<6.1	<15	<5.0
	<6.7	<9.0	<10	<7.0	<3.8	<3.5
OCTOBER	<12	<10	<13	<12	<3.2	<5.9
	<19	<10	<2.5	<4.6	<10	<8.4
	<4.3	<9.0	<13	<5.8	(3)	<4.3
	<5.6	<10	<8.6	<11	<6.3	<5.0
NOVEMBER	<5.6	<10	<7.3	<4.8	<17	<10
	<11	<9.0	<3.4	<7.0	(3)	<5.1
	<4.7	<10	<3.2	<6.0	<2.7	<2.7
	<12	<20	<7.4	<5.6	(3)	<4.2
DECEMBER	<9.2	<8.0	<8.9	<5.4	<5.5	<2.5
	<3.8	<20	<2.9	<2.6	(3)	<5.9
	<6.2	<20	(3)	<7.8	<3.5	<5.7
	<1.4	<10	<3.8	<4.5	<2.6	<5.3
	<6.4	<10	<5.3	<2.8	<5.5	<5.7
	<4.2	<10	<6.2	<6.3	<3.9	<3.7

\* I-131 results are corrected for decay to sample stop date.

\*\* Sampling dates can be found in Table C-5.

\*\*\* Results reported by the QC lab, Teledyne Isotopes Inc.

(1) Power interruption to the sampler, caused by storm. Results not included in any averages.

(2) Extended power outage due to Transformer failure. Results not included in any averages.

(3) Equipment malfunction. Results not included in any averages.

## 1993 SAMPLING DATES FOR AIR SAMPLES

<----- STATION ID ----->						
* MONTH	5S1	** 5D1	16E1	1F1	2F2	3H3 (Control)
JANUARY	12-29-92	12-29-92	12-28-92	12-29-92	12-29-92	12-28-92
	to	to	to	to	to	to
	01-04-93	01-04-93	01-04-93	01-04-93	01-04-93	01-04-93
	01-04-93	01-04-93	01-04-93	01-04-93	01-04-93	01-04-93
	to	to	to	to	to	to
	01-12-93	01-11-93	01-11-93	01-11-93	01-11-93	01-11-93
	01-12-93	01-11-93	01-11-93	01-11-93	01-11-93	01-11-93
	to	to	to	to	to	to
	01-18-93	01-18-93	01-18-93	01-18-93	01-18-93	01-18-93
	01-18-93	01-18-93	01-18-93	01-18-93	01-18-93	01-18-93
FEBRUARY	to	to	to	to	to	to
	01-25-93	01-25-93	01-25-93	01-25-93	01-25-93	01-25-93
	01-25-93	01-25-93	01-25-93	01-25-93	01-25-93	01-25-93
	to	to	to	to	to	to
	02-01-93	02-01-93	02-01-93	02-01-93	02-01-93	02-01-93
	02-01-93	02-01-93	02-01-93	02-01-93	02-01-93	02-01-93
	to	to	to	to	to	to
	02-08-93	02-08-93	02-08-93	02-08-93	02-08-93	02-08-93
	02-08-93	02-08-93	02-08-93	02-08-93	02-08-93	02-08-93
	to	to	to	to	to	to
MARCH	02-16-93	02-16-93	02-16-93	02-16-93	02-16-93	02-16-93
	02-16-93	02-16-93	02-16-93	02-16-93	02-16-93	02-16-93
	to	to	to	to	to	to
	02-22-93	02-22-93	02-22-93	02-22-93	02-22-93	02-22-93
	02-22-93	02-22-93	02-22-93	02-22-93	02-22-93	02-22-93
	to	to	to	to	to	to
	03-01-93	03-01-93	03-01-93	03-01-93	03-01-93	03-01-93
	03-01-93	03-01-93	03-01-93	03-01-93	03-01-93	03-01-93
	to	to	to	to	to	to
	03-08-93	03-08-93	03-08-93	03-08-93	03-08-93	03-08-93 <sup>(1)</sup>
	03-08-93	03-08-93	03-08-93	03-08-93	03-08-93	03-08-93
	to	to	to	to	to	to
	03-15-93	03-15-93	03-15-93	03-15-93	03-15-93	03-15-93

TABLE C-5 (Cont'd)  
1993 SAMPLING DATES FOR AIR SAMPLES

<----- STATION ID ----->						
* MONTH	5S1	** 5D1	16E1	1F1	2F2	3H3 (Control)
MARCH	03-15-93	03-15-93	03-15-93	03-15-93	03-15-93	03-15-93
	to	to	to	to	to	to
	03-22-93	03-22-93	03-22-93	03-22-93	03-22-93	03-22-93
	03-22-93	03-22-93	03-22-93	03-22-93	03-22-93	03-22-93
APRIL	to	to	to	to	to	to
	03-29-93	03-29-93	03-29-93	03-29-93	03-29-93	03-29-93
	03-29-93	03-29-93	03-29-93	03-29-93	03-29-93	03-29-93
	to	to	to	to	to	to
	04-05-93	04-05-93	04-05-93	04-05-93	04-05-93	04-05-93
	04-05-93	04-05-93	04-05-93	04-05-93	04-05-93	04-05-93
	to	to	to	to	to	to
	04-12-93	04-12-93	04-12-93	04-12-93	04-12-93	04-12-93
	04-12-93	04-12-93	04-12-93	04-12-93	04-12-93	04-12-93
	to	to	to	to	to	to
	04-19-93	04-19-93	04-19-93	04-19-93	04-19-93	04-19-93
	04-19-93	04-19-93	04-19-93	04-19-93	04-19-93	04-19-93
MAY	to	to	to	to	to	to
	04-26-93	04-26-93	04-27-93	04-26-93	04-26-93	04-26-93
	05-03-93	05-03-93	05-03-93	05-03-93	05-03-93	05-03-93
	05-03-93	05-03-93	05-03-93	05-03-93	05-03-93	05-03-93
	to	to	to	to	to	to
	05-10-93	05-10-93	05-10-93	05-10-93	05-10-93	05-10-93
	05-10-93	05-10-93	05-10-93	05-10-93	05-10-93	05-10-93
	to	to	to	to	to	to
	05-17-93	05-17-93	05-17-93	05-17-93	05-17-93	05-17-93
	05-17-93	05-17-93	05-17-93	05-17-93	05-17-93	05-17-93
	to	to	to	to	to	to
	05-24-93	05-24-93	05-24-93	05-24-93	05-24-93	05-24-93
	05-24-93	05-24-93	05-24-93	05-24-93	05-24-93	05-24-93
	to	to	to	to	to	to
	06-01-93	06-01-93	06-01-93	06-01-93	06-01-93	06-01-93

TABLE C (Cont'd)

## 1993 SAMPLING DATES FOR AIR SAMPLES

<----- STATION ID ----->						
* MONTH	5S1	** 5D1	16E1	1F1	2F2	3H3 (Control)
JUNE	06-01-93	06-01-93	06-01-93	06-01-93	06-01-93	06-01-93
	to	to	to	to	to	to
	06-07-93	06-07-93	06-07-93	06-07-93	06-07-93	06-07-93
	06-07-93	06-07-93	06-07-93	06-07-93	06-07-93	06-07-93
	to	to	to	to	to	to
	06-14-93	06-14-93	06-14-93	06-14-93	06-14-93	06-14-93
	06-14-93	06-14-93	06-14-93	06-14-93	06-14-93	06-14-93
	to	to	to	to	to	to
JULY	06-22-93 <sup>2</sup>	06-22-93	06-22-93	06-22-93	06-22-93	06-21-93
	06-22-93	06-22-93	06-22-93	06-22-93	06-22-93	06-21-93
	to	to	to	to	to	to
	06-28-93 <sup>2</sup>	06-28-93	06-28-93	06-28-93	06-28-93	06-28-93
	06-28-93	06-28-93	06-28-93	06-28-93	06-28-93	06-28-93
	to	to	to	to	to	to
	07-06-93	07-06-93	07-06-93	07-06-93	07-06-93	07-06-93
	07-06-93	07-06-93	07-06-93	07-06-93	07-06-93	07-06-93
	to	to	to	to	to	to
	07-12-93	07-12-93	07-12-93	07-12-93	07-12-93	07-12-93
	07-12-93	07-12-93	07-12-93	07-12-93	07-12-93	07-12-93
	to	to	to	to	to	to
AUGUST	07-19-93	07-19-93	07-19-93	07-19-93	07-19-93	07-19-93
	07-19-93	07-19-93	07-19-93	07-19-93	07-19-93	07-19-93
	to	to	to	to	to	to
	07-26-93	07-26-93	07-26-93	07-26-93	07-26-93	07-26-93
	07-26-93	07-26-93	07-26-93	07-26-93	07-26-93	07-26-93
	to	to	to	to	to	to
	08-02-93	08-02-93	08-02-93	08-02-93	08-02-93	08-02-93
	08-02-93	08-02-93	08-02-93	08-02-93	08-02-93	08-02-93
	to	to	to	to	to	to
	08-10-93	08-10-93	08-11-93	08-10-93	08-10-93	08-09-93

TABLE C-5 (Cont'd)  
1993 SAMPLING DATES FOR AIR SAMPLES

* MONTH	<----- STATION ID ----->					
	5S1	** 5D1	16E1	1F1	2F2	3H3 (Control)
AUGUST	08-10-93	08-10-93	08-11-93	08-10-93	08-10-93	08-09-93
	to	to	to	to	to	to
	08-17-93	08-17-93	08-16-93	08-16-93	08-16-93	08-16-93
	08-17-93	08-17-93	08-16-93	08-16-93	08-16-93	08-16-93
	to	to	to	to	to	to
	08-23-93	08-23-93	08-23-93	08-23-93	08-23-93	08-23-93
SEPTEMBER	08-23-93	08-23-93	08-23-93	08-23-93	08-23-93	08-23-93
	to	to	to	to	to	to
	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93	08-30-93
	to	to	to	to	to	to
	09-07-93	09-07-93	09-07-93	09-07-93	09-07-93	09-07-93
	09-07-93	09-07-93	09-07-93	09-07-93	09-07-93	09-07-93
	to	to	to	to	to	to
	09-13-93	09-13-93	09-13-93	09-13-93	09-13-93	09-13-93
	09-13-93	09-13-93	09-13-93	09-13-93	09-13-93	09-13-93
	to	to	to	to	to	to
	09-20-93	09-20-93	09-20-93	09-20-93	09-20-93	09-20-93
OCTOBER	09-20-93	09-20-93	09-20-93	09-20-93	09-20-93	09-20-93
	to	to	to	to	to	to
	09-27-93	09-27-93	09-28-93	09-27-93	09-27-93	09-27-93
	09-27-93	09-27-93	09-28-93	09-27-93	09-27-93	09-27-93
	to	to	to	to	to	to
	10-04-93	10-04-93	10-04-93	10-04-93	10-04-93	10-04-93
	10-04-93	10-04-93	10-04-93	10-04-93	10-04-93	10-04-93
	to	to	to	to	to	to
	10-12-93	10-12-93	10-12-93	10-12-93	10-12-93 <sup>(3)</sup>	10-12-93
	10-12-93	10-12-93	10-12-93	10-12-93	10-12-93	10-12-93
	to	to	to	to	to	to
	10-18-93	10-18-93	10-18-93	10-18-93	10-18-93	10-18-93
	10-18-93	10-18-93	10-18-93	10-18-93	10-18-93	10-18-93
	to	to	to	to	to	to
	10-25-93	10-25-93	10-25-93	10-25-93	10-25-93	10-25-93



TABLE C- (cont'd)  
1993 SAMPLING DATES FOR AIR SAMPLES

<----- STATION ID ----->						
* MONTH	5S1	** 5D1	16E1	1F1	2F2	3H3 (Control)
OCTOBER	10-25-93	10-25-93	10-25-93	10-25-93	10-25-93	10-25-93
	to 11-01-93	to 11-01-93	to 11-01-93	to 11-01-93	to 11-01-93 <sup>(1)</sup>	to 11-01-93
NOVEMBER	11-01-93	11-01-93	11-01-93	11-01-93	11-01-93	11-01-93
	to 11-08-93	to 11-08-93	to 11-09-93	to 11-08-93	to 11-08-93	to 11-08-93
	11-08-93	11-08-93	11-09-93	11-08-93	11-08-93	11-08-93
	to 11-15-93	to 11-15-93	to 11-15-93	to 11-15-93	to 11-15-93 <sup>(1)</sup>	to 11-15-93
	11-15-93	11-15-93	11-15-93	11-15-93	11-15-93	11-15-93
	to 11-22-93	to 11-22-93	to 11-23-93	to 11-22-93	to 11-22-93	to 11-22-93
	11-22-93	11-22-93	11-23-93	11-22-93	11-22-93	11-22-93
	to 11-29-93	to 11-29-93	to 11-29-93	to 11-29-93	to 11-29-93 <sup>(1)</sup>	to 11-29-93
DECEMBER	11-29-93	11-29-93	11-29-93	11-29-93	11-29-93	11-29-93
	to 12-06-93	to 12-06-93	to 11-29-93 <sup>3</sup>	to 12-06-93	to 12-06-93	to 12-06-93
	12-06-93	12-06-93	12-06-93	12-06-93	12-06-93	12-06-93
	to 12-13-93	to 12-13-93	to 12-13-93	to 12-13-93	to 12-13-93	to 12-13-93
	12-13-93	12-13-93	12-13-93	12-13-93	12-13-93	12-13-93
	to 12-20-93	to 12-20-93	to 12-20-93	to 12-20-93	to 12-20-93	to 12-20-93
	12-20-93	12-20-93	12-20-93	12-20-93	12-20-93	12-20-93
	to 12-27-93	to 12-27-93	to 12-27-93	to 12-27-93	to 12-27-93	to 12-27-93

- (1) Power interruption to the sampler, caused by a storm.  
(2) Extended power outage due to Transformer failure.  
(3) Equipment malfunction.

TABLE C-6

1993 CONCENTRATIONS OF GROSS ALPHA\* AND GROSS BETA EMITTERS\*,  
TRITIUM\* AND GAMMA EMITTERS\*\* IN PRECIPITATION

Results in Units of pCi/L  $\pm$  2 sigma

STATION ID: SA-RWA-2F2

SAMPLING PERIOD	GROSS ALPHA	GROSS BETA	TRITIUM	<-----GAMMA EMITTER----->		
				BE-7	K-40	RA-NAT
12-29-92 to 01-25-93	2.6 $\pm$ 2.0	<0.9	130 $\pm$ 80	66 $\pm$ 19	60 $\pm$ 17	<2.4
01-25-93 to 03-01-93	<2.5	1.3 $\pm$ 0.6	<130	61 $\pm$ 23	<21	<4.5
03-01-93 to 03-29-93	<2.7	0.9 $\pm$ 0.6	<140	55 $\pm$ 10	<14	<1.9
03-29-93 to 04-26-93	<2.8	3.5 $\pm$ 0.9	<180	120 $\pm$ 17	56 $\pm$ 22	<2.3
04-26-93 to 06-01-93	<1.4	4.5 $\pm$ 0.9	<190	79 $\pm$ 12	<15	<2.3
06-01-93 to 06-28-93 <sup>1</sup>	<4.3	2.6 $\pm$ 0.8	<160	39 $\pm$ 15	<40	<11
06-28-93 to 07-26-93	(2)	(2)	(2)	(2)	(2)	(2)
07-26-93 to 08-30-93	(2)	(2)	(2)	(2)	(2)	(2)
08-30-93 to 09-27-93	0.7 $\pm$ 0.5	2.2 $\pm$ 0.4	<160	<12	<16	8.3 $\pm$ 2.0
09-27-93 to 11-01-93	<0.6	1.1 $\pm$ 0.4	<170	<8.8	<15	7.3 $\pm$ 1.8
11-01-93 to 11-29-93	<0.5	0.5 $\pm$ 0.3	<110	<17	<18	<1.8
11-29-93 to 12-27-93	<0.4	0.8 $\pm$ 0.3	<110	39 $\pm$ 13	<15	<2.0
AVERAGE	-	1.8 $\pm$ 2.7	-	50 $\pm$ 69	-	-

\* Management audit analyses, not required by Technical Specifications.

\*\* All other gamma emitters searched for were <LLD; typical LLDs are given in Table C-27.

(1) Rainwater sampler was moved to location 2F6 on June 28.

(2) Results for these two months were invalidated because of automatic sprinkler system activation near the rain collector. Rainwater sampler was moved back to location 2F2 on August 30.

TABLE C-7

## 1993 DIRECT RADIATION MEASUREMENTS - QUARTERLY TLD RESULT

Results in mrad/standard month\*  $\pm$  2 sigma

(Results by Teledyne Isotopes)

STATION ID	JANUARY to MARCH	APRIL to JUNE	JULY to SEPTEMBER	OCTOBER to DECEMBER	AVERAGE
SA-IDM-2S2	4.6 $\pm$ 0.4	4.6 $\pm$ 0.6	5.1 $\pm$ 0.6	(1)	4.8 $\pm$ 0.6
SA-IDM-5S1	4.9 $\pm$ 0.2	3.9 $\pm$ 0.2	6.4 $\pm$ 1.6	(1)	5.1 $\pm$ 2.5
SA-IDM-6S2	5.5 $\pm$ 0.4	4.3 $\pm$ 0.3	6.2 $\pm$ 1.2	(1)	5.3 $\pm$ 1.9
SA-IDM-7S1	6.9 $\pm$ 1.1	5.6 $\pm$ 0.6	6.9 $\pm$ 1.3	(1)	6.5 $\pm$ 1.5
SA-IDM-10S1	7.8 $\pm$ 3.3	5.2 $\pm$ 0.6	6.2 $\pm$ 1.0	(1)	6.4 $\pm$ 2.6
SA-IDM-11S1	9.8 $\pm$ 2.2	6.1 $\pm$ 0.8	7.2 $\pm$ 1.5	(1)	7.7 $\pm$ 3.8
SA-IDM-4D2	5.7 $\pm$ 0.5	4.9 $\pm$ 0.6	6.8 $\pm$ 1.8	(1)	5.8 $\pm$ 1.9
SA-IDM-5D1	5.4 $\pm$ 0.5	4.5 $\pm$ 0.3	6.6 $\pm$ 1.2	(1)	5.5 $\pm$ 2.1
SA-IDM-10D1	5.6 $\pm$ 0.5	4.8 $\pm$ 0.4	6.9 $\pm$ 0.6	(1)	5.8 $\pm$ 2.1
SA-IDM-14D1	5.2 $\pm$ 0.4	4.8 $\pm$ 0.3	7.0 $\pm$ 1.6	(1)	5.7 $\pm$ 2.3
SA-IDM-2E1	5.4 $\pm$ 0.5	4.3 $\pm$ 0.5	7.1 $\pm$ 1.1	(1)	5.6 $\pm$ 2.8
SA-IDM-3E1	5.1 $\pm$ 0.3	3.9 $\pm$ 0.3	6.3 $\pm$ 1.0	(1)	5.1 $\pm$ 2.4
SA-IDM-9E1	6.1 $\pm$ 0.7	5.2 $\pm$ 0.6	6.6 $\pm$ 0.5	(1)	6.0 $\pm$ 1.4
SA-IDM-11E2	5.9 $\pm$ 0.6	5.0 $\pm$ 0.3	8.7 $\pm$ 2.4	(1)	6.5 $\pm$ 3.9
SA-IDM-12E1	5.2 $\pm$ 0.5	4.7 $\pm$ 0.4	6.9 $\pm$ 1.6	(1)	5.6 $\pm$ 2.3
SA-IDM-13E1	4.5 $\pm$ 0.4	4.0 $\pm$ 0.4	5.4 $\pm$ 1.5	(1)	4.6 $\pm$ 1.4
SA-IDM-16E1	5.6 $\pm$ 0.5	4.1 $\pm$ 0.2	6.5 $\pm$ 1.0	(1)	5.4 $\pm$ 2.4
SA-IDM-1F1	5.6 $\pm$ 0.2	4.0 $\pm$ 0.4	6.2 $\pm$ 0.9	(1)	5.3 $\pm$ 2.3
SA-IDM-2F2	4.5 $\pm$ 0.1	3.2 $\pm$ 0.3	6.5 $\pm$ 2.2	(1)	4.7 $\pm$ 3.3
SA-IDM-2F5	5.5 $\pm$ 0.4	4.1 $\pm$ 0.3	6.7 $\pm$ 2.6	(1)	5.4 $\pm$ 2.6
SA-IDM-2F6	5.4 $\pm$ 0.3	4.0 $\pm$ 0.3	5.2 $\pm$ 0.6	(1)	4.9 $\pm$ 1.5
SA-IDM-3F2	5.0 $\pm$ 0.3	3.8 $\pm$ 0.2	6.1 $\pm$ 1.2	(1)	5.0 $\pm$ 2.3
SA-IDM-3F3	5.0 $\pm$ 0.3	3.7 $\pm$ 0.2	5.7 $\pm$ 1.5	(1)	4.8 $\pm$ 2.0
SA-IDM-5F1	5.3 $\pm$ 0.3	3.9 $\pm$ 0.3	6.2 $\pm$ 1.8	(1)	5.1 $\pm$ 2.3
SA-IDM-6F1	4.7 $\pm$ 0.3	3.2 $\pm$ 0.1	6.2 $\pm$ 1.6	(1)	4.7 $\pm$ 3.0
SA-IDM-7F2	4.3 $\pm$ 0.1	3.0 $\pm$ 0.2	4.7 $\pm$ 1.3	(1)	4.0 $\pm$ 1.8
SA-IDM-10F2	5.8 $\pm$ 0.4	4.7 $\pm$ 0.3	6.4 $\pm$ 1.0	(1)	5.6 $\pm$ 1.7
SA-IDM-11F1	5.9 $\pm$ 0.4	4.6 $\pm$ 0.5	7.2 $\pm$ 1.2	(1)	5.9 $\pm$ 2.6
SA-IDM-12F1	5.5 $\pm$ 0.3	4.5 $\pm$ 0.2	6.2 $\pm$ 0.3	(1)	5.4 $\pm$ 1.7
SA-IDM-13F2	5.4 $\pm$ 0.3	4.5 $\pm$ 0.2	5.5 $\pm$ 0.7	(1)	5.1 $\pm$ 1.1
SA-IDM-13F3	5.6 $\pm$ 0.5	4.4 $\pm$ 0.3	5.1 $\pm$ 1.6	(1)	5.0 $\pm$ 1.2
SA-IDM-13F4	5.5 $\pm$ 0.5	4.4 $\pm$ 0.3	4.2 $\pm$ 0.8	(1)	4.7 $\pm$ 1.4
SA-IDM-14F2	6.4 $\pm$ 0.6	5.1 $\pm$ 0.3	5.4 $\pm$ 0.6	(1)	5.6 $\pm$ 1.4
SA-IDM-15F3	5.4 $\pm$ 0.5	4.9 $\pm$ 0.4	5.4 $\pm$ 1.0	(1)	5.2 $\pm$ 0.6
SA-IDM-16F2	5.2 $\pm$ 0.4	4.0 $\pm$ 0.2	4.1 $\pm$ 0.5	(1)	4.4 $\pm$ 1.3
SA-IDM-1G3 (C)	6.4 $\pm$ 0.5	4.9 $\pm$ 0.5	5.3 $\pm$ 0.4	(1)	5.5 $\pm$ 1.6
SA-IDM-3G1 (C)	5.7 $\pm$ 0.6	4.5 $\pm$ 0.5	4.8 $\pm$ 0.7	(1)	5.0 $\pm$ 1.2
SA-IDM-10G1 (C)	5.8 $\pm$ 0.5	4.7 $\pm$ 0.4	4.8 $\pm$ 0.3	(1)	5.1 $\pm$ 1.2
SA-IDM-16G1 (C)	5.9 $\pm$ 0.3	4.8 $\pm$ 0.5	5.1 $\pm$ 0.5	(1)	5.3 $\pm$ 1.1
SA-IDM-3H1 (C)	4.3 $\pm$ 0.3	4.1 $\pm$ 0.2	4.1 $\pm$ 0.4	(1)	4.2 $\pm$ 0.2
SA-IDM-3H3 (C)	5.8 $\pm$ 0.2	4.6 $\pm$ 0.3	4.8 $\pm$ 0.6	(1)	5.1 $\pm$ 1.3
AVERAGE	5.6 $\pm$ 1.9	4.4 $\pm$ 1.2	6.0 $\pm$ 2.0	(1)	
GRAND AVERAGE					5.3 $\pm$ 2.2

The standard month + 30.4 days.

(C) Control Station

(1) The 4th Quarter TLD results were invalidated by Teledyne due to anomalous readings by their instrumentation. (See Program Deviations)

TABLE C-8

## 1993 DIRECT RADIATION MEASUREMENTS - MONTHLY TLD RESULTS

Results in mrad/standard month\*  $\pm 2$  sigma

(Results by Teledyne Isotopes)

STATION ID	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE
SA-IDM-2S2	5.9 $\pm$ 0.5	6.5 $\pm$ 0.4	6.4 $\pm$ 0.4	9.2 $\pm$ 3.1	5.2 $\pm$ 0.5	6.6 $\pm$ 0.6
SA-IDM-5S1	5.4 $\pm$ 0.4	5.8 $\pm$ 0.8	5.2 $\pm$ 0.3	6.4 $\pm$ 0.6	4.6 $\pm$ 0.2	5.4 $\pm$ 0.3
SA-IDM-6S2	5.9 $\pm$ 0.7	6.9 $\pm$ 1.1	5.8 $\pm$ 0.5	6.9 $\pm$ 0.6	4.9 $\pm$ 0.4	6.0 $\pm$ 0.9
SA-IDM-7S1	7.2 $\pm$ 0.6	7.6 $\pm$ 0.7	7.4 $\pm$ 0.8	8.0 $\pm$ 0.9	6.2 $\pm$ 0.6	7.6 $\pm$ 0.6
SA-IDM-10S1	7.2 $\pm$ 1.4	7.8 $\pm$ 1.0	7.0 $\pm$ 0.8	7.6 $\pm$ 0.6	5.6 $\pm$ 0.5	6.8 $\pm$ 0.5
SA-IDM-11S1	11 $\pm$ 3	11 $\pm$ 3	9.6 $\pm$ 2.5	8.3 $\pm$ 1.2	6.2 $\pm$ 1.1	7.6 $\pm$ 1.2
SA-IDM-5D1	6.0 $\pm$ 0.6	6.1 $\pm$ 0.2	6.2 $\pm$ 0.5	6.7 $\pm$ 0.3	4.9 $\pm$ 0.6	6.0 $\pm$ 0.3
SA-IDM-10D1	6.0 $\pm$ 0.8	6.6 $\pm$ 0.6	6.4 $\pm$ 0.7	7.2 $\pm$ 0.5	5.5 $\pm$ 0.5	6.5 $\pm$ 0.4
SA-IDM-14D1	5.7 $\pm$ 0.8	6.3 $\pm$ 0.3	6.1 $\pm$ 0.4	6.6 $\pm$ 0.3	5.0 $\pm$ 0.3	7.1 $\pm$ 0.4
SA-IDM-2E1	5.6 $\pm$ 0.7	6.2 $\pm$ 0.3	6.0 $\pm$ 0.3	6.7 $\pm$ 0.6	4.9 $\pm$ 0.3	6.2 $\pm$ 0.3
SA-IDM-3E1	5.3 $\pm$ 0.6	5.9 $\pm$ 0.4	5.6 $\pm$ 0.4	6.3 $\pm$ 0.1	4.7 $\pm$ 0.3	5.8 $\pm$ 0.4
SA-IDM-13E1	5.3 $\pm$ 0.5	6.1 $\pm$ 0.4	6.0 $\pm$ 0.2	6.3 $\pm$ 0.3	4.6 $\pm$ 0.3	6.1 $\pm$ 0.4
SA-IDM-16E1	5.8 $\pm$ 0.6	6.4 $\pm$ 0.4	6.3 $\pm$ 0.2	6.8 $\pm$ 0.3	5.3 $\pm$ 0.3	7.0 $\pm$ 2.4
SA-IDM-1F1	5.9 $\pm$ 0.7	6.4 $\pm$ 0.4	6.2 $\pm$ 0.6	6.8 $\pm$ 0.4	5.1 $\pm$ 0.4	6.2 $\pm$ 0.6
SA-IDM-2F2	5.1 $\pm$ 0.5	5.8 $\pm$ 0.7	5.5 $\pm$ 0.2	5.8 $\pm$ 0.3	4.1 $\pm$ 0.2	5.4 $\pm$ 0.2
SA-IDM-2F6	5.6 $\pm$ 0.6	6.0 $\pm$ 0.3	6.1 $\pm$ 0.3	6.5 $\pm$ 0.4	5.1 $\pm$ 0.4	6.2 $\pm$ 0.3
SA-IDM-5F1	5.6 $\pm$ 0.5	5.9 $\pm$ 0.4	5.9 $\pm$ 0.3	6.4 $\pm$ 0.4	4.7 $\pm$ 0.3	5.9 $\pm$ 0.3
SA-IDM-6F1	5.2 $\pm$ 0.6	5.4 $\pm$ 0.3	5.4 $\pm$ 0.2	5.6 $\pm$ 0.2	4.1 $\pm$ 0.2	5.2 $\pm$ 0.4
SA-IDM-7F2	4.8 $\pm$ 0.4	4.9 $\pm$ 0.3	5.3 $\pm$ 0.2	5.7 $\pm$ 0.2	3.8 $\pm$ 0.1	4.9 $\pm$ 0.2
SA-IDM-11F1	6.1 $\pm$ 1.0	6.7 $\pm$ 0.3	6.7 $\pm$ 0.2	7.2 $\pm$ 0.6	5.7 $\pm$ 0.6	7.0 $\pm$ 0.4
SA-IDM-13F4	5.8 $\pm$ 0.9	6.6 $\pm$ 0.4	6.5 $\pm$ 0.3	6.7 $\pm$ 0.3	5.0 $\pm$ 0.4	6.3 $\pm$ 0.2
SA-IDM-3G1 (C)	5.9 $\pm$ 0.4	6.4 $\pm$ 0.2	6.8 $\pm$ 0.7	6.0 $\pm$ 0.4	5.4 $\pm$ 0.4	6.7 $\pm$ 0.5
SA-IDM-3H1 (C)	5.5 $\pm$ 0.4	6.1 $\pm$ 0.3	5.5 $\pm$ 0.3	6.3 $\pm$ 0.2	5.1 $\pm$ 0.5	6.3 $\pm$ 0.2
SA-IDM-3H3 (C)	6.8 $\pm$ 1.1	7.0 $\pm$ 0.4	7.1 $\pm$ 0.4	7.1 $\pm$ 0.8	5.6 $\pm$ 0.4	6.7 $\pm$ 0.3
AVERAGE	6.0 $\pm$ 2.4	6.5 $\pm$ 2.3	6.3 $\pm$ 1.8	6.8 $\pm$ 1.6	5.1 $\pm$ 1.2	6.3 $\pm$ 1.4

TABLE C-8 (Cont'd)

## 1993 DIRECT RADIATION MEASUREMENTS - MONTHLY TLD RESULTS

Results in mrad/standard month\*  $\pm$  2 sigma

(Results by Teledyne Isotopes)

STATION ID	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	AVERAGE
SA-IDM-2S2	5.8 $\pm$ 0.5	5.7 $\pm$ 0.6	6.6 $\pm$ 0.5	7.0 $\pm$ 0.6	6.1 $\pm$ 0.6	7.0 $\pm$ 0.2	6.5 $\pm$ 2.0
SA-IDM-5S1	5.1 $\pm$ 0.5	5.5 $\pm$ 0.4	5.7 $\pm$ 0.4	6.6 $\pm$ 0.8	5.3 $\pm$ 0.7	6.3 $\pm$ 0.3	5.6 $\pm$ 1.2
SA-IDM-6S2	5.1 $\pm$ 0.3	6.1 $\pm$ 0.4	6.3 $\pm$ 0.4	6.9 $\pm$ 0.5	5.7 $\pm$ 0.5	6.7 $\pm$ 0.5	6.1 $\pm$ 1.4
SA-IDM-7S1	6.5 $\pm$ 0.9	7.1 $\pm$ 0.3	7.8 $\pm$ 0.5	7.9 $\pm$ 0.6	7.2 $\pm$ 0.7	8.5 $\pm$ 0.7	7.4 $\pm$ 1.3
SA-IDM-10S1	5.9 $\pm$ 0.6	6.3 $\pm$ 0.4	6.8 $\pm$ 0.6	7.0 $\pm$ 0.6	6.2 $\pm$ 0.4	6.9 $\pm$ 0.4	6.8 $\pm$ 1.3
SA-IDM-11S1	5.9 $\pm$ 1.3	7.1 $\pm$ 0.6	7.8 $\pm$ 1.2	7.7 $\pm$ 1.1	6.6 $\pm$ 1.3	8.3 $\pm$ 1.2	8.1 $\pm$ 3.4
SA-IDM-5D1	5.4 $\pm$ 0.5	5.7 $\pm$ 0.3	6.0 $\pm$ 0.6	6.7 $\pm$ 0.5	5.8 $\pm$ 0.5	7.0 $\pm$ 0.6	6.0 $\pm$ 1.2
SA-IDM-10D1	6.4 $\pm$ 0.9	6.5 $\pm$ 0.6	7.0 $\pm$ 0.6	7.5 $\pm$ 0.5	6.0 $\pm$ 0.6	7.4 $\pm$ 0.5	6.6 $\pm$ 1.2
SA-IDM-14D1	6.1 $\pm$ 0.6	6.8 $\pm$ 0.5	7.0 $\pm$ 0.6	7.7 $\pm$ 0.3	6.0 $\pm$ 0.3	7.3 $\pm$ 0.3	6.5 $\pm$ 1.5
SA-IDM-2E1	5.7 $\pm$ 0.6	6.0 $\pm$ 0.6	6.3 $\pm$ 0.6	6.5 $\pm$ 0.5	5.6 $\pm$ 0.3	7.0 $\pm$ 0.7	6.1 $\pm$ 1.1
SA-IDM-3E1	4.7 $\pm$ 0.4	5.7 $\pm$ 0.1	6.0 $\pm$ 0.8	6.2 $\pm$ 0.5	5.3 $\pm$ 0.6	6.2 $\pm$ 0.1	5.6 $\pm$ 1.1
SA-IDM-13E1	5.9 $\pm$ 0.2	5.9 $\pm$ 0.3	5.9 $\pm$ 0.4	6.8 $\pm$ 0.3	5.2 $\pm$ 0.2	7.0 $\pm$ 0.4	5.9 $\pm$ 1.3
SA-IDM-16E1	5.8 $\pm$ 0.6	6.1 $\pm$ 0.4	6.2 $\pm$ 0.3	7.1 $\pm$ 0.4	5.8 $\pm$ 0.3	7.5 $\pm$ 0.2	6.3 $\pm$ 1.3
SA-IDM-1F1	5.6 $\pm$ 0.5	6.2 $\pm$ 0.3	6.6 $\pm$ 0.6	7.1 $\pm$ 0.5	6.1 $\pm$ 0.7	7.2 $\pm$ 0.6	6.3 $\pm$ 1.2
SA-IDM-2F2	4.6 $\pm$ 0.3	5.4 $\pm$ 0.5	5.4 $\pm$ 0.2	5.7 $\pm$ 0.3	4.8 $\pm$ 0.4	6.5 $\pm$ 0.4	5.3 $\pm$ 1.3
SA-IDM-2F6	5.3 $\pm$ 0.5	5.7 $\pm$ 0.2	6.4 $\pm$ 0.6	6.3 $\pm$ 0.3	5.6 $\pm$ 0.3	7.1 $\pm$ 0.4	6.0 $\pm$ 1.1
SA-IDM-5F1	5.2 $\pm$ 0.7	6.0 $\pm$ 0.8	6.2 $\pm$ 0.5	6.5 $\pm$ 0.5	5.4 $\pm$ 0.3	6.9 $\pm$ 0.3	5.9 $\pm$ 1.2
SA-IDM-6F1	4.4 $\pm$ 0.5	5.5 $\pm$ 0.3	5.6 $\pm$ 0.3	6.2 $\pm$ 0.6	4.9 $\pm$ 0.3	6.5 $\pm$ 0.3	5.3 $\pm$ 1.3
SA-IDM-7F2	4.2 $\pm$ 0.4	5.0 $\pm$ 0.4	4.8 $\pm$ 0.2	5.4 $\pm$ 0.2	4.5 $\pm$ 0.4	5.7 $\pm$ 0.2	4.9 $\pm$ 1.1
SA-IDM-11F1	6.4 $\pm$ 0.7	6.3 $\pm$ 0.3	7.0 $\pm$ 0.6	7.5 $\pm$ 0.4	6.4 $\pm$ 0.5	7.8 $\pm$ 0.7	6.7 $\pm$ 1.2
SA-IDM-13F4	5.7 $\pm$ 0.5	6.1 $\pm$ 0.4	6.7 $\pm$ 1.0	7.3 $\pm$ 0.8	6.0 $\pm$ 0.6	7.3 $\pm$ 0.3	6.3 $\pm$ 1.3
SA-IDM-3G1 (C)	6.0 $\pm$ 0.5	6.4 $\pm$ 0.2	6.8 $\pm$ 0.3	7.0 $\pm$ 0.5	6.4 $\pm$ 0.5	7.5 $\pm$ 0.4	6.5 $\pm$ 1.1
SA-IDM-3H1 (C)	6.0 $\pm$ 1.5	5.9 $\pm$ 0.3	6.2 $\pm$ 0.3	6.6 $\pm$ 0.4	5.7 $\pm$ 0.4	7.0 $\pm$ 1.1	6.0 $\pm$ 1.0
SA-IDM-3H3 (C)	5.9 $\pm$ 0.9	7.0 $\pm$ 1.0	7.3 $\pm$ 0.5	7.5 $\pm$ 0.2	6.6 $\pm$ 0.3	8.1 $\pm$ 0.4	6.9 $\pm$ 1.3
AVERAGE	5.6 $\pm$ 1.3	6.1 $\pm$ 1.1	6.4 $\pm$ 1.4	6.9 $\pm$ 1.3	5.8 $\pm$ 1.3	7.1 $\pm$ 1.3	
				GRAND AVERAGE		6.2 $\pm$ 1.9	

\* The standard month = 30.4 days

(C) Control Station

TABLE C-9

1993 CONCENTRATIONS OF IODINE-131\* AND GAMMA EMITTERS\*\* IN MILK

Results in Units of pCi/L  $\pm$  2 sigma

STATION ID	*** SAMPLING PERIOD	<-GAMMA EMITTERS->	
		I-131	K-40
SA-MLK-2F7	01/04-05/93	<0.3	1300 $\pm$ 87
SA-MLK-11F3	01/03-04/93	<0.4	1400 $\pm$ 86
SA-MLK-14F4	01/04-05/93	<0.1	1400 $\pm$ 79
SA-MLK-3G1 (C)	01/04-05/93	<0.3	1300 $\pm$ 100
SA-MLK-2F7	02/07-08/93	<0.3	1300 $\pm$ 84
SA-MLK-11F3	02/08-09/93	<0.1	1300 $\pm$ 85
SA-MLK-14F4	02/08-09/93	<0.3	1500 $\pm$ 79
SA-MLK-3G1 (C)	02/07-08/93	<0.2	1300 $\pm$ 99
SA-MLK-2F7	03/07-08/93	<0.3	1400 $\pm$ 96
SA-MLK-11F3	03/08-09/93	<0.3	1500 $\pm$ 80
SA-MLK-14F4	03/08-09/93	<0.2	1300 $\pm$ 84
SA-MLK-3G1 (C)	03/07-08/93	<0.5	1300 $\pm$ 79
SA-MLK-2F7	04/04-05/93	<0.4	1300 $\pm$ 98
SA-MLK-11F3	04/04-05/93	<0.3	1400 $\pm$ 82
SA-MLK-14F4	04/05-06/93	<0.4	1400 $\pm$ 84
SA-MLK-3G1 (C)	04/04-05/93	<0.3	1400 $\pm$ 84
SA-MLK-2F7	04/18-19/93	<0.3	1300 $\pm$ 97
SA-MLK-11F3	04/18-19/93	<0.4	1400 $\pm$ 67
SA-MLK-14F4	04/19-20/93	<0.4	1400 $\pm$ 86
SA-MLK-3G1 (C)	04/18-19/93	<0.3	1300 $\pm$ 84
SA-MLK-2F7	05/02-03/93	<0.2	1400 $\pm$ 95
SA-MLK-11F3	05/03-04/93	<0.2	1400 $\pm$ 69
SA-MLK-14F4	05/03-04/93	<0.4	1400 $\pm$ 86
SA-MLK-3G1 (C)	05/02-03/93	<0.3	1300 $\pm$ 85
SA-MLK-2F7	05/16-17/93	<0.3	1400 $\pm$ 99
SA-MLK-11F3	05/17-18/93	<0.3	1400 $\pm$ 90
SA-MLK-14F4	05/17-18/93	<0.1	1400 $\pm$ 86
SA-MLK-3G1 (C)	05/16-17/93	<0.2	1300 $\pm$ 65
SA-MLK-2F7	06/07-08/93	<0.2	1400 $\pm$ 85
SA-MLK-11F3	06/07-08/93	<0.3	1400 $\pm$ 67
SA-MLK-14F4	06/07-08/93	<0.4	1300 $\pm$ 73
SA-MLK-3G1 (C)	06/06-07/93	<0.5	1300 $\pm$ 97
SA-MLK-2F7	06/21-22/93	<0.4	1400 $\pm$ 83
SA-MLK-11F3	06/22-23/93	<0.4	1400 $\pm$ 86
SA-MLK-14F4	06/21-22/93	<0.3	1400 $\pm$ 76
SA-MLK-3G1 (C)	06/21-22/93	<0.3	1200 $\pm$ 100
SA-MLK-2F7	07/06-07/93	<0.2	1300 $\pm$ 73
SA-MLK-11F3	07/06-07/93	<0.2	1300 $\pm$ 87
SA-MLK-14F4	07/06-07/93	<0.4	1300 $\pm$ 85
SA-MLK-3G1 (C)	07/05-06/93	<0.4	1400 $\pm$ 98
SA-MLK-2F7	07/19-20/93	<0.4	930 $\pm$ 58
SA-MLK-11F3	07/18-19/93	<0.2	1400 $\pm$ 89
SA-MLK-14F4	07/18-19/93	<0.2	1400 $\pm$ 90
SA-MLK-3G1 (C)	07/19-20/93	<0.4	1300 $\pm$ 72

TABLE C-9 (Cont'd)

1993 CONCENTRATIONS OF IODINE-131\* AND GAMMA EMITTERS\*\* IN MILK

Results in Units of pCi/L  $\pm$  2 sigma

STATION ID	*** SAMPLING PERIOD	<-GAMMA EMITTERS->	
		I-131	K-40
SA-MLK-2F7	08/02-03/93	<0.3	1400 $\pm$ 96
SA-MLK-11F3	08/02-03/93	<0.2	1400 $\pm$ 76
SA-MLK-14F4	08/02-03/93	<0.4	1300 $\pm$ 68
SA-MLK-3G1 (C)	08/01-02/93	<0.3	1300 $\pm$ 85
SA-MLK-2F7	08/16-17/93	<0.2	1300 $\pm$ 88
SA-MLK-11F3	08/15-16/93	<0.2	1400 $\pm$ 79
SA-MLK-14F4	08/15-16/93	<0.1	1400 $\pm$ 72
SA-MLK-3G1 (C)	08/16-17/93	<0.4	1400 $\pm$ 65
SA-MLK-2F7	09/07-08/93	<0.7	1400 $\pm$ 100
SA-MLK-11F3	09/07-08/93	<0.3	1400 $\pm$ 77
SA-MLK-14F4	09/07-08/93	<0.2	1300 $\pm$ 68
SA-MLK-3G1 (C)	09/06-07/93	<0.2	1200 $\pm$ 84
SA-MLK-2F7	09/19-20/93	<0.4	1200 $\pm$ 87
SA-MLK-11F3	09/20-21/93	<0.2	1400 $\pm$ 80
SA-MLK-14F4	09/20-21/93	<0.5	1300 $\pm$ 66
SA-MLK-3G1 (C)	09/19-20/93	<0.2	1200 $\pm$ 95
SA-MLK-2F7	10/03-04/93	<0.2	1300 $\pm$ 86
SA-MLK-11F3	10/04-05/93	<0.2	1400 $\pm$ 77
SA-MLK-14F4	10/04-05/93	<0.2	1300 $\pm$ 66
SA-MLK-3G1 (C)	10/03-04/93	<0.8	1300 $\pm$ 100
SA-MLK-2F7	10/17-18/93	<0.4	1300 $\pm$ 110
SA-MLK-11F3	10/18-19/93	<0.3	1400 $\pm$ 81
SA-MLK-14F4	10/18-19/93	<0.2	1300 $\pm$ 70
SA-MLK-3G1 (C)	10/17-18/93	<0.4	1300 $\pm$ 87
SA-MLK-2F7	11/08-09/93	<0.2	1200 $\pm$ 80
SA-MLK-11F3	11/08-09/93	<0.8	1400 $\pm$ 64
SA-MLK-14F4	11/08-09/93	<0.2	1300 $\pm$ 78
SA-MLK-3G1 (C)	11/07-08/93	<0.4	1400 $\pm$ 98
SA-MLK-2F7	11/22-23/93	<0.3	1200 $\pm$ 80
SA-MLK-11F3	11/22-23/93	<0.2	1500 $\pm$ 63
SA-MLK-14F4	11/22-23/93	<0.1	1500 $\pm$ 110
SA-MLK-3G1 (C)	11/22-23/93	<0.2	1300 $\pm$ 100
SA-MLK-2F7	12/06-07/93	<0.1	1300 $\pm$ 74
SA-MLK-11F3	12/06-07/93	<0.2	1300 $\pm$ 88
SA-MLK-14F4	12/06-07/93	<0.2	1400 $\pm$ 68
SA-MLK-3G1 (C)	12/06-07/93	<0.2	1300 $\pm$ 69
AVERAGE		-	1340 $\pm$ 170

\* Iodine-131 results are corrected for decay to midpoint of collection period.  
Iodine-131 analyzed to a sensitivity of 1.0 pCi/liter.

\*\* All other gamma emitters searched for were <LLD; typical LLDS are given in Table C-27.

\*\*\* Monthly sample collected during Jan., Feb., March and Dec., when animals are not on pasture.

(C) Control Station.

TABLE C-10

1993 CONCENTRATIONS OF STRONTIUM-89\* AND  
STRONTIUM-90\* IN MILK\*\*Results in Units of pCi/L  $\pm$  2 sigma

STATION ID	SAMPLING PERIOD	<-----STRONTIUM----->	
		Sr-89	Sr-90
SA-MLK-2F7	7/05-06/93	<1.4	4.7 $\pm$ 0.6
SA-MLK-11F3	7/05-06/93	<0.8	1.1 $\pm$ 0.3
SA-MLK-14F4	7/06-07/93	<1.0	1.8 $\pm$ 0.4
SA-MLK-3G1 (Control)	7/05-06/93	<1.1	2.2 $\pm$ 0.4
AVERAGE			2.5 $\pm$ 3.1

\* Strontium results are corrected for decay to midpoint of collection period.

\*\* Management audit analyses, not required by Technical Specifications or by specific commitments to local officials.



TABLE C-11

1993 CONCENTRATIONS OF GROSS ALPHA AND GROSS BETA EMITTERS,  
POTASSIUM-40 AND TRITIUM IN WELL WATERResults in Units of pCi/L  $\pm$  2 sigma

STATION ID	SAMPLING DATE	GROSS ALPHA	GROSS BETA	K-40	TRITIUM
SA-WWA-2S3	01/25/93	<2.4	3.1 $\pm$ 0.8	3.0 $\pm$ 0.3	<130
SA-WWA-3E1 (C)	01/25/93	<0.4	10 $\pm$ 1	9.8 $\pm$ 1.0	<130
SA-WWA-2S3	03/1/93	<3.2	2.8 $\pm$ 0.8	3.3 $\pm$ 0.3	<140
SA-WWA-3E1 (C)	03/1/93	<2.9	8.8 $\pm$ 1.2	8.6 $\pm$ 0.9	<140
SA-WWA-2S3	03/29/93	<1.7	3.9 $\pm$ 0.9	3.5 $\pm$ 0.3	140 $\pm$ 80
SA-WWA-3E1 (C)	03/29/93	<2.0	11 $\pm$ 1	6.5 $\pm$ 0.6	<130
SA-WWA-2S3	04/26/93	<3.0	2.9 $\pm$ 0.8	3.6 $\pm$ 0.4	<140
SA-WWA-3E1 (C)	04/26/93	<3.2	9.4 $\pm$ 1.2	11 $\pm$ 1	<140
SA-WWA-2S3	05/24/93	<2.5	4.4 $\pm$ 0.8	3.5 $\pm$ 0.3	<200
SA-WWA-3E1 (C)	05/24/93	<1.8	9.7 $\pm$ 1.2	9.7 $\pm$ 1.0	<210
SA-WWA-2S3	06/28/93	<4.5	2.7 $\pm$ 0.7	3.0 $\pm$ 0.3	<180
SA-WWA-3E1 (C)	06/28/93	<4.7	11 $\pm$ 1	9.3 $\pm$ 0.9	<180
SA-WWA-2S3	07/27/93	<2.1	3.3 $\pm$ 0.8	3.2 $\pm$ 0.3	300 $\pm$ 110
SA-WWA-3E1 (C)	07/26/93	<2.4	11 $\pm$ 1	9.0 $\pm$ 0.9	<180
SA-WWA-2S3	08/31/93	<0.8	3.1 $\pm$ 0.5	3.5 $\pm$ 0.3	<150
SA-WWA-3E1 (C)	08/30/93	1.7 $\pm$ 0.9	10 $\pm$ 1	11 $\pm$ 1	<160
SA-WWA-2S3	09/27/93	<1.5	3.5 $\pm$ 0.5	3.4 $\pm$ 0.3	350 $\pm$ 110
SA-WWA-3E1 (C)	09/27/93	<1.5	11 $\pm$ 1	11 $\pm$ 1	<170
SA-WWA-2S3	10/25/93	5.9 $\pm$ 1.8	3.7 $\pm$ 0.5	3.4 $\pm$ 0.3	<160
SA-WWA-3E1 (C)	10/25/93	<1.7	10 $\pm$ 1	8.4 $\pm$ 0.8	<160
SA-WWA-2S3	11/29/93	<15	3.2 $\pm$ 0.5	3.4 $\pm$ 0.3	<120
SA-WWA-3E1 (C)	11/29/93	1.8 $\pm$ 1.2	10 $\pm$ 1	11 $\pm$ 1	<120
SA-WWA-2S3	12/27/93	<1.4	3.0 $\pm$ 0.5	3.6 $\pm$ 0.4	<110
SA-WWA-3E1 (C)	12/27/93	<1.3	9.8 $\pm$ 0.8	12 $\pm$ 1	<110
AVERAGE		-	3.3 $\pm$ 1.0	3.4 $\pm$ 0.4	-
SA-WWA-2S3		-	10 $\pm$ 1	9.8 $\pm$ 3.1	-
SA-WWA-3E1 (C)					
GRAND AVERAGE		-	6.7 $\pm$ 7.1	6.6 $\pm$ 6.9	-

(C) Control Station

TABLE C-12

1993 CONCENTRATIONS OF IODINE-131\* AND GAMMA EMITTERS\*\* IN WELL WATER

Results in Units of pCi/L  $\pm$  2 sigma

STATION ID	SAMPLING PERIOD	<-----GAMMA EMITTERS----->		
		I-131	K-40	RA-NAT
SA-WWA-2S3	01/25/93	<0.2	<22	9.3 $\pm$ 2.0
SA-WWA-3E1 (C)	01/25/93	<0.2	<19	160 $\pm$ 7
SA-WWA-2S3	03/01/93	<0.2	<14	84 $\pm$ 4
SA-WWA-3E1 (C)	03/01/93	<0.2	<16	56 $\pm$ 4
SA-WWA-2S3	03/29/93	<0.1	<21	100 $\pm$ 6
SA-WWA-3E1 (C)	03/29/93	<0.2	<20	140 $\pm$ 5
SA-WWA-2S3	04/26/93	<0.4	<8.9	<4.5
SA-WWA-3E1 (C)	04/26/93	<0.2	<14	96 $\pm$ 5
SA-WWA-2S3	05/24/93	<0.2	<24	150 $\pm$ 7
SA-WWA-3E1 (C)	05/24/93	<0.4	<22	78 $\pm$ 6
SA-WWA-2S3	06/28/93	<0.1	<19	70 $\pm$ 5
SA-WWA-3E1 (C)	06/28/93	<0.1	<19	89 $\pm$ 5
SA-WWA-2S3	07/27/93	<0.3	<60	14 $\pm$ 3
SA-WWA-3E1 (C)	07/26/93	<0.3	<15	83 $\pm$ 4
SA-WWA-2S3	08/31/93	<0.2	<22	10 $\pm$ 2
SA-WWA-3E1 (C)	08/30/93	<0.3	<16	120 $\pm$ 5
SA-WWA-2S3	09/27/93	<0.3	64 $\pm$ 25	20 $\pm$ 4
SA-WWA-3E1 (C)	09/27/93	<0.2	<15	58 $\pm$ 4
SA-WWA-2S3 (C)	10/25/93	<0.3	<17	<7.4
SA-WWA-3E1	10/25/93	<0.2	<16	150 $\pm$ 4
SA-WWA-2S3	11/29/93	<0.3	<17	10 $\pm$ 3
SA-WWA-3E1 (C)	11/29/93	<0.1	<24	120 $\pm$ 8
SA-WWA-2S3	12/27/93	<0.2	<22	90 $\pm$ 5
SA-WWA-3E1 (C)	12/27/93	<0.2	<21	130 $\pm$ 8
AVERAGE				
SA-WWA-2S3		-	-	47 $\pm$ 98
SA-WWA-3E1 (C)		-	-	107 $\pm$ 70
GRAND AVERAGE		-	-	77 $\pm$ 103

\* Iodine-131 analyzed to a sensitivity of 1.0 pCi/liter.

\*\* All other gamma emitters searched for were &lt;LLD; typical LLDs are given in Table C-27.

(C) Control Station

TABLE C-13

1993 CONCENTRATIONS OF STRONTIUM-89\* AND STRONTIUM-90\*  
IN QUARTERLY COMPOSITES OF WELL WATER

Results in Units of pCi/L

STATION ID	SAMPLING PERIOD	<-- STRONTIUM -->	
		Sr-89	Sr-90
SA-WWA-2S3	01/25/93 to 03/29/93	<0.6	<0.5
SA-WWA-3E1 (C)	01/25/93 to 03/29/93	<0.5	<0.4
SA-WWA-2S3	04/26/93 to 06/28/93	<0.8	<0.5
SA-WWA-3E1 (C)	04/26/93 to 06/28/93	<0.8	<0.5
SA-WWA-2S3	07/27/93 to 09/27/93	<1.1	<0.8
SA-WWA-3E1 (C)	07/26/93 to 09/27/93	<0.5	<0.4
SA-WWA-2S3	09/27/93 to 12/27/93	<0.8	<0.6
SA-WWA-3E1 (C)	09/27/93 to 12/27/93	<0.6	<0.5

\* Strontium results are corrected for decay to stop date of collection period.

Control Station

TABLE C-14

1993 CONCENTRATIONS OF GROSS ALPHA AND GROSS BETA EMITTERS,  
POTASSIUM-40 AND TRITIUM IN RAW AND TREATED POTABLE WATER

Results in Units of pCi/L  $\pm$  2 sigma

STATION ID: SA-PWR/T-2F3

TYPE	SAMPLING PERIOD	GROSS ALPHA	GROSS BETA	K-40	TRITIUM
Raw	01/1-31/93	<2.8	3.5 $\pm$ 0.8	2.2 $\pm$ 0.2	<130
Treated	01/1-31/93	<2.5	3.3 $\pm$ 0.8	2.2 $\pm$ 0.2	<130
Raw	02/1-28/93	<3.9	2.9 $\pm$ 0.7	2.0 $\pm$ 0.2	<130
Treated	02/1-28/93	<3.7	2.8 $\pm$ 0.7	1.9 $\pm$ 0.2	<130
Raw	03/1-31/93	<2.1	4.4 $\pm$ 0.9	2.2 $\pm$ 0.2	150 $\pm$ 80
Treated	03/1-31/93	<1.8	2.4 $\pm$ 0.7	2.1 $\pm$ 0.2	<160
Raw	04/1-30/93	<4.6	3.7 $\pm$ 0.8	2.2 $\pm$ 0.2	180 $\pm$ 90
Treated	04/1-30/93	<2.3	3.3 $\pm$ 0.8	2.1 $\pm$ 0.2	<140
Raw	05/1-31/93	3.2 $\pm$ 2.1	3.3 $\pm$ 0.7	2.1 $\pm$ 0.2	<200
Treated	05/1-31/93	<1.6	2.8 $\pm$ 0.7	2.0 $\pm$ 0.2	<190
Raw	06/1-30/93	<3.8	2.7 $\pm$ 0.7	1.4 $\pm$ 0.1	200 $\pm$ 100
Treated	06/1-30/93	<4.0	2.7 $\pm$ 0.7	1.6 $\pm$ 0.2	<160
Raw	07/1-31/93	<2.1	2.9 $\pm$ 0.8	1.4 $\pm$ 0.1	<170
Treated	07/1-31/93	<1.9	2.8 $\pm$ 0.8	1.6 $\pm$ 0.2	<170
Raw	08/1-31/93	1.0 $\pm$ 0.5	2.3 $\pm$ 0.4	1.6 $\pm$ 0.2	<160
Treated	08/1-31/93	0.9 $\pm$ 0.6	3.0 $\pm$ 0.5	1.6 $\pm$ 0.2	<160
Raw	09/1-30/93	0.8 $\pm$ 0.6	2.5 $\pm$ 0.4	1.7 $\pm$ 0.2	<170
Treated	09/1-30/93	<1.0	2.5 $\pm$ 0.4	1.7 $\pm$ 0.2	<160
Raw	10/1-31/93	1.3 $\pm$ 0.7	1.9 $\pm$ 0.4	1.8 $\pm$ 0.2	240 $\pm$ 110
Treated	10/1-31/93	<1.0	2.1 $\pm$ 0.4	1.8 $\pm$ 0.2	<180
Raw	11/1-30/93	<0.8	3.2 $\pm$ 0.5	2.0 $\pm$ 0.2	<110
Treated	11/1-30/93	1.5 $\pm$ 0.8	2.9 $\pm$ 0.5	2.1 $\pm$ 0.2	<110
Raw	12/1-31/93	1.0 $\pm$ 0.6	4.3 $\pm$ 0.5	2.9 $\pm$ 0.3	<110
Treated	12/1-31/93	1.2 $\pm$ 0.8	4.0 $\pm$ 0.5	3.1 $\pm$ 0.3	<110
AVERAGE					
Raw		-	3.1 $\pm$ 1.5	2.0 $\pm$ 0.8	-
Treated		-	2.9 $\pm$ 1.0	2.0 $\pm$ 0.8	-
GRAND AVERAGE		-	3.0 $\pm$ 1.3	2.0 $\pm$ 0.8	-

TABLE C-15

1993 CONCENTRATIONS OF IODINE-131\* AND GAMMA EMITTERS\*\*  
IN RAW AND TREATED POTABLE WATER

Results in Units of pCi/L  $\pm$  2 sigma

STATION ID: SA-PWR/T-2F3

TYPE	SAMPLING PERIOD	I-131	<-----GAMMA EMITTERS----->	
			K-40	RA-NAT
Raw	01/01-31/93	<0.2	<18	<2.3
Treated	01/01-31/93	<0.2	<40	<2.6
Raw	02/01-28/93	<0.2	<22	<5.6
Treated	02/01-28/93	<0.2	<45	<2.2
Raw	03/01-31/93	<0.2	<17	27 $\pm$ 0.3
Treated	03/01-31/93	<0.4	<20	<2.1
Raw	04/01-30/93	<0.3	<19	<2.5
Treated	04/01-30/93	<0.4	<45	<5.0
Raw	05/01-31/93	<0.3	<21	<2.4
Treated	05/01-31/93	<0.4	<17	<2.6
Raw	06/01-30/93	<0.3	<14	<2.0
Treated	06/01-30/93	<0.4	<38	<2.5
Raw	07/01-31/93	<0.4	<14	<6.0
Treated	07/01-31/93	<0.4	<14	<6.3
Raw	08/01-31/93	<0.3	<16	<2.0
Treated	08/01-31/93	<0.6	<14	<6.3
Raw	09/01-30/93	<0.2	<14	<1.8
Treated	09/01-30/93	<0.2	<14	6.8 $\pm$ 1.9
Raw	10/01-31/93	<0.6	<18	<2.6
Treated	10/01-31/93	<0.2	<14	5.2 $\pm$ 1.9
Raw	11/01-30/93	<0.2	<13	<1.6
Treated	11/01-30/93	<0.1	<21	<2.2
Raw	12/01-31/93	<0.4	<15	<1.7
Treated	12/01-31/93	<0.2	<12	<1.3

\* Iodine-131 analyzed to a sensitivity of 1.0 pCi/liter.

\*\* All other gamma emitters searched for were <LLD; typical LLDs are given in Table C-27.

TABLE C-16

1993 CONCENTRATIONS OF STRONTIUM-89\* AND STRONTIUM-90\* IN  
QUARTERLY COMPOSITES OF RAW AND TREATED POTABLE WATERResults in Units of pCi/L  $\pm$  2 SIGMA

STATION ID: SA-PWR/T-2F3

TYPE	SAMPLING PERIOD	<-- STRONTIUM -->	
		Sr-89	Sr-90
Raw	01-01-93 to 03-31-93	<0.6	<0.5
Treated	01-01-93 to 03-31-93	<0.6	<0.5
Raw	04-01-93 to 06-30-93	<0.8	<0.6
Treated	04-01-93 to 06-30-93	<0.8	<0.6
Raw	07-01-93 to 09-30-93	<0.7	<0.6
Treated	07-01-93 to 09-30-93	<0.5	<0.5
Raw	10-01-93 to 12-31-93	<0.6	<0.5
Treated	10-01-93 to 12-31-93	<0.6	<0.5

\* Strontium results are corrected for decay to stop date of collection period.

TABLE C-17

## 1993 CONCENTRATIONS OF GAMMA EMITTERS\* IN VEGETABLES

Results in Units of pCi/kg (wet)  $\pm$  2 sigma

STATION ID	SAMPLING DATE	SAMPLE TYPE	<---GAMMA EMITTERS---> K-40
SA-FPV-3E3	05/18/93	Asparagus	1800 $\pm$ 210
SA-FPV-2G1 (C)	05/18/93	Asparagus	1700 $\pm$ 200
AVERAGE			1750 $\pm$ 140
SA-FPL-3H5 (C)	08/04/93	Cabbage	2800 $\pm$ 200
SA-FPL-5F3	08/04/93	Cabbage	2400 $\pm$ 180
AVERAGE			2600 $\pm$ 570
SA-FPV-2F4	08/03/93	Corn	2500 $\pm$ 220
SA-FPV-14F3	08/04/93	Corn	2600 $\pm$ 160
SA-FPV-1G1 (C)	08/03/93	Corn	2400 $\pm$ 180
SA-FPV-3H5 (C)	08/03/93	Corn	2300 $\pm$ 210
AVERAGE			2450 $\pm$ 260
SA-FPV-14F3	08/04/93	Peppers	1300 $\pm$ 150
SA-FPV-2F4	08/04/93	Peppers	2100 $\pm$ 170
SA-FPV-3H5 (C)	08/02/93	Peppers	1000 $\pm$ 130
SA-FPV-1G1 (C)	08/03/93	Peppers	1900 $\pm$ 220
SA-FPV-2G2 (C)	08/04/93	Peppers	1700 $\pm$ 130
AVERAGE			1600 $\pm$ 890
SA-FPV-2F4	08/04/93	Tomatoes	1900 $\pm$ 170
SA-FPV-14F3	08/04/93	Tomatoes	1700 $\pm$ 160
SA-FPV-1G1 (C)	08/03/93	Tomatoes	2000 $\pm$ 190
SA-FPV-3H5 (C)	08/03/93	Tomatoes	1500 $\pm$ 160
AVERAGE			1780 $\pm$ 440
GRAND AVERAGE			1980 $\pm$ 970

\* All other gamma emitters searched for were <LLD; typical LLDS are given in Table C-27.

TABLE C-18

## 1993 CONCENTRATIONS OF GAMMA EMITTERS\* IN BEEF AND GAME

Results in Units of pCi/kg (wet)  $\pm$  2 sigma

STATION ID	SAMPLING DATE	SAMPLE TYPE	<--GAMMA EMITTERS-->
			K-40
SA-FPB-3E1	4/19/93	Beef	2600 $\pm$ 160
SA-GAM-11D1 (Control)	2/02-06/93	Muskrat	2300 $\pm$ 160
SA-GAM-3E1	1/25-29/93	Muskrat	2000 $\pm$ 200
AVERAGE		Muskrat	2150 $\pm$ 420

\* All other gamma emitters searched for were <LLD; typical LLDS are given in Table C-27.

\*\*\* Although not required by Technical Specifications, beef samples are normally collected twice each year. However, due to uncertain availability of the sample, only one beef sample was obtained in 1993.



TABLE C-19

## 1993 CONCENTRATIONS OF GAMMA EMITTERS\* IN FODDER CROPS

Results in Units of pCi/kg (wet)  $\pm$  2 sigma

STATION ID	SAMPLING DATE	SAMPLE TYPE	<-----GAMMA EMITTERS----->		
			K-40	Be-7	RA-NAT
SA-VGT-11F3	09/18/93	Silage	5300 $\pm$ 210	530 $\pm$ 61	<28
SA-VGT-2F7	10/03/93	Corn Silage	2800 $\pm$ 210	760 $\pm$ 100	35 $\pm$ 10
SA-VGT-14F4	09/08/93	Silage	5800 $\pm$ 370	1100 $\pm$ 150	<26
SA-VGT-3G1 (C)	09/07/93	Silage	6500 $\pm$ 480	940 $\pm$ 160	<16
AVERAGE			5100 $\pm$ 3200	830 $\pm$ 490	-
SA-VGT-11F3	11/20/93	Soybeans	16000 $\pm$ 240	<48	<19
SA-VGT-2F7	11/08/93	Soybeans	14000 $\pm$ 600	<150	<22
SA-VGT-3G1 (C)	11/07/93	Soybeans	12000 $\pm$ 510	<43	<15
SA-VGT-14F4	10/03/93	Soybeans	17000 $\pm$ 690	<48	59 $\pm$ 22
AVERAGE			14800 $\pm$ 4400	-	-

All other gamma emitters searched for were <LLD; typical LLDS are given in Table C-27.  
Control Station

TABLE C-20

## 1993 CONCENTRATIONS OF GROSS ALPHA EMITTERS IN SURFACE WATER

Results in Units of pCi/L  $\pm$  2 sigma

SAMPLING DATE	<----- STATION ID ----->					AVERAGE
	SA-SWA-11A1	SA-SWA-12C1 (Control)	SA-SWA-7E1	SA-SWA-1F2	SA-SWA-16F1	
01-19-93	<1.4	<1.3	<1.3	<1.3	<1.3	-
02-11-93	4.7 $\pm$ 3.6	<3.7	<3.4	<3.5	<3.5	-
03-12-93	<3.4	<3.4	<3.2	<3.1	<2.2	-
04-08-93	<1.9	<1.8	2.2 $\pm$ 1.5	<1.6	4.1 $\pm$ 2.0	-
05-07-93	<2.1	<2.6	<2.2	<2.0	<2.1	-
06-10-93	3.4 $\pm$ 2.0	2.0 $\pm$ 1.7	2.6 $\pm$ 1.8	<3.3	3.5 $\pm$ 2.1	3.0 $\pm$ 1.2
07-09-93	<2.0	2.1 $\pm$ 1.6	2.0 $\pm$ 1.6	<1.7	2.9 $\pm$ 1.8	2.1 $\pm$ 0.9
08-06-93	1.4 $\pm$ 1.1	<1.3	<1.7	<1.4	<1.5	-
09-09-93	<2.0	<1.3	<2.2	1.5 $\pm$ 1.2	<2.7	-
10-10-93	<2.9	<1.4	<3.9	<1.5	2.8 $\pm$ 2.1	-
11-11-93	2.1 $\pm$ 1.4	2.8 $\pm$ 2.0	1.8 $\pm$ 1.1	1.6 $\pm$ 1.2	<1.4	1.9 $\pm$ 1.1
12-09-93	<1.6	<1.5	<2.8	2.5 $\pm$ 1.7	<1.4	-

TABLE 1

## 1993 CONCENTRATIONS OF GROSS BETA EMITTERS IN SURFACE WATER

Results in Units of pCi/L  $\pm$  2 sigma

SAMPLING DATE	<----- STATION ID ----->					AVERAGE
	SA-SWA-11A1	SA-SWA-12C1 (Control)	SA-SWA-7E1	SA-SWA-1F2	SA-SWA-16F1	
01-19-93	48 $\pm$ 7	14 $\pm$ 4	65 $\pm$ 8	19 $\pm$ 4	17 $\pm$ 5	33 $\pm$ 45
02-11-93	79 $\pm$ 9	81 $\pm$ 9	120 $\pm$ 12	35 $\pm$ 5	53 $\pm$ 7	74 $\pm$ 64
03-12-93	60 $\pm$ 7	44 $\pm$ 6	88 $\pm$ 9	20 $\pm$ 4	31 $\pm$ 5	49 $\pm$ 53
04-08-93	8.0 $\pm$ 3.0	<3.5	<3.5	<3.5	4.0 $\pm$ 2.5	5 $\pm$ 4
05-07-93	14 $\pm$ 3	6.2 $\pm$ 2.4	22 $\pm$ 4	6.8 $\pm$ 2.5	4.7 $\pm$ 2.2	11 $\pm$ 14
06-10-93	45 $\pm$ 6	53 $\pm$ 7	85 $\pm$ 9	26 $\pm$ 4	36 $\pm$ 5	49 $\pm$ 45
07-09-93	91 $\pm$ 9	76 $\pm$ 8	97 $\pm$ 10	46 $\pm$ 6	56 $\pm$ 7	73 $\pm$ 44
08-06-93	110 $\pm$ 7	90 $\pm$ 6	120 $\pm$ 7	71 $\pm$ 5	52 $\pm$ 4	89 $\pm$ 56
09-09-93	110 $\pm$ 9	85 $\pm$ 8	120 $\pm$ 10	69 $\pm$ 5	68 $\pm$ 5	90 $\pm$ 47
10-10-93	61 $\pm$ 5	56 $\pm$ 4	90 $\pm$ 6	32 $\pm$ 4	18 $\pm$ 3	51 $\pm$ 56
11-11-93	73 $\pm$ 4	60 $\pm$ 3	110 $\pm$ 5	61 $\pm$ 3	53 $\pm$ 3	71 $\pm$ 45
12-09-93	12 $\pm$ 2	9.3 $\pm$ 1.8	32 $\pm$ 3	4.8 $\pm$ 1.5	5.1 $\pm$ 1.5	13 $\pm$ 22
AVERAGE	59 $\pm$ 71	48 $\pm$ 65	79 $\pm$ 81	33 $\pm$ 48	33 $\pm$ 46	
				GRAND AVERAGE		51 $\pm$ 71

TABLE C-22  
1993 CONCENTRATIONS OF GAMMA EMITTERS\*  
IN SURFACE WATER

Results in Units of pCi/L  $\pm$  2 sigma

SAMPLING STATION ID	DATE	<-----GAMMA EMITTERS----->			Co-60	Cs-137
		K-40	RA-NAT	Co-58		
SA-SWA-11A1	01-19-93	99 $\pm$ 18	<2.2	<0.9	<0.4	<0.9
SA-SWA-12C1 (C)	01-19-93	<23	<2.2	<0.8	<0.5	<0.9
SA-SWA-7E1	01-19-93	45 $\pm$ 12	<5.4	<0.9	<0.8	<0.6
SA-SWA-1F2	01-19-93	<17	<4.0	<0.7	<0.3	<0.8
SA-SWA-16F1	01-19-93	52 $\pm$ 24	<2.3	<0.4	<0.5	<0.8
SA-SWA-11A1	02-11-93	<9.2	<1.6	<0.6	<1.4	<0.4
SA-SWA-12C1 (C)	02-11-93	<11	<2.2	<0.6	<0.5	<0.2
SA-SWA-7E1	02-11-93	150 $\pm$ 24	<2.3	<1.1	<1.4	<1.1
SA-SWA-1F2	02-11-93	30 $\pm$ 9	<0.6	<0.3	<0.4	<0.3
SA-SWA-16F1	02-11-93	<25	<4.0	<0.5	<0.5	<0.8
SA-SWA-11A1	03-12-93	100 $\pm$ 19	<2.2	<0.9	<1.1	<1.0
SA-SWA-12C1 (C)	03-12-93	48 $\pm$ 18	<1.9	<0.3	<0.7	<0.6
SA-SWA-7E1	03-12-93	110 $\pm$ 29	<1.6	<1.1	<1.6	<0.8
SA-SWA-1F2	03-12-93	82 $\pm$ 25	<4.3	<1.0	<0.6	<1.2
SA-SWA-16F1	03-12-93	66 $\pm$ 18	<1.9	<0.7	<0.7	<0.8
SA-SWA-11A1	04-08-93	62 $\pm$ 25	15 $\pm$ 2	<1.1	<1.1	<0.7
SA-SWA-12C1 (C)	04-08-93	<19	<2.4	<1.1	<0.5	<0.9
SA-SWA-7E1	04-08-93	59 $\pm$ 23	<6.8	<1.1	<0.7	<3.0
SA-SWA-1F2	04-08-93	<14	<2.0	<0.7	<0.5	<0.7
SA-SWA-16F1	04-08-93	<13	<2.0	<0.7	<1.0	<0.9
SA-SWA-11A1	05-07-93	56 $\pm$ 19	<4.4	<1.6	<0.7	<0.6
SA-SWA-12C1 (C)	05-07-93	<16	<1.9	<1.4	<1.0	<0.8
SA-SWA-7E1	05-07-93	62 $\pm$ 27	<6.3	<0.6	<1.5	<0.9
SA-SWA-1F2	05-07-93	<19	<2.2	<0.5	<1.1	<0.8
SA-SWA-16F1	05-07-93	<18	<2.2	<0.9	<0.8	<0.9
SA-SWA-11A1	06-10-93	<29	<3.6	<1.4	<1.7	<1.0
SA-SWA-12C1 (C)	06-10-93	110 $\pm$ 21	<4.1	<1.1	<0.9	<1.0
SA-SWA-7E1	06-10-93	69 $\pm$ 23	<2.4	<0.5	<0.8	<1.3
SA-SWA-1F2	06-10-93	47 $\pm$ 17	<1.7	<0.4	<0.8	<0.4
SA-SWA-16F1	06-10-93	95 $\pm$ 18	<2.2	<1.1	<0.9	<0.6
SA-SWA-11A1	07-09-93	72 $\pm$ 24	<3.1	<0.7	<3.2	<1.0
SA-SWA-12C1 (C)	07-09-93	70 $\pm$ 23	<3.4	<0.6	<1.1	<0.5
SA-SWA-7E1	07-09-93	150 $\pm$ 25	<1.9	<0.7	<0.5	<1.0
SA-SWA-1F2	07-09-93	83 $\pm$ 21	<1.6	<0.7	<0.8	<1.0
SA-SWA-16F1	07-09-93	86 $\pm$ 33	<2.0	<1.1	<0.6	<1.0

TABLE C-22 (Cont'd)

1993 CONCENTRATIONS OF GAMMA EMITTERS\*  
IN SURFACE WATERResults in Units of pCi/L  $\pm$  2 sigma

SAMPLING STATION ID	DATE	<-----GAMMA EMITTERS----->			Co-60	Cs-137
		K-40	RA-NAT	Co-58		
SA-SWA-11A1	08-06-93	150 $\pm$ 21	<2.9	<1.0	<0.9	<0.4
SA-SWA-12C1 (C)	08-06-93	67 $\pm$ 23	<2.3	<3.3	<1.2	<1.1
SA-SWA-7E1	08-06-93	140 $\pm$ 21	<5.8	<0.5	<0.6	<0.5
SA-SWA-1F2	08-06-93	120 $\pm$ 36	<2.3	<0.9	<1.0	<1.1
SA-SWA-16F1	08-06-93	93 $\pm$ 24	<6.5	<0.7	<0.8	<0.7
SA-SWA-11A1	09-09-93	100 $\pm$ 25	<5.5	5.5 $\pm$ 1.8	4.0 $\pm$ 1.7	5.4 $\pm$ 1.8
SA-SWA-12C1 (C)	09-09-93	130 $\pm$ 26	<2.2	<1.2	<1.4	<1.3
SA-SWA-7E1	09-09-93	140 $\pm$ 28	<3.2	<0.9	<0.5	<0.7
SA-SWA-1F2	09-09-93	<18	<3.1	<0.7	<0.8	<0.6
SA-SWA-16F1	09-09-93	51 $\pm$ 20	<2.3	<0.9	<0.5	<0.5
SA-SWA-11A1	10-10-93	55 $\pm$ 16	6.5 $\pm$ 1.8	<0.4	<0.9	<0.3
SA-SWA-12C1 (C)	10-10-93	56 $\pm$ 20	<2.3	<0.8	<0.3	<1.1
SA-SWA-7E1	10-10-93	61 $\pm$ 28	<2.0	<0.7	<1.3	<1.1
SA-SWA-1F2	10-10-93	<25	<2.1	<0.5	<1.3	<1.1
SA-SWA-16F1	10-10-93	<21	<4.3	<0.5	<0.6	<0.8
SA-SWA-11A1	11-11-93	<22	5.4 $\pm$ 1.8	<4.2	<0.8	<1.0
SA-SWA-12C1 (C)	11-11-93	76 $\pm$ 20	7.2 $\pm$ 2.3	<0.4	<0.4	<0.8
SA-SWA-7E1	11-11-93	110 $\pm$ 31	<1.7	<1.2	<1.4	<1.2
SA-SWA-1F2	11-11-93	<42	<2.2	<0.8	<1.2	<2.4
SA-SWA-16F1	11-11-93	55 $\pm$ 16	7.4 $\pm$ 1.9	<0.8	<0.8	<0.6
SA-SWA-11A1	12-09-93	<16	<5.6	<0.8	<0.6	<0.5
SA-SWA-12C1 (C)	12-09-93	<15	<1.8	<0.7	<0.6	<0.4
SA-SWA-7E1	12-09-93	<24	<2.3	<0.8	<0.8	<1.5
SA-SWA-1F2	12-09-93	<25	<2.5	<0.5	<1.3	<1.0
SA-SWA-16F1	12-09-93	<18	<2.3	<0.8	<0.5	<0.4
AVERAGE		61 $\pm$ 83	-	-	-	-

\* All other gamma emitters searched for were <LLD; typical LLDs are given in Table C-27.  
Control Station

TABLE C-23

## 1993 CONCENTRATIONS OF TRITIUM IN QUARTERLY COMPOSITES OF SURFACE WATER

Results in Units of pCi/L  $\pm$  2 sigma

SAMPLING PERIOD	<----- STATION ID ----->					AVERAGE
	SA-SWA-11A1	SA-SWA-12C1 (Control)	SA-SWA-7E1	SA-SWA-1F2	SA-SWA-16F1	
01-19-93 to 03-12-93	460 $\pm$ 80	<130	<130	<130	<130	-
04-08-93 to 06-10-93	<170	<170	<190	<200	<170	-
07-09-93 to 09-09-93	390 $\pm$ 100	<160	<160	<170	<160	-
10-10-93 to 12-09-93	130 $\pm$ 70	<110	<110	<110	<110	-
AVERAGE	290 $\pm$ 320	-	-	-	-	-

TABLE 24

## 1993 CONCENTRATIONS OF STRONTIUM-89 AND STRONTIUM-90, TRITIUM AND GAMMA EMITTERS\*\* IN EDIBLE FISH

Results in Units of pCi/kg (wet)  $\pm$  2 sigma  
 (Except for strontium in bone analyses which are reported in pCi/kg (dry))

		STRONTIUM					
		<--- BONES --->		<---FLESH----->		***	
STATION ID	SAMPLING PERIOD	Sr-89	Sr-90	Sr-89	Sr-90	TRITIUM (FLESH) AQUEOUS FRACTION	<-GAMMA EMITTERS (FLESH)-> K-40
SA-ESF-11A1	05/28-30/93	<79	290±21	<25	<18	<100	2800±220
SA-ESF-12C1 (C)	05/28-30/93	<73	180±19	<30	<23	<100	2700±200
SA-ESF-7E1	05/28-30/93	<51	100±13	<42	<29	<100	2600±200
AVERAGE		-	190±190	-	-	-	2700±200
SA-ESF-11A1	10/20-24/93	<15	41±9	<32	<19	<90	3100±190
SA-ESF-12C1 (C)	10/20-24/93	<41	30±11	<30	<19	150±70	3500±210
SA-ESF-7E1	10/20-24/93	<16	48±9	<31	<20	170±90	3000±210
AVERAGE		-	40±18	-	-	140±83	3200±530
GRAND AVERAGE		-	120±200	-	-	-	3000±650

\* Strontium results are corrected for decay to sample stop date.

\*\* All other gamma emitters searched for were <LLD; typical LLDS are given in Table C-27.

\*\*\* Tritium results are reported by Teledyne Isotopes, Inc.

(C) Control Station

TABLE C-25

1993 CONCENTRATIONS OF STRONTIUM-89 AND STRONTIUM-90, TRITIUM  
AND GAMMA EMITTERS\*\* IN BLUE CRABS

Results in Units of pCi/kg (wet)  $\pm$  2 sigma  
(Except for strontium in shell analyses which are reported in pCi/kg (dry))

STATION ID	SAMPLING DATE	<-----STRONTIUM----->				*** TRITIUM (FLESH) AQUEOUS FRACTION	GAMMA EMITTERS (FLESH)	
		<----FLESH----> Sr-89	Sr-90	<----SHELL-----> Sr-89	Sr-90		K-40	RA-NAT
SA-ECH-11A1	06/28/93	<24	<15	<72	180 $\pm$ 23	<100	2700 $\pm$ 210	<12
SA-ECH-12C1 (C)	06/28/93	<24	<16	<70	200 $\pm$ 24	<90	2200 $\pm$ 210	<10
AVERAGE		-	-	-	190 $\pm$ 20	-	2400 $\pm$ 500	-
SA-ECH-11A1	09/13/93	<31	<19	<40	200 $\pm$ 14	<100	2900 $\pm$ 200	<11
SA-ECH-12C1 (C)	09/13/93	<31	<20	<37	140 $\pm$ 13	<100	2500 $\pm$ 160	38 $\pm$ 9
AVERAGE		-	-	-	170 $\pm$ 60	-	2700 $\pm$ 400	-
GRAND AVERAGE		-	-	-	180 $\pm$ 57	-	2600 $\pm$ 600	-

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\* Strontium results are corrected for decay to sample stop date.

\*\* All other gamma emitters searched for were <LLD; typical LLDS are given in Table C-27.

\*\*\* Tritium results by Teledyne Isotopes, Inc.

(C) Control Station



## 1993 CONCENTRATIONS OF STRONTIUM-89 AND STRONTIUM-90 AND GAMMA EMITTERS\*\* IN SEDIMENT

Results in Units of pCi/kg (dry)  $\pm$  2 sigma

## &lt;-----GAMMA EMITTERS-----&gt;

STATION ID	SAMPLING DATE	Sr-90	K-40	Mn-54	Co-58	Co-60	Cs-134	Cs-137	RA-NAT	Th-232
SA-ESS-11A1	06/07/93	<22	3200 $\pm$ 220	<16	45 $\pm$ 14	46 $\pm$ 18	<20	<7.3	540 $\pm$ 27	460 $\pm$ 43
SA-ESS-15A1	06/07/93	<28	3700 $\pm$ 180	23 $\pm$ 8	48 $\pm$ 8	61 $\pm$ 10	<5.2	<4.8	290 $\pm$ 19	430 $\pm$ 40
SA-ESS-16A1	06/07/93	48 $\pm$ 14	7000 $\pm$ 250	41 $\pm$ 11	46 $\pm$ 16	110 $\pm$ 11	<11	<16	1900 $\pm$ 49	1600 $\pm$ 86
SA-ESS-12C1 (C)	06/07/93	<25	13000 $\pm$ 400	<8.4	<9.1	<38	<10	<10	860 $\pm$ 44	790 $\pm$ 78
SA-ESS-7E1	06/07/93	<27	12000 $\pm$ 410	<26	83 $\pm$ 22	130 $\pm$ 37	<36	94 $\pm$ 19	620 $\pm$ 48	790 $\pm$ 86
SA-ESS-16F1	06/07/93	<76	17000 $\pm$ 610	<16	67 $\pm$ 24	<20	<16	60 $\pm$ 18	640 $\pm$ 40	910 $\pm$ 100
AVERAGE		-	9300 $\pm$ 11000	-	50 $\pm$ 50	68 $\pm$ 86	-	-	810 $\pm$ 1100	830 $\pm$ 850
113 SA-ESS-11A1	11/23/93	<25	13000 $\pm$ 500	<22	<21	<19	51 $\pm$ 21	130 $\pm$ 17	730 $\pm$ 40	800 $\pm$ 120
SA-ESS-15A1	11/23/93	<27	17000 $\pm$ 460	<8.5	<13	<18	68 $\pm$ 17	180 $\pm$ 20	700 $\pm$ 30	1000 $\pm$ 79
SA-ESS-16A1	11/23/93	<26	9700 $\pm$ 290	29 $\pm$ 12	74 $\pm$ 16	140 $\pm$ 13	70 $\pm$ 13	71 $\pm$ 13	1200 $\pm$ 30	900 $\pm$ 61
SA-ESS-12C1 (C)	11/11/93	<36	16000 $\pm$ 360	<7.5	<8.9	<10	49 $\pm$ 14	<12	590 $\pm$ 22	830 $\pm$ 54
SA-ESS-7E1	11/11/93	<28	7100 $\pm$ 320	<14	<7.9	34 $\pm$ 10	46 $\pm$ 16	33 $\pm$ 9	590 $\pm$ 24	630 $\pm$ 58
SA-ESS-16F1	11/23/93	<31	18000 $\pm$ 440	<24	<9.5	<13	<10	<6.0	650 $\pm$ 30	1000 $\pm$ 80
AVERAGE		-	13500 $\pm$ 8700	-	-	-	49 $\pm$ 43	72 $\pm$ 140	740 $\pm$ 460	860 $\pm$ 280
GRAND AVERAGE		-	11400 $\pm$ 10400	-	36 $\pm$ 56	53 $\pm$ 94	-	52 $\pm$ 110	780 $\pm$ 830	840 $\pm$ 600

\* All other gamma emitters searched for were <LLD; typical LLDs are given in Table C-27.  
 (C) Control Station

TABLE C-27  
1993 PSE&G RESEARCH & TESTING LABORATORY  
LLDs FOR GAMMA SPECTROMETRY

SAMPLE TYPE:	<-----AIR----->		<-----WATER----->		<-----MILK----->	
	IODINE	PARTICULATES	GAMMA SCAN	IODINE	GAMMA SCAN	IODINE
ACTIVITY:	10-3 pCi/m <sup>3</sup>	10 <sup>-3</sup> pCi/m <sup>3</sup>	pCi/L	pCi/L	pCi/L	pCi/L
GEOMETRY:	100ML	13 FILTERS	3.5 LITER	100 ML	3.5 LITER	100 ML
COUNT TIME:	120 MINS	1000 MINS	100 MINS	1000 MINS	500 MINS	1000 MINS
DELAY TO COUNT:	2 DAYS	5 DAYS	7 DAYS	3 DAYS	2 DAYS	2 DAYS

NUCLIDES						
BE-7	-	6.8	15	-	22	-
NA-22	-	0.45	11	-	4.5	-
K-40	-	7.1	35	-	120	-
CR-51	-	2.9	16	-	22	-
MN-54	-	0.32	1.7	-	3.4	-
CO-58	-	0.33	1.6	-	2.9	-
FE-59	-	0.79	3.7	-	7.2	-
CO-60	-	0.36	2.1	-	4.0	-
ZN-65	-	0.69	3.9	-	8.6	-
NB-95	-	0.49	-	-	3.1	-
ZR-95	-	0.44	-	-	5.7	-
ZRNB-95	-	-	3	-	-	-
MO-99	-	550	200	-	41	-
RU-103	-	0.33	1.6	-	2.5	-
RU-106	-	2.9	14	-	28	-
AG-100M	-	0.55	2.0	-	3.4	-
SB-125	-	0.77	4.0	-	8.2	-
TE-129M	-	120	62	-	99	-
I-131	13.0	0.98	3.8	0.60	3.2	0.42
TE-132	-	41	13	-	3.9	-
BA-133	-	3.7	-	-	-	-
CS-134	-	0.39	1.8	-	3.0	-
CS-136	-	0.56	2.9	-	3.3	-
CS-137	-	0.28	1.6	-	3.2	-
BA-140	-	2.2	-	-	-	-
LA-140	-	1	-	-	-	-
BALA-140	-	-	15	-	15	-
CE-141	-	0.31	2.3	-	3.9	-
CE-144	-	1.1	9.2	-	17	-
RA-NAT	-	0.87	7.4	-	6.6	-
TH-232	-	1.2	7.1	-	12	-

TABLE C-27 (cont'd)  
1993 PSE&G RESEARCH & TESTING LABORATORY  
LLDs FOR GAMMA SPECTROMETRY

SAMPLE TYPE:	<-----FOOD PRODUCTS----->		FOOD & GREEN CHOP	BEEF & GAME	FISH SHELLFISH	SEDIMENT & SOIL
ACTIVITY:	pCi/KG WET		pCi/kg WET	pCi/kg WET	pCi/kg WET	pCi/kg DRY
GEOMETRY:	100ml	500 ml	500 ml	500 ml	500 ml	500 ml
COUNT TIME:	1000 MINS	500 MINS	500 MINS	500 MINS	500 MINS	500 MINS
DELAY TO COUNT:	10 DAYS	3 DAYS	7 DAYS	5 DAYS	5 DAYS	30 DAYS
NUCLIDES						
BE-7	0.99	59	580	44	44	90
NA-22	2.1	9.4	15	6.9	6.9	30
K-40	32	70	85	70	70	70
CR-51	9.2	25	100	41	41	125
MN-54	1.2	4.8	10	69	69	28
CO-58	1.8	8.0	13	5.3	5.3	15
FE-59	3.6	16	53	14	14	46
CO-60	2.3	7.6	21	6.8	6.8	32
ZN-65	3.6	12	38	14	14	42
NB-95	2.0	10	16	10	10	36
ZR-95	2.2	27	30	27	27	43
RNB-95	-	-	-	-	-	-
MO-99	96	95	442	213	213	316000
RU-103	1.0	5.0	7.9	4.9	4.9	24
RU-106	12	49	110	38	38	109
AG-100M	2.2	8.7	19	12	12	21
SB-125	2.8	14	36	12	12	36
TE-129M	4.7	208	539	204	204	586
I-131	2	8.3	28	8.4	8.4	185
TE-132	4.4	8.5	150	15	15	7200
BA-133	-	-	-	-	-	-
CS-134	0.96	6.5	15	5.7	5.7	22
CS-136	1.5	6.1	19	7.5	7.5	46
CS-137	1.4	6.7	19	18	18	20
BA-140	6.0	35	75	35	35	240
LA-140	2.2	15	30	15	15	80
BALA-140	-	-	-	-	-	-
CE-141	1.0	5.1	9.8	5.2	5.2	26
CE-144	4.2	20	45	24	24	52
RA-NAT	2.3	15	48	36	36	40
TH-232	6.1	31	74	29	29	110

## APPENDIX D

### SYNOPSIS OF ANALYTICAL PROCEDURES

## APPENDIX D

### SYNOPSIS OF ANALYTICAL PROCEDURES

Appendix D presents a synopsis of the analytical procedures utilized by the PSE&G Research and Testing Laboratory and contract laboratories for analyzing the 1993 Artificial Island Radiological Environmental Monitoring Program samples.

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\* PSE&G - PSE&G Research and Testing Laboratory  
 TI - Teledyne Isotopes

## SYNOPSIS OF PSE&G RESEARCH AND TESTING LABORATORY PROCEDURE

### GROSS ALPHA ANALYSIS OF AIR PARTICULATE SAMPLES

After allowing at least a three-day (extending from the sample stop date to the sample count time) period for the short-lived radionuclides to decay out, air particulate samples are counted for gross alpha activity on a low background gas proportional counter. Along with a set of air particulate samples, clean air filter is included as a blank with an Am-241 air filter geometry alpha counting standard.

The specific alpha activity is computed on the basis of total corrected air flow sampled during the collection period. This corrected air flow takes into account the air pressure correction due to the vacuum being drawn, the correction factor of the temperature-corrected gas meter as well as the gas meter efficiency itself.

#### Calculation of Gross Alpha Activity:

Air flow is corrected first by using the following equations:

$$P = (B - \bar{V}) / 29.92$$

P = Pressure correction factor  
B = Time-averaged barometric pressure during sampling period, "Hg  
 $\bar{V}$  = Time-averaged vacuum during sampling period, "Hg

29.92 = Standard atmospheric pressure at 32°F, "Hg

$$V = \frac{F * P * 0.946 * 0.0283}{E}$$

F = Uncorrected air flow, ft<sup>3</sup>  
0.946 = Temperature correction factor from 60°F to 32°F  
0.0283 = Cubic meters per cubic foot  
E = Gas meter efficiency (= % efficiency/100)  
V = Corrected air flow, m<sup>3</sup>  
P = Pressure correction factor

Using these corrected air flows, the gross alpha activity is computed as follows:

$$\text{Result (pCi/m}^3\text{)} = \frac{(G - B) / T}{(2.22) * (E) * (V)}$$

G = Sample gross counts  
B = Background counts (from blank filter)  
T = Count time of sample and blank, mins.  
E = Fractional Am-241 counting efficiency  
V = Corrected air flow of sample, m<sup>3</sup>  
2.22 = No. of dpm per pCi

$$2\text{-sigma error (pCi/m}^3\text{)} = \frac{(1.96 * (G+B)^{1/2}) * A}{(G-B)}$$

A = Gross alpha activity, pCi/m<sup>3</sup>  
 G = Sample gross counts  
 B = Background counts (from blank filter)

Calculation of lower limit of detection:

A sample activity is assumed to be LLD if the sample net count is less than 4.66 times the standard deviation of the count on the blank.

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

B = Background counts (from blank filter)  
 E = Fractional Am-241 counting efficiency  
 V = Corrected air flow of sample, m<sup>3</sup>  
 T = Count time of blank, mins.



## SYNOPSIS OF PSE&G RESEARCH AND TESTING LABORATORY PROCEDURE

### GROSS ALPHA ANALYSIS OF WATER SAMPLES

Water samples require pretreatment of all suspended material for the purpose of keeping the final sample thickness to a minimum. This is accomplished by filtering a measured aliquot of the sample (while the filtrate is set aside) and ashing the collected residue in a crucible. A blank of the same volume is handled in the same manner. Whatever leftover sample residue remains, after the ashing, is dissolved in concentrated nitric acid and passed through a hardened fast filter paper and combined with the sample filtrate. The combined sample is then neutralized with dilute ammonium hydroxide. From this point, both sample and blank are acidified with dilute sulfuric acid. Barium carrier is added and the sample is heated to 50°C in order to help precipitate barium sulfate. Maintaining the same temperature for the remainder of the procedure, iron carrier is then introduced. After a 30 minute equilibration period, the sample is neutralized with dilute ammonium hydroxide to precipitate ferric hydroxide. The mixed precipitates are then filtered onto a membrane filter, dried under an infrared heat lamp, weighed and mounted on a stainless steel planchet. The sample is then alpha-counted for the appropriate time on a low background gas proportional counter, along with a U-238 source of the same geometry. The blank is treated in the same manner as the sample.

#### Calculation of Gross Alpha Activity:

$$\text{Result (pCi/L)} = \frac{(G-B)/T}{(2.22)*(E)*(V)*(S)}$$

G = Sample gross counts

B = Background counts (from blank sample)

T = Count time of sample and blank

E = Fractional counting efficiency from U-238 source

V = Sample volume, liters

S = Normalized efficiency regression equation as a function of thickness

2.22 = No. of dpm per pCi

$$2\text{-sigma error (pCi/L)} = \frac{(1.96*(G+B)^{1/2})*A}{(G-B)}$$

A = Gross alpha activity, pCi/L

G = Sample gross counts

B = Background counts (from blank sample)

# SYNOPSIS OF PSE&G RESEARCH AND TESTING LABORATORY PROCEDURE

## GROSS BETA ANALYSIS OF AIR PARTICULATE SAMPLES

After allowing at least a three-day (extending from the sample stop date to the sample count time) period for the short-lived radionuclides to decay out, air particulate samples are counted for gross beta activity on a low background gas proportional counter. Along with a set of air particulate samples, a clean air filter is included as a blank with an Sr-90 air filter geometry beta counting standard.

The gross beta activity is computed on the basis of total corrected air flow sampled during the collection period. This corrected air flow takes into account the air pressure correction due to the vacuum being drawn, the correction factor of the temperature-corrected gas meter as well as the gas meter efficiency itself.

### Calculation of Gross Beta Activity:

Air flow is corrected first by using the following equations:

$$P = (B - \bar{V}) / 29.92$$

P = Pressure correction factor

B = Time-averaged barometric pressure during sampling period, "Hg

$\bar{V}$  = Time-averaged vacuum during sampling period, "Hg

29.92 = Standard atmospheric pressure at 32°F, "Hg

$$V = \frac{F * P * 0.946 * 0.0283}{E}$$

F = Uncorrected air flow, ft<sup>3</sup>

0.946 = Temperature correction factor from 60°F to 32°F

0.0283 = Cubic meters per cubic foot

E = Gas meter efficiency (= % efficiency/100)

V = Corrected air flow, m<sup>3</sup>

P = Pressure correction factor

Using these corrected air flows, the gross beta activity is computed as follows:

$$\text{Result (pCi/m}^3\text{)} = \frac{(G - B) / T}{(2.22) * (E) * (V)}$$

G = Sample gross counts

B = Background counts (from blank filter)

T = Count time of sample and blank, mins.

E = Fractional Sr-90 counting efficiency

V = Corrected air flow of sample, m<sup>3</sup>

2.22 = No. of dpm per pCi

$$\text{sigma error (pCi/m}^3\text{)} = \frac{(1.96 * (G+B)^{1/2}) * A}{(G-B)}$$

A = Gross beta activity, pCi/m<sup>3</sup>  
 G = Sample gross counts  
 B = Background counts (from blank filter)

Calculation of lower limit of detection:

A sample activity is assumed to be LLD if the sample net count is less than 4.66 times the standard deviation of the count on the blank.

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

B = Background counts (from blank filter)  
 E = Fractional Sr-90 counting efficiency  
 V = Corrected air flow of sample, m<sup>3</sup>  
 T = Count time of blank, mins.

## SYNOPSIS OF PSE&G RESEARCH AND TESTING LABORATORY PROCEDURE

### GROSS BETA ANALYSIS OF WATER SAMPLES

The sample is mixed thoroughly. Then, a 1.0 liter portion is removed from the potable, rain or well water container and 250ml taken from each surface water. A deionized water blank is prepared for each different volume of sample (e.g. 1.0 liter blank for 1.0 liter samples and 250ml for 250ml samples). All samples and blanks are then evaporated on a hotplate until the volume approaches 20 to 25ml. At that point, the samples and blanks are transferred to tared stainless steel ribbed planchets and evaporated to dryness under an infrared heat lamp. They are subsequently cooled in a desiccator, weighed and counted on a low background gas proportional counter along with an Sr-90 source of the same geometry.

Calculation of Gross Beta Activity:

$$\text{Result (pCi/L)} = \frac{(G-B)/T}{(2.22)*(E)*V)*(S)}$$

G = Sample gross counts  
B = Background counts (from blank sample)  
T = Count time of sample and blank  
E = Fractional counting efficiency from Sr-90 source  
V = Sample volume, liters  
S = Normalized efficiency regression equation as a function of thickness  
2.22 = No. of dpm per pCi

$$\text{2-sigma error (pCi/L)} = \frac{(1.96*(G+B)^{1/2})*A}{(G-B)}$$

A = Gross beta activity, pCi/L  
G = Sample gross counts  
B = Background counts (from blank sample)

## SYNOPSIS OF PSE&G RESEARCH AND TESTING LABORATORY PROCEDURE

### ANALYSIS OF WATER FOR POTASSIUM 40

A 60 ml aliquot of water is acidified to pH <2 with concentrated nitric acid and then analyzed for potassium by the following Atomic Absorption Spectrophotometry method: potassium standards of known concentrations (similar to that of the samples) are first prepared. An aliquot of each sample and standard is pipetted into stoppered erlenmeyer flasks. In addition, a duplicate sample, water blank and a quality control sample are likewise pipetted into their respective flasks. A solution consisting of 1% sodium is added to all flasks to achieve a minimum of 2,000mg/L of sodium in the final sample volume. The spectrophotometer generates the calibration curve based upon standard absorbance and sample absorbance is converted to concentration automatically. If the concentration of any sample is greater than the highest standard, the sample is either diluted, the burner head is rotated 90°, or a less sensitive wavelength is selected.

The results, reported in parts per million (ppm), are converted to pCi/L by means of a computer program.

Calculation of K-40 Activity:

$$\text{K-40 Activity (pCi/L)} = 0.85 * C$$

0.85 = Proportionality constant for  
converting ppm to pCi/L  
C = Potassium concentration, ppm

# SYNOPSIS OF PSE&G RESEARCH AND TESTING LABORATORY PROCEDURE

## ANALYSIS OF WATER FOR TRITIUM

Approximately 50ml of raw sample is mixed with sodium hydroxide and potassium permanganate and is distilled under vacuum. Eight ml of distilled sample is mixed with 10ml of Instagel liquid scintillation solution, and placed in the liquid scintillation spectrometer for counting. An internal standard is prepared by mixing 8ml of sample, 10ml of Instagel, and 0.1ml-0.2ml of a standard with known activity. The efficiency is determined from this. Also prepared is a blank consisting of 8ml of distilled low-tritiated water and 10ml of Instagel, to be used for a background determination. This is done for each pair of samples to be counted.

Activity is computed as follows:

$$A \text{ (pCi/L)} = \frac{(G-B) \cdot (1000)}{2.22 \cdot (E) \cdot (V) \cdot (T)}$$

A = Activity  
 B = Background count of sample  
 G = Gross count of sample  
 E = Counting Efficiency  
 V = Aliquot volume (ml)  
 T = Count time (min)  
 2.22 = DPM/pCi  
 1000 = Number of ml per L

Efficiency (E) is computed as follows:

$$E = \frac{(N) \cdot (D)}{A'}$$

N = Net CPM of spiked sample  
 D = Decay factor of spike  
 A' = DPM of spike

N is determined as follows:

$$N = C - (G/T)$$

C = CPM of spiked sample  
 G = Gross counts of sample  
 T = Count time (min)

The associated error is expressed at 95% confidence limit, as follows:

$$\frac{1.96 \cdot (G/T^2 + B/T^2)^{1/2} \cdot (1000)}{2 \cdot 2.22 \cdot (V) \cdot (E)}$$

Samples are designated LLD if the activity is less than the following value:

$$\text{LLD (pCi/L)} = \frac{(4.66) \cdot (B)^{1/2} \cdot (1000)}{2.22 \cdot (V) \cdot (E) \cdot (T)}$$

## SYNOPSIS OF TELEDYNE ISOTOPES PROCEDURE

### TRITIUM ANALYSIS OF AQUEOUS FRACTION OF BIOLOGICAL MATERIALS

A weighed aliquot of fish or crab flesh is placed in a suitable flask or container having a connection to a vacuum system. Water is removed from the sample by vacuum distillation. Three or ten milliliters (depending on the total volume of water distilled) are added to a scintillating cocktail to a total of 20 milliliters.

The resultant mixture is counted in a Packard automatic sample changing liquid scintillator for at least 100 minutes. The efficiency of the counting system is determined with a tritium standard traceable to NIST. A quench correction to the counting efficiency is automatically applied to the results. The calculation of the tritium activity is related to the original, equivalent weight of the sample in units of pCi/g (wet).

# SYNOPSIS OF PSE&G RESEARCH AND TESTING LABORATORY PROCEDURE

## GAMMA ANALYSIS OF AIR IODINE

Approximately 300m<sup>3</sup> of air is drawn through a 50ml bed of triethylenediamine (TEDA)-impregnated charcoal granules at a rate which closely corresponds to the breathing rate of an adult male. The contents of the exposed air iodine cartridge are emptied into an aluminum sample can containing 50ml of fresh TEDA-impregnated charcoal. The can is hermetically sealed and then counted on a gamma detector.

### Calculation of Gamma Activity:

The following are the calculations performed for the gamma activity, 2-sigma error and LLD:

$$\text{Result (pCi/m}^3\text{)} = \frac{N \cdot D}{(2.22) \cdot (E) \cdot (A) \cdot (T) \cdot (V)} = R$$

N = Net counts under photopeak

D = Decay correction factor

$$\lambda t_1 \cdot \text{EXP}(\lambda t_2)$$

$$1 - \text{EXP}(-\lambda t_1)$$

t<sub>1</sub> = Acquisition live time

t<sub>2</sub> = Elapsed time from sample

collection to start of

acquisition

$$\lambda = 0.693/\text{nuclide half life}$$

E = Detector efficiency

A = Gamma abundance factor (no. of photons per disintegration)

T = Acquisition live time, mins.

V = Sample volume, m<sup>3</sup>

2.22 = No. of dpm per pCi

$$\text{2-sigma error (pCi/m}^3\text{)} = \frac{1.96 \cdot (GC + BC)^{1/2} \cdot R}{N}$$

GC = Gross counts

BC = Background counts

All other variables are as defined earlier.

$$\text{The LLD (pCi/m}^3\text{)} = \frac{4.66 \cdot (BC)^{1/2} \cdot D}{(2.22) \cdot (E) \cdot (A) \cdot (T) \cdot (V)}$$



# SYNOPSIS OF PSE&G RESEARCH AND TESTING LABORATORY PROCEDURE

## ANALYSIS OF RAW MILK FOR IODINE-131

Stable iodine carrier is equilibrated in a 4-liter volume of raw milk before two separate 50ml batches of anion exchange resin are introduced to extract iodine. After each batch has been stirred in the milk for an appropriate time, both are then transferred to an aluminum sample can where the resins are rinsed with demineralized water several times and any leftover rinsewater removed with an aspirator stick. The can is hermetically sealed and then counted on a gamma detector.

### Calculation of I-131 Activity:

$$\text{Result (pCi/L)} = \frac{N \cdot D}{(2.22) \cdot (E) \cdot (A) \cdot (T) \cdot (V)} = R$$

- N = Net counts under photopeak
- D = Decay correction factor  
 $\lambda t_1 \cdot \text{EXP}(\lambda t_2)$   
 $1 - \text{EXP}(-\lambda t_1)$
- t<sub>1</sub> = Acquisition live time
- t<sub>2</sub> = Elapsed time from sample collection to start of acquisition
- $\lambda$  = 0.693/nuclide half life
- E = Detector efficiency
- A = Gamma abundance factor (no. of photons per disintegration)
- T = Acquisition live time, mins.
- V = Sample volume, L
- 2.22 = No. of dpm per pCi

$$2\text{-sigma error (pCi/L)} = \frac{1.96 \cdot (GC + BC)^{1/2} \cdot R}{N}$$

- GC = Gross counts
- BC = Background counts

All other variables are as defined earlier.

$$\text{The LLD (pCi/L)} = \frac{4.66 \cdot (BC)^{1/2} \cdot D}{(2.22) \cdot (E) \cdot (A) \cdot (T) \cdot (V)}$$

# SYNOPSIS OF PSE&G RESEARCH AND TESTING LABORATORY PROCEDURE

## ANALYSIS OF WATER FOR IODINE-131

Stable iodine carrier is equilibrated with Sodium Bisulfite in a 4-liter volume of water, and then filtered, before two separate 50ml batches of anion exchange resin are introduced to extract iodine. After each batch has been stirred in the water for an appropriate time, both are then transferred to an aluminum sample can where the resins are rinsed with demineralized water several times and any leftover rinsewater removed with an aspirator stick. The can is hermetically sealed and then counted on a gamma detector.

Calculation of I-131 Activity:

$$\text{Result (pCi/L)} = \frac{N \cdot D}{(2.22) \cdot (E) \cdot (A) \cdot (T) \cdot (V)} = R$$

N = Net counts under photopeak  
D = Decay correction factor  
 $\lambda t_1 \cdot \text{EXP}(\lambda t_2)$   
 $1 - \text{EXP}(-\lambda t_1)$   
t1 = Acquisition live time  
t2 = Elapsed time from sample collection to start of acquisition  
 $\lambda$  = 0.693/nuclide half life  
E = Detector efficiency  
A = Gamma abundance factor (no. of photons per disintegration)  
T = Acquisition live time, mins.  
V = Sample volume, L  
2.22 = No. of dpm per pCi

$$\text{2-sigma error (pCi/L)} = \frac{1.96 \cdot (\text{GC} + \text{BC})^{1/2} \cdot R}{N}$$

GC = Gross counts  
BC = Background counts

All other variables are as defined earlier.

$$\text{The LLD (pCi/L)} = \frac{4.66 \cdot (\text{BC})^{1/2} \cdot D}{(2.22) \cdot (E) \cdot (A) \cdot (T) \cdot (V)}$$

# SYNOPSIS OF PSE&G RESEARCH AND TESTING LABORATORY PROCEDURE

## RADIOSTRONTIUM ANALYSIS OF AIR FILTERS

The air filters are placed in a small beaker and just enough fuming nitric acid is added to cover the filters. A blank, composed of the same number of clean air filters, is prepared in the same way. Stable strontium carrier is then introduced into each sample and several fuming nitric acid leachings are carried out to remove the radiostrontium from the filter media. Once this is done, the resultant nitrates are dissolved in distilled water and the filter residue is filtered out. Radioactive interferences are stripped out by coprecipitation on ferric hydroxide (yttrium strip) followed by a barium chromate strip. The strontium is precipitated as a carbonate, which is dried and weighed. The samples and blank are then counted on a low background gas proportional counter and, again, at least 14 days later. The basis for this two count method is that Sr-90 and Sr-89 are both unknown quantities requiring two simultaneous equations to solve for them.

Calculation of Sr-90 Activity:

$$\text{Sr-90 Results (pCi/m}^3\text{)} = \frac{N_4/R}{(2.22) * (E) * (E(15)/E') * (S_6) * (V) * (U)}$$

$$= W_2$$

where  $S_6 = A + B * M + C * M^2$  (This is the general form of the normalized Sr-90 efficiency regression equation for one particular gas proportional counter, where A, B and C are regression coefficients.)

$M =$  Thickness density of strontium carbonate precipitate,  $\text{mg/cm}^2$

$E(15)/E' =$  Ratio of Sr-90 efficiency at thickness value of  $15\text{mg/cm}^2$  to Sr-90 counting standard efficiency run at the time of instrument calibration (This standard is run with each group of environmental strontium samples)

$E =$  Sr-90 counting standard efficiency

$V =$  Sample quantity ( $\text{m}^3$ )

$U =$  Chemical yield

$N_4 = (N_2 - F_1 * N_1) / W_1 =$  net counts due to Sr-90 only

$W_1 = ((1 + R_1 * I_2) - (1 + R_1 * I_1) * F_1)$

$I_1 = 1 - \text{EXP}((-0.693/2.667) * t_1)$

$I_2 = 1 - \text{EXP}((-0.693/2.667) * t_2)$

$t_1 =$  Elapsed time from Y-90 strip to first count

$t_2$  = Elapsed time from Y-90 strip to second count  
 2.667 = Half-life of Y-90, days  
 $R_1 = D + E \cdot M + F \cdot M^2$  (This is the general form of the regression equation for Y-90 eff'y/Sr-90 eff'y ratio for one particular gas proportional counter, where D, E and F are regression coefficients.)  
 $N_2 = X - Y$ , where X and Y are recount gross counts and background counts, respectively  
 $N_1 = X_1 - Y_1$ , where  $X_1$  and  $Y_1$  are initial gross counts and background counts, respectively  
 2.22 = No. of dpm per pCi  
 $F_1 = \text{EXP}((-0.693/2.667) \cdot t_2)$   
 $R$  = Count time of sample and blank

Using the same variable definitions as above,  
 the 2-sigma error for Sr-90 (pCi/m<sup>3</sup>) =

$$\left[ \frac{2 \cdot (X+Y)}{W_1^2} + \frac{(X_1+Y_1) \cdot F_1^2}{W_1^2} \right]^{1/2} \cdot \frac{(W_1 \cdot W_2)}{(N_2 - F_1 \cdot N_1)}$$

Again, keeping the same variable definitions,  
 the LLD for Sr-90 (pCi/m<sup>3</sup>) =

$$\left[ \frac{4.66 \cdot (X+Y)}{W_{12}} + \frac{(X_1+Y_1) \cdot F_1^2}{W_1^2} \right]^{1/2}$$

Calculation of Sr-89 Activity:

$$\text{Sr-89 Results (pCi/m}^3\text{)} = \frac{N_6/R}{(2.22) \cdot (E) \cdot (E(15)/E') \cdot (S_7) \cdot (V) \cdot (U) \cdot (F_9)}$$

$$= W_3$$

$S_7 = G + H \cdot M + I \cdot M^2$  (This is the general form of the normalized Sr-89 efficiency regression equation for one particular gas proportional counter where G, H and I are regression coefficients.)  
 $N_6 = N_1 - N_7 \cdot (1 + R_1 \cdot I_1)$   
 $N_7 = (N_2 - F_1 \cdot N_1)/W_1$  (This represents counts due to Sr-90)

5)/E' = Ratio of Sr-89 efficiency at thickness value of 15mg/cm<sup>2</sup> to Sr-90 counting standard efficiency run at the time of instrument calibration (This standard is run with each group of environmental strontium samples)

$$F9 = \text{EXP } ((-0.693/50.5)*t)$$

t = Elapsed time from midpoint of collection period to time of recount for milk samples only. For all other samples, this represents the elapsed time from sample stop date to time of recount.

50.5 = Half-life of Sr-89, days

All other quantities are as previously defined.

$$\text{The 2-sigma error for Sr-89 (pCi/m}^3\text{)} = 2 * \frac{(S8^2 + S9^2)^2 * W3}{(N1 - N7*(1+R1*I1))}$$

$$S8 = \left[ \frac{(X+Y)}{W1^2} + \frac{(X1+Y1)*F1^2}{W1^2} \right]^{1/2}$$

$$S9 = (X1+Y1)^{1/2}$$

All other variables are as previously defined.

$$\text{Using the same variable definitions, the LLD for Sr-89 (pCi/m}^3\text{)} = 4.66*(S8^2 + S9^2)^{1/2}$$

# SYNOPSIS OF PSE&G RESEARCH AND TESTING LABORATORY PROCEDURE

## RADIOSTRONTIUM ANALYSIS OF RAW MILK

Stable strontium carrier is first introduced into a milk sample and into a distilled water sample of equal volume to be used as a blank. The sample(s) and blank are passed through cation resin columns which adsorb strontium, calcium, magnesium and other cations. These cations are then eluted off with a TRIS-buffered 4N sodium chloride solution into a beaker and precipitated as carbonates. The carbonates are converted to nitrates with 6N nitric acid and, by acidifying further to an overall concentration of 70% nitric acid, strontium is forced out of solution somewhat ahead of calcium. Barium chromate precipitation is then performed to remove any traces of radium and radiobarium. Strontium recrystallization is carried out to remove residual calcium which may have been coprecipitated with the initial strontium precipitation. Another recrystallization removes ingrown Y-90, marking the time of the yttrium strip. The strontium is precipitated as its carbonate, filtered, dried and weighed to determine strontium recovery. The samples and blank are then counted on a low background gas proportional counter and, again, at least 14 days later. The basis for this two-count method is that Sr-90 and Sr-89 are both unknown quantities requiring two simultaneous equations to solve for them.

Calculation of Sr-90 Activity:

$$\text{Sr-90 Results (pCi/L)} = \frac{N4/R}{(2.22)*(E)*(E(15)/E')*(S6)*(V)*(U)}$$

$$= W2$$

where  $S6 = A + B*M + C*M^2$  (This is the general form of the normalized Sr-90 efficiency regression equation for one particular gas proportional counter, where A, B and C are regression coefficients.)

$M =$  Thickness density of strontium carbonate precipitate,  $\text{mg/cm}^2$

$E(15)/E' =$  Ratio of Sr-90 efficiency at thickness value of  $15\text{mg/cm}^2$  to Sr-90 counting standard efficiency run at the time of instrument calibration (This standard is run with each group of environmental strontium samples)

$E =$  Sr-90 counting standard efficiency

$V =$  Sample quantity (liters)

$U =$  Chemical yield

$N4 = (N2 - F1*N1)/W1 =$  net counts due to Sr-90 only

$W1 = ((1 + R1*I2) - (1 + R1*I1)*F1)$

$I1 = 1 - \text{EXP}((-0.693/2.667)*t1)$

$$I2 = 1 - \text{EXP} ((-0.693/2.667)*t2)$$

t1 = Elapsed time from Y-90 strip to first count

t2 = Elapsed time from Y-90 strip to second count

2.667 = Half-life of Y-90, days

R1 =  $D + E*M + F*M^2$  (This is the general form of the regression equation for Y-90 eff'y/Sr-90 eff'y ratio for one particular gas proportional counter, where D, E and F are regression coefficients.)

N2 = X - Y, where X and Y are recount gross counts and background counts, respectively

N1 = X1 - Y1, where X1 and Y1 are initial gross counts and background counts, respectively

2.22 = No. of dpm per pCi

$$F1 = \text{EXP} ((-0.693/2.667)*t2)$$

R = Count time of sample and blank

Using the same variable definitions as above,  
the 2-sigma error for Sr-90 (pCi/L) =

$$\left[ \frac{2* (X+Y)}{W1^2} + \frac{(X1+Y1)*F1^2}{W1^2} \right]^{1/2} * \frac{(W1*W2)}{(N2-F1*N1)}$$

Again, keeping the same variable definitions,  
the LLD for Sr-90 (pCi/L) =

$$\left[ \frac{4.66* (X+Y)}{W1^2} + \frac{(X1+Y1)*F1^2}{W1^2} \right]^{1/2}$$

Calculation of Sr-89 Activity:

$$\text{Sr-89 Results (pCi/L)} = \frac{N6/R}{(2.22)*(E)*(E(15)/E')*(S7)*(V)*(U)*(F9)}$$

$$= W3$$

S7 =  $G + H*M + I*M^2$  (This is the general form of the normalized Sr-89 efficiency regression equation for one particular gas proportional counter where G, H and I are regression coefficients.)

$$N6 = N1 - N7*(1 + R1*I1)$$

$$N7 = (N2 - F1*N1)/W1 \text{ (This represents counts due to Sr-90)}$$

$E(15)/E' =$  Ratio of Sr-89 efficiency at thickness value of 15mg/cm<sup>2</sup> to Sr-90 counting standard efficiency run at the time of instrument calibration (This standard is run with each group of environmental strontium samples)

$$F9 = \text{EXP } ((-0.693/50.5)*t)$$

$t =$  Elapsed time from midpoint of collection period to time of recount for milk samples only. For all other samples, this represents the elapsed time from sample stop date to time of recount.

50.5 = Half-life of Sr-89, days

All other quantities are as previously defined.

$$\text{The 2-sigma error for Sr-89 (pCi/L)} = \frac{2 * (S8^2 + S9^2)^{1/2} * W3}{(N1 - N7 * (1 + R1 * I1))}$$

$$S8 = \left[ \frac{(X+Y)}{W1^2} + \frac{(X1+Y1)*F1}{W1^2} \right]^{1/2}$$

$$S9 = (X1+Y1)^{1/2}$$

All other variables are as previously defined.

Keeping the same variable definitions, the LLD for Sr-89 (pCi/L) =  $4.66 * (S8^2 + S9^2)^{1/2}$



# SYNOPSIS OF PSE&G RESEARCH AND TESTING LABORATORY PROCEDURE

## RADIOSTRONTIUM ANALYSIS OF WATER

Stable strontium carrier is introduced into a water sample and into a distilled water sample of the same volume which is used as a blank. The sample(s) and blank are then made alkaline and heated to near boiling before precipitating the carbonates. The carbonates are converted to nitrates by fuming nitric acid recrystallization which acts to purify the sample of most of the calcium. Radioactive interferences are stripped out by coprecipitation on ferric hydroxide (yttrium strip) followed by a barium chromate strip. The strontium is precipitated as a carbonate before being dried and weighed. The samples and blank are then counted on a low background gas proportional counter and, again, at least 14 days later. The basis for this two count method is that Sr-90 and Sr-89 are both unknown quantities requiring two simultaneous equations to solve for them.

Since surface waters, as well as some drinking water samples, have been found to contain significant amounts of stable strontium, a separate aliquot from each sample is analyzed for stable strontium. These results are used in correcting the chemical recovery of strontium to its true value.

Calculation of Sr-90 Activity:

$$\begin{aligned} \text{Sr-90 Results (pCi/L)} &= \frac{N4/R}{(2.22)*(E)*(E(15)/E')*(S6)*(V)*(U)} \\ &= W2 \end{aligned}$$

where  $S6 = A + B*M + C*M^2$  (This is the general form of the normalized Sr-90 efficiency regression equation for one particular gas proportional counter, where A, B and C are regression coefficients.)

$M =$  Thickness density of strontium carbonate precipitate,  $\text{mg/cm}^2$

$E(15)/E' =$  Ratio of Sr-90 efficiency at thickness value of  $15\text{mg/cm}^2$  to Sr-90 counting standard efficiency run at the time of instrument calibration (This standard is run with each group of environmental strontium samples)

$E =$  Sr-90 counting standard efficiency

$V =$  Sample quantity (liters)

$U =$  Chemical yield

$N4 = (N2 - F1*N1)/W1 =$  net counts due to Sr-90 only

$W1 = ((1 + R1*I2) - (1 + R1*I1)*F1)$

$I1 = 1 - \text{EXP}((-0.693/2.667)*t1)$

$$I2 = 1 - \text{EXP} ((-0.693/2.667)*t2)$$

t1 = Elapsed time from Y-90 strip to first count

t2 = Elapsed time from Y-90 strip to second count

2.667 = Half-life of Y-90, days

R1 = D + E\*M + F\*M<sup>2</sup> (This is the general form of the regression equation for Y-90 eff'y/Sr-90 eff'y ratio for one particular gas proportional counter, where D, E and F are regression coefficients.)

N2 = X - Y, where X and Y are recount gross counts and background counts, respectively

N1 = X1 - Y1, where X1 and Y1 are initial gross counts and background counts, respectively

2.22 = No. of dpm per pCi

$$F1 = \text{EXP} ((-0.693/2.667)*t2)$$

R = Count time of sample and blank

Using the same variable definitions as above,  
the 2-sigma error for Sr-90 (pCi/L) =

$$\left[ \frac{2 * (X+Y)}{W1^2} + \frac{(X1+Y1)*F1^2}{W1^2} \right]^{1/2} * \frac{(W1*W2)}{(N2-F1*N1)}$$

Again, keeping the same variable definitions,  
the LLD for Sr-90 (pCi/L) =

$$\left[ \frac{4.66 * (X+Y)}{W1^2} + \frac{(X1+Y1)*F1^2}{W1^2} \right]^{1/2}$$

Calculation of Sr-89 Activity:

$$\text{Sr-89 Results (pCi/L)} = \frac{N6/R}{(2.22)*(E)*(E(15)/E')*(S7)*(V)*(U)*(F9)}$$

$$= W3$$

S7 = G + H\*M + I\*M<sup>2</sup> (This is the general form of the normalized Sr-89 efficiency regression equation for one particular gas proportional counter where G, H and I are regression coefficients.)

$$N6 = N1 - N7*(1 + R1*I1)$$

$$N7 = (N2 - F1*N1)/W1 \text{ (This represents counts due to Sr-90)}$$

15)/E' = Ratio of Sr-89 efficiency at thickness value of 15mg/cm<sup>2</sup> to Sr-90 counting standard efficiency run at the time of instrument calibration (This standard is run with each group of environmental strontium samples)

$$F9 = \text{EXP } ((-0.693/50.5)*t)$$

t = Elapsed time from midpoint of collection period to time of recount for milk samples only. For all other samples, this represents the elapsed time from sample stop date to time of recount.

50.5 = Half-life of Sr-89, days

All other quantities are as previously defined.

$$\text{The 2-sigma error for Sr-89 (pCi/L)} = \frac{2 * (S8^2 + S9^2)^{1/2} * W3}{(N1 - N7 * (1 + R1 * I1))}$$

$$S8 = \left[ \frac{(X+Y)}{W1^2} + \frac{(X1+Y1)*F1^2}{W1^2} \right]^{1/2}$$

$$S9 = (X1+Y1)^{1/2}$$

All other variables are as previously defined.

$$\text{Using the same variable definitions, the LLD for Sr-89 (pCi/L)} = 4.66 * (S8^2 + S9^2)^{1/2}$$

# SYNOPSIS OF PSE&G RESEARCH AND TESTING LABORATORY PROCEDURE

## RADIOSTRONTIUM ANALYSIS OF VEGETATION, MEAT, CRAB SHELL AND AQUATIC SAMPLES

The samples are weighed (recorded as "wet" weight) as received, before being placed in an oven to dry at 100°C. At the completion of the drying period, samples are again weighed (recorded as "dry" weight) and then pulverized. A measured amount (quantity dependent on desired sensitivity) of the pulverized sample is first charred over a Bunsen burner and then ashed in a muffle furnace. The ash is fused with 40g sodium carbonate, along with 20mg strontium carrier, at 900°C for 1/2 hour. After removal from the furnace, the melt is cooled, pulverized and added to 500ml distilled water and heated to near boiling for 30 minutes, with stirring. The sample is filtered (filtrate discarded) and the carbonates on the filter dissolved with 1:1 nitric acid (HNO<sub>3</sub>). The resultant nitrates are heated to dryness and are dissolved in 20ml distilled water before adding 60ml fuming HNO<sub>3</sub>. After calcium removal with anhydrous acetone, radioactive interferences are stripped out by coprecipitation on ferric hydroxide followed by coprecipitation on barium chromate. The strontium is precipitated as its carbonate, which is dried and weighed. The samples are then counted on a low background gas proportional counter and, again, at least 14 days later. The basis for this two-count method is that Sr-90 and Sr-89 are both unknown quantities requiring two simultaneous equations to solve for them.

Calculation of Sr-90 Activity:

$$\begin{aligned} \text{Sr-90 Results (pCi/kg wet)} &= \frac{N4/R}{(2.22)*(E)*(E(15)/E')*(S6)*(V)*(U)} \\ &= W2 \end{aligned}$$

where S6 =  $A + B*M + C*M^2$  (This is the general form of the normalized Sr-90 efficiency regression equation for one particular gas proportional counter, where A, B and C are regression coefficients.)

M = Thickness density of strontium carbonate precipitate, mg/cm<sup>2</sup>

E(15)/E' = Ratio of Sr-90 efficiency at thickness value of 15mg/cm<sup>2</sup> to Sr-90 counting standard efficiency run at the time of instrument calibration (This standard is run with each group of environmental strontium samples)

E = Sr-90 counting standard efficiency

V = Sample quantity (kg wet)

U = Chemical yield

N4 =  $(N2 - F1*N1)/W1$  = net counts due to Sr-90 only

W1 =  $((1 + R1*I2) - (1 + R1*I1)*F1)$

$$I1 = 1 - \text{EXP} ((-0.693/2.667)*t1)$$

$$I2 = 1 - \text{EXP} ((-0.693/2.667)*t2)$$

t1 = Elapsed time from Y-90 strip to first count

t2 = Elapsed time from Y-90 strip to second count

2.667 = Half-life of Y-90, days

R1 = D + E\*M + F\*M<sup>2</sup> (This is the general form of the regression equation for Y-90 eff'y/Sr-90 eff'y ratio for one particular gas proportional counter, where D, E and F are regression coefficients.)

N2 = X - Y, where X and Y are recount gross counts and background counts, respectively

N1 = X1 - Y1, where X1 and Y1 are initial gross counts and background counts, respectively

2.22 = No. of dpm per pCi

$$F1 = \text{EXP} ((-0.693/2.667)*t2)$$

R = Count time of sample and blank

Using the same variable definitions as above,  
the 2-sigma error for Sr-90 (pCi/kg wet) =

$$\left[ \frac{2 * (X+Y)}{W1^2} + \frac{(X1+Y1)*F1^2}{W1^2} \right]^{1/2} * \frac{(W1*W2)}{(N2-F1*N1)}$$

Again, keeping the same variable definitions,  
the LLD for Sr-90 (pCi/kg wet) =

$$\left[ \frac{4.66 * (X+Y)}{W1^2} + \frac{(X1+Y1)*F1^2}{W1^2} \right]^{1/2}$$

Calculation of Sr-89 Activity:

$$\begin{aligned} \text{Sr-89 Results (pCi/kg wet)} &= \frac{N6/R}{(2.22)*(E)*(E(15)/E')*(S7)*(V)*(U)*(F9)} \\ &= W3 \end{aligned}$$

S7 = G + H\*M + I\*M<sup>2</sup> (This is the general form of the normalized Sr-89 efficiency regression equation for one particular gas proportional counter where G, H and I are regression coefficients.)

$$N6 = N1 - N7*(1 + R1*I1)$$

$$N7 = (N2 - F1 \cdot N1) / W1 \text{ (This represents counts due to Sr-90)}$$

$E(15)/E'$  = Ratio of Sr-89 efficiency at thickness value of 15mg/cm<sup>2</sup> to Sr-90 counting standard efficiency run at the time of instrument calibration (This standard is run with each group of environmental strontium samples)

$$F9 = \text{EXP} ((-0.693/50.5) \cdot t)$$

$t$  = Elapsed time from midpoint of collection period to time of recount for milk samples only. For all other samples, this represents the elapsed time from sample stop date to time of recount.

50.5 = Half-life of Sr-89, days

All other quantities are as previously defined.

$$\text{The 2-sigma error for Sr-89 (pCi/kg wet)} = \frac{2 \cdot (S8^2 + S9^2)^{1/2} \cdot W3}{(N1 - N7 \cdot (1 + R1 \cdot I1))}$$

$$S8 = \left[ \frac{(X+Y)}{W1^2} + \frac{(X1+Y1) \cdot F1^2}{W1^2} \right]^{1/2}$$

$$S9 = (X1+Y1)^{1/2}$$

All other variables are as previously defined.

Keeping the same variable definitions, the LLD for Sr-89 (pCi/kg wet) =  $4.66 \cdot (S8^2 + S9^2)^{1/2}$

# SYNOPSIS OF PSE&G RESEARCH AND TESTING LABORATORY PROCEDURE

## RADIOSTRONTIUM ANALYSIS OF BONE

The bone or shell is first physically separated from the rest of the sample before being broken up and boiled in 6N sodium hydroxide (NaOH) solution for a brief time to digest remaining flesh/collagen material adhering to the sample. After multiple rinses with distilled water, the bone/shell is then oven dried and pulverized. An aliquot of the sample is removed, weighed and ashed in a muffle furnace. Then, in the presence of strontium carrier and cesium holdback carrier, the radiostrontium is leached out of the ash by boiling in diluted nitric acid, after which the sample is filtered.

The sample is then treated with concentrated (70%) nitric acid and boiled until strontium nitrate crystallizes out. The strontium nitrate is freed of calcium by repeated fuming nitric acid recrystallizations. From this point on, any radiological impurities are removed by coprecipitation with ferric hydroxide followed by coprecipitation with barium chromate. The strontium is precipitated as strontium carbonate, which is dried, weighed, then betacounted on a low background gas proportional counter. A second count is performed at least 14 days later. The basis for this two-count method is that Sr-90 and Sr-89 are both unknown quantities requiring two simultaneous equations to solve for them.

Calculation of Sr-90 Activity:

$$\begin{aligned} \text{Sr-90 Results (pCi/kg dry)} &= \frac{N4/R}{(2.22)*(E)*(E(15)/E')*(S6)*(V)*(U)} \\ &= W2 \end{aligned}$$

where  $S6 = A + B*M + C*M^2$  (This is the general form of the normalized Sr-90 efficiency regression equation for one particular gas proportional counter, where A, B and C are regression coefficients.)

$M =$  Thickness density of strontium carbonate precipitate,  $\text{mg/cm}^2$

$E(15)/E' =$  Ratio of Sr-90 efficiency at thickness value of  $15\text{mg/cm}^2$  to Sr-90 counting standard efficiency run at the time of instrument calibration (This standard is run with each group of environmental strontium samples)

$E =$  Sr-90 counting standard efficiency

$V =$  Sample quantity (kg dry)

$U =$  Chemical yield

$N4 = (N2 - F1*N1)/W1 =$  net counts due to Sr-90 only

$$W1 = ((1 + R1*I2) - (1 + R1*I1)*F1)$$

$$I1 = 1 - \text{EXP}((-0.693/2.667)*t1)$$

$$I2 = 1 - \text{EXP}((-0.693/2.667)*t2)$$

t1 = Elapsed time from Y-90 strip to first count

t2 = Elapsed time from Y-90 strip to second count

2.667 = Half-life of Y-90, days

R1 =  $D + E*M + F*M^2$  (This is the general form of the regression equation for Y-90 eff'y/Sr-90 eff'y ratio for one particular gas proportional counter, where D, E and F are regression coefficients.)

N2 = X - Y, where X and Y are recount gross counts and background counts, respectively

N1 = X1 - Y1, where X1 and Y1 are initial gross counts and background counts, respectively

2.22 = No. of dpm per pCi

$$F1 = \text{EXP}((-0.693/2.667)*t2)$$

R = Count time of sample and blank

Using the same variable definitions as above,  
the 2-sigma error for Sr-90 (pCi/kg dry) =

$$\left[ \frac{2*(X+Y)}{W1^2} + \frac{(X1+Y1)*F1^2}{W1^2} \right]^{1/2} * \frac{(W1*W2)}{(N2-F1*N1)}$$

Again, keeping the same variable definitions,  
the LLD for Sr-90 (pCi/kg dry) =

$$\left[ \frac{4.66*(X+Y)}{W1^2} + \frac{(X1+Y1)*F1^2}{W1^2} \right]^{1/2}$$

Calculation of Sr-89 Activity:

$$\begin{aligned} \text{Sr-89 Results (pCi/kg dry)} &= \frac{N6/R}{(2.22)*(E)*(E(15)/E')*(S7)*(V)*(U)*(F9)} \\ &= W3 \end{aligned}$$

S7 =  $G + H*M + I*M^2$  (This is the general form of the normalized Sr-89 efficiency regression equation for one particular gas proportional counter where G, H and I are regression coefficients.)



$$N6 = N1 - N7*(1 + R1*I1)$$

$$N7 = (N2 - F1*N1)/W1 \text{ (This represents counts due to Sr-90)}$$

$E(15)/E'$  = Ratio of Sr-89 efficiency at thickness value of 15mg/cm<sup>2</sup> to Sr-90 counting standard efficiency run at the time of instrument calibration (This standard is run with each group of environmental strontium samples)

$$F9 = \text{EXP } ((-0.693/50.5)*t)$$

t = Elapsed time from midpoint of collection period to time of recount for milk samples only. For all other samples, this represents the elapsed time from sample stop date to time of recount.

50.5 = Half-life of Sr-89, days

All other quantities are as previously defined.

$$\text{The 2-sigma error for Sr-89 (pCi/kg dry)} = \frac{2 * (S8^2 + S9^2)^{1/2} * W3}{(N1 - N7*(1+R1*I1))}$$

$$S8 = \left[ \frac{(X+Y)}{W1^2} + \frac{(X1+Y1)*F1^2}{W1^2} \right]^{1/2}$$

$$S9 = (X1+Y1)^{1/2}$$

All other variables are as previously defined.

Keeping the same variable definitions, the LLD for Sr-89 (pCi/kg dry) =  $4.66*(S8^2 + S9^2)^{1/2}$

# SYNOPSIS OF PSE&G RESEARCH AND TESTING LABORATORY PROCEDURE

## RADIOSTRONTIUM ANALYSIS OF SOIL AND SEDIMENT

After the soil or sediment sample has been dried and pulverized, a 50gm aliquot is added to approximately 1/3 - liter concentrated hydrochloric acid (HCl), containing 5ml of strontium carrier (10mg Sr<sup>++</sup>/ml). A blank containing only 1/3 - liter concentrated HCl and 5ml strontium carrier is run in parallel with the sample. The samples are stirred vigorously for at least 30 minutes and then filtered. The filtrate is then diluted to a known volume and aliquots removed for stable strontium. The remaining sample is alkalized with ammonium hydroxide to precipitate all the transitional elements. After filtering out these interferences, the filtrate is heated and sodium carbonate added to precipitate strontium and calcium carbonate. These carbonates are first filtered and then digested with 6N HNO<sup>3</sup>. Two fuming (90%) HNO<sup>3</sup> recrystallizations are then performed to remove calcium. Subsequently, radioactive impurities are removed by two precipitation steps, using ferric hydroxide and barium chromate as carriers. The strontium is precipitated as strontium carbonate before being dried and weighed. The samples are counted for beta activity in a low background gas proportional counter (Count time will vary, depending on the desired sensitivity.). There is a second count at least 14 days later. The basis for this two-count method is that Sr-90 and Sr-89 are both unknown quantities requiring two simultaneous equations to solve for them.

### Calculation of Sr-90 Activity:

$$\begin{aligned} \text{Sr-90 Results (pCi/kg dry)} &= \frac{N_4/R}{(2.22)*(E)*(E(15)/E')*(S_6)*(V)*(U)} \\ &= W_2 \end{aligned}$$

where  $S_6 = A + B*M + C*M^2$  (This is the general form of the normalized Sr-90 efficiency regression equation for one particular gas proportional counter, where A, B and C are regression coefficients.)

M = Thickness density of strontium carbonate precipitate, mg/cm<sup>2</sup>

$E(15)/E'$  = Ratio of Sr-90 efficiency at thickness value of 15mg/cm<sup>2</sup> to Sr-90 counting standard efficiency run at the time of instrument calibration (This standard is run with each group of environmental strontium samples)

E = Sr-90 counting standard efficiency

V = Sample quantity (kg dry)

U = Chemical yield

$N_4 = (N_2 - F_1*N_1)/W_1$  = net counts due to Sr-90 only

$W_1 = ((1 + R_1*I_2) - (1 + R_1*I_1)*F_1)$

$$I1 = 1 - \text{EXP} ((-0.693/2.667)*t1)$$

$$I2 = 1 - \text{EXP} ((-0.693/2.667)*t2)$$

t1 = Elapsed time from Y-90 strip to first count

t2 = Elapsed time from Y-90 strip to second count

2.667 = Half-life of Y-90, days

R1 =  $D + E*M + F*M^2$  (This is the general form of the regression equation for Y-90 eff'y/Sr-90 eff'y ratio for one particular gas proportional counter, where D, E and F are regression coefficients.)

N2 = X - Y, where X and Y are recount gross counts and background counts, respectively

N1 = X1 - Y1, where X1 and Y1 are initial gross counts and background counts, respectively

2.22 = No. of dpm per pCi

$$F1 = \text{EXP} ((-0.693/2.667)*t2)$$

R = Count time of sample and blank

Using the same variable definitions as above,  
the 2-sigma error for Sr-90 (pCi/kg dry) =

$$\left[ \frac{2* (X+Y)}{W1^2} + \frac{(X1+Y1)*F1^2}{W1^2} \right]^{1/2} * \frac{(W1*W2)}{(N2-F1*N1)}$$

Again, keeping the same variable definitions,  
the LLD for Sr-90 (pCi/kg dry) =

$$\left[ \frac{4.66* (X+Y)}{W1^2} + \frac{(X1+Y1)*F1^2}{W1^2} \right]^{1/2}$$

Calculation of Sr-89 Activity:

$$\begin{aligned} \text{Sr-89 Results (pCi/kg dry)} &= \frac{N6/R}{(2.22)*(E)*(E(15)/E')*(S7)*(V)*(U)*(F9)} \\ &= W3 \end{aligned}$$

S7 =  $G + H*M + I*M^2$  (This is the general form of the normalized Sr-89 efficiency regression equation for one particular gas proportional counter where G, H and I are regression coefficients.)

$$N6 = N1 - N7*(1 + R1*I1)$$

$N7 = (N2 - F1 \cdot N1) / W1$  (This represents counts due to Sr-90)

$E(15)/E' =$  Ratio of Sr-89 efficiency at thickness value of 15mg/cm<sup>2</sup> to Sr-90 counting standard efficiency run at the time of instrument calibration (This standard is run with each group of environmental strontium samples)

$F9 = \text{EXP}((-0.693/50.5) \cdot t)$

$t =$  Elapsed time from midpoint of collection period to time of recount for milk samples only. For all other samples, this represents the elapsed time from sample stop date to time of recount.

50.5 = Half-life of Sr-89, days

All other quantities are as previously defined.

The 2-sigma error for Sr-89 (pCi/kg dry) =  $\frac{2 \cdot (S8^2 + S9^2)^{1/2} \cdot W3}{(N1 - N7 \cdot (1 + R1 \cdot I1))}$

$$S8 = \left[ \frac{(X+Y)}{W1^2} + \frac{(X1+Y1) \cdot F1^2}{W1^2} \right]^{1/2}$$

$$S9 = (X1+Y1)^{1/2}$$

All other variables are as previously defined.

Keeping the same variable definitions, the LLD for Sr-89 (pCi/kg dry) =  $4.66 \cdot (S8^2 + S9^2)^{1/2}$

## SYNOPSIS OF PSE&G RESEARCH AND TESTING LABORATORY PROCEDURE

### ANALYSIS OF ENVIRONMENTAL SAMPLES FOR STABLE STRONTIUM

It has been the practice of the Chemical/Environmental Division to perform a stable strontium determination on any samples to be analyzed for strontium 90 and 89, if they are likely to contain significant amounts of the stable isotopes. In the case of mineral (soil or sediment) or biological (bone and shell) media, an ashing and/or acid leaching is performed to extract the element of interest. The removal of the aliquot is done early in the course of the radiostrontium analysis and involves the withdrawal of 25 ml of diluted leachate (soil and sediment only) from the regular sample, transferring it to a flask. Bone and shell are prepared by ashing 2 g of sample, digesting in 6N HCl, filtering out insoluble residues and then transferring to a flask. All the above samples are analyzed by the method of Standard Additions, whereby each sample leachate is spiked with known concentrations of stable strontium. The sample, spiked samples and blank absorbance are determined by Atomic Absorption Spectroscopy (AAS) and are plotted graphically. The true sample concentrations are then extrapolated from this graph. Chemical and ionization interferences are controlled by the addition of 0.1% or more of lanthanum to all samples.

For analysis of water, a 60-ml aliquot of sample is removed, acidified to pH <2 with hydrochloric or Nitric acid and analyzed by AAS or AES as follows: A series of strontium standards (of similar concentration to the unknowns) is prepared. Then, to 9 ml of each prepared sample, blank and standard, is added 1 ml of lanthanum to achieve a minimum of 0.1% lanthanum in all solutions.

Results (calculated as milligrams of strontium per liter) are then used to find the true chemical recovery of strontium based on both the amount of carrier added (only in the case of soil and sediment) and the quantity of strontium intrinsic to the sample.

Sample Calculation of Corrected Chemical Recovery of Strontium in Soil and Sediment:

Reported concentration of stable strontium (mg/L): 119  
Volume of specimen (ml): 25 (removed from 1000ml of diluted leachate)  
Proportion of sample used for aliquot: 0.025

Milligrams strontium in 25ml flask =  $(119\text{mg/L}) \times (.025\text{L}/25\text{ml}) \times (25\text{ml})$   
= 2.98mg Sr

Since 2.98mg Sr represents the quantity of stable strontium in 2 1/2 percent of the sample, total strontium (stable + carrier) in the full sample =

$$\frac{2.98\text{mg Sr}}{0.025} = 119 \text{ mg}$$

Net weight of  $\text{SrCO}_3$  precipitate (mg): 125

Percent of Sr in precipitate: 59.35

Quantity of strontium recovered =  $(125\text{mg}) \times (.5935) = 74.2$

Corrected chemical recovery of strontium =  $\frac{74.2}{119.0} = 0.623$

The calculations follow the same sequence for bone and shell samples.

Sample Calculation of Corrected Chemical Recovery of Strontium in Water:

Reported concentrations of stable strontium (mg/L): 1.65

Volume of radiochemical water sample (liters): 2.0

Stable strontium in 2 liter sample =  $(1.65\text{mg/L}) \times (2.0\text{L})$   
= 3.30mg

Quantity of strontium carrier added to sample (mg): 20.0

Total amount of strontium in sample (mg):  $20.0 + 3.30 = 23.3\text{mg}$

Net weight of  $\text{SrCO}_3$  precipitate (mg): 28.9

Percent of Sr in precipitate: 59.35

Quantity of strontium recovered =  $(28.9\text{mg}) \times (.5935) = 17.2\text{mg}$

Corrected chemical recovery of strontium =  $\frac{17.2\text{mg}}{23.3\text{mg}} = .738$

# SYNOPSIS OF PSE&G RESEARCH AND TESTING LABORATORY PROCEDURE

## GAMMA ANALYSIS OF AIR PARTICULATE COMPOSITES

At the end of each calendar quarter, 13 weekly air filters from a given location are stacked in a two inch diameter Petri dish in chronological order, with the oldest filter at the bottom, nearest the detector, and the newest one on top. The Petri dish is closed and the sample counted on a gamma detector.

The following are the calculations performed for the gamma activity, 2-sigma error and LLD:

$$\text{Result (pCi/m}^3\text{)} = \frac{N \cdot D}{(2.22) \cdot (E) \cdot (A) \cdot (T) \cdot (V)} = R$$

N = Net counts under photopeak

D = Decay correction factor

$$\lambda t_1 \cdot \text{EXP}(\lambda t_2)$$

$$1 - \text{EXP}(-\lambda t_1)$$

t1 = Acquisition live time

t2 = Elapsed time from sample collection to start of acquisition

$\lambda$  = 0.693/nuclide half life

E = Detector efficiency

A = Gamma abundance factor (no. of photons per disintegration)

T = Acquisition live time, mins.

V = Sample volume, m<sup>3</sup>

2.22 = No. of dpm per pCi

$$\text{2-sigma error (pCi/m}^3\text{)} = \frac{1.96 \cdot (GC + BC)^{1/2} \cdot R}{N}$$

GC = Gross counts

BC = Background counts

All other variables are as defined earlier.

$$\text{The LLD (pCi/m}^3\text{)} = \frac{4.66 \cdot (BC)^{1/2} \cdot D}{(2.22) \cdot (E) \cdot (A) \cdot (T) \cdot (V)}$$

# SYNOPSIS OF PSE&G RESEARCH AND TESTING LABORATORY PROCEDURE

## GAMMA ANALYSIS OF RAW MILK

A well mixed 3.5-liter sample of raw milk is poured into a calibrated Marinelli beaker. The sample is brought to ambient temperature and then counted on a gamma detector.

### Calculation of Gamma Activity:

The following are the calculations performed for the gamma activity, 2-sigma error and LLD:

$$\text{Result (pCi/L)} = \frac{N \cdot D}{(2.22) \cdot (E) \cdot (A) \cdot (T) \cdot (V)} = R$$

N = Net counts under photopeak

D = Decay correction factor

$$\lambda t_1 \cdot \text{EXP}(\lambda t_2)$$

$$1 - \text{EXP}(-[\lambda t_1])$$

t1 = Acquisition live time

t2 = Elapsed time from sample collection to start of acquisition

$\lambda$  = 0.693/nuclide half life

E = Detector efficiency

A = Gamma abundance factor (no. of photons per disintegration)

T = Acquisition live time, mins.

V = Sample volume, liters

2.22 = No. of dpm per pCi

$$\text{2-sigma error (pCi/L)} = \frac{1.96 \cdot (GC + BC)^{1/2} \cdot R}{N}$$

GC = Gross counts

BC = Background counts

All other variables are as defined earlier.

$$\text{The LLD (pCi/L)} = \frac{4.66 \cdot (BC)^{1/2} \cdot D}{(2.22) \cdot (E) \cdot (A) \cdot (T) \cdot (V)}$$



# SYNOPSIS OF PSE&G RESEARCH AND TESTING LABORATORY PROCEDURE

## GAMMA ANALYSIS OF WATER

After thoroughly agitating the sample container, 3.5 liters of water sample is poured into a calibrated Marinelli beaker and then counted on a gamma detector.

### Calculation of Gamma Activity:

The following are the calculations performed for the gamma activity, 2-sigma error and LLD:

$$\text{Result (pCi/L)} = \frac{N \cdot D}{(2.22) \cdot (E) \cdot (A) \cdot (T) \cdot (V)} = R$$

N = Net counts under photopeak

D = Decay correction factor

$$\lambda t_1 \cdot \text{EXP}(\lambda t_2)$$

$$1 - \text{EXP}(-\lambda t_1)$$

t1 = Acquisition live time

t2 = Elapsed time from sample collection to start of acquisition

$$\lambda = 0.693 / \text{nuclide half life}$$

E = Detector efficiency

A = Gamma abundance factor (no. of photons per disintegration)

T = Acquisition live time, mins.

V = Sample volume, liters

2.22 = No. of dpm per pCi

$$\text{2-sigma error (pCi/L)} = \frac{1.96 \cdot (GC + BC)^{1/2} \cdot R}{N}$$

GC = Gross counts

BC = Background counts

All other variables are as defined earlier.

$$\text{The LLD (pCi/L)} = \frac{4.66 \cdot (BC)^{1/2} \cdot D}{(2.22) \cdot (E) \cdot (A) \cdot (T) \cdot (V)}$$

# SYNOPSIS OF PSE&G RESEARCH AND TESTING LABORATORY PROCEDURE

## GAMMA ANALYSIS OF SOLIDS

Several methods are employed in preparing solids for gamma analysis, depending the type of sample or sensitivity required. For high sensitivity analysis of vegetation, meat and seafood, the sample is first weighed, then oven-dried to a constant weight. A ratio of wet-to-dry weight is computed before the sample is ground and compressed to unit density ( $1\text{g/cm}^3$ ), when possible, in a tared aluminum can. The can is weighed, hermetically sealed and counted.

In most cases, a wet sample is prepared (when a lower sensitivity is acceptable) by either grinding/chopping the wet sample or by using a food processor to puree it. The sample is poured into a calibrated, tared clear plastic container, aluminum can, or marinelli beaker until a standard volume is reached for that container. The sample is weighed, sealed, and counted.

Soil and sediment samples are first oven dried until a constant weight is achieved and then pulverized. The sample is added to a tared aluminum can, compacted to a standard volume and weighed. It is hermetically sealed, cured for 30 days to allow for ingrowth, and counted.

### Calculation of Gamma Activity:

The following are the calculations performed for the gamma activity, 2-sigma error and LLD:

$$\text{Result (pCi/kg)} = \frac{N \cdot D}{(2.22) \cdot (E) \cdot (A) \cdot (T) \cdot (V)} = R$$

$N$  = Net counts under photopeak  
 $D$  = Decay correction factor  
 $\lambda t_1 \cdot \text{EXP}(\lambda t_2)$   
 $1 - \text{EXP}(-\lambda t_1)$   
 $t_1$  = Acquisition live time  
 $t_2$  = Elapsed time from sample collection to start of acquisition  
 $\lambda$  =  $0.693/\text{nuclide half life}$   
 $E$  = Detector efficiency  
 $A$  = Gamma abundance factor (no. of photons per disintegration)  
 $T$  = Acquisition live time, mins.  
 $V$  = Sample volume, kilograms  
 $2.22$  = No. of dpm per pCi

$$\text{2-sigma error (pCi/kg)} = \frac{1.96 \cdot (GC + BC)^{1/2} \cdot R}{N}$$

$GC$  = Gross counts  
 $BC$  = Background counts

All other variables are as defined earlier.

$$\text{The LLD (pCi/kg)} = \frac{4.66 \cdot (BC)^{1/2} \cdot D}{(2.22) \cdot (E) \cdot (A) \cdot (T) \cdot (V)}$$

## SYNOPSIS OF TELEDYNE ISOTOPES PROCEDURE

### ANALYSIS OF TELEDYNE ISOTOPES THERMOLUMINESCENT DOSIMETERS

These devices are rectangular Teflon wafers impregnated with 25%  $\text{CaSO}_4:\text{Dy}$  phosphor. They are first annealed in a 250°C oven prior to exposure in the field. Following field exposure (for a 1-month or 3-month period) four separate areas of the dosimeter are read in a Teledyne Isotopes model 8300 TLD reader. The dosimeter is then re-irradiated by a standardized Cs-137 source and the four areas are read again. Calculation of the environmental exposure is performed by computer, using the re-irradiation readings to determine the sensitivity of each area of the dosimeter. The readings of control dosimeters are subtracted to allow for transit dose and system background.

The results are computed as follows:

For any given area of the dosimeter, the dose in mR is calculated by the following formula:

$$\text{DOSE} = R * (\text{REDOSE}/\text{RR}) - \text{AVC}$$

R = Initial reading of the area

RR = Second reading of the area  
(after re-irradiation)

REDOSE = Re-irradiation dose, mR

AVC = Average of control values, mR

$$\text{where AVC} = \frac{\sum_{i=1}^{4N} \text{CDOSE}}{4N}$$

N = Total number of control  
dosimeters

$$\text{CDOSE} = \text{CR} * (\text{CREDOSE}/\text{CRR})$$

CDOSE = Control area dose, mR

CR = Initial reading of control area

CRR = Second reading of the control  
area (after re-irradiation)

CREDOSE = Re-irradiation dose of the  
control dosimeter, mR

## **APPENDIX E**

### **SUMMARY OF USEPA ENVIRONMENTAL RADIOACTIVITY LABORATORY INTERCOMPARISON STUDIES PROGRAM RESULTS**

## APPENDIX E

### SUMMARY OF USEPA INTERCOMPARISON STUDIES PROGRAM

Appendix E presents a summary of the analytical results for the 1993 USEPA Environmental Radioactivity Laboratory Intercomparison Studies Program.

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TABLE E-1  
USEPA ENVIRONMENTAL RADIOACTIVITY LABORATORY INTERCOMPARISON STUDY PROGRAM

Gross Alpha and Gross Beta Analysis of Water (pCi/L)  
and Air Particulate (pCi/filter)

DATE MM-YY	ENV SAMPLE CODE	MEDIUM	ANALYSIS	* PSE&G Mean $\pm$ s.d.	** EPA Known
01-93	EPA-WAT-AB359 <sup>1</sup>	Water	Alpha Beta	15 $\pm$ 3 39 $\pm$ 0.5	34 $\pm$ 9 44 $\pm$ 5
04-93	EPA-WAT-P361	Water	Alpha Beta	110 $\pm$ 5 168 $\pm$ 2.4	95 $\pm$ 24 177 $\pm$ 27
07-93	EPA-WAT-AB365	Water	Alpha Beta	16 $\pm$ 0.5 40 $\pm$ 2.6	15 $\pm$ 5 43 $\pm$ 6.9
08-93	EPA-APT-GABS366	APT	Alpha Beta	22 $\pm$ 0 48 $\pm$ 0.5	19 $\pm$ 5 47 $\pm$ 5
10-93	EPA-WAT-P369	Water	Alpha Beta	55 $\pm$ 1.2 57 $\pm$ 1.2	40 $\pm$ 10 58 $\pm$ 10
10-93	EPA-WAT-AB372	Water	Alpha Beta	18 $\pm$ 2.4 20 $\pm$ 1.2	20 $\pm$ 5 15 $\pm$ 5

- (1) The PSE&G results for the January 93 gross alpha in water were not within the EPA limit values of 34  $\pm$  17.3 (two sigma). An examination of the analyses and counting parameters showed no apparent discrepancies in how the results were developed. A review of the performance of other participants in the cross check program indicated that 65% of the responding laboratories developed results outside the EPA control limits with a grand average value of 17.1 pCi/L. In conversations with the EPA it was determined that the Agency recently switched over to using Th-230 as the gross alpha reference standard. Previously the EPA and PSE&G used Am-241. The difference in detector response to Am-241 and Th-230 is approximately a factor of two for our instruments. If Th-230 was used as the gross reference standard the calculated response would have been doubled. A Th-230 standard was obtained from EPA in order to develop a new self-absorption curve and to recalibrate the detectors. Subsequent results have been in agreement.

\* s.d. - one standard deviation of three individual analytical results  
\*\* known value plus or minus one sigma as reported by EPA

TABLE E-2

## USEPA ENVIRONMENTAL RADIOACTIVITY LABORATORY INTERCOMPARISON STUDY PROGRAM

Gamma Analysis of Milk, Water (pCi/L) and  
Air Particulate (pCi/filter)

DATE MM-YY	ENV SAMPLE CODE	MEDIUM	ANALYSIS	* PSE&G Mean $\pm$ s.d.	** EPA Known
06-93	EPA-WAT-G363	Water	Ba-133	94 $\pm$ 2.1	99 $\pm$ 10
			Co-60	15 $\pm$ 0.5	15 $\pm$ 5
			Zn-65	103 $\pm$ 2.9	103 $\pm$ 10
			Ru-106	100 $\pm$ 3.7	119 $\pm$ 12
			Cs-134	7 $\pm$ 1.6	5 $\pm$ 5
			Cs-137	7 $\pm$ 0.9	5 $\pm$ 5
04-93	EPA-WAT-P361	Water	Cs-134	27 $\pm$ 1.2	27 $\pm$ 5
			Cs-137	31 $\pm$ 1.2	32 $\pm$ 5
			Co-60	41 $\pm$ 1.6	39 $\pm$ 5
08-93	EPA-APT-GABS366	APT	Cs-137	11 $\pm$ 0.5	9 $\pm$ 5
09-93	EPA-MLK-GS367	Milk	Cs-137	48 $\pm$ 1.2	49 $\pm$ 5
			K(1)	1640 $\pm$ 16	1680 $\pm$ 84
			I-131	117 $\pm$ 1.4	120 $\pm$ 12
10-93	EPA-WAT-P369	Water	Co-60	11 $\pm$ 0.5	10 $\pm$ 5
			Cs-134	10 $\pm$ 0	12 $\pm$ 5
			Cs-137	11 $\pm$ 0	10 $\pm$ 5
11-93	EPA-WAT-G371	Water	Co-60	31 $\pm$ 0.9	30 $\pm$ 5
			Zn-65	155 $\pm$ 2.6	150 $\pm$ 15
			Ru-106	200 $\pm$ 9.5	201 $\pm$ 20
			Cs-134	57 $\pm$ 0.9	59 $\pm$ 5
			Cs-137	42 $\pm$ 0.5	40 $\pm$ 5
			Ba-133	76 $\pm$ 1.7	79 $\pm$ 8

(1) Reported as mg/l of Potassium

\* s.d. - one standard deviation of three individual analytical results  
 \*\* known value plus or minus one sigma as reported by EPA

TABLE E-3

## USEPA ENVIRONMENTAL RADIOACTIVITY LABORATORY INTERCOMPARISON STUDY PROGRAM

## Tritium Analysis of Water (pCi/L)

DATE MM-YY	ENV SAMPLE CODE	MEDIUM	ANALYSIS	* PSE&G Mean $\pm$ s.d.	** EPA Known
06-93	EPA-WAT-H362	Water	H-3	9260 $\pm$ 258	9840 $\pm$ 980
11-93	EPA-WAT-H370	Water	H-3	7030 $\pm$ 33	7400 $\pm$ 740

\* s.d. - one standard deviation of three individual analytical results  
\*\* known value plus or minus one sigma as reported by EPA



TABLE E-4

## USEPA ENVIRONMENTAL RADIOACTIVITY LABORATORY INTERCOMPARISON STUDY PROGRAM

## Iodine Analysis of Water (pCi/L)

DATE MM-YY	ENV SAMPLE CODE	MEDIUM	ANALYSIS	* PSE&G Mean $\pm$ s.d.	** EPA Known
02-93	EPA-WAT-I360 <sup>1</sup>	Water	I-131	125 $\pm$ 3.3	100 $\pm$ 10
10-93	EPA-WAT-I368	Water	I-131	106 $\pm$ 1.9	117 $\pm$ 12

- 1) The PSE&G results for the February 1993 I-131 in water did not agree with the EPA known. An evaluation indicated a difference in the counting geometry which altered the results by a factor of 25%. The sample counting geometry was realigned and subsequent results have been in agreement. Previous results were not effected by this error.

\* s.d. - one standard deviation of three individual analytical results  
\*\* known value plus or minus one sigma as reported by EPA

TABLE E-5

## USEPA ENVIRONMENTAL RADIOACTIVITY LABORATORY INTERCOMPARISON STUDY PROGRAM

Strontium-89 and Strontium-90 Analysis of Air Particulates (pCi/filter),  
Milk (pCi/L) and Water (pCi/L)

DATE MM-YY	ENV SAMPLE CODE	MEDIUM	ANALYSIS	* PSE&G Mean $\pm$ s.d.	** EPA Known
01-93	EPA-WAT-S358	Water	Sr-89 Sr-90	16 $\pm$ 0.4 9 $\pm$ 0.2	15 $\pm$ 5 10 $\pm$ 5
04-93	EPA-WAT-P361	Water	Sr-89 Sr-90	44 $\pm$ 5.1 28 $\pm$ 1.4	41 $\pm$ 5 29 $\pm$ 5
07-93	EPA-WAT-S364	Water	Sr-89 Sr-90	35 $\pm$ 2.5 25 $\pm$ 0.8	34 $\pm$ 5 25 $\pm$ 5
08-93	EPA-APT-GABS366	APT	Sr-90	18 $\pm$ 0.9	19 $\pm$ 5
09-93	EPA-MLK-GS367	Milk	Sr-89 Sr-90	27 $\pm$ 0.9 24 $\pm$ 0.5	30 $\pm$ 5 25 $\pm$ 5
10-93	EPA-WAT-P369	Water	Sr-89 Sr-90	13 $\pm$ 0 10 $\pm$ 0.5	15 $\pm$ 5 10 $\pm$ 5

\* s.d. - one standard deviation of three individual analytical results

\*\* known value plus or minus one sigma as reported by EPA

## **APPENDIX F**

### **SYNOPSIS OF LAND USE CENSUS**

## APPENDIX F

### SYNOPSIS OF 1993 LAND USE CENSUS

A land use census was conducted to identify, within a distance of 8 km (5 miles), the location of the nearest milk animal, the nearest residence, and the nearest garden of greater than 50m<sup>2</sup> (500ft<sup>2</sup>) producing broad leaf vegetation, in each of the 16 meteorological sectors.

Tabulated below are the results of these surveys:

<u>Meteorological Sector</u>	<u>Milk Animal Aug., 1993 km (miles)</u>	<u>Nearest Residence Aug., 1993 km (miles)</u>	<u>Vegetable Garden Aug., 1993 km (miles)</u>
N	None	None	None
NNE	None	6.9 (4.3)	None
NE	None	6.4 (4.0)	None
ENE	None	5.8 (3.6)	None
E	None	5.4 (3.4)	None
ESE	None	None	None
SE	None	None	None
SSE	None	None	None
S	None	None	None
SSW	None	5.5 (3.4)	None
SW	None	6.9 (4.3)	None
WSW	None	7.1 (4.4)	None
W	7.8 (4.9)	6.5 (4.0)	None
WNW	None	5.5 (3.4)	None
NW	None	5.9 (3.7)	None
NNW	None	6.8 (4.2)	None