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Kewaunee Nuclear Power Plant
Annual Environmental Monitoring Report January-December 1998

Attached is the 1998 Annual Environmental Monitoring Report for the Kewaunee Nuclear Power Plant (KNPP). This report was prepared by Teledyne Isotopes and satisfies the requirements of KNPP Technical Specification 6.9.b.1.

The results of the 1998 Land Use Census, submitted in accordance with KNPP's Offsite Dose Calculation Manual, Section 3/4.7.1, are included in this report.

Sincerely,

Mark L. Marchi
Vice President-Nuclear

BRG/jmf

Attach.

cc - US NRC, Region III
US NRC Senior Resident Inspector

50-305 KEWAUNEE WPS

ANNUAL ENVIRONMENTAL MONITORING REPORT (1998)

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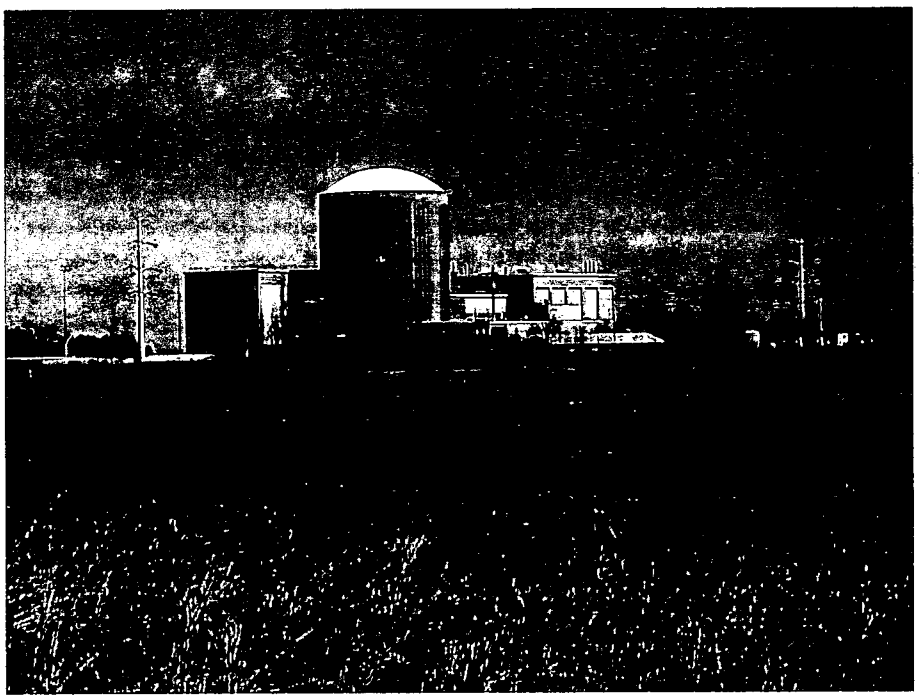

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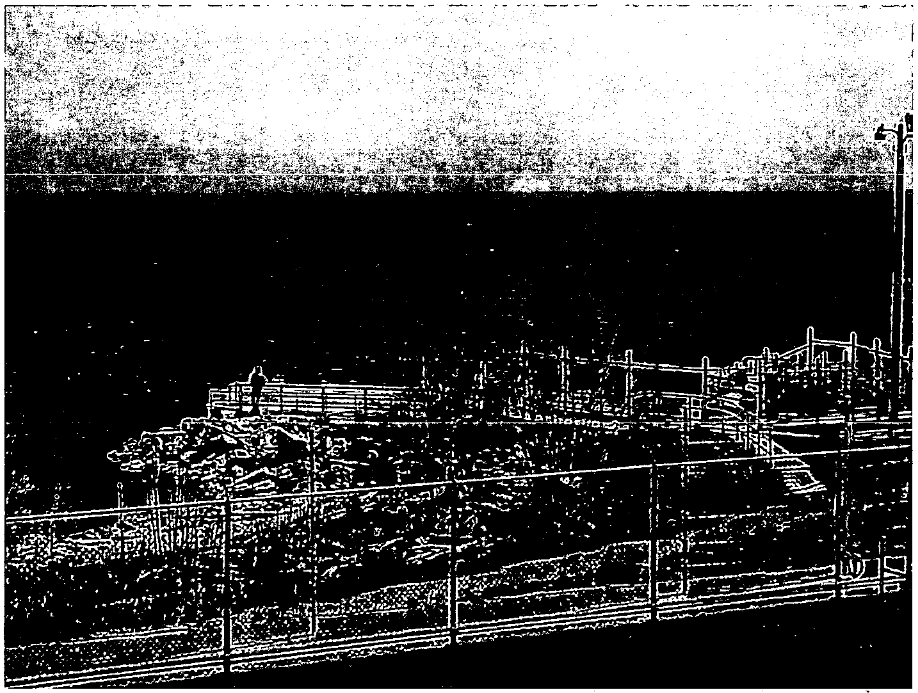

Kewaunee's discharge and fishing pier

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REPORT TO

WISCONSIN PUBLIC SERVICE CORPORATION
WISCONSIN POWER AND LIGHT COMPANY
MADISON GAS AND ELECTRIC COMPANY

RADIOLOGICAL MONITORING PROGRAM FOR THE KEWAUNEE NUCLEAR POWER PLANT KEWAUNEE, WISCONSIN

ANNUAL REPORT - PART I
SUMMARY AND INTERPRETATION
January - December 1998

PREPARED AND SUBMITTED
BY
TELEDYNE BROWN ENGINEERING ENVIRONMENTAL SERVICES
MIDWEST LABORATORY

PROJECT NO. 8002

Approved by: ______________________
Bronia Grob, M.S.
Technical Lead

31 March 1999

PREFACE

The staff of the Teledyne Brown Engineering Environmental Services, Midwest Laboratory (TBEESML) were responsible for the acquisition of data presented in this report. Assistance in sample collection was provided by Wisconsin Public Service Corporation personnel. The report was prepared by staff members of Teledyne Brown Engineering Environmental Services, Midwest Laboratory.

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1.0 INTRODUCTION

The Kewaunee Nuclear Power Plant is a 535 megawatt pressurized water reactor located on the Wisconsin shore of Lake Michigan in Kewaunee County. The Kewaunee Nuclear Power Plant became critical on March 7, 1974. Initial Power generation was achieved on April 8, 1974, and the Plant was declared commercial on June 16, 1974. This report summarizes the environmental operation data collected during the period January - December 1998.

Wisconsin Public Service Corporation, an operating company for the Kewaunee Nuclear Power Plant, assumes the responsibility for the environmental program at the Plant and any questions relating to this subject should be directed to Mr. Mark Reinhart, Superintendent of Plant Radiation Protection at (920) 388-8369.

2.0 SUMMARY

Results of sample analyses during the period January - December 1998 are summarized in Table 4.5. Radionuclide concentrations measured at indicator locations are compared with levels measured at control locations and in preoperational studies. The comparisons indicate background-level radioactivities in all samples collected.

3.0 RADIOLOGICAL SURVEILLANCE PROGRAM

Following is a description of the Radiological Surveillance Program and its execution.

3.1 Methodology

The sampling locations are shown in Figure 4-1. Table 4.1 describes the locations, lists for each direction and distance from the reactor, and indicates which are indicators and which are control locations.

The sampling program monitors the air, terrestrial, and aquatic environments. The types of samples collected at each location and the frequency of collections are presented in Table 4.2, using sample codes defined in Table 4.3. The collections and analyses that comprise the program are described below. Finally, the execution of the program in the current reporting year is discussed.

3.1.1 The Air Program

Airborne Particulates

The airborne particulate samples are collected on 47 mm diameter glass fiber filters at a volumetric rate of approximately one cubic foot per minute. The filters are collected weekly from six locations (K-1f, K-2, K-7, K-8, K-31 and K-16), and dispatched by mail to Teledyne for radiometric analysis. The material on the filter is counted for gross beta activity approximately 72 hours or later after collection to allow for decay of naturally-occurring short-lived radionuclides.

Quarterly composites from each sampling location are analyzed for gamma-emitting isotopes by germanium detector.

Airborne Iodine

Charcoal filters are located at locations K-1f, K-2, K-7, K-8, K-31 and K-16. The filters are changed bi-weekly and analyzed for iodine-131 immediately after arrival at the laboratory.

Ambient Gamma Radiation - TLDs

The integrated gamma-ray background is measured at six sampling locations (K-1f, K-2, K-7, K-8, K-15 and K-16), at four milk sampling locations (K-3, K-4, K-5 and K-6), and four additional sites (K-17, located 4.25 miles west of the plant; K-27, located 1.5 miles northwest of the plant; K-30, located 1.0 miles north of the plant and K-31, located 6.25 miles north-northwest of the plant) by thermoluminescent dosimetry (TLDs). Two TLD cards, each having four main readout areas containing $CaSO_4$:Dy phosphor, are placed at each location (eight TLDs at each location). One card is exchanged quarterly, the other card is exchanged annually and read only on an emergency basis.

Precipitation

Monthly composites of precipitation samples collected at K-11 are analyzed for tritium activity and counted using a liquid scintillation method.

3.1.2 The Terrestrial Program

Milk

Milk samples are collected semimonthly (one gallon from each location) from May through October, and monthly (two gallons from each location) during the rest of the year from four herds that graze within four miles of the reactor site (K-4, K-5, K-12 and K-19), from two herds that graze between four and ten miles from the reactor site (K-3 and K-6), and from a dairy in Green Bay (K-28). The milk samples are analyzed for iodine-131, strontium-89 and-90, cesium-137, barium-lanthanum-140, potassium-40, calcium and stable potassium.

Well Water

One gallon of water is collected quarterly from four off-site wells located at K-10, K-11, K-12 and K-13 and from two on-site wells located at K-1g and K-1h.

Gamma spectroscopic analyses and gross beta on the total residue are performed for each water sample. The concentration of potassium-40 is calculated from total potassium, which is determined by flame photometry on all samples.

Additionally, samples of water from two on-site wells (K-1g and K-1h) are analyzed for gross alpha. Water from the on-site well (K-1g) is also analyzed for tritium, strontium-89 and strontium-90.

Domestic Meat

Domestic meat samples (chickens) are obtained annually (in the third quarter) at locations K-24, K-27 (if available), K-29 and K-32. The flesh is separated from the bones and analyzed for gross alpha, gross beta and gamma emitting isotopes.

Eggs

Eggs are collected quarterly from locations K-24 and K-32. The samples are analyzed for gross beta, strontium-89, strontium-90 and gamma emitting isotopes.

Vegetables

Vegetable samples (6 varieties) are collected at locations K-17 and K-26, and two varieties of grain, if available, at location K-23. The samples are analyzed for gross beta, strontium-89, strontium-90 and gamma emitting isotopes.

Grass and Cattle Feed

Grass samples are collected during the second, third and fourth quarters from two on-site locations (K-1b and K-1f) and from six dairy farms (K-3, K-4, K-5, K-6, K-12 and K-19). The samples are analyzed for gross beta, strontium-89, strontium-90 and gamma emitting isotopes. During the first quarter, cattle feed is collected from the same six dairy farms and the same analyses are performed.

Soil

Soil samples are collected twice a year on-site at K-1f and from the six dairy farms (K-3, K-4, K-5, K-6, K-12 and K-19). The samples are analyzed for gross alpha, gross beta, strontium-89, strontium-90 and gamma emitting isotopes.

3.1.3 The Aquatic Program

Surface Water

One-gallon water samples are taken monthly from three locations on Lake Michigan: 1) at the point where the condenser water is discharged into Lake Michigan (K-1d); 2) Two Creeks Park (K-14) located 2.5 miles south of the reactor site; and 3) at the main pumping station located approximately equidistant from Kewaunee and Green Bay, which pumps water from the Rostok water intake (K-9) located 11.5 miles north of the reactor site. Both raw and tap water are collected at K-9. One-gallon water samples are taken monthly from three creeks that pass through the site (K-1a, K-1b, and K-1e). Samples from North and Middle Creeks (K-1a, K-1b) are collected near the mouth of each creek. Samples from the South Creek (K-1e) are collected about ten feet downstream from the point where the outflow from the two drain pipes meet. Additionally, the drainage pond (K-1k), located approximately 0.6 miles southwest of the plant, is included in the sampling program. Water samples at K-14 are collected and analyzed in duplicate.

The water samples are analyzed for gamma emitting isotopes, gross beta activity in total residue, dissolved solids and suspended solids, and potassium-40. The concentration of potassium-40 is calculated from total potassium, which is determined by flame photometry. In addition, quarterly composites of the monthly grab samples are analyzed for tritium, strontium-89 and strontium-90.

Fish

Fish samples are collected during the second, third and fourth quarters at location K-1d. The flesh is separated from the bones, gamma scanned and analyzed for gross beta activity. Ashed bone samples are analyzed for gross beta, strontium-89 and strontium-90 activities.

Slime

Slime samples are collected during the second and third quarters from three Lake Michigan locations (K-1d, K-9 and K-14), from three creek locations (K-1a, K-1b and K-1e) and from the drainage pond (K-1k), if available. The samples are analyzed for gross beta activity. If the quantity is sufficient, they are also gamma scanned and analyzed for strontium-89 and strontium-90 activities.

Bottom Sediments

Bottom sediments are collected in May and November from five locations (K-1c, K-1d, K-1j, K-9 and K-14). The samples are analyzed for gross beta, strontium-89, strontium-90 and gamma emitting isotopes. It is known that the measured radioactivity per unit mass of sediment increases with decreasing particle size, and the sampling procedure is designed to assure collection of very fine particles.

3.1.4 Program Execution

Program execution is summarized in Table 4.4. The program was executed as described in the preceding sections, with the following exceptions:

No TLD data was available for the first quarter, 1998 from location K-6. The dosimeter cards were lost due to power line pole replacement.

A surface water sample was not available for the month of February, 1998 at location K-1k. The pond was frozen.

No domestic meat sample was available at location K-27 during 1998.

3.1.5 Program Modifications

There were no program modifications made during 1998.

3.2 Results and Discussion

The results for the reporting period January to December 1998 are presented in summary form in Table 4.5. For each type of analysis of each sampled medium, this table shows the annual mean and range for all indicator locations and for all control locations. The location with the highest annual mean and the results for this location are also given.

The discussion of the results has been divided into three broad categories: the air, terrestrial, and aquatic environments. Within each category, samples will be discussed in the order listed in Table 4.4. Any discussion of previous environmental data for the Kewaunee Nuclear Power Plant refers to data collected by Teledyne Brown Engineering Environmental Services, Midwest Laboratory or its predecessor, Hazleton Environmental Sciences.

The tabulated results of all measurements made in 1998 are not included in this section, although references to these results will be made in the discussion. The complete tabulation of the 1998 results is contained in Part II of the 1998 annual report on the Radiological Monitoring Program for the Kewaunee Nuclear Power Plant.

3.2.1 Atmospheric Nuclear Detonations and Nuclear Accidents

There were no reported atmospheric nuclear tests in 1998. The last reported test was conducted by the People's Republic of China on October 16, 1980.

There were no reported accidents at nuclear facilities in 1998.

3.2.2 The Air Environment

Airborne Particulates

In air particulates, the annual gross beta concentration at both indicator and control locations measured 0.019 pCi/m^3. These averages were similar to or slightly lower than the average means observed from 1988 (and prior to) through 1997. The average results are tabulated below.

Year	Average of Indicators	Average of Controls
	Concentration (pCi/m^3)	
1988	0.025	0.023
1989	0.025	0.024
1990	0.024	0.024
1991	0.018	0.019
1992	0.018	0.019
1993	0.020	0.020
1994	0.016	0.018
1995	0.019	0.018
1996	0.020	0.019
1997	0.019	0.019
1998	0.019	0.019

Average annual gross beta concentrations in airborne particulates.

Airborne Particulates (continued)

Gamma spectroscopic analyses of quarterly composites of air particulate filters yielded similar results for indicator and control locations. Beryllium-7, which is produced continuously in the upper atmosphere by cosmic radiation (Arnold and Al-Salih, 1955), was detected in all samples. All other gamma-emitting isotopes were below their respective LLD limits.

Airborne Iodine

Bi-monthly levels of airborne iodine-131 were below the lower limit of detection (LLD) of 0.03 pCi/m^3 at all locations. There is no indication of an effect of the plant operation on the local air environment.

Ambient Gamma Radiation - TLDs

Ambient gamma radiation was monitored by TLDs at fourteen locations: seven indicator and seven control.

The quarterly TLDs at the indicator locations measured a mean dose equivalent of (16.1 mR/91 days), in agreement with the mean at the control locations of (15.5 mR/91 days), and were similar to the means obtained in 1988 (and prior to) through 1997. The results are tabulated below. No plant effect on ambient gamma radiation was indicated These values are slightly lower than the United States average value of 19.5 mR/91 days due to natural background radiation (National Council on Radiation Protection and Measurements, 1975). The highest annual mean was 18.6 mR/91 days, measured at the indicator location K-7.

Year	Average (Indicators)	Average (Controls)
	Dose rate (mR/91 days)	
1988	18.0	17.4
1989	17.5	16.9
1990	14.4	14.4
1991	13.7	12.5
1992	15.0	13.8
1993	15.0	13.8
1994	14.8	13.8
1995	16.7	15.6
1996	15.9	14.9
1997	16.0	15.1
1998	16.1	15.5

Ambient gamma radiation as measured by thermoluminescent dosimetry. Average quarterly dose rates.

Precipitation

Precipitation was monitored at one indicator location, K-11. The tritium concentration was below the LLD level of 330 pCi/L in all samples.

3.2.3 The Terrestrial Environment

Milk

Of the 126 analyses for iodine-131 in milk, all were below the LLD level of 0.5 pCi/L.

Strontium-89 concentrations were below the LLD level of 1.4 pCi/L in all samples. Low levels of Strontium-90 were found in seventy-nine out of eighty-four samples tested. The mean values were similar for indicator and control locations (1.3 and 1.4 pCi/L, respectively) and are similar to or less than averages seen from 1978 through 1997.

Barium-lanthanum-140 concentrations were below the LLD of 15 pCi/L and Cesium-137 concentrations were below the LLD of 10 pCi/L in all samples. Potassium-40 results are similar at both the indicator and control locations (1390 and 1350 pCi/L, respectively), and are essentially identical to the levels observed from 1978 through 1997.

Due to the chemical similarities between strontium and calcium, and cesium and potassium, organisms tend to deposit cesium-137 in the soft tissue and muscle and strontium-89 and strontium-90 in the bones. Consequently, the ratios of strontium-90 activity to the weight of calcium in milk and cesium-137 activity to the weight of potassium in milk were monitored in order to detect potential environmental accumulation of these radionuclides. No statistically significant variations in the ratios were observed. The measured concentrations of stable potassium and calcium are in agreement with previously determined values of 1.50 ± 0.21 g/L and 1.16 ± 0.08 g/L, respectively (National Center for Radiological Health, 1968).

Well Water

Gross alpha concentration was measured at the two on-site wells, (K-1g and K-1h) and averaged 5.0 pCi/L. Gross beta concentrations in well water averaged 1.3 pCi/L in samples from the control location. The mean value for all indicator locations was 3.1 pCi/L, essentially the same values observed from 1978 through 1997 (3.4, 3.0, 3.0, 3.6, 3.2, 2.9, 2.3, 2.6, 2.5, 2.1, 3.3, 2.5, 2.0, 2.2, 2.6, 2.2, 2.0, 2.6, 3.6 and 3.3 pCi/L, respectively). The differences between mean gross beta concentrations are not statistically significant because the counting uncertainties of the individual measurements are typically 0.3 to 1.3 pCi/L in all samples.

Tritium concentration in the on-site well (K-1g) was below the LLD of 330 pCi/L in all samples.

All gamma-emitting isotopes were below their respective LLDs in all samples.

Concentrations of strontium-89 and strontium-90 in well water were below the detection limits of 2.2 and 0.5 pCi/L, respectively, for all samples.

Potassium-40 averages are generally in proportion to gross beta measurements and were in agreement with previously measured values.

Domestic Meat

In meat (chickens), gross alpha concentration measured 0.1 pCi/g wet weight at one indicator location and 0.05 pCi/g wet weight for the control location. Gross beta concentration averaged 2.1 pCi/g wet weight for indicator locations and 3.0 pCi/g wet weight for the control location. The differences are not significant. Gamma-

Domestic Meat (continued)

spectroscopic analyses showed that almost all of the beta activity was due to naturally occurring potassium-40. All other gamma-emitting isotopes were below their respective LLD limits.

Eggs

In egg samples, gross beta concentration averaged 1.33 pCi/g wet weight, similar to the concentration of the naturally-occurring potassium-40 observed in the samples (1.31 pCi/g). All other gamma-emitting isotopes were below their respective LLDs. The level of strontium-89 was below the LLD of 0.010 pCi/g wet weight in all samples. Strontium-90 was below the LLD level of 0.003 pCi/g wet weight in all samples.

Vegetables and Grain

In vegetables, gross beta concentrations were similar at both the indicator and control locations (2.25 and 2.52 pCi/g wet weight, respectively) and was due primarily to potassium-40 activity. Strontium-89 was below the LLD level of 0.043 pCi/g wet weight in all samples. Strontium-90 was detected in samples of oats and clover at an average concentration of 0.022 pCi/g wet weight.

All other gamma-emitting isotopes were below their respective LLD levels.

In addition to potassium-40, naturally-occurring beryllium-7 was detected in both oats and clover samples. These samples are of similar radioisotopic composition to vegetables, but the concentration of radionuclides was slightly higher due to the lower water content.

Grass and Cattle Feed

In grass, mean gross beta concentrations were similar at both indicator and control locations (6.55 and 7.28 pCi/g wet weight, respectively) and in both cases was predominantly due to naturally occurring potassium-40 and beryllium-7. All other gamma-emitting isotopes were below their respective LLDs. Strontium-89 was below the LLD of 0.016 pCi/g wet weight in all samples. Strontium-90 activity was below the LLD of 0.008 pCi/g wet weight in all samples.

In cattlefeed, the mean gross beta concentration was lower at the control locations (9.16 pCi/g wet weight) than at indicator locations (12.49 pCi/g wet weight). The highest average gross beta levels were in samples from the indicator locations K-4 and K-5 (14.65 pCi/g wet weight), and reflected the high combined beryllium-7 and potassium-40 levels observed in the samples. This pattern was similar to that observed since 1978. Strontium-89 levels were below the LLD level of 0.027 pCi/g wet weight in all samples. Strontium-90 activity measured 0.022 pCi/g wet at the indicator locations and 0.041 pCi/g wet weight at the control locations, similar or lower than levels observed in 1995, 1996, and 1997. The presence of the radiostrontium is attributable to fallout from previous nuclear testing. All other gamma-emitting isotopes were below their respective LLD levels.

Soil

Gross alpha concentrations in soil samples measured 11.14 pCi/g dry weight at the indicator locations averaged and 8.24 pCi/g dry weight at the control locations. Mean gross beta levels measured at the indicator and control locations averaged 22.94 and

Soil (continued)

26.33 pCi/g dry weight, respectively, and is primarily due to the potassium-40 activity. Strontium-89 was below the LLD level of 0.072 pCi/g dry weight in all samples. Strontium-90 was detected in nine of fourteen samples and levels were similar at both indicator and control locations (0.067 and 0.059 pCi/g dry weight, respectively).

Low levels of Cesium-137 were detected in eleven of fourteen samples and were nearly identical at indicator and control locations (0.16 and 0.17 pCi/g dry weight, respectively). Beryllium-7 was detected above the LLD level of 0.30 pCi/g dry weight in one sample collected at location K-12 and measured 0.47 pCi/g dry weight. Potassium-40 was detected in all samples and averaged 18.20 and 20.97 pCi/g dry weight at indicator and control locations, respectively. All other gamma-emitting isotopes were below their respective LLD's. These levels of detected activities are similar to those observed from 1979 through 1997.

3.2.4 The Aquatic Environment

Surface Water

In surface water, mean gross beta activity in suspended solids was below the LLD level of 1.5 pCi/L in all samples. Mean gross beta concentration in dissolved solids was higher at indicator locations (5.9 pCi/L) as compared to the control locations (2.1 pCi/L) and was slightly higher than activities observed in 1978 (5.4 and 2.7 pCi/L), 1979 (5.7 and 2.7 pCi/L), 1980 (5.1 and 2.7 pCi/L), 1981 (4.3 and 2.7 pCi/L), 1982 (4.9 and 2.4 pCi/L), 1983 (5.1 and 2.6 pCi/L), 1984 (5.0 and 2.7 pCi/L), 1985 (5.6 and 2.7 pCi/L), 1986 (4.1 and 2.5 pCi/L), 1987 (5.3 and 2.5 pCi/L) in 1988 (4.8 and 3.6 pCi/L), in 1989 (5.7 and 3.0 pCi/L), in 1990 (4.1 and 2.6 pCi/L), in 1991 (5.1 and 2.2 pCi/L), in 1992 (4.5 and 2.2 pCi/L), in 1993 and 1994 (5.0 and 2.3 pCi/L) and in 1995 and 1996 (4.3 and 2.2 pCi/L) and 1997 (6.3 and 2.4 pCi/L). The increase in levels are due in part to the addition of a new indicator location (K-1k), a pond formed by drainage of surrounding fields to the southwest. The control sample is Lake Michigan water, which varies very little in gross beta concentration during the year, while indicator samples include two creek locations (K-1a and K-1e) which are much higher in gross beta concentration and exhibit large month-to-month variations. The K-1a creek draws its water from the surrounding fields which are heavily fertilized; and the K-1e creek draws its water mainly from the Sewage Treatment Plant. In general, gross beta concentration levels were high when potassium-40 levels were high and low when potassium-40 levels were low, indicating that the fluctuations in beta concentration were due to variations in potassium-40 concentrations and not to plant operations. The fact that similar fluctuations at these locations were observed in the pre-operational studies conducted prior to 1974 supports this assessment.

Tritium was detected in two composite samples for the first quarter, 1998, collected from location K-14, at an average concentration of 725 pCi/L. All other samples tested were below the LLD level of 330 pCi/L.

Strontium-89 concentrations were below the LLD of 1.5 pCi/L in all samples. Strontium-90 concentrations were below the LLD of 0.7 pCi/L in all samples.

Gamma-emitting isotopes were below their respective LLDs in all samples.

Fish

In fish samples, the gross beta concentration averaged 2.76 pCi/g wet weight in muscles and 1.97 pCi/g wet weight in bone fractions. In muscle, the gross beta concentration was primarily due to potassium-40 activity. The average beta concentration of 2.12 pCi/g wet weight was lower than the average of the 1973 range of 3.34 to 3.62 pCi/g wet weight. Cesium-137 concentration in muscle averaged 0.075 pCi/g wet weight, lower than levels observed between 1979 and 1991 (average of 0.12 pCi/g wet weight), and similar to levels seen in 1992 (0.066 pCi/g wet weight), in 1993 (0.068 pCi/g wet weight), in 1994 (0.067 pCi/g wet weight), in 1995 (0.056 pCi/g wet weight), in 1996 (0.055 pCi/g wet weight) and in 1997 (0.053 pCi/g wet weight). The strontium-89 concentration was below the LLD of 0.18 pCi/g wet weight in all samples. Strontium-90 was detected in all bone samples and averaged 0.14 pCi/g wet weight.

Periphyton (Slime)

In periphyton (slime) samples, mean gross beta concentrations were lower at the indicator locations than at the control (4.08 and 2.23 pCi/g wet weight, respectively) Strontium-89 concentrations were below the LLD level of 0.13 pCi/g wet weight in all samples. Strontium-90 concentrations were below the LLD level of 0.08 pCi/g wet weight. Co-58 was detected in one sample from location K-1e at a concentration of 0.048 pCi/g wet weight. Cs-137 was detected in samples from locations K-1d and K-1e at concentrations of 0.033 pCi/g wet, compared with observations in 1995 (0.079 pCi/g wet weight), in 1996 (0.063 pCi/g wet weight) and <0.041 pCi/g wet weight in 1997. All other gamma-emitting isotopes, except naturally-occurring beryllium-7 and potassium-40, were below their respective LLDs.

Bottom Sediments

In bottom sediment samples, the mean gross beta concentration was similar at both indicator and control locations, (7.3 pCi/g dry weight) and (6.4 pCi/g dry weight), respectively, and due primarily to potassium-40.

Low levels of cesium-137 were detected in three of ten samples and averaged 0.032 pCi/g dry weight at indicator locations and less than 0.025 pCi/g dry weight at control locations. Cs-134 was below the LLD level of 0.038 pCi/g dry weight in all samples. The cesium-137 level was lower than the levels observed from 1979 through 1997.

Levels of Strontium-89 were below the detection limit of 0.038 pCi/g dry weight in all samples. Strontium-90 concentrations were below the detection limit of 0.021 pCi/g dry weight in all samples.

3.3 Land Use Census

The 1998 Land Use Census satisfies the requirements of the KNPP Radiological Environmental Monitoring Manual. Section 2.2.2 states:

> "A land use census shall be conducted and shall identify within a distance of 8 km (5 miles) the location, in each of the 10 meteorological sectors, of the nearest milk animal, the nearest residence and the nearest garden of greater than $50m^2$ (500 ft^2) producing broad leaf vegetation."

The 1998 Land Use Census was an annual census conducted in the years between the complete five year census. This census is used to verify that no changes have occurred with the locations of the nearest residence, milk animal or garden. "Drive-bys" were conducted to verify that no changes have occurred over the previous census.

The Land Use Census was completed on June 30, 1998. This census is conducted annually during the growing season per Health Physics Procedure HP 1.14.

Table 4.6.1 lists the results of the 1998 census. There were no changes identified from the 1997 census.

Table 4.6.2 describes the changes from 1997 to 1998.

4.0 FIGURES AND TABLES

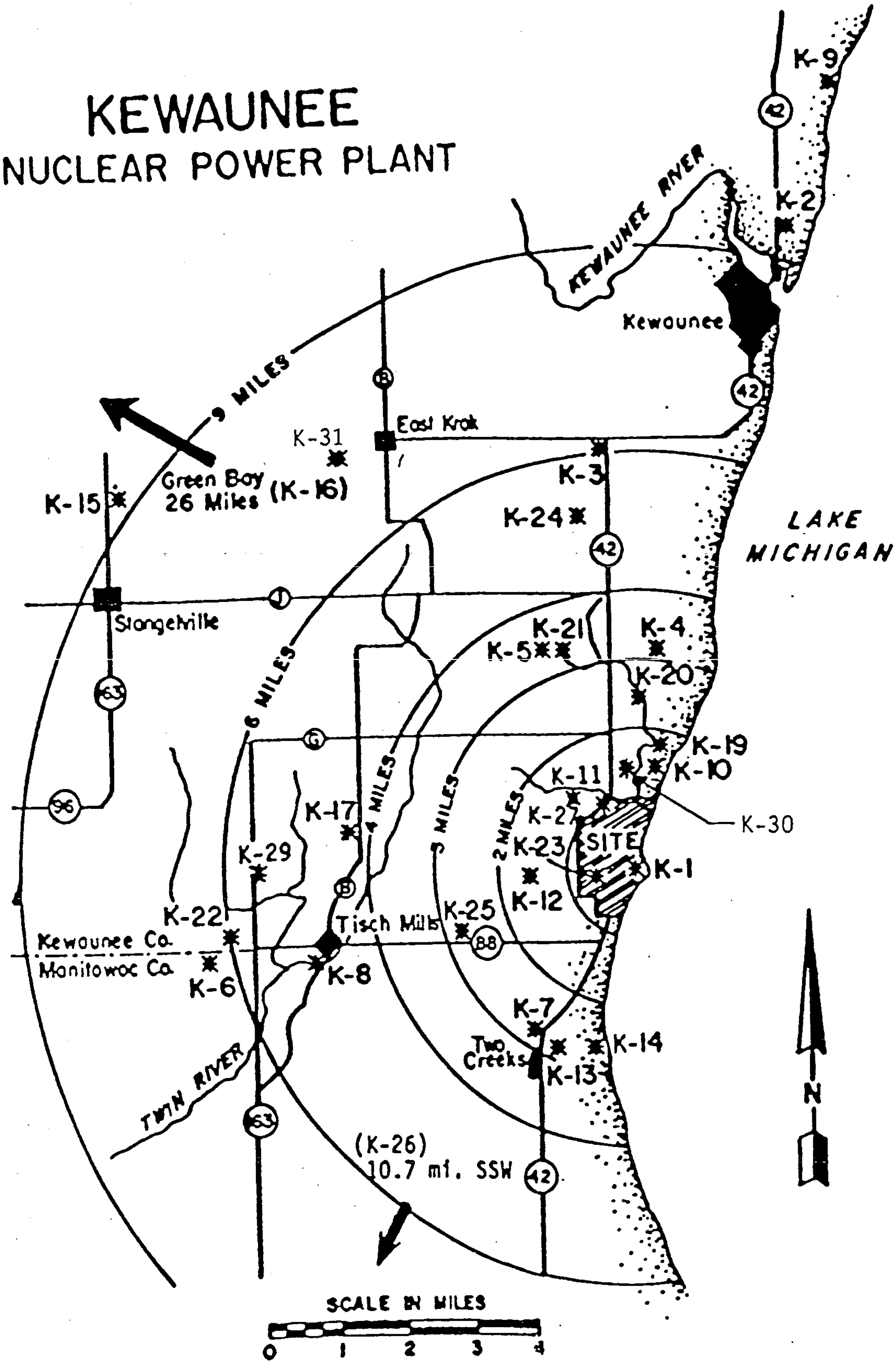

Figure 4-1. Sampling locations, Kewaunee Nuclear Power Plant

Table 4.1. Sampling locations, Kewaunee Nuclear Power Plant.

Code	Type[a]	Distance (miles)[b] and Sector	Location
K-1			Onsite
K-1a	I	0.62 N	North Creek
K-1b	I	0.12 N	Middle Creek
K-1c	I	0.10 N	500' north of condenser discharge
K-1d	I	0.10 E	Condenser discharge
K-1e	I	0.12 S	South Creek
K-1f	I	0.12 S	Meteorological Tower
K-1g	I	0.06 W	South Well
K-1h	I	0.12 NW	North Well
K-1j	I	0.10 S	500' south of condenser discharge
K-1k	I	0.60 SW	Drainage Pond
K-2	C	9.5 NNE	WPS Operations Building in Kewaunee
K-3	C	6.0 N	Lyle and John Siegmund Farm, Route 1, Kewaunee
K-4	I	3.0 N	Tom Stangel Farm, Route 1, Kewaunee
K-5	I	3.5 NNW	Ed Paplham Farm, Route 1, Kewaunee
K-6	C	6.7 WSW	Novitsky Farm
K-7	I	2.75 SSW	Ron Zimmerman Farm, Route 3, Two Rivers
K-8	C	5.0 WSW	Saint Mary's Church, Tisch Mills
K-9	C	11.5 NNE	Rostok Water Intake for Green Bay, Wisconsin, two miles north of Kewaunee
K-10	I	1.5 NNE	Turner Farm, Kewaunee site
K-11	I	1.0 NW	Harlan Ihlenfeld Farm
K-12	I	1.5 WSW	Lecaptain Farm, one mile west of site
K-13	C	3.0 SSW	Rand's General Store
K-14	I	2.5 S	Two Creeks Park, 2.5 miles south of site
K-15	C	9.25 NW	Gas Substation, 1.5 miles north of Stangelville
K-16	C	26 NW	WPS Division Office Building, Green Bay, Wisconsin
K-17	I	4.25 W	Jansky's Farm, Route 1, Kewaunee
K-19	I	1.75 NNE	Wayne Paral Farm, Route 1, Kewaunee
K-20	I	2.5 N	Carl Struck Farm, Route 1, Kewaunee
K-23	I	0.5 W	0.5 miles west of plant, Kewaunee site
K-24	C	5.45 N	Fectum Farm, Route 1, Kewaunee
K-25	C	2.75 WSW	Wotachek Farm, Route 1, Denmark
K-26	C	10.7 SSW	Bertler's Fruit Stand (8.0 miles south of "BB")
K-27	I	1.5 NW	Schlies Farm, 0.5 miles west of K-11
K-28	C	26 NW	Hansen Dairy, Green Bay, Wisconsin
K-29	I	5.75 W	Kunesh Farm, Route 1, Kewaunee
K-30	I	1.00 N	End of site boundary
K-31	C	6.25 NNW	E. Krok Substation
K-32	C	11.5 N	Piggly Wiggly Foods, 931 Marquette Dr., Kewaunee

[a] I= indicator; C = control.

[b] Distances are measured from reactor stack.

Table 4.2. Type and frequency of collection.

Location	Frequency					
	Weekly	Biweekly	Monthly	Quarterly	Semiannually	Annually
K-1a			SW		SL	
K-1b			SW	GR[a]	SL	
K-1c					BS[b]	
K-1d			SW	FI	BS[b], SL	
K-1e			SW		SL	
K-1f	AP	AI		GR[a], TLD	SO	
K-1g				WW		
K-1h				WW		
K-1j					BS[b]	
K-1k			SW		SL	
K-2	AP	AI		TLD		
K-3			MI[c]	GR[a], TLD, CF[d]	SO	
K-4			MI[c]	GR[a], TLD, CF[d]	SO	
K-5			MI[c]	GR[a], TLD, CF[d]	SO	
K-6			MI[c]	GR[a], TLD, CF[d]	SO	
K-7	AP	AI		TLD		
K-8	AP	AI		TLD		
K-9			SW		BS[b], SL	
K-10				WW		
K-11			PR	WW		
K-12			MI[c]	GR[a], CF[d], WW	SO	
K-13				WW		
K-14			SW		BS[b], SL	
K-15[e]				TLD		
K-16	AP	AI		TLD		
K-17				TLD		VE
K-19			MI[c]	GR[a], CF[d]	SO	
K-20						DM
K-23						GRN
K-24				EG		DM
K-26						VE
K-27				TLD, EG		DM
K-28			MI[c]			
K-29						DM
K-30				TLD		
K-31	AP	AI		TLD		
K-32						DM

[a] Three times a year, second (April, May, June), third (July, August, September), and fourth (October, November, December) quarters.
[b] To be collected in May and November.
[c] Monthly from November through April; semimonthly May through October.
[d] First quarter (January, February, March) only.
[e] Air sampler moved to K-31, September, 1997.

Table 4.3. Sample codes used in Table 4.2.

Code	Description
AP	Airborne Particulate
AI	Airborne Iodine
TLD	Thermoluminescent Dosimeter
PR	Precipitation
MI	Milk
WW	Well Water
DM	Domestic Meat
EG	Eggs
VE	Vegetables
GRN	Grain
GR	Grass
CF	Cattlefeed
SO	Soil
SW	Surface Water
FI	Fish
SL	Slime
BS	Bottom Sediments

Table 4.4. Sampling Summary, January - December 1998.

Sample Type	Collection Type and Frequency[a]	Number of Locations	Number of Samples Collected	Number of Samples Missed
Air Environment				
Airborne particulates	C/W	6	312	0
Airborne Iodine	C/BW	6	156	0
TLD's	C/Q	14	55	1
Precipitation	C/M	1	12	0
Terrestrial Environment				
Milk (May-Oct)	G/SM	7	84	0
(Nov-Apr)	G/M	7	42	0
Well water	G/Q	6	24	0
Domestic meat	G/A	4	3	1
Eggs	G/Q	2	7	1
Vegetables - 5 varieties	G/A	2	7	0
Grain - oats	G/A	1	1	0
- clover	G/A	1	1	0
Grass	G/TA	8	24	0
Cattle feed	G/A	6	12	0
Soil	G/SA	7	14	0
Aquatic Environment				
Surface water	G/M	8	107	1
Fish	G/TA	1	5	0
Slime	G/SA	7	14	0
Bottom sediments	G/SA	5	10	0

[a] Type of collection is coded as follows: C = continuous; G = grab.
Frequency is coded as follows: W = weekly; SM = semimonthly; M = monthly; Q=quarterly; SA = semiannually; TA = three times per year; FA = four times per year; A = annually; BW = bi-weekly.

Table 4.5 Environmental Radiological Monitoring Program Summary.

Name of Facility Kewaunee Nuclear Power Plant — Docket No. 50-305

Location of Facility Kewaunee County, Wisconsin (County, State) — Reporting Period January - December 1998

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean: Location[d]	Location with Highest Annual Mean: Mean (F)[c] Range[c]	Control Locations Mean (F)[c] Range	Number Non-Routine Results[e]
Airborne particulates	GB 312	0.003	0.019 (104/104) (0.004-0.037)	K-1f, K-2, K-7, K-8, K-31, K-16, All locations identical annual means	0.019 (311/312) (0.004-0.0038)	0.019 (207/208) (0.005-0.038)	0
(pCi/m^3)	GS 24						
	Be-7	0.020	0.069 (8/8) (0.054-0.089)	K-8, St. Mary's, 5.0 mi. WSW / K-16, WPS Div. Office, 26 mi. NW;	0.073 (8/8) (0.047-0.085)	0.072 (16/16) (0.047-0.091)	0
	Nb-95	0.0023	< LLD	-	-	< LLD	0
	Zr-95	0.0036	< LLD	-	-	< LLD	0
	Ru-103	0.0016	< LLD	-	-	< LLD	0
	Ru-106	0.012	< LLD	-	-	< LLD	0
	Cs-134	0.0017	< LLD	-	-	< LLD	0
	Cs-137	0.0013	< LLD	-	-	< LLD	0
	Ce-141	0.0030	< LLD	-	-	< LLD	0
	Ce-144	0.0089	< LLD	-	-	< LLD	0
Airborne Iodine (pCi/m^3)	I-131 156	0.03	< LLD	-	-	< LLD	0
TLD-Quarterly (mR/91 days)	Gamma 55	1	16.1 (28/28) (12.3-20.4)	K-7, Zimmerman Farm, 2.75 mi. SSW	18.6 (4/4) (17.1-20.4)	15.5 (27/28) (13.5-18.8)	0
Precipitation (pCi/L)	H-3 12	330	<LLD	-	-	None	0
Milk	I-131 126	0.5	< LLD	-	-	< LLD	0
	Sr-89 84	1.4	< LLD	-	-	< LLD	0
	Sr-90 84	0.5	1.3 (48/48) (0.7-2.7)	K-12, Lecaptain Farm 1.5 mi. WSW	1.6 (12/12) (1.0-2.4)	1.4 (36/36) (0.8-3.3)	0
	GS 126						
	K-40	50	1390 (72/72) (1080-1730)	K-12, Lecaptain Farm 1.5 mi. WSW	1460 (18/18) (1260-1680)	1350 (54/54) (1070-1650)	0
	Cs-134	10	< LLD	-	-	< LLD	0
	Cs-137	10	< LLD	-	-	< LLD	0
	Ba-La-140	15	< LLD	-	-	< LLD	0
(g/L)	K-stable 84	1.0	1.60 (48/48) (1.39-1.90)	K-12, Lecaptain Farm 1.5 mi. WSW	1.71 (12/12) (1.55-1.90)	1.60 (36/36) (1.30-1.91)	0
(g/L)	Ca 84	0.4	0.86 (48/48) (0.70-1.03)	K-6, Novitsky Farm 6.7 mi. WSW	0.98 (12/12) (0.87-1.07)	0.91 (36/36) (0.75-1.10)	0
Well Water (pCi/L)	GA 8	2.7	5.0 (2/8) (3.8-6.1)	K-1h, North Well Onsite, 0.12 mi. NW	6.1 (1/4)	None	0
	GB 24	1.1[f]	3.1 (14/20) (1.2-5.7)	K-1g, South Well Onsite, 0.06 mi. W	4.6 (3/4) (3.6-5.7)	1.3 (2/4) (1.2-1.4)	0
	H-3 4	330	<LLD	-	-	None	0
	K-40 (flame) 24	0.87	1.84 (15/20) (0.91-2.77)	K-1g, South Well Onsite, 0.06 mi. W	2.58 (4/4) (2.25-2.77)	0.97 (4/4) (0.95-1.04)	0
	Sr-89 4	2.2	< LLD	-	-	None	0
	Sr-90 4	0.5	< LLD	-	-	None	0
	GS 24						0
	Mn-54	15	< LLD	-	-	< LLD	0
	Fe-59	30	< LLD	-	-	< LLD	0
	Co-58	15	< LLD	-	-	< LLD	0
	Co-60	15	< LLD	-	-	< LLD	0
	Zr-Nb-95	15	< LLD	-	-	< LLD	0
	Cs-134	10	< LLD	-	-	< LLD	0
	Cs-137	10	< LLD	-	-	< LLD	0
	Ba-La-140	15	< LLD	-	-	< LLD	0

Table 4.5 Environmental Radiological Monitoring Program Summary.

Name of Facility Kewaunee Nuclear Power Plant — Docket No. 50-305
Location of Facility Kewaunee County, Wisconsin (County, State) — Reporting Period January - December 1998

Sample Type (Units)	Type and Number of Analyses[a]		LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean: Location[d]	Location with Highest Annual Mean: Mean (F)[c] Range[c]	Control Locations Mean (F)[c] Range	Number Non-Routine Results[e]
Domestic	GA	3	0.04	<LLD	K-24, Fectum Farm 5.45 mi. N	0.10 (1/1)	0.05 (1/1)	0
Meat (Chickens)	GB	3	0.03	2.14 (2/2) (1.76-2.52)	K-32, Grocery Store, 11.5 mi. N	3.00 (1/1)	3.00 (1/1)	
(pCi/g wet)	GS	3						0
	Be-7		0.41	< LLD	-	-	< LLD	0
	K-40		0.5	2.91 (2/2) (2.76-3.06)	K-24, Fectum Farm 5.45 mi. N	3.06 (1/1)	2.19 (1/1)	0
	Nb-95		0.083	< LLD	-	-	< LLD	0
	Zr-95		0.060	< LLD	-	-	< LLD	0
	Ru-103		0.032	< LLD	-	-	< LLD	0
	Ru-106		0.23	< LLD	-	-	< LLD	0
	Cs-134		0.021	< LLD	-	-	< LLD	0
	Cs-137		0.021	< LLD	-	-	< LLD	0
	Ce-141		0.063	< LLD	-	-	< LLD	0
	Ce-144		0.13	< LLD	-	-	< LLD	0
Eggs (pCi/g wet)	GB	4	0.01	1.19 (4/4) (1.15-1.23)	K-32, Grocery Store, 11.5 mi. N	1.51 (3/3) (1.16-2.07)	1.51 (3/3) (1.16-2.07)	0
	Sr-89	4	0.010	< LLD	-	-	< LLD	0
	Sr-90	4	0.003	0.004 (1/4)	K-24, Fectum Farm 5.45 mi. N	0.004 (1/4)	< LLD	0
	GS							
	Be-7		0.092	< LLD	-	-	< LLD	0
	K-40		0.10	1.25 (4/4) (1.11-1.32)	K-32, Grocery Store, 11.5 mi. N	1.38 (3/3) (1.20-1.48)	1.38 (3/3) (1.20-1.48)	0
	Nb-95		0.020	< LLD	-	-	< LLD	0
	Zr-95		0.022	< LLD	-	-	< LLD	0
	Ru-103		0.013	< LLD	-	-	< LLD	0
	Ru-106		0.099	< LLD	-	-	< LLD	0
	Cs-134		0.009	< LLD	-	-	< LLD	0
	Cs-137		0.011	< LLD	-	-	< LLD	0
	Ce-141		0.023	< LLD	-	-	< LLD	0
	Ce-144		0.063	< LLD	-	-	< LLD	0
Vegetables (pCi/g wet)	GB	6	0.1	2.25 (3/3) (1.17-3.48)	K-26, Bertler's , 10.7 mi. SSW	2.52 (4/4) (1.93-3.75)	2.52 (4/4) (1.93-3.75)	0
	Sr-89	6	0.014	< LLD	-	-	< LLD	0
	Sr-90	6	0.006	< LLD	-	-	< LLD	0
	GS	6						
	Be-7		0.16	< LLD	-	-	< LLD	0
	K-40		0.75	1.95 (3/3) (1.05-2.77)	K-26, Bertler's , 10.7 mi. SSW	2.18 (4/4) (1.94-2.58)	2.18 (4/4) (1.94-2.58)	0
	Nb-95		0.019	< LLD	-	-	< LLD	0
	Zr-95		0.025	< LLD	-	-	< LLD	0
	Ru-103		0.012	< LLD	-	-	< LLD	0
	Ru-106		0.067	< LLD	-	-	< LLD	0
	Cs-134		0.013	< LLD	-	-	< LLD	0
	Cs-137		0.018	< LLD	-	-	< LLD	0
	Ce-141		0.019	< LLD	-	-	< LLD	0
	Ce-144		0.069	< LLD	-	-	< LLD	0

Table 4.5 Environmental Radiological Monitoring Program Summary.

Name of Facility	Kewaunee Nuclear Power Plant	Docket No.	50-305
Location of Facility	Kewaunee County, Wisconsin (County, State)	Reporting Period	January - December 1998

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean: Location[d]	Location with Highest Annual Mean: Mean (F)[c] Range[c]	Control Locations Mean (F)[c] Range	Number Non-Routine Results[e]
Grain - Oats & Clover (pCi/g wet)	GB 2	0.10	6.69 (2/2) (4.92-8.46)	K-23, Kewaunee Site 0.5 mi. W	6.69 (2/2) (4.92-8.46)	None	0
	Sr-89 2	0.043	< LLD	-	-	None	0
	Sr-90 2	0.022	< LLD		-	None	0
	GS 2						
	Be-7	0.27	0.92 (2/2) (0.86-0.97)	K-23, Kewaunee Site 0.5 mi. W	0.92 (2/2) (0.86-0.97)	None	0
	K-40	0.10	5.09 (2/2) (4.08-6.10)	K-23, Kewaunee Site 0.5 mi. W	5.09 (2/2) (4.08-6.10)	None	0
	Nb-95	0.031	< LLD	-	-	None	0
	Zr-95	0.078	< LLD		-	None	0
	Ru-103	0.037	< LLD	-	-	None	0
	Ru-106	0.26	< LLD		-	None	0
	Cs-134	0.021	< LLD	-	-	None	0
	Cs-137	0.028	< LLD		-	None	0
	Ce-141	0.060	< LLD	-	-	None	0
	Ce-144	0.18	< LLD		-	None	0
Cattlefeed (pCi/g wet)	GB 12	0.1	12.49 (8/8) (2.07-23.62)	K-4 Stangel Farm 3.0 mi. N / K-5, Paplham Farm 3.5 mi. NNW	14.65 (4/4) (5.68-23.62)	9.16 (4/4) (3.79-11.94)	0
	Sr-89 12	0.027	< LLD	-	-	< LLD	0
	Sr-90 12	0.005	0.022 (7/8) (0.007-0.035)	K-6, Novitsky Farm 6.7 mi. WSW	0.055 (2/2) (0.050-0.060)	0.041 (3/4) (0.013-0.060)	0
	GS 12						
	Be-7	0.20	0.47 (8/8) (0.22-0.67)	K-6, Novitsky Farm 6.7 mi. WSW	1.08 (2/2) (0.93-1.23)	0.87 (3/4) (0.44-1.23)	0
	K-40	1.0	13.57 (8/8) (1.97-26.79)	K-5, Paplham Farm 3.5 mi. NNW	15.96 (2/2) (9.66-22.26)	8.70 (4/4) (4.66-10.38)	0
	Nb-95	0.043	< LLD	-	-	< LLD	0
	Zr-95	0.070	< LLD	-	-	< LLD	0
	Ru-103	0.029	< LLD	-	-	< LLD	0
	Ru-106	0.25	< LLD	-	-	< LLD	0
	Cs-134	0.033	< LLD	-	-	< LLD	0
	Cs-137	0.033	< LLD	-	-	< LLD	0
	Ce-141	0.067	< LLD	-	-	< LLD	0
	Ce-144	0.20	< LLD	-	-	< LLD	0
Grass (pCi/g wet)	GB 24	0.1	6.55 (18/18) (4.86-11.83)	K-3, Siegmund Farm, 6.0 mi. N	8.42 (3/3) (6.63-11.98)	7.28 (6/6) (5.29-11.98)	0
	Sr-89 24	0.016	< LLD	-	-	< LLD	0
	Sr-90 24	0.008	0.010 (1/18)	K-12, Lecaptain Farm 1.5 mi. WSW	0.010 (1/3)	< LLD	0
	GS 24						
	Be-7	0.29	2.18 (18/18) (0.34-3.94)	K-1f, Met. Tower, 0.12 mi. S	2.76 (3/3) (1.45-3.94)	1.68 (6/6) (0.70-2.92)	0
	K-40	0.1	6.26 (18/18) (4.31-8.11)	K-5, Paplham Farm 3.5 mi. NNW	7.50 (3/3) (7.17-8.11)	6.70 (6/6) (6.08-8.19)	0
	Nb-95	0.056	< LLD	-	-	< LLD	0
	Zr-95	0.082	< LLD	-	-	< LLD	0
	Ru-103	0.043	< LLD	-	-	< LLD	0
	Ru-106	0.37	< LLD	-	-	< LLD	0
	Cs-134	0.051	< LLD	-	-	< LLD	0
	Cs-137	0.044	< LLD	-	-	< LLD	0
	Ce-141	0.084	< LLD	-	-	< LLD	0
	Ce-144	0.38	< LLD	-	-	< LLD	0

Table 4.5 Environmental Radiological Monitoring Program Summary.

Name of Facility Kewaunee Nuclear Power Plant Docket No. 50-305
Location of Facility Kewaunee County, Wisconsin (County, State) Reporting Period January - December 1998

Sample Type (Units)	Type and Number of Analyses[a]	LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean		Control Locations Mean (F)[c] Range	Number Non-Routine Results[e]
				Location[d]	Mean (F)[c] Range[c]		
Soil (pCi/g dry)	GA 14	7.0	11.14 (3/10) (9.28-14.41)	K-5, Paplham Farm 3.5 mi. NNW	11.84 (2/2) (9.28-14.41)	8.24 (4/4) (7.01-10.05)	0
	GB 14	2.0	22.94 (10/10) (14.84-35.57)	K-5, Paplham Farm 3.5 mi. NNW	33.12 (2/2) (30.66-35.57)	26.33 (4/4) (25.00-29.35)	0
	Sr-89 14	0.072	< LLD	-	-	< LLD	0
	Sr-90 14	0.023	0.067 (5/10) (0.024-0.094)	K-5, Paplham Farm 3.5 mi. NNW	0.094 (1/2)	0.059 (4/4) (0.041-0.079)	0
	GS 14						
	Be-7	0.30	0.47 (1/10)	K-12, LeCaptain Farm 1.5 mi. WSW	0.47 (1/2)	< LLD	0
	K-40	1.4	18.20 (10/10) (12.78-26.28)	K-5, Paplham Farm 3.5 mi. NNW	22.82 (2/2) (19.36-26.28)	20.97 (4/4) (18.88-22.37)	0
	Nb-95	0.051	< LLD	-	-	< LLD	0
	Zr-95	0.12	< LLD	-	-	< LLD	0
	Ru-103	0.038	< LLD	-	-	< LLD	0
	Ru-106	0.27	< LLD	-	-	< LLD	0
	Cs-134	0.058	< LLD	-	-	< LLD	0
	Cs-137	0.021	0.16 (7/10) (0.047-0.28)	K-12, LeCaptain Farm 1.5 mi. WSW	0.27 (1/2)	0.17 (4/4) (0.14-0.19)	0
	Ce-141	0.067	< LLD	-	-	< LLD	0
	Ce-144	0.26	< LLD	-	-	< LLD	0
Surface Water (pCi/L)	GB (SS) 107	1.5	< LLD	-	-	< LLD	0
	GB (DS) 107	1.0	5.9 (83/83) (1.7-25.8)	K-1a, North Creek, 0.62 mi. N	13.9 (12/12) (8.1-25.8)	2.1 (24/24) (1.4-2.7)	0
	GB (TR) 107	1.0	5.9 (83/83) (1.7-25.8)	K-1a, North Creek, 0.62 mi. N	13.9 (12/12) (8.1-25.8)	2.1 (24/24) (1.4-2.7)	0
	GS 107						
	Mn-54	15	< LLD	-	-	< LLD	0
	Fe-59	30	< LLD	-	-	< LLD	0
	Co-58	15	< LLD	-	-	< LLD	0
	Co-60	15	< LLD	-	-	< LLD	0
	Zr-Nb-95	15	< LLD	-	-	< LLD	0
	Cs-134	10	< LLD	-	-	< LLD	0
	Cs-137	10	< LLD	-	-	< LLD	0
	Ba-La-140	15	< LLD	-	-	< LLD	0
	H-3 36	330	725 (2/28) (694-755)	K-14, Two Creeks Park, 2.5 mi. S	725 (2/8) (694-755)	<LLD	0
	Sr-89 36	1.5	< LLD	-	-	< LLD	0
	Sr-90 36	0.7	0.8 (3/28) (0.8-0.9)	K-9, Rostok Water Intake, 11.5 mi. NNE	1.0 (2/8) (0.9-1.0)	1.0 (2/8) (0.9-1.0)	0
	K-40 103 (flame)	0.87	4.05 (82/83) (0.95-22.49)	K-1a, North Creek Onsite 0.62 mi. N	11.38 (12/12) (5.97-22.49)	1.10 (24/24) (0.95-1.38)	0
Fish - Muscle (pCi/g wet)	GB 5	0.5	2.76 (5/5) (2.10-4.49)	K-1d, Condenser Discharge, 0.10 mi. E	2.76 (5/5) (2.10-4.49)	None	0
	GS 5						
	K-40	0.1	2.59 (5/5) (2.15-3.50)	K-1d, Condenser Discharge, 0.10 mi. E	2.59 (5/5) (2.15-3.50)	None	0
	Mn-54	0.023	< LLD	-	-	None	0
	Fe-59	0.081	< LLD	-	-	None	0
	Co-58	0.025	< LLD	-	-	None	0
	Co-60	0.028	< LLD	-	-	None	0
	Cs-134	0.020	< LLD	-	-	None	0
	Cs-137	0.015	0.075 (5/5) (0.029-0.15)	K-1d, Condenser Discharge, 0.10 mi. E	0.075 (5/5) (0.029-0.15)	None	0

Table 4.5 Environmental Radiological Monitoring Program Summary.

Name of Facility: Kewaunee Nuclear Power Plant — Docket No. 50-305
Location of Facility: Kewaunee County, Wisconsin (County, State) — Reporting Period: January - December 1998

Sample Type (Units)	Type and Number of Analyses[a]		LLD[b]	Indicator Locations Mean (F)[c] Range[c]	Location with Highest Annual Mean: Location[d]	Location with Highest Annual Mean: Mean (F)[c] Range[c]	Control Locations Mean (F)[c] Range	Number Non-Routine Results[e]
Fish - Bones (pCi/g wet)	GB	5	0.1	1.97 (5/5) (0.85-2.88)	K-1d, Condenser Discharge, 0.10 mi. E	1.97 (5/5) (0.85-2.88)	None	0
	Sr-89	5	0.18	< LLD	-	-	None	0
	Sr-90	5	0.026	0.14 (5/5) (0.050-0.28)	K-1d, Condenser Discharge, 0.10 mi. E	0.14 (5/5) (0.050-0.28)	None	0
Periphyton (Slime) (pCi/g wet)	GB	14	0.1	4.08 (12/12) (3.09-5.47)	K-1b, Middle Creek, 0.12 mi. N	5.17 (2/2) (4.87-5.47)	2.23 (2/2) (1.81-2.64)	0
	Sr-89	14	0.13	< LLD	-	-	< LLD	0
	Sr-90	14	0.08	< LLD	-	-	< LLD	0
	GS	14						
	Be-7		0.26	0.77 (7/12) (0.31-1.22)	K-1e, South Creek, 0.12 mi. S	1.22 (1/2)	0.35 (1/2)	0
	K-40		0.50	3.56 (12/12) (0.94-5.38)	K-1b, Middle Creek, 0.12 mi. N	4.94 (2/2) (4.57-5.31)	2.32 (2/2) (2.06-2.57)	0
	Mn-54		0.027	<LLD	-	-	< LLD	0
	Co-58		0.026	0.048 (1/12)	K-1e, South Creek, 0.12 mi. S	0.048 (1/2)	< LLD	0
	Co-60		0.037	< LLD	-	-	< LLD	0
	Nb-95		0.035	< LLD	-	-	< LLD	0
	Zr-95		0.054	< LLD	-	-	< LLD	0
	Ru-103		0.033	< LLD	-	-	< LLD	0
	Ru-106		0.19	< LLD	-	-	< LLD	0
	Cs-134		0.032	< LLD	-	-	< LLD	0
	Cs-137		0.028	0.033 (2/12)	K-1d, Discharge, 0.10 mi. E / K-1e, South Creek, 0.12 mi. S	0.033 (2/2)	< LLD	0
	Ce-141		0.054	< LLD	-	-	< LLD	0
	Ce-144		0.18	< LLD	-	-	< LLD	0
Bottom Sediments (pCi/g dry)	GB	10	1.0	7.25 (8/8) (4.18-8.84)	K-1d, Condenser Discharge, 0.10 mi. E	8.12 (2/2) (7.73-8.50)	6.40 (2/2) (5.15-7.64)	0
	Sr-89	10	0.038	< LLD	-	-	< LLD	0
	Sr-90	10	0.021	< LLD	-	-	< LLD	0
	GS	10						
	K-40		1.0	6.46 (8/8) (4.87-8.22)	K-14, Two Creeks Park, 2.5 mi. S	7.66 (2/2) (7.09-8.22)	5.98 (2/2) (5.71-6.24)	0
	Co-58		0.031	< LLD	-	-	< LLD	0
	Co-60		0.031	< LLD	-	-	< LLD	0
	Cs-134		0.038	< LLD	-	-	< LLD	0
	Cs-137		0.025	0.032 (3/8) (0.026-0.037)	K-1d, Condenser Discharge, 0.10 mi. E	0.035 (2/2) (0.033-0.037)	< LLD	0

a GA = gross alpha, GB = gross beta, GS = gamma spectroscopy, SS = suspended solids, DS = dissolved solids, TR = total residue.

b LLD = nominal lower limit of detection based on 4.66 sigma counting error for background sample.

c Mean based upon detectable measurements only. Fraction of detectable measurements at specified locations is indicated in parentheses (F).

d Locations are specified by station code (Table 4.1), distance (miles) and direction relative to reactor site.

e Non-routine results are those which exceed ten times the control station value. If no control station value is available, the result is considered non-routine if it exceeds ten times the pre-operational value for the location.

f One result for gross alpha (< 3.6 pCi/L) was eliminated from the calculation for LLD. A lower sample volume had to be used for analysis due to high solids content of the water.

Table 4.6.1 Land Use Census

The following table lists an inventory of residence, gardens 500 ft^2 and milk animals found nearest to the plant in each of the 10 meteorological sectors within a five mile radius of the Kewaunee Nuclear Power Plant.

Sector	Township No.	Residence	Garden	Milk Animals	Distance From Plant (miles)	Sample ID
A	24	X	X		1.95	
A	13			X	2.66	
B	24	X			1.20	
B	24			X	1.16	K-19
B	24		X		1.27	K-19
R	23			X	2.05	
R	26	X	X		1.00	K-11
Q	23	X			1.31	
Q	23			X	1.39	
Q	23		X		1.33	K-27
P	26	X			1.33	
P	26		X		1.37	
P	22			X	1.97	
N	35	X			0.95	
N	26		X		1.04	
N	34			X	1.44	K-12
M	35	X	X		1.33	
M	34			X	1.49	
L	35	X			0.85	
L	35		X	X	1.28	
K	35	X	X		0.80	
K	10			X	1.80	
J	11	X	(Note 1)	(Note 1)	2.68	

Note 1.: There were no milk animals or gardens 500 ft^2 located in Sector J within five miles of the Kewaunee Nuclear Power Plant.

Table 4.6.2 Land Use Census

The following is a sector by sector listing of those changes between the 1997 and 1998 census.

Sector A	No changes
Sector B	No changes
Sector R	No changes
Sector Q	No changes
Sector P	No changes
Sector N	No changes
Sector M	No changes
Sector L	No changes
Sector K	No changes
Sector J	No changes

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APPENDIX A

INTERLABORATORY COMPARISON PROGRAM RESULTS

NOTE: Teledyne's Midwest Laboratory participates in intercomparison studies administered by U.S. EPA Environmental Monitoring Systems Laboratory, Las Vegas, Nevada. The results are reported in Appendix A. Also reported are results of International Intercomparison and Teledyne testing of TLD's, as well as, in-house spikes, blanks, duplicates and mixed analyte performance evaluation program results. Appendix A is updated four times a year; the complete Appendix is included in March, June, September and December monthly progress reports only.

January, 1998 through December, 1998

Appendix A

Interlaboratory Comparison Program Results

Teledyne Brown Engineering Environmental Services Midwest Laboratory (formerly Hazleton Environmental Sciences) has participated in interlaboratory comparison (crosscheck) programs since the formulation of it's quality control program in December 1971. These programs are operated by agencies which supply environmental type samples (e.g., milk or water) containing concentrations of radionuclides known to the issuing agency but not to participant laboratories. The purpose of such a program is to provide an independent check on the laboratory's analytical procedures and to alert it to any possible problems.

Participant laboratories measure the concentration of specified radionuclides and report them to the issuing agency. Several months later, the agency reports the known values to the participant laboratories and specifies control limits. Results consistently higher or lower than the known values or outside the control limits indicate a need to check the instruments or procedures used.

The results in Table A-1 were obtained through participation in the environmental sample crosscheck program for milk, water and air filters during the past twelve months. Data for previous years is available upon request.
This program is conducted by the U.S. Environmental Protection Agency Office of Research and Developement National Exposure Research Laboratory Characterization Research Division-Las Vegas, Nevada.

The results in Table A-2 were obtained for Thermoluminescent Dosimeters (TLDs), via various International Intercomparisons of Environmental Dosimeters under the sponsorships listed in Table A-2. Also Teledyne testing results are listed.

Table A-3 lists results of the analyses on in-house "spiked" samples for the past twelve months. All samples are prepared using NIST traceable sources. Data for previous years available upon request.

Table A-4 lists results of the analyses on in-house "blank" samples for the past twelve months. Data for previous years available upon request.

Table A-5 list results of the in-house "duplicate" program for the past twelve months. Acceptance is based on the difference of the results being less than the sum of the errors. Data for previous years available upon request.

The results in Table A-6 were obtained through participation in the mixed analyte performance evaluation program.

The results in Table A-7 were obtained through participation in the Environmental Measurement Laboratory Quality Assessment Program.

Attachment A lists acceptance criteria for "spiked" samples.

Out-of-limit results are explained directly below the result.

ATTACHMENT A

ACCEPTANCE CRITERIA FOR "SPIKED" SAMPLES

LABORATORY PRECISION: ONE STANDARD DEVIATION VALUES FOR VARIOUS ANALYSES[a]

Analysis	Level	One Standard Deviation for single determinations
Gamma Emitters	5 to 100 pCi/liter or kg >100 pCi/liter or kg	5.0 pCi/liter 5% of known value
Strontium-89[b]	5 to 50 pCi/liter or kg >50 pCi/liter or kg	5.0 pCi/liter 10% of known value
Strontium-90[b]	2 to 30 pCi/liter or kg >30 pCi/liter or kg	5.0 pCi/liter 10% of known value
Potassium-40	>0.1 g/liter or kg	5% of known value
Gross alpha	≤20 pCi/liter >20 pCi/liter	5.0 pCi/liter 25% of known value
Gross beta	≤100 pCi/liter >100 pCi/liter	5.0 pCi/liter 5% of known value
Tritium	≤4,000 pCi/liter >4,000 pCi/liter	1s = (pCi/liter) = $169.85 \times (\text{known})^{0.0933}$ 10% of known value
Radium-226,-228	<0.1 pCi/liter	15% of known value
Plutonium	0.1 pCi/liter, gram, or sample	10% of known value
Iodine-131, Iodine-129[b]	≤55 pCi/liter >55 pCi/liter	6.0 pCi/liter 10% of known value
Uranium-238, Nickel-63[b] Technetium-99[b]	≤35 pCi/liter >35 pCi/liter	6.0 pCi/liter 15% of known value
Iron-55[b]	50 to 100 pCi/liter >100 pCi/liter	10 pCi/liter 10% of known value
Others[b]	–	20% of known value

[a] From EPA publication, "Environmental Radioactivity Laboratory Intercomparison Studies Program, Fiscal Year, 1981-1982, EPA-600/4-81-004.

[b] Teledyne limit.

Table A-1. U.S. Environmental Protection Agency's crosscheck program, comparison of EPA and Teledyne's Midwest Laboratory results[a].

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b]: Teledyne Results ±2 Sigma[c]	EPA Result[d] 1s, N=1	Control Limits
STW-815	WATER	Jan, 1998	Sr-89	6.0 ± 1.0	8.0 ± 5.0	2.2 - 13.8
STW-815	WATER	Jan, 1998	Sr-90	27.3 ± 1.2	32.0 ± 5.0	26.2 - 37.8
STW-816	WATER	Jan, 1998	Gr. Alpha	31.2 ± 2.3	30.5 ± 7.6	21.7 - 39.3
STW-816	WATER	Jan, 1998	Gr. Beta	6.6 ± 0.6	3.9 ± 5.0	0.0 - 9.7
STW-817	WATER	Feb, 1998	I-131	111.1 ± 0.9	104.9 ± 10.5	86.7 - 123.1
STW-818	WATER	Feb, 1998	Ra-226	14.9 ± 1.3	16.0 ± 2.4	11.8 - 20.2
STW-818	WATER	Feb, 1998	Ra-228	30.9 ± 1.9	33.3 ± 8.3	18.9 - 47.7
STW-818	WATER	Feb, 1998	U	25.8 ± 1.1	32.0 ± 3.0	26.8 - 37.2
The presence of U-232 in the sample interfered with the recovery calculation. Result of recalculation; 28.2±1.2 pCi/L.						
STW-823	WATER	Mar, 1998	H-3	2,151.0 ± 75.2	2,155.0 ± 348.0	1,551.2 - 2,758.8
STW-824	WATER	Apr, 1998	Gr. Alpha	48.3 ± 1.5	54.4 ± 13.6	30.8 - 70.8
STW-824	WATER	Apr, 1998	Ra-226	15.3 ± 0.9	15.0 ± 2.3	11.0 - 19.0
STW-824	WATER	Apr, 1998	Ra-228	7.8 ± 1.0	9.3 ± 2.3	5.3 - 13.3
STW-824	WATER	Apr, 1998	Uranium	5.1 ± 0.1	5.0 ± 3.0	0.0 - 10.2
STW-825	WATER	Apr, 1998	Co-60	50.0 ± 1.7	50.0 ± 5.0	41.3 - 58.7
STW-825	WATER	Apr, 1998	Cs-134	20.7 ± 1.2	22.0 ± 5.0	13.3 - 30.7
STW-825	WATER	Apr, 1998	Cs-137	9.0 ± 1.0	10.0 ± 5.0	1.3 - 18.7
STW-825	WATER	Apr, 1998	Gr. Beta	92.1 ± 3.2	94.7 ± 10.0	77.4 - 112.0
STW-825	WATER	Apr, 1998	Sr-89	5.3 ± 1.5	6.0 ± 5.0	0.0 - 14.7
STW-825	WATER	Apr, 1998	Sr-90	17.3 ± 1.5	18.0 ± 5.0	9.3 - 26.7
STW-826	WATER	Jun, 1998	Ba-133	36.0 ± 1.0	40.0 ± 5.0	31.3 - 48.7
STW-826	WATER	Jun, 1998	Co-60	14.0 ± 1.0	12.0 ± 5.0	3.3 - 20.7
STW-826	WATER	Jun, 1998	Cs-134	26.7 ± 1.2	31.0 ± 5.0	22.3 - 39.7
STW-826	WATER	Jun, 1998	Cs-137	32.7 ± 3.8	35.0 ± 5.0	26.3 - 43.7
STW-826	WATER	Jun, 1998	Zn-65	99.0 ± 11.8	104.0 ± 10.0	86.7 - 121.3
STW-827	WATER	Jun, 1998	Ra-226	4.7 ± 0.4	4.9 ± 0.7	3.7 - 6.1
STW-827	WATER	Jun, 1998	Ra-228	2.6 ± 0.7	2.1 ± 0.5	1.2 - 3.0
STW-827	WATER	Jun, 1998	Uranium	3.0 ± 0.1	3.0 ± 3.0	0.0 - 8.2
STW-831	WATER	Jul, 1998	Sr-89	19.0 ± 3.0	21.0 ± 5.0	12.3 - 29.7
STW-831	WATER	Jul, 1998	Sr-90	7.0 ± 0.0	7.0 ± 5.0	0.0 - 15.7
STW-832	WATER	Jul, 1998	Gr. Alpha	5.8 ± 0.4	7.2 ± 5.0	0.0 - 15.9
STW-832	WATER	Jul, 1998	Gr. Beta	12.4 ± 0.4	12.8 ± 5.0	4.1 - 21.5
STW-833	WATER	Aug, 1998	H-3	17,732.0 ± 31.0	17,996.0 ± 1,800.0	14,873.0 - 21,119.0
STW-840	WATER	Sep, 1998	I-131	5.9 ± 0.1	6.1 ± 2.0	2.6 - 9.6
STW-841	WATER	Sep, 1998	Ra-226	1.7 ± 0.1	1.7 ± 0.3	1.2 - 2.2
STW-841	WATER	Sep, 1998	Ra-228	6.1 ± 0.6	5.7 ± 1.4	3.3 - 8.1
STW-841	WATER	Sep, 1998	Uranium	8.2 ± 0.5	9.1 ± 3.0	3.9 - 14.3

Table A-1. U.S. Environmental Protection Agency's crosscheck program, comparison of EPA and Teledyne's Midwest Laboratory results[a].

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[b] Teledyne Results ±2 Sigma[c]	EPA Result[d] 1s, N=1	Control Limits
STW-844	WATER	Nov, 1998	Ba-133	54.7 ± 0.6	56.0 ± 6.0	45.6 - 66.4
STW-844	WATER	Nov, 1998	Co-60	38.3 ± 1.5	38.0 ± 5.0	29.3 - 46.7
STW-844	WATER	Nov, 1998	Cs-134	91.0 ± 6.0	105.0 ± 5.0	96.3 - 113.7
The average for Cs-134 from all participating laboratories was 97.11 pCi/L. Other isotopes tested for in this sample were well within the control limits. Values for Cs-134 were checked and confirmed. No further action is planned.						
STW-844	WATER	Nov, 1998	Cs-137	109.7 ± 5.8	111.0 ± 6.0	100.6 - 121.4
STW-844	WATER	Nov, 1998	Zn-65	121.0 ± 7.8	131.0 ± 13.0	108.4 - 153.6

[a] Results obtained by Teledyne Brown Engineering Environmental Services Midwest Laboratory as a participant in the environmental sample crosscheck program operated by the Intercomparison and Calibration Section, Quality Assurance Branch, Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency (EPA), Las Vegas, Nevada.

[b] All results are in pCi/L, except for elemental potassium (K) data in milk, which are in mg/L; air filter samples, which are in pCi/Filter.

[c] Unless otherwise indicated, the TBEESML results are given as the mean ± 2 standard deviations for three determinations.

[d] USEPA results are presented as the known values and expected laboratory precision (1s, 1 determination) and control limits as defined by the EPA.

Table A-2. Crosscheck program results; Thermoluminescent Dosimeters. (TLDs).

Lab Code	TLD Type	Date	Measurement	mR: Teledyne Results ± 2 Sigma	mR: Known Value	mR: Average ± 2 Sigma (All Participants)
11th International Intercomparison						
115-11A	LiF-100 Chips	Apr, 1997	Field	13.2 ± 1.0	19.0	17.8 ± 8.4
115-11A	LiF-100 Chips	Apr, 1997	Lab, Cs	32.1 ± 2.0	58.1	55.2 ± 9.9
The readings for LiF chips were low in both field and Lab Cs tests. No errors found in efficiency or test calculations, however the reader setting is suspect. Interlaboratory test comparisons for LiF were satisfactory.						
11th International Intercomparison						
115-11B	$CaSO_4$: Dy Cards	Apr, 1997	Field	19.1 ± 1.4	19.1	18.9 ± 8.7
115-11B	$CaSO_4$: Dy Cards	Apr, 1997	Lab, Cs	55.7 ± 4.1	58.3	55.2 ± 14.9
The Eleventh International Intercomparison of Environmental Dosimeters was conducted in 1997 and was organized by the Department of Energy's Environmental Measurements Laboratory in collaboration with Brookhaven National Laboratory and the National Institute of Standards and Technology.						
Teledyne Testing						
96-1	LiF-100 Chips	Mar, 1996	Lab, 1	15.9 ± 0.3	15.4	
96-1	LiF-100 Chips	Mar, 1996	Lab, 2	29.4 ± 0.3	30.8	
96-1	LiF-100 Chips	Mar, 1996	Lab, 3	62.5 ± 1.3	62.5	
96-1	$CaSO_4$: Dy Cards	Mar, 1996	Reader 1, #1	14.4 ± 0.1	15.4	ND
96-1	$CaSO_4$: Dy Cards	Mar, 1996	Reader 1, #2	31.8 ± 0.1	30.8	ND
96-1	$CaSO_4$: Dy Cards	Mar, 1996	Reader 1, #3	64.7 ± 0.4	62.5	ND
Teledyne Testing						
96-2	$CaSO_4$: Dy Cards	Mar, 1996	Reader 2, #1	14.3 ± 0.4	15.4	ND
96-2	$CaSO_4$: Dy Cards	Mar, 1996	Reader 2, #2	31.8 ± 0.1	30.8	ND
96-2	$CaSO_4$: Dy Cards	Mar, 1996	Reader 2, #3	68.6 ± 0.1	62.5	ND
ND = No Data; Teledyne Testing was only performed by Teledyne. Chips and Cards were irradiated by Teledyne Isotopes, Inc., Westwood, New Jersey, in March, 1996.						
Teledyne Testing						
97-1	LiF-100 Chips	Mar, 1997	Lab, 1	13.4 ± 1.4	15.0	
97-1	LiF-100 Chips	Mar, 1997	Lab, 2	29.8 ± 0.6	30.1	
97-1	LiF-100 Chips	Mar, 1997	Lab, 3	63.4 ± 0.9	60.2	

Table A-2. Crosscheck program results; Thermoluminescent Dosimeters. (TLDs).

Lab Code	TLD Type	Date	Measurement	mR: Teledyne Results ± 2 Sigma	mR: Known Value	mR: Average ± 2 Sigma (All Participants)
97-1	$CaSO_4$: Dy Cards	Mar, 1997	Reader 1, #1	15.5 ± 0.1	15.0	ND
97-1	$CaSO_4$: Dy Cards	Mar, 1997	Reader 1, #2	34.0 ± 0.1	30.1	ND
97-1	$CaSO_4$: Dy Cards	Mar, 1997	Reader 1, #3	68.3 ± 2.1	60.2	ND
Teledyne Testing						
97-2	$CaSO_4$: Dy Cards	Mar, 1997	Reader 2, #1	16.8 ± 0.3	15.0	ND
97-2	$CaSO_4$: Dy Cards	Mar, 1997	Reader 2, #2	36.2 ± 0.2	30.1	ND
97-2	$CaSO_4$: Dy Cards	Mar, 1997	Reader 2, #3	69.6 ± 0.2	60.2	ND

ND = No Data; Teledyne Testing was only performed by Teledyne.
Chips and Cards were irradiated by Teledyne Isotopes, Inc., Westwood, New Jersey, in March, 1997.

Lab Code	TLD Type	Date	Measurement	mR: Teledyne Results ± 2 Sigma	mR: Known Value	mR: Average ± 2 Sigma (All Participants)
Teledyne Testing						
98-1	LiF-100 Chips	May, 1998	Lab, 1	15.5 ± 1.3	16.7	
98-1	LiF-100 Chips	May, 1998	Lab, 2	23.9 ± 0.9	32.4	
98-1	LiF-100 Chips	May, 1998	Lab, 3	59.8 ± 1.9	60.2	
98-1	$CaSO_4$: Dy Cards	May, 1998	Reader 1, #1	18.5 ± 0.8	16.7	ND
98-1	$CaSO_4$: Dy Cards	May, 1998	Reader 1, #2	27.3 ± 1.7	32.4	ND
98-1	$CaSO_4$: Dy Cards	May, 1998	Reader 1, #3	70.0 ± 4.7	60.2	ND

ND = No Data; Teledyne Testing was only performed by Teledyne.
Chips and Cards were irradiated by Teledyne Isotopes, Inc., Westwood, New Jersey, in May, 1998.

Table A-3. In-house "spike" samples.

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[a] Teledyne Results 2s, n=1[b]	Known Activity	Control[c] Limits
SPW-77	WATER	Jan, 1998	Cs-137	78.64 ± 7.76	77.23	67.23 - 87.23
SPW-129	WATER	Jan, 1998	Am-241	16.96 ± 1.24	20.64	12.38 - 28.90
SPW-130	WATER	Jan, 1998	Ra-226	9.39 ± 0.14	10.35	7.25 - 13.46
SPW-130	WATER	Jan, 1998	Ra-226	12.74 ± 3.05	14.03	9.82 - 18.24
SPMI-498	MILK	Jan, 1998	Co-60	41.40 ± 3.61	36.92	26.92 - 46.92
SPMI-498	MILK	Jan, 1998	Cs-134	31.78 ± 3.15	32.52	22.52 - 42.52
SPMI-498	MILK	Jan, 1998	Cs-137	37.03 ± 4.57	38.56	28.56 - 48.56
SPW-499	WATER	Jan, 1998	Co-60	44.38 ± 7.85	36.92	26.92 - 46.92
SPW-499	WATER	Jan, 1998	Cs-134	34.97 ± 7.78	32.52	22.52 - 42.52
SPW-499	WATER	Jan, 1998	Cs-137	39.15 ± 10.40	38.56	28.56 - 48.56
SPW-594	WATER	Jan, 1998	H-3	45125.00 ± 568.00	45598.00	36478.40 - 54717.60
SPAP-5330	AIR FILTER	Jan, 1998	Cs-137	1.68 ± 0.02	1.90	1.14 - 2.66
SPW-664	WATER	Feb, 1998	U-234	2.63 ± 0.40	3.00	1.80 - 4.20
SPW-664	WATER	Feb, 1998	U-238	3.26 ± 0.49	3.00	0.00 - 15.00
SPCH-746	CHARCOAL CANISTER	Feb, 1998	I-131(g)	1.73 ± 0.06	2.03	1.22 - 2.84
SPVE-750	VEGETATION	Feb, 1998	I-131(g)	6.16 ± 0.14	5.43	0.00 - 15.43
SPW-790	WATER	Feb, 1998	I-131	136.35 ± 1.33	137.03	109.62 - 164.44
SPMI-791	MILK	Feb, 1998	I-131	132.63 ± 1.63	137.03	109.62 - 164.44
SPW-497	WATER	Feb, 1998	Gr. Alpha	43.73 ± 7.61	41.27	20.64 - 61.91
SPW-497	WATER	Feb, 1998	Gr. Beta	59.45 ± 2.90	61.70	51.70 - 71.70
SPW-9854	WATER	Feb, 1998	Gr. Alpha	62.60 ± 5.10	53.88	26.94 - 80.82
SPAP-748	AIR FILTER	Feb, 1998	Gr. Beta	1.72 ± 0.02	1.66	0.00 - 11.66
SPW-1663	WATER	Feb, 1998	Ra-226	14.44 ± 0.50	13.80	9.66 - 17.94
SPW-1663	WATER	Feb, 1998	Ra-228	18.79 ± 1.58	18.29	12.80 - 23.78
SPW-1665	WATER	Mar, 1998	Ra-226	14.16 ± 0.29	13.80	9.66 - 17.94
SPW-1665	WATER	Mar, 1998	Ra-228	18.06 ± 1.70	18.29	12.80 - 23.78
SPW-1666	WATER	Mar, 1998	Sr-89	65.40 ± 2.70	75.94	60.75 - 91.13
SPW-1666	WATER	Mar, 1998	Sr-90	28.04 ± 1.22	32.65	26.12 - 39.18
SPAP-1728	AIR FILTER	Mar, 1998	Gr. Beta	8.15 ± 0.03	7.98	0.00 - 17.98
SPW-1998	WATER	Apr, 1998	Ra-226	13.70 ± 0.33	13.80	9.66 - 17.94
SPW-1998	WATER	Apr, 1998	Ra-228	14.65 ± 1.38	18.20	12.74 - 23.66
SPW-792	WATER	Apr, 1998	Th-230	18.62 ± 2.85	17.39	10.43 - 24.35
SPW-2278	WATER	Apr, 1998	H-3	41641.00 ± 552.00	43287.00	34629.60 - 51944.40
SPW-2284	WATER	Apr, 1998	Gr. Alpha	41.09 ± 1.83	41.26	20.63 - 61.89
SPW-2284	WATER	Apr, 1998	Gr. Beta	32.01 ± 1.10	30.72	20.72 - 40.72
SPMI-5451	MILK	Apr, 1998	Cs-137	80.78 ± 6.60	76.68	66.68 - 86.68
SPW-5459	WATER	Apr, 1998	Co-60	48.50 ± 3.74	44.65	34.65 - 54.65
SPW-5459	WATER	Apr, 1998	Cs-137	42.31 ± 4.32	38.34	28.34 - 48.34
SPW-2977	WATER	May, 1998	Ra-226	11.91 ± 0.27	13.80	9.66 - 17.94
SPW-2977	WATER	May, 1998	Ra-228	16.26 ± 1.67	18.00	12.60 - 23.40

Table A-3. In-house "spike" samples.

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[a] Teledyne Results 2s, n=1[b]	Known Activity	Control[c] Limits
SPAP-3041	AIR FILTER	May, 1998	Cs-137	2.00 ± 0.02	1.89	1.13 - 2.65
SPW-3043	WATER	May, 1998	Gr. Alpha	40.49 ± 2.57	41.25	20.63 - 61.88
SPW-3043	WATER	May, 1998	Gr. Beta	35.79 ± 1.52	30.66	20.66 - 40.66
SPSO-3898	SOIL	May, 1998	Cs-134	0.11 ± 0.01	0.10	0.06 - 0.14
SPSO-3898	SOIL	May, 1998	Cs-137	0.48 ± 0.02	0.43	0.26 - 0.61
SPF-3900	FISH	May, 1998	Cs-134	0.36 ± 0.03	0.38	0.23 - 0.53
SPF-3900	FISH	May, 1998	Cs-137	0.29 ± 0.03	0.31	0.18 - 0.43
SPW-4162	WATER	Jun, 1998	Ra-226	12.98 ± 0.18	13.80	9.66 - 17.94
SPW-4162	WATER	Jun, 1998	Ra-228	16.73 ± 1.62	17.80	12.46 - 23.14
SPW-5340	WATER	Jun, 1998	Gr. Alpha	41.38 ± 1.87	41.25	20.62 - 61.87
SPW-5340	WATER	Jun, 1998	Gr. Beta	61.92 ± 1.51	64.92	54.92 - 74.92
SPW-4718	WATER	Jul, 1998	Ra-226	12.93 ± 0.12	13.80	9.66 - 17.94
SPW-4718	WATER	Jul, 1998	Ra-228	13.13 ± 1.59	17.67	12.37 - 22.97
SPCH-5129	CHARCOAL CANISTER	Jul, 1998	I-131(g)	0.61 ± 0.05	0.57	0.34 - 0.80
SPMI-5131	MILK	Jul, 1998	Cs-137	83.87 ± 9.09	76.36	66.36 - 86.36
SPMI-5131	MILK	Jul, 1998	I-131	63.98 ± 0.77	61.03	48.82 - 73.24
SPMI-5131	MILK	Jul, 1998	I-131(g)	62.05 ± 11.00	61.03	36.62 - 71.03
SPMI-5131	MILK	Jul, 1998	Sr-89	52.66 ± 2.13	62.05	49.64 - 74.46
SPMI-5131	MILK	Jul, 1998	Sr-90	29.78 ± 1.39	32.41	25.93 - 38.89
SPW-5134	WATER	Jul, 1998	H-3	20918.00 ± 396.00	21666.00	17332.80 - 25999.20
SPW-5137	WATER	Jul, 1998	Co-60	44.96 ± 4.00	43.56	33.56 - 53.56
SPW-5137	WATER	Jul, 1998	Cs-137	72.05 ± 5.84	76.36	66.36 - 86.36
SPW-5137	WATER	Jul, 1998	I-131	52.07 ± 0.69	61.03	48.82 - 73.24
SPW-5137	WATER	Jul, 1998	I-131(g)	58.78 ± 7.69	61.03	36.62 - 71.03
SPW-5136	WATER	Jul, 1998	Gr. Alpha	50.02 ± 2.28	41.24	20.62 - 61.86
SPW-5136	WATER	Jul, 1998	Gr. Beta	70.19 ± 1.88	64.80	54.80 - 74.80
SPAP-5611	AIR FILTER	Jul, 1998	Cs-137	1.68 ± 0.02	1.86	1.12 - 2.60
SPF-5453	FISH	Jul, 1998	Cs-137	0.33 ± 0.03	0.31	0.18 - 0.43
SPAP-5611	AIR FILTER	Jul, 1998	Cs-137	1.96 ± 0.02	1.86	1.12 - 2.60
SPW-6091	WATER	Aug, 1998	Gr. Alpha	30.59 ± 1.69	41.23	20.62 - 61.85
SPW-6091	WATER	Aug, 1998	Gr. Beta	30.28 ± 1.17	30.48	20.48 - 40.48
SPW-6092	WATER	Aug, 1998	Ra-226	6.29 ± 0.19	6.90	4.83 - 8.97
SPW-6092	WATER	Aug, 1998	Ra-228	7.85 ± 1.28	8.72	6.10 - 11.34
SPW-7143	WATER	Sep, 1998	Ra-226	12.31 ± 0.48	13.79	9.65 - 17.93
SPW-7143	WATER	Sep, 1998	Ra-228	15.70 ± 1.68	17.25	12.08 - 22.43
SPW-7144	WATER	Sep, 1998	Gr. Alpha	35.48 ± 1.65	33.97	16.99 - 50.96
SPW-7144	WATER	Sep, 1998	Gr. Beta	33.06 ± 1.11	30.41	20.41 - 40.41
SPAP-7394	AIR FILTER	Sep, 1998	Gr. Beta (ss)	6.71 ± 0.03	6.77	4.06 - 9.48
SPMI-7592	MILK	Sep, 1998	Cs-137	34.40 ± 7.11	37.99	27.99 - 47.99

Table A-3. In-house "spike" samples.

Lab Code	Sample Type	Date Collected	Analysis	Concentration in pCi/L[a] Teledyne Results 2s, n=1[b]	Known Activity	Control[c] Limits
SPMI-7592	MILK	Sep, 1998	I-131	58.15 ± 0.90	61.55	49.24 - 73.86
SPW-7594	WATER	Sep, 1998	Co-60	46.15 ± 8.78	42.34	32.34 - 52.34
SPW-7594	WATER	Sep, 1998	I-131	77.97 ± 0.81	82.07	65.66 - 98.48
SPW-7594	WATER	Sep, 1998	I-131(g)	80.62 ± 13.90	82.07	49.24 - 92.07
SPVE-7596	VEGETATION	Sep, 1998	I-131(g)	2.61 ± 0.08	2.46	1.48 - 3.44
SPCH-7615	CHARCOAL CANISTER	Sep, 1998	I-131(g)	1.41 ± 0.06	1.28	0.77 - 1.79
SPF-1602	FISH	Oct, 1998	Cs-137	0.56 ± 0.04	0.61	0.37 - 0.85
SPW-8178	WATER	Oct, 1998	Gr. Alpha	25.22 ± 1.90	33.96	16.98 - 50.94
SPW-8178	WATER	Oct, 1998	Gr. Beta	30.20 ± 1.31	30.36	20.36 - 40.36
SPW-8179	WATER	Oct, 1998	Ra-226	11.12 ± 0.16	13.80	9.66 - 17.94
SPW-8179	WATER	Oct, 1998	Ra-228	17.83 ± 1.87	17.09	11.96 - 22.22
SPAP-8457	AIR FILTER	Oct, 1998	Cs-137	1.78 ± 0.02	1.84	1.10 - 2.58
SPAP-8567	AIR FILTER	Oct, 1998	Gr. Beta	6.54 ± 0.10	6.47	0.00 - 16.47
SPSO-9953	SOIL	Oct, 1998	Cs-134	0.08 ± 0.01	0.09	0.05 - 0.12
SPSO-9953	SOIL	Oct, 1998	Cs-137	0.45 ± 0.01	0.43	0.26 - 0.60
SPW-9386	WATER	Nov, 1998	Ra-226	14.75 ± 0.47	13.80	9.66 - 17.94
SPW-9386	WATER	Nov, 1998	Ra-228	15.67 ± 1.59	16.95	11.87 - 22.04
SPW-9387	WATER	Nov, 1998	Gr. Alpha	27.49 ± 2.38	33.97	16.99 - 50.96
SPW-9387	WATER	Nov, 1998	Gr. Beta	36.04 ± 2.14	30.31	20.31 - 40.31
SPW-10347	WATER	Nov, 1998	Sr-90	4.30 ± 1.10	3.20	0.00 - 13.20
SPW-10345	WATER	Nov, 1998	H-3	38980.00 ± 548.00	38848.00	31078.40 - 46617.60
SPW-10340	WATER	Dec, 1998	Ra-226	6.73 ± 0.25	6.89	4.82 - 8.96
SPW-10340	WATER	Dec, 1998	Ra-228	7.44 ± 1.77	8.40	5.88 - 10.92
SPW-10341	WATER	Dec, 1998	Gr. Alpha	49.30 ± 3.35	33.97	16.99 - 50.96
SPW-10341	WATER	Dec, 1998	Gr. Beta	33.63 ± 1.70	30.25	20.25 - 40.25
SPW-10389	WATER	Dec, 1998	U	4.10 ± 0.25	4.17	2.50 - 5.84
SPW-10390	WATER	Dec, 1998	U	4.29 ± 0.25	4.17	2.50 - 5.84

[a] All results are in pCi/L, except for elemental potassium (K) in milk, which are in mg/L.; air filter samples, which are in pCi/Filter; and food products, which are in mg/kg.
[b] All samples are the results of single determinations.
[c] Control limits are based on Attachment A, page A2 of this report.

NOTE: For fish, Jello is used for the spike matrix. For vegetation, Sawdust is used for the spike matrix.

Table A-4. In-house "blank" samples.

Lab Code	Sample Type	Sample Date	Analysis	Concentration pCi/L[a] Teledyne Results (4.66 Sigma) LLD	Activity[b]	Acceptance Criteria (4.66 Sigma)
RA-1	WATER	Jan 1998	Ra-226	<0.015	0.018 ± 0.011	< 1.00
RA-1	WATER	Jan 1998	Ra-228	<0.8745	0.657 ± 0.486	< 1.00
SPW-333	WATER	Jan 1998	Am-241	<0.0934	0.015 ± 0.068	< 1.00
SPW-495	WATER	Jan 1998	Gr. Alpha	<0.3138	0.004 ± 0.206	< 1.00
SPW-495	WATER	Jan 1998	Gr. Beta	<0.8107	1.475 ± 0.612	< 3.20
SPW-495	WATER	Jan 1998	Sr-90	<0.8595	0.552 ± 0.461	< 1.00
SPMI-496	MILK	Jan 1998	Sr-89	<0.9576	0.595 ± 0.864	< 5.00
SPMI-496	MILK	Jan 1998	Sr-90	N/A	0.813 ± 0.300	< 1.00
Low level of Sr-90 concentration in milk (1-5 pCi/L) is not unusual.						
SPW-593	WATER	Jan 1998	H-3	<156.02	10.408 ± 77.815	< 200.00
SPAP-5331	AIR FILTER	Jan 1998	Cs-137	<0.0009	0.000 ± 0.001	< 10.00
SPW-1662	WATER	Feb 1998	Ra-226	<0.0134	0.041 ± 0.010	< 1.00
SPW-1662	WATER	Feb 1998	Ra-228	<0.889	0.386 ± 0.548	< 1.00
SPW-793	WATER	Feb 1998	I-131	<0.3448	-0.351 ± 0.140	< 0.50
SPMI-794	MILK	Feb 1998	I-131	<0.3849	-0.005 ± 0.190	< 0.50
SPAP-749	AIR FILTER	Feb 1998	Gr. Beta	<0.6	0.109 ± 0.381	< 3.20
SPW-1664	WATER	Mar 1998	Ra-226	<0.0197	0.029 ± 0.013	< 1.00
SPAP-1729	AIR FILTER	Mar 1998	Gr. Beta	<0.0014	0.000 ± 0.001	< 3.20
SPW-1997	WATER	Apr 1998	Ra-226	<0.0139	0.006 ± 0.011	< 1.00
SPW-2279	WATER	Apr 1998	H-3	<156.87	54.220 ± 80.200	< 200.00
SPW-2285	WATER	Apr 1998	Gr. Alpha	<0.3124	-0.056 ± 0.199	< 1.00
SPW-2285	WATER	Apr 1998	Gr. Beta	<0.8822	-0.356 ± 0.569	< 3.20
SPMI-5450	MILK	Apr 1998	Cs-137	<5.27	0.529 ± 2.640	< 10.00
SPW-5458	WATER	Apr 1998	Co-60	<1.63	-1.930 ± 15.900	< 10.00
SPW-5458	WATER	Apr 1998	Cs-137	<4.01	0.464 ± 3.070	< 10.00
SPW-2976	WATER	May 1998	Ra-226	<0.0115	0.015 ± 0.010	< 1.00
SPW-2976	WATER	May 1998	Ra-228	<0.865	0.152 ± 0.420	< 1.00
SPAP-3042	AIR FILTER	May 1998	Cs-137	<0.0010	0.000 ± 0.001	< 10.00
SPW-3044	WATER	May 1998	Gr. Alpha	<0.5036	-0.184 ± 0.251	< 1.00
SPW-3044	WATER	May 1998	Gr. Beta	<1.1494	0.140 ± 0.643	< 3.20
SPW-4161	WATER	Jun 1998	Ra-226	<0.0203	0.049 ± 0.014	< 1.00
SPW-4161	WATER	Jun 1998	Ra-228	<0.802	0.221 ± 0.400	< 1.00
SPW-5339	WATER	Jun 1998	Gr. Alpha	<0.4785	0.098 ± 0.322	< 1.00
SPW-5339	WATER	Jun 1998	Gr. Beta	<1.0833	1.037 ± 0.735	< 3.20
SPW-4719	WATER	Jul 1998	Ra-226	<0.0117	0.047 ± 0.010	< 1.00

Table A-4. In-house "blank" samples.

Lab Code	Sample Type	Sample Date	Analysis	Concentration pCi/L[a]. Teledyne Results (4.66 Sigma) LLD	Activity[b]	Acceptance Criteria (4.66 Sigma)
SPW-4719	WATER	Jul 1998	Ra-228	<0.435	0.389 ±0.251	< 1.00
SPCH-5128	CHARCOAL CANISTER	Jul 1998	I-131(g)	<0.0088	-0.001 ±0.007	< 9.60
SPMI-5130	MILK	Jul 1998	Co-60	<2.60	-1.090 ±25.300	< 10.00
SPMI-5130	MILK	Jul 1998	Cs-137	<4.43	-1.510 ±2.690	< 10.00
SPMI-5130	MILK	Jul 1998	I-131	<0.444	-0.141 ±0.239	< 0.50
SPMI-5130	MILK	Jul 1998	I-131(g)	<6.94	-1.710 ±7.030	< 20.00
SPMI-5130	MILK	Jul 1998	Sr-90	N/A	1.320 ±0.370	< 1.00
Low level of Sr-90 concentration in milk (1-5 pCi/L) is not unusual.						
SPW-5132	WATER	Jul 1998	H-3	<157	-81.700 ±74.150	< 200.00
SPW-5135	WATER	Jul 1998	I-131	<0.2796	-0.059 ±0.152	< 0.50
SPW-5135	WATER	Jul 1998	Co-60	<1.90	3.260 ±3.920	< 10.00
SPW-5135	WATER	Jul 1998	Cs-137	<3.29	1.110 ±2.930	< 10.00
SPW-5135	WATER	Jul 1998	I-131(g)	<8.41	2.660 ±7.660	< 20.00
SPW-5135	WATER	Jul 1998	Gr. Alpha	<0.3589	0.486 ±0.274	< 1.00
SPW-5135	WATER	Jul 1998	Gr. Beta	<0.8127	0.791 ±0.552	< 3.20
SPW-6093	WATER	Aug 1998	Gr. Alpha	<0.3766	0.104 ±0.317	< 1.00
SPW-6093	WATER	Aug 1998	Gr. Beta	<1.741	-0.339 ±0.839	< 3.20
SPW-6093	WATER	Aug 1998	Ra-226	<0.0166	0.053 ±0.012	< 1.00
SPW-6093	WATER	Aug 1998	Ra-228	<0.670	-0.050 ±0.304	< 1.00
SPW-7145	WATER	Sep 1998	Gr. Alpha	<0.2485	0.192 ±0.191	< 1.00
SPW-7145	WATER	Sep 1998	Gr. Beta	<0.7483	0.391 ±0.533	< 3.20
SPW-7145	WATER	Sep 1998	Ra-226	<0.0192	0.020 ±0.012	< 1.00
SPW-7145	WATER	Sep 1998	Ra-228	<0.997	0.033 ±0.562	< 1.00
SPAP-7395	AIR FILTER	Sep 1998	Gr. Beta	<0.002	-0.001 ±0.001	< 3.20
SPMI-7593	MILK	Sep 1998	Cs-137	<5.41	1.470 ±3.560	< 10.00
SPMI-7593	MILK	Sep 1998	I-131	<0.4127	-0.257 ±0.215	< 0.50
SPMI-7593	MILK	Sep 1998	I-131(g)	<9.60	4.120 ±24.900	< 20.00
SPW-7595	WATER	Sep 1998	Co-60	<4.60	2.320 ±1.340	< 10.00
SPW-7595	WATER	Sep 1998	I-131	<0.2981	-0.223 ±0.153	< 0.50
SPW-7595	WATER	Sep 1998	I-131(g)	<8.71	2.820 ±6.660	< 20.00
SPVE-7597	VEGETATION	Sep 1998	I-131(g)	<0.0166	-0.001 ±0.001	< 20.00
SPW-8180	WATER	Oct 1998	Ra-226	N/A	0.049 ±0.015	< 1.00
SPW-8180	WATER	Oct 1998	Ra-226	< 0.0209	0.049 ±0.015	< 1.00
SPW-8180	WATER	Oct 1998	Ra-228	< 0.840	0.666 ±0.465	< 1.00

Table A-4. In-house "blank" samples.

Lab Code	Sample Type	Sample Date	Analysis	Concentration pCi/L[a]. Teledyne Results (4.66 Sigma) LLD	Activity[b]	Acceptance Criteria (4.66 Sigma)
SPW-9388	WATER	Nov 1998	Gr. Alpha	<0.74	0.270 ± 0.480	< 1.00
SPW-9388	WATER	Nov 1998	Gr. Beta	<1.99	1.036 ± 1.244	< 3.20
SPW-9388	WATER	Nov 1998	Ra-226	< 0.0203	0.039 ± 0.013	< 1.00
SPW-9388	WATER	Nov 1998	Ra-228	<0.932	0.317 ± 0.561	< 1.00
SPW-10344	WATER	Nov 1998	H-3	<175	-8.130 ± 86.410	< 200.00
SPW-10339	WATER	Dec 1998	Gr. Alpha	<0.95	-0.650 ± 0.570	< 1.00
SPW-10339	WATER	Dec 1998	Gr. Beta	<1.80	-0.280 ± 1.180	< 3.20
SPW-10339	WATER	Dec 1998	Ra-226	<0.0261	0.020 ± 0.015	< 1.00
SPW-10339	WATER	Dec 1998	Ra-228	<0.83	0.244 ± 0.418	< 1.00

[a] Liquid sample results are reported in pCi/Liter, air filter sample results are in pCi/filter, charcoal sample results are in pCi/charcoal, and solid sample results are in pCi/kilogram.
[b] The activity reported is the net activity result.

Table A-5. In-house "duplicate" samples.

Lab Codes[b]	Sample Date	Analysis	Concentration in pCi/L[a] First Result	Second Result	Averaged Result
WW-10052, 10053	Jan, 1998	Gr. Beta	1.1720 ± 0.6030	2.1820 ± 0.6630	1.6770 ± 0.4481
CF-20, 21	Jan, 1998	Gr. Beta	17.5458 ± 0.5866	17.6346 ± 0.5614	17.5902 ± 0.4060
CF-20, 21	Jan, 1998	K-40	21.1870 ± 0.6570	20.8610 ± 0.7520	21.0240 ± 0.4993
CF-20, 21	Jan, 1998	Sr-90	0.0302 ± 0.0085	0.0298 ± 0.0071	0.0300 ± 0.0055
WW-195, 196	Jan, 1998	Gr. Beta	2.9349 ± 0.6584	2.9020 ± 0.6291	2.9185 ± 0.4553
SW-298, 299	Jan, 1998	H-3	144.2200 ± 93.5400	92.1100 ± 91.4500	118.1650 ± 65.4080
SW-349, 350	Jan, 1998	Co-60	1.1100 ± 9.1700	1.7900 ± 2.4700	1.4500 ± 4.7484
SW-349, 350	Jan, 1998	Cs-137	-2.4900 ± 3.2300	-0.6700 ± 1.9400	-1.5800 ± 1.8839
CW-737, 738	Jan, 1998	H-3	559.2800 ± 100.4400	524.8100 ± 99.1900	542.0450 ± 70.5812
PW-607, 608	Jan, 1998	Co-60	0.3400 ± 0.0340	0.7200 ± 4.6200	0.5300 ± 2.3101
PW-607, 608	Jan, 1998	Cs-137	1.1700 ± 1.8100	-0.0400 ± 1.8700	0.5650 ± 1.3012
SWU-531, 532	Jan, 1998	Gr. Beta	3.4928 ± 0.6902	3.9923 ± 0.7129	3.7426 ± 0.4961
LW-653, 654	Jan, 1998	Gr. Beta	2.3404 ± 0.5778	1.6742 ± 0.5968	2.0073 ± 0.4153
SW-587, 588	Feb, 1998	Gr. Beta	3.2097 ± 0.7915	2.1021 ± 0.7800	2.6559 ± 0.5556
WW-897, 898	Feb, 1998	Co-60	0.2600 ± 0.4800	0.4700 ± 4.5900	0.3650 ± 2.3075
WW-897, 898	Feb, 1998	Cs-137	0.2800 ± 1.8700	0.3200 ± 2.5200	0.3000 ± 1.5690
WW-897, 898	Feb, 1998	H-3	4,582.7400 ± 197.9300	5,013.4400 ± 205.6500	4,798.0900 ± 142.7132
CW-920, 921	Feb, 1998	Gr. Beta	8.1600 ± 1.3000	8.5200 ± 1.3000	8.3400 ± 0.9192
CW-920, 921	Feb, 1998	Gr. Beta	0.2500 ± 1.2100	0.0000 ± 1.2000	0.1250 ± 0.8521
CW-1378, 1379	Mar, 1998	Gr. Beta	2.6100 ± 1.3700	4.1400 ± 1.5800	3.3750 ± 1.0456
CW-1378, 1379	Mar, 1998	Gr. Beta	-0.1000 ± 1.1000	0.0000 ± 1.2000	-0.0500 ± 0.8139
MI-1552, 1553	Mar, 1998	K-40	1,392.5000 ± 133.0000	1,280.8000 ± 204.0000	1,336.6500 ± 121.7631
WW-1406, 1407	Mar, 1998	Gr. Beta	7.0991 ± 0.8467	7.0712 ± 0.5658	7.0852 ± 0.5092
LW-1921, 1922	Mar, 1998	Gr. Beta	2.9722 ± 0.6466	2.5972 ± 0.6466	2.7847 ± 0.4572
AP-2599, 2600	Mar, 1998	Co-60	-0.0003 ± 0.0004	-0.0003 ± 0.0002	-0.0003 ± 0.0002
AP-2599, 2600	Mar, 1998	Cs-137	-0.0001 ± 0.0004	0.0001 ± 0.0005	0.0000 ± 0.0003
SW-2040, 2041	Mar, 1998	H-3	6,004.3600 ± 224.0000	6,322.4700 ± 229.1400	6,163.4150 ± 160.2195
SW - 2040, 2041	Mar, 1998	H-3	6,322.4678 ± 229.1356	6,004.3639 ± 224.0020	6,163.4158 ± 160.2186
AP-2620, 2621	Mar, 1998	Co-60	0.0005 ± 0.0004	0.0009 ± 0.0027	0.0007 ± 0.0013
AP-2620, 2621	Mar, 1998	Cs-137	0.0005 ± 0.0005	-0.0000 ± 0.0006	0.0002 ± 0.0004
LW-2253, 2254	Mar, 1998	Gr. Beta	1.9075 ± 0.7042	2.1691 ± 0.7478	2.0383 ± 0.5136
AP-2487, 2488	Mar, 1998	Be-7	0.0569 ± 0.0071	0.0601 ± 0.0008	0.0585 ± 0.0035
E-1966, 1967	Apr, 1998	Gr. Beta	1.1740 ± 0.0530	1.1530 ± 0.0530	1.1635 ± 0.0375
E-1966, 1967	Apr, 1998	K-40	1.3900 ± 0.1300	1.2422 ± 0.1700	1.3161 ± 0.1070
AP-2466, 2467	Apr, 1998	Be-7	0.0693 ± 0.0158	0.0605 ± 0.0113	0.0649 ± 0.0097
WW-2012, 2013	Apr, 1998	Co-60	0.6300 ± 0.6200	2.6700 ± 2.3500	1.6500 ± 1.2152

Table A-5. In-house "duplicate" samples.

Lab Codes[b]	Sample Date	Analysis	First Result	Second Result	Averaged Result
			Concentration in pCi/L[a]		
WW-2012, 2013	Apr, 1998	Cs-137	0.5800 ± 1.5600	1.2800 ± 2.2800	0.9300 ± 1.3813
WW-2012, 2013	Apr, 1998	H-3	616.5800 ± 100.3800	646.9400 ± 101.4600	631.7600 ± 71.3622
MI-2112, 2113	Apr, 1998	I-131	-0.0500 ± 0.1600	-0.0500 ± 0.1700	-0.0500 ± 0.1167
CW-2225, 2226	Apr, 1998	Gr. Beta	1.8900 ± 1.4200	2.6400 ± 1.4100	2.2650 ± 1.0006
CW-2225, 2226	Apr, 1998	Gr. Beta	-1.2600 ± 1.0300	0.1500 ± 1.2500	-0.5550 ± 0.8098
SWU-2302, 2303	Apr, 1998	Gr. Beta	3.4606 ± 0.6485	3.2027 ± 0.6811	3.3317 ± 0.4702
SWU-2302, 2303	Apr, 1998	H-3	435.3500 ± 96.3410	593.3260 ± 102.1870	514.3380 ± 70.2207
CW-2325, 2326	Apr, 1998	Gr. Beta	16.1700 ± 2.4300	14.3400 ± 2.1600	15.2550 ± 1.6256
CW-2325, 2326	Apr, 1998	Gr. Beta	5.0100 ± 1.5900	5.9000 ± 1.7300	5.4550 ± 1.1748
BS-2508, 2509	Apr, 1998	Cs-137	0.3186 ± 0.0538	0.2849 ± 0.0601	0.3018 ± 0.0403
BS-2508, 2509	Apr, 1998	Gr. Alpha	15.5814 ± 2.8742	15.4353 ± 5.7607	15.5084 ± 3.2190
BS-2508, 2509	Apr, 1998	Gr. Beta	26.4292 ± 2.2859	30.1462 ± 4.3906	28.2877 ± 2.4750
BS-2508, 2509	Apr, 1998	K-40	18.6870 ± 1.2400	17.6740 ± 0.9500	18.1805 ± 0.7810
BS-2508, 2509	Apr, 1998	Sr-90	0.0490 ± 0.0150	0.0280 ± 0.0130	0.0385 ± 0.0099
G-2531, 2532	Apr, 1998	Cs-137	0.2387 ± 0.0353	0.2089 ± 0.0182	0.2238 ± 0.0199
G-2531, 2532	Apr, 1998	K-40	10.2470 ± 0.5750	9.3951 ± 0.3670	9.8211 ± 0.3411
DW-2790, 2791	Apr, 1998	Gr. Alpha	0.3001 ± 0.2051	0.1634 ± 0.2668	0.2318 ± 0.1683
DW-2790, 2791	Apr, 1998	Gr. Beta	0.5947 ± 0.2942	0.7350 ± 0.3478	0.6649 ± 0.2278
MI-2368, 2369	Apr, 1998	K-40	1,176.4000 ± 162.0000	1,374.6000 ± 108.0000	1,275.5000 ± 97.3499
MI-2368, 2369	Apr, 1998	Sr-89	0.2160 ± 1.0300	-0.3060 ± 1.2300	-0.0450 ± 0.8022
MI-2368, 2369	Apr, 1998	Sr-90	1.5430 ± 0.4910	1.1744 ± 0.4060	1.3587 ± 0.3186
CW-2411, 2412	Apr, 1998	Gr. Beta	2.2800 ± 1.0500	3.0100 ± 1.5100	2.6450 ± 0.9196
SWU-2067, 2068	Apr, 1998	Gr. Beta	2.4865 ± 0.7089	3.3197 ± 0.6627	2.9031 ± 0.4852
SS-2666, 2667	Apr, 1998	Cs-137	0.0395 ± 0.0194	0.0299 ± 0.0133	0.0347 ± 0.0118
SS-2666, 2667	Apr, 1998	Gr. Beta	9.0977 ± 2.0893	6.7058 ± 1.9219	7.9018 ± 1.4194
SS-2666, 2667	Apr, 1998	K-40	5.3384 ± 0.2820	5.9439 ± 0.4020	5.6412 ± 0.2455
WW-2701, 2702	Apr, 1998	H-3	184.5500 ± 86.5200	223.1700 ± 88.1500	203.8600 ± 61.7579
WW-2850, 2851	Apr, 1998	Co-60	-0.1700 ± 1.6000	-0.3400 ± 6.3800	-0.2550 ± 3.2888
WW-2850, 2851	Apr, 1998	Cs-137	0.2900 ± 2.4800	2.1600 ± 2.0300	1.2250 ± 1.6024
WW-2850, 2851	Apr, 1998	H-3	5,665.6200 ± 217.4400	5,770.5600 ± 219.2100	5,718.0900 ± 154.3804
SS-3004, 3005	Apr, 1998	Gr. Alpha	6.6840 ± 4.0000	6.9820 ± 4.4020	6.8330 ± 2.9740
SS-3004, 3005	Apr, 1998	Gr. Beta	19.9460 ± 3.1700	20.7720 ± 3.1970	20.3590 ± 2.2511
SS-3004, 3005	Apr, 1998	K-40	15.1560 ± 0.9910	13.9010 ± 0.5860	14.5285 ± 0.5756
BS-3240, 3241	Apr, 1998	Gr. Beta	7.5126 ± 1.9277	8.4047 ± 1.9386	7.9587 ± 1.3669
BS-3240, 3241	Apr, 1998	K-40	10.2890 ± 0.5380	10.1520 ± 0.3430	10.2205 ± 0.3190
MI-2941, 2942	May, 1998	K-40	1,209.3000 ± 152.0000	1,422.5000 ± 193.0000	1,315.9000 ± 122.8342

Table A-5. In-house "duplicate" samples.

Lab Codes[b]	Sample Date	Analysis	Concentration in pCi/L[a] First Result	Second Result	Averaged Result
SO-2962, 2963	May, 1998	Cs-137	0.1835 ± 0.0463	0.1531 ± 0.0261	0.1683 ± 0.0266
SO-2962, 2963	May, 1998	Gr. Alpha	9.7590 ± 3.4730	10.3360 ± 3.5720	10.0475 ± 2.4910
SO-2962, 2963	May, 1998	Gr. Beta	27.2230 ± 2.8430	31.4690 ± 3.0280	29.3460 ± 2.0767
SO-2962, 2963	May, 1998	K-40	23.0890 ± 1.1600	21.6540 ± 0.8142	22.3715 ± 0.7086
SO-2962, 2963	May, 1998	Sr-90	0.0421 ± 0.0117	0.0396 ± 0.0146	0.0408 ± 0.0094
LW-3048, 3049	May, 1998	Gr. Beta	1.9020 ± 0.6920	2.0920 ± 0.7010	1.9970 ± 0.4925
WW-3097, 3098	May, 1998	Gr. Beta	4.6000 ± 0.6640	4.4740 ± 0.6600	4.5370 ± 0.4681
WW - 3173, 3174	May, 1998	H-3	155.2485 ± 83.4086	153.4076 ± 83.3273	154.3280 ± 58.9500
F-3305, 3306	May, 1998	Gr. Beta	2.9966 ± 0.1303	2.8744 ± 0.1364	2.9355 ± 0.0943
F-3305, 3306	May, 1998	K-40	2.5354 ± 0.3690	2.5317 ± 0.4260	2.5336 ± 0.2818
SS-3463, 3464	May, 1998	K-40	13.2060 ± 0.6940	12.1740 ± 0.5670	12.6900 ± 0.4481
F - 3284, 3285	May, 1998	Co-60	0.0073 ± 0.0286	-0.0054 ± 0.0097	0.0009 ± 0.0151
F - 3284, 3285	May, 1998	Cs-137	-0.0001 ± 0.0047	0.0080 ± 0.0095	0.0039 ± 0.0053
CW - 3439, 3440	May, 1998	Gr. Beta	2.1268 ± 1.3641	2.0093 ± 1.1263	2.0681 ± 0.8845
G-3546, 3547	May, 1998	Be-7	0.7130 ± 0.2340	0.6940 ± 0.1850	0.7035 ± 0.1491
G-3546, 3547	May, 1998	Gr. Beta	10.7190 ± 0.3340	10.9340 ± 0.3370	10.8265 ± 0.2372
G-3546, 3547	May, 1998	K-40	7.5468 ± 0.5310	7.8713 ± 0.6930	7.7091 ± 0.4365
BS-3669, 3670	May, 1998	Cs-137	0.2010 ± 0.0535	0.2022 ± 0.0215	0.2016 ± 0.0288
BS-3669, 3670	May, 1998	K-40	14.9080 ± 0.4820	16.1580 ± 1.0800	15.5330 ± 0.5913
F-3694, 3695	May, 1998	K-40	1.7695 ± 0.2850	1.6797 ± 0.3440	1.7246 ± 0.2234
PW - 3572, 3573	May, 1998	H-3	49.8073 ± 97.6829	83.0122 ± 98.9291	66.4098 ± 69.5142
WW - 3763, 3764	May, 1998	Co-60	0.0478 ± 0.0234	0.0551 ± 0.0311	0.0515 ± 0.0195
WW - 3790, 3791	May, 1998	Co-60	-0.0847 ± 0.6250	0.5220 ± 10.9000	0.2187 ± 5.4590
WW - 3790, 3791	May, 1998	Cs-137	0.9210 ± 1.9700	1.1200 ± 1.5000	1.0205 ± 1.2380
WW - 3790, 3791	May, 1998	H-3	723.8914 ± 114.0882	705.2824 ± 113.4795	714.5869 ± 80.4576
F - 3715, 3716	May, 1998	Co-60	-0.0048 ± 0.0567	0.0077 ± 0.0214	0.0015 ± 0.0303
F - 3715, 3716	May, 1998	Cs-137	0.0015 ± 0.0090	0.0127 ± 0.0137	0.0071 ± 0.0082
BS - 3763, 3764	May, 1998	Cs-137	0.0884 ± 0.0206	0.0754 ± 0.0257	0.0819 ± 0.0165
SWU-3882, 3883	May, 1998	Gr. Beta	2.9052 ± 0.6786	3.7390 ± 0.6595	3.3221 ± 0.4731
SWU-3882, 3883	May, 1998	H-3	43.3000 ± 79.9590	34.1540 ± 79.5400	38.7270 ± 56.3916
CW - 4314, 4315	May, 1998	H-3	441.3905 ± 96.6703	424.7922 ± 96.0349	433.0913 ± 68.1319
F-3861, 3862	May, 1998	K-40	3.2973 ± 0.5280	3.6404 ± 0.3530	3.4689 ± 0.3176
CW - 4044, 4045	May, 1998	Gr. Beta	4.6775 ± 1.6138	4.8186 ± 1.6342	4.7481 ± 1.1484
CW - 4044, 4045	May, 1998	Gr. Beta	-0.7495 ± 1.2072	-0.6833 ± 1.0704	-0.7164 ± 0.8067
SW-4020, 4021	Jun, 1998	K-40 (FP)	1.0380	1.0380	1.0380
AP-4111, 4112	Jun, 1998	Be-7	0.1860 ± 0.0833	0.2650 ± 0.1120	0.2255 ± 0.0698

Table A-5. In-house "duplicate" samples.

Lab Codes[b]	Sample Date	Analysis	Concentration in pCi/L[a] First Result	Second Result	Averaged Result
P-4183, 4184	Jun, 1998	H-3	22.7850 ± 81.0520	44.7120 ± 81.6170	33.7485 ± 57.5125
CW - 4195, 4196	Jun, 1998	Gr. Beta	2.9189 ± 1.4811	2.8922 ± 1.4740	2.9055 ± 1.0448
CW - 4195, 4196	Jun, 1998	Gr. Beta	-0.4892 ± 1.0638	-0.4909 ± 1.1091	-0.4900 ± 0.7684
WW-4410, 4411	Jun, 1998	Gr. Beta	4.9907 ± 0.7658	5.7601 ± 0.8338	5.3754 ± 0.5661
WW-4410, 4411	Jun, 1998	H-3	-5.3910 ± 77.2770	66.4880 ± 80.5500	30.5485 ± 55.8123
MI - 4389, 4390	Jun, 1998	Co-60	0.1420 ± 0.2080	1.4200 ± 13.6000	0.7810 ± 6.8008
MI - 4389, 4390	Jun, 1998	Cs-137	0.1810 ± 2.7600	0.6020 ± 4.0700	0.3915 ± 2.4588
MI - 4389, 4390	Jun, 1998	I-131	-0.0469 ± 0.2433	-0.1152 ± 0.2559	-0.0811 ± 0.1765
AP-4664, 4665	Jun, 1998	Be-7	0.1539 ± 0.0750	0.2627 ± 0.1220	0.2083 ± 0.0716
MI - 4685, 4686	Jun, 1998	I-131	-0.1010 ± 0.1620	-0.0221 ± 0.1728	-0.0616 ± 0.1184
SW - 4901, 4902	Jun, 1998	H-3	2,541.2239 ± 156.4571	2,510.5125 ± 155.7462	2,525.8682 ± 110.3808
AP-5188, 5189	Jun, 1998	Be-7	0.0844 ± 0.0163	0.0733 ± 0.0117	0.0789 ± 0.0100
SWU-4798, 4799	Jun, 1998	Gr. Beta	1.9402 ± 0.5398	1.8412 ± 0.5411	1.8907 ± 0.3822
LW-4993, 4994	Jun, 1998	Gr. Beta	3.1224 ± 0.6129	2.0740 ± 0.5328	2.5982 ± 0.4061
LW-4993, 4994	Jun, 1998	H-3	3,543.4600 ± 184.5020	3,482.0770 ± 183.2600	3,512.7685 ± 130.0242
WW-4819, 4820	Jul, 1998	Gr. Beta	1.2760 ± 0.6431	0.7313 ± 0.6161	1.0037 ± 0.4453
WW-4819, 4820	Jul, 1998	K-40	0.8650 ± 0.0865	0.9515 ± 0.0950	0.9083 ± 0.0642
AP-5209, 5210	Jul, 1998	Be-7	0.1079 ± 0.0180	0.0901 ± 0.0107	0.0990 ± 0.0105
AP-5392, 5393	Jul, 1998	Be-7	0.0782 ± 0.0143	0.0885 ± 0.0144	0.0833 ± 0.0101
AP-5413, 5414	Jul, 1998	Be-7	0.0625 ± 0.0072	0.0718 ± 0.0091	0.0671 ± 0.0058
WW-4848, 4849	Jul, 1998	Co-60	0.2220 ± 0.1290	0.5080 ± 0.8150	0.3650 ± 0.4126
WW-4848, 4849	Jul, 1998	Cs-134	0.9310 ± 2.0500	0.8130 ± 0.8130	0.8720 ± 1.1027
WW-4848, 4849	Jul, 1998	Cs-137	0.7040 ± 1.8700	-0.1190 ± 1.8300	0.2925 ± 1.3082
WW-4848, 4849	Jul, 1998	H-3	37.2000 ± 89.2000	-13.0000 ± 87.0000	12.1000 ± 62.3010
CW-4947, 4948	Jul, 1998	Gr. Beta	5.2400 ± 1.5700	5.1900 ± 1.5700	5.2150 ± 1.1102
SW-7804, 7805	Jul, 1998	Gr. Alpha	0.3147 ± 0.6025	1.7030 ± 0.5568	1.0089 ± 0.4102
SW-7804, 7805	Jul, 1998	Gr. Beta	2.0032 ± 0.7183	2.5489 ± 0.6474	2.2761 ± 0.4835
WW-4880, 4881	Jul, 1998	Co-60	0.2540 ± 0.6210	-0.4430 ± 0.8250	-0.0945 ± 0.5163
WW-4880, 4881	Jul, 1998	Cs-137	1.4600 ± 1.2800	1.1400 ± 2.0000	1.3000 ± 1.1873
WW-4880, 4881	Jul, 1998	H-3	308.5000 ± 102.7000	328.9000 ± 103.5000	318.7000 ± 72.9033
G-5090, 5091	Jul, 1998	Be-7	1.5334 ± 0.2310	1.5696 ± 0.2550	1.5515 ± 0.1720
G-5090, 5091	Jul, 1998	K-40	6.2521 ± 0.4900	6.0430 ± 0.4800	6.1476 ± 0.3430
SW-5281, 5282	Jul, 1998	Gr. Alpha	5.7564 ± 1.0355	5.4517 ± 0.9702	5.6041 ± 0.7095
SW-5281, 5282	Jul, 1998	Gr. Beta	8.8798 ± 0.7835	9.9157 ± 0.8418	9.3978 ± 0.5750
SW-5281, 5282	Jul, 1998	H-3	12.9950 ± 87.9900	46.4090 ± 89.3890	29.7020 ± 62.7149
VE-5323, 5324	Jul, 1998	K-40	9.4179 ± 0.7440	8.3494 ± 0.4700	8.8837 ± 0.4400

Table A-5. In-house "duplicate" samples.

Lab Codes[b]	Sample Date	Analysis	Concentration in pCi/L[a] First Result	Second Result	Averaged Result
SWU-5744, 5745	Jul, 1998	Gr. Beta	2.0648 ± 0.5650	2.4432 ± 0.6352	2.2540 ± 0.4251
VE-5302, 5303	Jul, 1998	Gr. Alpha	0.1233 ± 0.0458	0.0816 ± 0.0381	0.1025 ± 0.0298
VE-5302, 5303	Jul, 1998	Gr. Beta	3.8738 ± 0.1201	3.4382 ± 0.1081	3.6560 ± 0.0808
VE-5302, 5303	Jul, 1998	K-40	3,845.0000 ± 384.0000	3,561.0000 ± 419.0000	3,703.0000 ± 284.1729
G-5346, 5347	Jul, 1998	Be-7	1.0649 ± 0.3460	1.1877 ± 0.2220	1.1263 ± 0.2055
G-5346, 5347	Jul, 1998	Gr. Beta	5.5890 ± 0.2200	5.4932 ± 0.1571	5.5411 ± 0.1352
G-5346, 5347	Jul, 1998	K-40	5.8497 ± 0.7760	6.4013 ± 0.5600	6.1255 ± 0.4785
AP-5371, 5372	Jul, 1998	Be-7	0.2899 ± 0.0987	0.2565 ± 0.0949	0.2732 ± 0.0685
AP-5530, 5531	Jul, 1998	Be-7	0.2559 ± 0.0941	0.3365 ± 0.0984	0.2962 ± 0.0681
SO-5556, 5557	Jul, 1998	Gr. Beta	17.8997 ± 2.6057	15.8321 ± 2.3577	16.8659 ± 1.7570
CW-6134, 6135	Jul, 1998	Gr. Beta	4.8400 ± 1.2300	4.0700 ± 1.0900	4.4550 ± 0.8217
AP-5721, 5722	Jul, 1998	Be-7	0.2175 ± 0.0616	0.2461 ± 0.1180	0.2318 ± 0.0666
SWU-5744, 5745	Jul, 1998	H-3	223.9760 ± 86.8830	209.4480 ± 86.2730	216.7120 ± 61.2203
WW-5836, 5837	Jul, 1998	H-3	80.4980 ± 80.6500	65.9720 ± 79.9940	73.2350 ± 56.7967
WW-6176, 6177	Jul, 1998	H-3	31.0590 ± 81.2420	1.8270 ± 79.9170	16.4430 ± 56.9802
WW-6176, 6177	Jul, 1998	Gr. Beta	0.6954 ± 0.5544	1.3234 ± 0.5462	1.0094 ± 0.3891
LW-5965, 5966	Aug, 1998	Gr. Beta	3.1093 ± 0.6160	2.2762 ± 0.6288	2.6928 ± 0.4401
LW-5965, 5966	Aug, 1998	H-3	80.4580 ± 82.3350	36.9020 ± 80.3920	58.6800 ± 57.5368
G-5986, 5987	Aug, 1998	Be-7	2.2321 ± 0.3670	1.9885 ± 0.3010	2.1103 ± 0.2373
G-5986, 5987	Aug, 1998	K-40	5.4909 ± 0.6280	6.3514 ± 0.7550	5.9212 ± 0.4910
CW-6013, 6014	Aug, 1998	Gr. Beta	0.5400 ± 1.2300	0.9900 ± 1.2500	0.7650 ± 0.8768
CW-6134, 6135	Aug, 1998	Gr. Beta	3.2200 ± 1.5200	4.1200 ± 1.1600	3.6700 ± 0.9560
F-6447, 6448	Aug, 1998	Gr. Beta	2.1416 ± 0.0774	1.9173 ± 0.0791	2.0295 ± 0.0553
F-6447, 6448	Aug, 1998	K-40	2.1309 ± 0.2570	1.8657 ± 0.1280	1.9983 ± 0.1436
AP-6467, 6468	Aug, 1998	Be-7	0.1612 ± 0.0873	0.1293 ± 0.1260	0.1453 ± 0.0766
VE-6489, 6490	Aug, 1998	Cs-134	1.0300 ± 1.8700	0.1500 ± 0.1000	0.5900 ± 0.9363
VE-6489, 6490	Aug, 1998	Cs-137	0.9500 ± 1.4300	0.6800 ± 2.0400	0.8150 ± 1.2456
AP-6722, 6723	Aug, 1998	Be-7	0.3063 ± 0.1590	0.3100 ± 0.0937	0.3082 ± 0.0923
VE-6774, 6775	Aug, 1998	Be-7	0.5894 ± 0.2720	0.4208 ± 0.1520	0.5051 ± 0.1558
VE-6774, 6775	Aug, 1998	Gr. Beta	5.9406 ± 0.1789	5.6841 ± 0.1706	5.8124 ± 0.1236
CW-6800, 6801	Aug, 1998	Gr. Beta	2.2300 ± 1.4400	2.1300 ± 1.3100	2.1800 ± 0.9734
LW-7129, 7130	Aug, 1998	Gr. Alpha	0.6433 ± 0.3557	0.5551 ± 0.3614	0.5992 ± 0.2535
LW-7129, 7130	Aug, 1998	Gr. Beta	2.4016 ± 0.4281	2.3041 ± 0.4447	2.3529 ± 0.3086
LW-7129, 7130	Aug, 1998	H-3	170.2100 ± 87.3900	37.4100 ± 81.5000	103.8100 ± 59.7479
LW-7129, 7130	Aug, 1998	H-3	154.7950 ± 94.8090	104.6950 ± 92.7500	129.7450 ± 66.3161
SO-6943, 6944	Sep, 1998	Co-60	0.1466 ± 0.0399	0.1452 ± 0.0303	0.1459 ± 0.0251

Table A-5. In-house "duplicate" samples.

Lab Codes[b]	Sample Date	Analysis	Concentration in pCi/L[a] First Result	Second Result	Averaged Result
SO-6943, 6944	Sep, 1998	Cs-137	15.1000 ± 0.2000	15.7000 ± 0.3000	15.4000 ± 0.1803
SO-6943, 6944	Sep, 1998	K-40	16.5680 ± 0.7660	17.3780 ± 1.1000	16.9730 ± 0.6702
CW-7043, 7044	Sep, 1998	Gr. Beta	4.5000 ± 1.6000	4.9000 ± 1.5000	4.7000 ± 1.0966
VE-7250, 7251	Sep, 1998	Cs-134	0.0800 ± 1.1800	0.4600 ± 0.5100	0.2700 ± 0.6427
VE-7250, 7251	Sep, 1998	Cs-137	0.1300 ± 0.7200	0.0100 ± 0.3400	0.0700 ± 0.3981
VE-7064, 7065	Sep, 1998	Cs-134	-0.1100 ± 0.0800	0.1200 ± 1.4900	0.0050 ± 0.7461
VE-7064, 7065	Sep, 1998	Cs-137	-0.3600 ± 0.7600	0.0200 ± 0.8200	-0.1700 ± 0.5590
VE-7171, 7172	Sep, 1998	Cs-134	0.0600 ± 0.5200	-0.1300 ± 13.1000	-0.0350 ± 6.5552
VE-7171, 7172	Sep, 1998	Cs-137	0.6300 ± 0.5200	0.6800 ± 0.8000	0.6550 ± 0.4771
CW-7204, 7205	Sep, 1998	Gr. Beta	2.6900 ± 1.4300	1.5600 ± 1.3000	2.1250 ± 0.9663
SW-6363, 6364	Sep, 1998	Gr. Beta	4.3450 ± 0.7618	4.1456 ± 0.7464	4.2453 ± 0.5333
SW-6363, 6364	Sep, 1998	H-3	133.9370 ± 82.9580	148.6820 ± 83.6110	141.3095 ± 58.8915
VE-7279, 7280	Sep, 1998	K-40	2.1575 ± 0.2580	2.3167 ± 0.3420	2.2371 ± 0.2142
SWU-7452, 7453	Sep, 1998	Gr. Beta	4.1567 ± 0.6600	4.1515 ± 0.7395	4.1541 ± 0.4956
F-7819, 7820	Sep, 1998	K-40	3.0166 ± 0.3920	2.7430 ± 0.5190	2.8798 ± 0.3252
[illegible]W-7375, 7376	Sep, 1998	Gr. Beta	1.7100 ± 1.1500	2.2000 ± 1.1900	1.9550 ± 0.8274
BS-7598, 7599	Sep, 1998	K-40	9.5919 ± 0.7430	8.9290 ± 0.4590	9.2605 ± 0.4367
AP-7598, 7599	Sep, 1998	Be-7	0.0639 ± 0.0188	0.0815 ± 0.0156	0.0727 ± 0.0122
VE-7397, 7398	Sep, 1998	Cs-134	0.1900 ± 2.6800	0.6300 ± 1.3500	0.4100 ± 1.5004
VE-7397, 7398	Sep, 1998	Cs-137	-0.0900 ± 0.9400	0.5200 ± 0.9500	0.2150 ± 0.6682
SWU-7452, 7453	Sep, 1998	H-3	23.7170 ± 81.6810	-19.3480 ± 79.6820	2.1845 ± 57.0548
SWT-7765, 7766	Sep, 1998	Gr. Beta	3.2443 ± 0.6638	2.9078 ± 0.6593	3.0761 ± 0.4678
WW - 7831, 7832	Oct, 1998	Co-60	0.6760 ± 2.3800	1.2100 ± 1.4300	0.9430 ± 1.3883
WW - 7831, 7832	Oct, 1998	Cs-137	0.2340 ± 1.3900	1.5900 ± 2.1200	0.9120 ± 1.2675
WW - 7831, 7832	Oct, 1998	H-3	11.8861 ± 81.2490	21.2699 ± 81.6813	16.5780 ± 57.6048
SW-7857, 7858	Oct, 1998	Gr. Beta	2.3410 ± 0.7265	2.1443 ± 0.7591	2.2427 ± 0.5254
SO-7878, 7879	Oct, 1998	Gr. Beta	19.3527 ± 4.1969	23.2850 ± 4.0731	21.3189 ± 2.9242
SO-7878, 7879	Oct, 1998	Sr-90	0.0034 ± 0.0110	0.0080 ± 0.0130	0.0057 ± 0.0085
AP-,	Oct, 1998	Be-7	0.0680 ± 0.0527	0.0931 ± 0.0702	0.0806 ± 0.0439
WW-8073, 8074	Oct, 1998	Gr. Beta	2.4196 ± 0.5973	3.1890 ± 0.6509	2.8043 ± 0.4417
WW-8073, 8074	Oct, 1998	H-3	90.5270 ± 84.1470	113.3172 ± 85.1690	101.9221 ± 59.8633
SS-8202, 8203	Oct, 1998	Cs-137	0.0509 ± 0.0284	0.0222 ± 0.0102	0.0365 ± 0.0151
SS-8202, 8203	Oct, 1998	Gr. Beta	4.5670 ± 1.9890	6.3930 ± 2.0860	5.4800 ± 1.4411
SS-8202, 8203	Oct, 1998	K-40	7.2289 ± 0.6170	7.1271 ± 0.4380	7.1780 ± 0.3783
SS-8202, 8203	Oct, 1998	K-40	6.9700 ± 0.5400	7.1800 ± 0.3800	7.0750 ± 0.3302
WW-8358, 8359	Oct, 1998	Gr. Beta	1.0464 ± 0.5347	1.4246 ± 0.5276	1.2355 ± 0.3756

Table A-5. In-house "duplicate" samples.

Lab Codes[b]	Sample Date	Analysis	Concentration in pCi/L[a] First Result	Second Result	Averaged Result
WW-8358, 8359	Oct, 1998	H-3	16.2810 ± 81.9530	53.8530 ± 83.6580	35.0670 ± 58.5554
BS - 8270, 8271	Oct, 1998	Co-60	0.0151 ± 0.0090	0.0072 ± 0.0884	0.0111 ± 0.0444
BS - 8270, 8271	Oct, 1998	Cs-137	0.0732 ± 0.0186	0.0913 ± 0.0451	0.0823 ± 0.0244
AP-,	Oct, 1998	Be-7	0.1094 ± 0.0878	0.1708 ± 0.0934	0.1401 ± 0.0641
SO-7878, 7879	Oct, 1998	K-40	16.3430 ± 0.9100	18.2150 ± 1.1000	17.2790 ± 0.7138
SL-8624, 8625	Oct, 1998	K-40	2.0091 ± 0.4260	1.9401 ± 0.3310	1.9746 ± 0.2697
SS-8689, 8690	Oct, 1998	K-40	14.8820 ± 0.8900	16.8160 ± 1.2200	15.8490 ± 0.7551
BS-8864, 8865	Oct, 1998	Co-60	0.1424 ± 0.0225	0.1313 ± 0.0199	0.1368 ± 0.0150
BS-8864, 8865	Oct, 1998	Cs-137	0.0972 ± 0.0204	0.1081 ± 0.0207	0.1026 ± 0.0145
BS-8864, 8865	Oct, 1998	K-40	9.5076 ± 0.4940	10.4040 ± 0.5000	9.9558 ± 0.3514
SO-10497, 10498	Oct, 1998	K-40	19.0930 ± 1.0800	19.7410 ± 0.9100	19.4170 ± 0.7061
SO-9098, 9099	Oct, 1998	Cs-137	0.5240 ± 0.0580	0.5300 ± 0.0390	0.5270 ± 0.0349
SO-9098, 9099	Oct, 1998	K-40	17.7200 ± 1.0700	18.4100 ± 0.8000	18.0650 ± 0.6680
BS-11122, 11123	Oct, 1998	Be-7	0.4800 ± 0.2700	0.3700 ± 0.2200	0.4250 ± 0.1741
BS-11122, 11123	Oct, 1998	Co-60	0.0263 ± 0.0084	0.0291 ± 0.0090	0.0277 ± 0.0062
BS-11122, 11123	Oct, 1998	Cs-137	0.2714 ± 0.0179	0.2747 ± 0.0167	0.2730 ± 0.0122
BS-11122, 11123	Oct, 1998	K-40	9.0446 ± 0.2600	8.9737 ± 0.2760	9.0092 ± 0.1896
VE-9182, 9183	Oct, 1998	Be-7	2.1684 ± 0.4480	1.8643 ± 0.4300	2.0164 ± 0.3105
VE-9182, 9183	Oct, 1998	K-40	4.9628 ± 0.6160	5.4867 ± 0.6600	5.2248 ± 0.4514
VE-9203, 9204	Oct, 1998	Be-7	1.9163 ± 0.6090	1.9606 ± 0.3870	1.9385 ± 0.3608
VE-9203, 9204	Oct, 1998	Cs-137	0.2744 ± 0.0568	0.2623 ± 0.0361	0.2684 ± 0.0337
VE-9203, 9204	Oct, 1998	K-40	3.9727 ± 0.6770	4.0116 ± 0.4430	3.9922 ± 0.4045
F - 8773, 8774	Oct, 1998	Co-60	0.0013 ± 0.0008	0.0024 ± 0.0037	0.0019 ± 0.0019
F - 8773, 8774	Oct, 1998	Cs-137	0.0040 ± 0.0055	0.0027 ± 0.0088	0.0034 ± 0.0052
F - 8794, 8795	Oct, 1998	Co-60	-0.0062 ± 0.0213	0.0011 ± 0.0065	-0.0026 ± 0.0111
F - 8794, 8795	Oct, 1998	Cs-137	0.0008 ± 0.0076	0.0011 ± 0.0056	0.0010 ± 0.0047
SO-9119, 9120	Oct, 1998	Cs-137	0.5500 ± 0.0397	0.5500 ± 0.0480	0.5500 ± 0.0311
SO-9119, 9120	Oct, 1998	K-40	20.2600 ± 1.0200	20.5090 ± 0.8050	20.3845 ± 0.6497
SO-9161, 9162	Oct, 1998	Cs-137	0.7715 ± 0.0584	0.7532 ± 0.0525	0.7624 ± 0.0393
SO-9161, 9162	Oct, 1998	K-40	18.1200 ± 1.1200	20.0600 ± 1.2000	19.0900 ± 0.8207
WW - 9277, 9278	Oct, 1998	H-3	97.6157 ± 83.0917	64.2534 ± 81.5898	80.9345 ± 58.2261
SWU-9014, 9015	Oct, 1998	Gr. Beta	2.7210 ± 0.6386	3.3308 ± 0.6187	3.0259 ± 0.4446
SWU-9014, 9015	Oct, 1998	H-3	161.5360 ± 85.8760	157.8370 ± 85.7160	159.6865 ± 60.6670
MI-9035, 9036	Oct, 1998	K-40	1,531.4000 ± 129.0000	1,426.0000 ± 188.0000	1,478.7000 ± 114.0011
F - 8972, 8973	Oct, 1998	Co-60	-0.0127 ± 0.0489	0.0018 ± 0.0111	-0.0055 ± 0.0251
F - 8972, 8973	Oct, 1998	Cs-137	0.0070 ± 0.0120	-0.0022 ± 0.0070	0.0024 ± 0.0069

Table A-5. In-house "duplicate" samples.

Lab Codes[b]	Sample Date	Analysis	Concentration in pCi/L[a] First Result	Second Result	Averaged Result
CW - 9414, 9415	Oct, 1998	Gr. Beta	2.6433 ± 1.5016	3.4161 ± 1.5235	3.0297 ± 1.0696
CW - 9414, 9415	Oct, 1998	Gr. Beta	0.3371 ± 1.2445	-1.2723 ± 1.1437	-0.4676 ± 0.8451
WW - 9256, 9257	Oct, 1998	Co-60	-1.2600 ± 0.9300	-1.5100 ± 4.3900	-1.3850 ± 2.2437
WW - 9256, 9257	Oct, 1998	Cs-137	0.6770 ± 3.4400	1.8800 ± 3.6200	1.2785 ± 2.4969
WW - 9256, 9257	Oct, 1998	H-3	4,953.1843 ± 206.9523	5,147.0443 ± 210.3507	5,050.1143 ± 147.5438
LW-9479, 9480	Oct, 1998	Gr. Beta	2.0720 ± 0.5550	1.9860 ± 0.5500	2.0290 ± 0.3907
BS-9349, 9350	Nov, 1998	Cs-137	0.0239 ± 0.0156	0.0277 ± 0.0151	0.0258 ± 0.0109
BS-9349, 9350	Nov, 1998	Gr. Beta	8.4550 ± 2.1970	6.4700 ± 2.0840	7.4625 ± 1.5141
BS-9349, 9350	Nov, 1998	K-40	6.9294 ± 0.4400	6.4650 ± 0.4290	6.6972 ± 0.3073
MI-9437, 9438	Nov, 1998	I-131	-0.1516 ± 0.2458	-0.0769 ± 0.2776	-0.1143 ± 0.1854
MI-9437, 9438	Nov, 1998	K-40	681.2300 ± 128.0000	714.6700 ± 122.0000	697.9500 ± 88.4138
MI - 9526, 9527	Nov, 1998	Co-60	2.7000 ± 5.7200	-1.9500 ± 7.4300	0.3750 ± 4.6884
MI - 9526, 9527	Nov, 1998	Cs-137	-2.2200 ± 2.8500	0.7490 ± 2.1600	-0.7355 ± 1.7880
MI - 9526, 9527	Nov, 1998	I-131	-0.0873 ± 0.2233	-0.0122 ± 0.2343	-0.0497 ± 0.1618
VE-9667, 9668	Nov, 1998	Gr. Beta	4.4810 ± 0.1970	4.3670 ± 0.1940	4.4240 ± 0.1382
VE-9667, 9668	Nov, 1998	K-40	4.2338 ± 0.2840	3.7245 ± 0.4880	3.9792 ± 0.2823
CW - 9761, 9762	Nov, 1998	Gr. Beta	2.3323 ± 1.4667	2.6450 ± 1.4133	2.4887 ± 1.0184
CW - 9761, 9762	Nov, 1998	Gr. Beta	-0.2608 ± 1.2213	0.9390 ± 1.2890	0.3391 ± 0.8878
SWT-10167, 10168	Nov, 1998	Gr. Beta	2.1779 ± 0.5699	1.9517 ± 0.5841	2.0648 ± 0.4080
CW - 10123, 10124	Nov, 1998	Gr. Beta	0.7677 ± 1.2537	1.4828 ± 1.3165	1.1252 ± 0.9090
CW - 10123, 10124	Nov, 1998	Gr. Beta	0.4380 ± 1.2388	-0.3370 ± 1.1818	0.0505 ± 0.8560
SW - 10263, 10264	Nov, 1998	Co-60	-0.9560 ± 1.1500	0.0517 ± 0.1100	-0.4522 ± 0.5776
SW - 10263, 10264	Nov, 1998	Cs-137	0.3210 ± 2.0200	-0.2150 ± 3.3100	0.0530 ± 1.9388
SW - 10263, 10264	Nov, 1998	Gr. Beta	7.9278 ± 1.9497	6.7850 ± 1.9373	7.3564 ± 1.3743
WW-9667, 9668	Nov, 1998	Gr. Beta	2.2847 ± 0.6184	1.7189 ± 0.5495	2.0018 ± 0.4136
SW-10069, 10070	Nov, 1998	Gr. Alpha	1.6469 ± 0.5301	1.5758 ± 0.5574	1.6114 ± 0.3846
SW-10069, 10070	Nov, 1998	Gr. Beta	3.4363 ± 0.4683	3.5768 ± 0.4928	3.5066 ± 0.3399
MI-10146, 10147	Dec, 1998	Calcium	0.7600 ± 0.0800	0.8000 ± 0.0800	0.7800 ± 0.0566
MI-10146, 10147	Dec, 1998	K-40	1,403.6000 ± 178.0000	1,372.9000 ± 149.0000	1,388.2500 ± 116.0657
CW - 10527, 10528	Dec, 1998	H-3	749.0265 ± 108.8588	822.9436 ± 111.3401	785.9851 ± 77.8570
SO-10573, 10574	Dec, 1998	Cs-137	367.0300 ± 80.5000	337.1100 ± 32.8000	352.0700 ± 43.4629
SO-10573, 10574	Dec, 1998	Gr. Alpha	12.1661 ± 4.0570	9.1124 ± 3.5682	10.6393 ± 2.7014
SO-10573, 10574	Dec, 1998	Gr. Beta	24.7427 ± 3.0098	26.7558 ± 3.1255	25.7493 ± 2.1695
SO-10573, 10574	Dec, 1998	K-40	17,459.0000 ± 1,260.0000	16,004.0000 ± 716.0000	16,731.5000 ± 724.6130
AP-11164, 11165	Dec, 1998	Be-7	0.0598 ± 0.0077	0.0610 ± 0.0061	0.0604 ± 0.0049
MI-10686, 10687	Dec, 1998	K-40	1,320.3000 ± 160.0000	1,350.3000 ± 166.0000	1,335.3000 ± 115.2779

Table A-5. In-house "duplicate" samples.

Lab Codes[b]	Sample Date	Analysis	Concentration in pCi/L[a] First Result	Second Result	Averaged Result
WW - 10997, 10998	Dec, 1998	H-3	803.9290 ± 109.1145	771.1156 ± 108.0125	787.5223 ± 76.7670
CW - 10793, 10794	Dec, 1998	Gr. Beta	2.6622 ± 1.4937	3.4664 ± 1.5461	3.0643 ± 1.0749
CW - 10793, 10794	Dec, 1998	Gr. Beta	-0.5610 ± 1.8946	-0.1869 ± 1.9184	-0.3740 ± 1.3481
AP-9119, 9120	Dec, 1998	Be-7	0.1386 ± 0.0876	0.1016 ± 0.0396	0.1201 ± 0.0481
WW - 10997, 10998	Dec, 1998	Co-60	-0.5400 ± 1.2300	0.1850 ± 0.5010	-0.1775 ± 0.6641
WW - 10997, 10998	Dec, 1998	Cs-137	-0.0998 ± 1.8800	-1.5000 ± 2.7400	-0.7999 ± 1.6615
AP - 11267, 11268	Dec, 1998	Co-60	0.0006 ± 0.0005	0.0002 ± 0.0002	0.0004 ± 0.0003
AP - 11267, 11268	Dec, 1998	Cs-137	0.0003 ± 0.0006	-0.0000 ± 0.0004	0.0001 ± 0.0004
SWU-10920, 10921	Dec, 1998	Gr. Beta	2.6300 ± 0.7110	2.2760 ± 0.6910	2.4530 ± 0.4957
SW-10969, 10970	Dec, 1998	Gr. Beta	2.5524 ± 0.7559	1.7077 ± 0.7056	2.1301 ± 0.5170
WW - 11018, 11019	Dec, 1998	H-3	72.8851 ± 81.0523	56.4860 ± 80.3116	64.6855 ± 57.0513
AP-11225, 11226	Dec, 1998	Be-7	0.0643 ± 0.0133	0.0674 ± 0.0087	0.0658 ± 0.0080
AP - 11246, 11247	Dec, 1998	Co-60	-0.0001 ± 0.0001	0.0002 ± 0.0003	0.0001 ± 0.0002
AP - 11246, 11247	Dec, 1998	Cs-137	-0.0002 ± 0.0004	-0.0001 ± 0.0004	-0.0001 ± 0.0003
AP-10948, 10949	Dec, 1998	Be-7	0.1379 ± 0.0647	0.2164 ± 0.0753	0.1772 ± 0.0496
SWU-10920, 10921	Dec, 1998	H-3	364.3700 ± 93.2290	364.3700 ± 93.2290	364.3700 ± 65.9229
AP-11079, 11080	Dec, 1998	Be-7	0.0680 ± 0.0120	0.0680 ± 0.0120	0.0680 ± 0.0085
WW-11101, 11102	Dec, 1998	Gr. Beta	2.2867 ± 0.6521	2.2342 ± 0.6525	2.2605 ± 0.4612
WW-11101, 11102	Dec, 1998	H-3	178.9370 ± 99.8660	165.4690 ± 99.3450	172.2030 ± 70.4320
BS-11222, 11223	Dec, 1998	Gr. Beta	7.4244 ± 1.8665	6.5452 ± 1.8652	6.9848 ± 1.3194
AP-11222, 11223	Dec, 1998	Be-7	0.1195 ± 0.0713	0.1350 ± 0.0766	0.1272 ± 0.0523

Table A-6. Department of Energy's Mixed Analyte Performance Evaluation Program (MAPEP), comparison of MAPEP and Teledyne's Midwest Laboratory results for various sample media[a].

Lab Code	Sample Type	Date Collected	Analysis	Concentration[b] Teledyne Results ±Standard Deviation[c]	MAPEP Result[d] 1s, N=1	Control Limits
SPSO-828	SOIL	Jan, 1998	Co-57	862.20 ± 86.22	1,190.00	833.00 - 1,547.00
SPSO-828	SOIL	Jan, 1998	Co-60	886.60 ± 88.66	1,110.00	777.00 - 1,443.00
SPSO-828	SOIL	Jan, 1998	Cs-137	442.80 ± 44.28	552.00	386.40 - 717.60
SPSO-828	SOIL	Jan, 1998	K-40	540.30 ± 54.03	652.00	456.40 - 847.60
SPSO-828	SOIL	Jan, 1998	Mn-54	867.40 ± 86.74	1,090.00	763.00 - 1,417.00
SPSO-828	SOIL	Jan, 1998	Ni-63	326.10 ± 32.61	405.00	283.50 - 526.50
SPSO-828	SOIL	Jan, 1998	Pu-238	52.30 ± 5.23	50.60	35.42 - 65.78
SPSO-828	SOIL	Jan, 1998	Sr-90	587.60 ± 58.76	624.00	436.80 - 811.20
SPSO-828	SOIL	Jan, 1998	U-234/233	38.20 ± 3.82	51.40	35.98 - 66.82
SPSO-828	SOIL	Jan, 1998	U-238	105.40 ± 10.54	120.00	84.00 - 156.00
SPSO-828	SOIL	Jan, 1998	Zn-65	2,256.80 ± 225.70	2,780.00	1,946.00 - 3,614.00
STW-814	WATER	Jan, 1998	Am-241	2.05 ± 0.21	2.13	1.49 - 2.77
STW-814	WATER	Jan, 1998	Co-57	253.00 ± 25.30	277.50	194.25 - 360.75
STW-814	WATER	Jan, 1998	Co-60	133.00 ± 13.30	132.46	92.72 - 172.20
STW-814	WATER	Jan, 1998	Cs-137	218.00 ± 2.18	213.12	149.18 - 277.06
STW-814	WATER	Jan, 1998	Fe-55	397.80 ± 39.80	492.10	344.47 - 639.73
STW-814	WATER	Jan, 1998	Mn-54	221.00 ± 22.10	221.63	155.14 - 288.12
STW-814	WATER	Jan, 1998	Ni-63	265.50 ± 26.50	358.90	251.23 - 466.57
STW-814	WATER	Jan, 1998	Pu-238	1.27 ± 0.13	1.40	0.98 - 1.82
STW-814	WATER	Jan, 1998	Pu-239/240	3.16 ± 0.32	3.44	2.41 - 4.47
STW-814	WATER	Jan, 1998	Sr-90	33.40 ± 3.34	32.12	22.48 - 41.76
STW-814	WATER	Jan, 1998	U-234/233	3.24 ± 0.32	3.60	2.52 - 4.68
STW-814	WATER	Jan, 1998	U-238	0.09 ± 0.01	0.00	0.00 - 0.10
STW-814	WATER	Jan, 1998	Zn-65	612.00 ± 61.20	588.30	411.81 - 764.79

[a] Results obtained by Teledyne Brown Engineering Environmental Services Midwest Laboratory as a participant in the Department of Energy's Mixed Analyte Performance Evaluation Program, Idaho Operations office, Idaho Falls, Idaho.

[b] All results are in Bq/kg or Bq/L as requested by the Department of Energy.

[c] Unless otherwise indicated, the TBEESML results are given as the mean ± 1 standard deviations for three determinations.

[d] MAPEP results are presented as the known values and expected laboratory precision (1 sigma, 1 determination) and control limits as defined by the MAPEP.

Table A-7. Environmental Measurements Laboratory Quality Assessment Program (EML), comparison of EML and Teledyne's Midwest Laboratory results for various sample media[a].

				Concentration in Bq/L[b]		
Lab Code	Sample Type	Date Collected	Analysis	Teledyne Result[c]	EML Result[d]	Control Limits[e]
STW-819	WATER	Mar, 1998	Co-60	14.80 ± 0.60	13.60 ± 1.20	0.92 - 1.18
STW-819	WATER	Mar, 1998	Cs-137	51.20 ± 1.20	46.00 ± 1.70	0.90 - 1.28
STW-819	WATER	Mar, 1998	Fe-55	243.00 ± 29.40	257.00 ± 2.50	0.31 - 1.54
STW-819	WATER	Mar, 1998	Gr. Alpha	1,592.90 ± 63.80	1,421.00 ± 100.00	0.50 - 1.29
STW-819	WATER	Mar, 1998	Gr. Beta	2,509.00 ± 67.10	2,200.00 ± 100.00	0.60 - 1.64
STW-819	WATER	Mar, 1998	H-3	399.70 ± 32.50	218.30 ± 6.51	0.65 - 1.91
The sample was acidic, causing a breakdown of resin in the tritium column. The sample was neutralized to pH 7 and reanalyzed. Result of reanalysis: 178.3±15.5 Bq/L.						
STW-819	WATER	Mar, 1998	Mn-54	61.70 ± 1.30	57.00 ± 1.90	0.87 - 1.22
STW-819	WATER	Mar, 1998	Pu-238	2.61 ± 0.27	2.53 ± 0.06	0.78 - 1.42
STW-819	WATER	Mar, 1998	Pu-239	1.79 ± 0.21	1.65 ± 0.06	0.78 - 1.42
STW-819	WATER	Mar, 1998	Sr-90	1.70 ± 0.40	4.36 ± 0.19	0.72 - 1.66
STW-819	WATER	Mar, 1998	U-238	0.50 ± 0.20	0.40 ± 0.04	0.77 - 1.35
STSO-820	SOIL	Mar, 1998	Am-241	1.67 ± 1.11	2.68 ± 0.21	0.52 - 2.65
STSO-820	SOIL	Mar, 1998	Cs-137	322.59 ± 4.57	329.50 ± 9.26	0.80 - 1.34
STSO-820	SOIL	Mar, 1998	K-40	322.10 ± 24.32	313.50 ± 10.15	0.73 - 1.67
STSO-820	SOIL	Mar, 1998	Pu-239	4.65 ± 1.66	5.31 ± 0.25	0.66 - 1.93
STSO-820	SOIL	Mar, 1998	Sr-90	9.89 ± 3.83	13.09 ± 0.28	0.46 - 2.84
STSO-820	SOIL	Mar, 1998	U-238	13.44 ± 2.49	31.90 ± 2.55	0.35 - 1.55
STVE-821	VEGETATION	Mar, 1998	Am-241	0.70 ± 0.40	± 0.05	0.68 - 2.78
STVE-821	VEGETATION	Mar, 1998	Cm-244	1.78 ± 0.33	2.17 ± 0.07	0.49 - 1.69
STVE-821	VEGETATION	Mar, 1998	Co-60	10.17 ± 1.54	10.58 ± 0.21	0.62 - 1.42
STVE-821	VEGETATION	Mar, 1998	Cs-137	166.03 ± 3.46	181.50 ± 7.14	0.81 - 1.45
STVE-821	VEGETATION	Mar, 1998	K-40	677.16 ± 31.47	707.50 ± 24.99	0.79 - 1.50
STVE-821	VEGETATION	Mar, 1998	Sr-90	315.31 ± 15.06	359.01 ± 6.02	0.48 - 1.29
STAF-822	AIR FILTER	Mar, 1998	Am-241	0.07 ± 0.01	0.07 ± 0.00	0.68 - 2.01
STAF-822	AIR FILTER	Mar, 1998	Ce-144	7.77 ± 0.62	8.21 ± 0.80	0.60 - 1.50
STAF-822	AIR FILTER	Mar, 1998	Co-57	10.15 ± 0.11	11.11 ± 0.85	0.62 - 1.22
STAF-822	AIR FILTER	Mar, 1998	Co-60	9.24 ± 0.16	9.09 ± 0.73	0.74 - 1.24
STAF-822	AIR FILTER	Mar, 1998	Cs-134	18.98 ± 0.20	19.74 ± 1.38	0.72 - 1.21
STAF-822	AIR FILTER	Mar, 1998	Cs-137	12.88 ± 0.20	11.86 ± 0.96	0.72 - 1.32
STAF-822	AIR FILTER	Mar, 1998	Mn-54	6.18 ± 0.20	5.44 ± 0.49	0.75 - 1.27
STAF-822	AIR FILTER	Mar, 1998	Pu-238	0.07 ± 0.02	0.07 ± 0.00	0.62 - 1.46
STAF-822	AIR FILTER	Mar, 1998	Pu-239	0.07 ± 0.02	0.06 ± 0.00	0.62 - 1.46
STAF-822	AIR FILTER	Mar, 1998	Sb-125	13.54 ± 0.56	12.16 ± 1.15	0.62 - 1.39
STAF-822	AIR FILTER	Mar, 1998	Sr-90	1.82 ± 0.21	1.76 ± 0.04	0.66 - 2.65

Table A-7. Environmental Measurements Laboratory Quality Assessment Program (EML), comparison of EML and Teledyne's Midwest Laboratory results for various sample media[a].

Lab Code	Sample Type	Date Collected	Analysis	Concentration in Bq/L[b] Teledyne Result[c]	EML Result[d]	Control Limits[e]
STAF-822	AIR FILTER	Mar, 1998	U-238	0.39 ± 0.08	0.03 ± 0.00	0.78 - 3.00
The cause is unknown. A dilution problem is suspected, the result is approximately ten times the known value. The calculations were reviewed, no error was found.						
STSO-834	SOIL	Sep, 1998	Ac-228	54.10 ± 3.30	52.60 ± 2.90	0.50 - 1.50
STSO-834	SOIL	Sep, 1998	Bi-212	55.40 ± 10.30	58.30 ± 5.90	0.50 - 1.50
STSO-834	SOIL	Sep, 1998	Bi-214	28.50 ± 6.50	28.80 ± 0.50	0.50 - 1.50
STSO-834	SOIL	Sep, 1998	Cs-137	915.70 ± 8.20	954.00 ± 38.00	0.80 - 1.34
STSO-834	SOIL	Sep, 1998	K-40	296.20 ± 39.90	314.00 ± 13.00	0.73 - 1.67
STSO-834	SOIL	Sep, 1998	Pb-212	53.60 ± 1.50	52.80 ± 3.70	0.50 - 1.50
STSO-834	SOIL	Sep, 1998	Pb-214	31.00 ± 5.90	29.10 ± 1.20	0.50 - 1.50
STSO-834	SOIL	Sep, 1998	Ra-226	115.30 ± 2.20	29.00 ± 1.00	0.00 - 3.00
Acceptable results according to EML. Data is under review.						
STSO-834	SOIL	Sep, 1998	Sr-90	37.40 ± 1.90	39.63 ± 0.00	0.46 - 2.84
STSO-834	SOIL	Sep, 1998	Tl-208	20.10 ± 3.10	18.30 ± 1.10	0.50 - 1.50
STW-835	WATER	Sep, 1998	Co-60	49.30 ± 2.80	49.40 ± 1.20	0.92 - 1.18
STW-835	WATER	Sep, 1998	Cs-137	50.10 ± 3.20	50.00 ± 1.70	0.90 - 1.28
STW-835	WATER	Sep, 1998	Fe-55	140.60 ± 9.20	139.00 ± 2.00	0.31 - 1.54
STW-835	WATER	Sep, 1998	Gr. Alpha	1,178.30 ± 47.20	1,080.00 ± 60.00	0.50 - 1.29
STW-835	WATER	Sep, 1998	Gr. Beta	1,613.60 ± 171.80	1,420.00 ± 60.00	0.60 - 1.64
STW-835	WATER	Sep, 1998	H-3	102.20 ± 4.50	76.20 ± 2.90	0.65 - 1.91
STW-835	WATER	Sep, 1998	Mn-54	35.90 ± 3.40	32.40 ± 1.40	0.87 - 1.22
STW-835	WATER	Sep, 1998	Sr-90	3.00 ± 0.90	2.11 ± 0.18	0.72 - 1.66
STAF-837	AIR FILTER	Sep, 1998	Co-60	9.30 ± 0.30	9.16 ± 0.58	0.74 - 1.24
STAF-837	AIR FILTER	Sep, 1998	Cs-137	22.40 ± 0.50	22.47 ± 1.03	0.72 - 1.32
STAF-837	AIR FILTER	Sep, 1998	Mn-54	5.30 ± 0.30	4.92 ± 0.40	0.75 - 1.27
STAF-837	AIR FILTER	Sep, 1998	Sb-125	10.00 ± 0.80	8.89 ± 0.55	0.60 - 1.39
STAF-838	AIR FILTER	Sep, 1998	Gr. Alpha	2.20 ± 0.10	1.65 ± 0.16	0.83 - 1.55
STAF-838	AIR FILTER	Sep, 1998	Gr. Beta	2.80 ± 0.10	2.16 ± 0.07	0.73 - 1.84
STAF-838	AIR FILTER	Sep, 1998	Sr-90	1.10 ± 0.10	1.12 ± 0.05	0.66 - 2.65
STVE-839	VEGETATION	Sep, 1998	Co-60	18.10 ± 1.50	20.00 ± 1.00	0.62 - 1.42
STVE-839	VEGETATION	Sep, 1998	Cs-137	340.40 ± 4.80	390.00 ± 20.00	0.81 - 1.45
STVE-839	VEGETATION	Sep, 1998	K-40	417.50 ± 28.20	460.00 ± 20.00	0.79 - 1.50
STVE-839	VEGETATION	Sep, 1998	Sr-90	672.50 ± 32.50	606.00 ± 40.00	0.48 - 1.29

Table A-7. Environmental Measurements Laboratory Quality Assessment Program (EML), comparison of EML and Teledyne's Midwest Laboratory results for various sample media[a].

				Concentration in Bq/L[b]		
Lab Code	Sample Type	Date Collected	Analysis	Teledyne Result[c]	EML Result[d]	Control Limits[e]

[a] The Environmental Measurements Laboratory provides the following nuclear species : Air Filters, Soil, Tissue, Vegetation and Water. Teledyne does not participate in the Tissue program.

[b] Results are reported in Bq/L^{-1} with the following exceptions: Air Filter results are reported in $Bq/Filter^{-1}$, Soil results are reported in Bq/Kg^{-1}, Vegetation results are reported in Bq/Kg^{-1}. The results of elemental Uranium are reported in $ug/filter^{-1}$, g, or ml.

[c] Teledyne results are reported as the mean of three determinations±standard deviation.

[d] The EML result listed is the mean of replicate determinations for each nuclide±the standard error of the mean.

[e] The control limits are reported by EML and are established from percentiles of historic data distributions (1982-1992). The evaluation of this historic data and the development of the control limits is presented in DOE report EML-564.

APPENDIX B

DATA REPORTING CONVENTIONS

1.0. All activities except gross alpha and gross beta are decay corrected to collection time or the end of the collection period.

2.0. Single Measurements

Each single measurement is reported as follows:

$$x \pm s$$

where x = value of the measurement;

s = 2σ counting uncertainty (corresponding to the 95% confidence level).

In cases where the activity is found to be below the lower limit of detection L it is reported as

<L

where L = the lower limit of detection based on 4.66σ uncertainty for a background sample.

3.0. Duplicate analyses

3.1 Individual results: $x_1 \pm s_1$
$x_2 \pm s_2$

Reported result: $x \pm s$

where $x = (1/2)\,(x_1 + x_2)$

$$s = (1/2)\sqrt{s_1^2 + s_2^2}$$

3.2. Individual results: $<L_1$

$<L_2$

Reported result: <L

where L = lower of L_1 and L_2

3.3. Individual results: $x \pm s$

<L

Reported result: $x \pm s$ if $x \geq L$;

<L otherwise

4.0. Computation of Averages and Standard Deviations

4.1 Averages and standard deviations listed in the tables are computed from all of the individual measurements over the period averaged; for example, an annual standard deviation would not be the average of quarterly standard deviations. The average $\bar{x}$ and standard deviation s of a set of n numbers $x_1, x_2 \ldots x_n$ are defined as follows:

$$\bar{x} = \frac{1}{n} \Sigma x$$

$$s = \sqrt{\frac{\Sigma (x - \bar{x})^2}{n-1}}$$

4.2 Values below the highest lower limit of detection are not included in the average.

4.3 If all of the values in the averaging group are less than the highest LLD, the highest LLD is reported.

4.4 If all but one of the values are less than the highest LLD, the single value x and associated two sigma error is reported.

4.5 In rounding off, the following rules are followed:

4.5.1. If the figure following those to be retained is less than 5, the figure is dropped, and the retained figures are kept unchanged. As an example, 11.443 is rounded off to 11.44.

4.5.2. If the figure following those to be retained is equal to or greater than 5, the figure is dropped and the last retained figure is raised by 1. As an example, 11.445 is rounded off to 11.45.

APPENDIX C

Maximum Permissible Concentrations

of Radioactivity in Air and Water

Above Background in Unrestricted Areas

Table C-1. Maximum permissible concentrations of radioactivity in air and water above natural background in unrestricted areas[a].

Air		Water	
Gross alpha	3 pCi/m^3	Strontium-89	3,000 pCi/L
Gross beta	100 pCi/m^3	Strontium-90	300 pCi/L
Iodine-131[b]	0.14 pCi/m^3	Cesium-137	20,000 pCi/L
		Barium-140	20,000 pCi/L
		Iodine-131	300 pCi/L
		Potassium-40[c]	3,000 pCi/L
		Gross alpha	30 pCi/L
		Gross beta	100 pCi/L
		Tritium	3×10^6 pCi/L

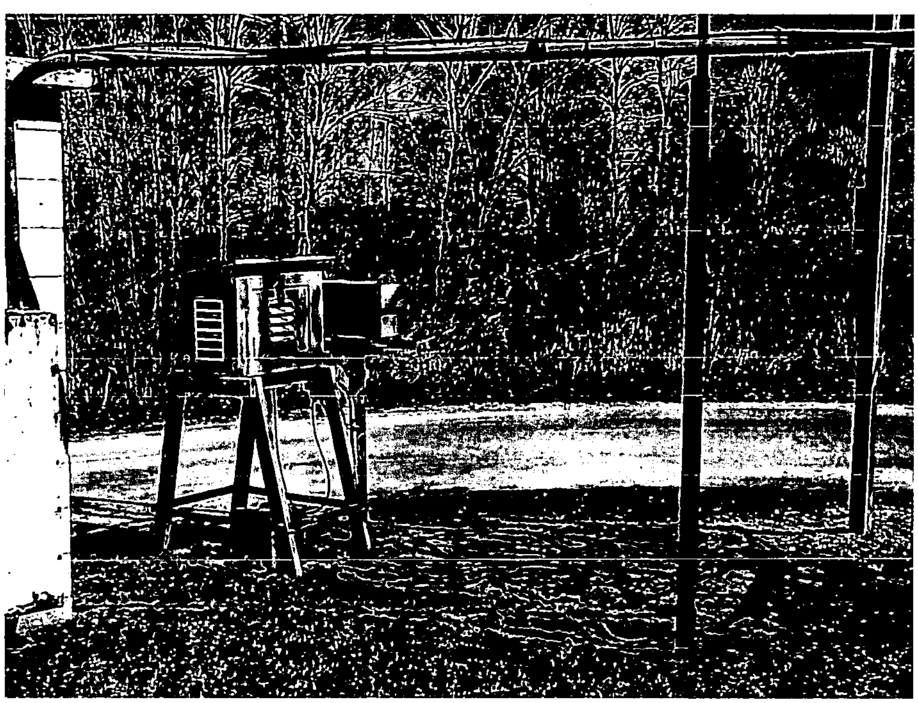
[a] Taken from Table II of Appendix B to Code of Federal Regulations Title 10, Part 20.1-20.601, and appropriate footnotes. Concentrations may be averaged over a period not greater than one year.

[b] From 10 CFR 20.1-20.601 but adjusted by a factor of 700 to reduce the dose resulting from the air-grass-cow-milk-child pathway.

[c] A natural radionuclide.

ANNUAL REPORT PART II

DATA TABULATIONS
GRAPHS AND ANALYSES



Air sampler located at K-1k

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REPORT TO

WISCONSIN PUBLIC SERVICE CORPORATION
WISCONSIN POWER AND LIGHT COMPANY
MADISON GAS AND ELECTRIC COMPANY

RADIOLOGICAL MONITORING PROGRAM FOR THE KEWAUNEE NUCLEAR POWER PLANT KEWAUNEE, WISCONSIN

ANNUAL REPORT - PART II
DATA TABULATIONS AND ANALYSES
January - December 1998

PREPARED AND SUBMITTED
BY
TELEDYNE BROWN ENGINEERING ENVIRONMENTAL SERVICES
MIDWEST LABORATORY

PROJECT NO. 8002

Approved by: ______________________
Bronia Grob, M.S.
Technical Lead

19 April 1999

PREFACE

The staff members of the Teledyne Brown Engineering Environmental Services, Midwest Laboratory (TBEESML) were responsible for the acquisition of data presented in this report. Samples were collected by the personnel of TBEESML and Wisconsin Public Service Corporation.

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KEWAUNEE

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1.0 INTRODUCTION

The following constitutes Part II of the final report for the 1998 Radiological Monitoring Program conducted at the Kewaunee Nuclear Power Plant (KNPP), Kewaunee, Wisconsin. Included are tabulations of data for all samples collected in 1998, statistical analyses of the data, graphs of data trends, and descriptions of radiochemical procedures. A summary and interpretation of the data presented here are published in Part I of the 1998 Annual Report on the Radiological Monitoring Program for the Kewaunee Nuclear Power Plant.

NOTE: Page 2 is intentionally left out.

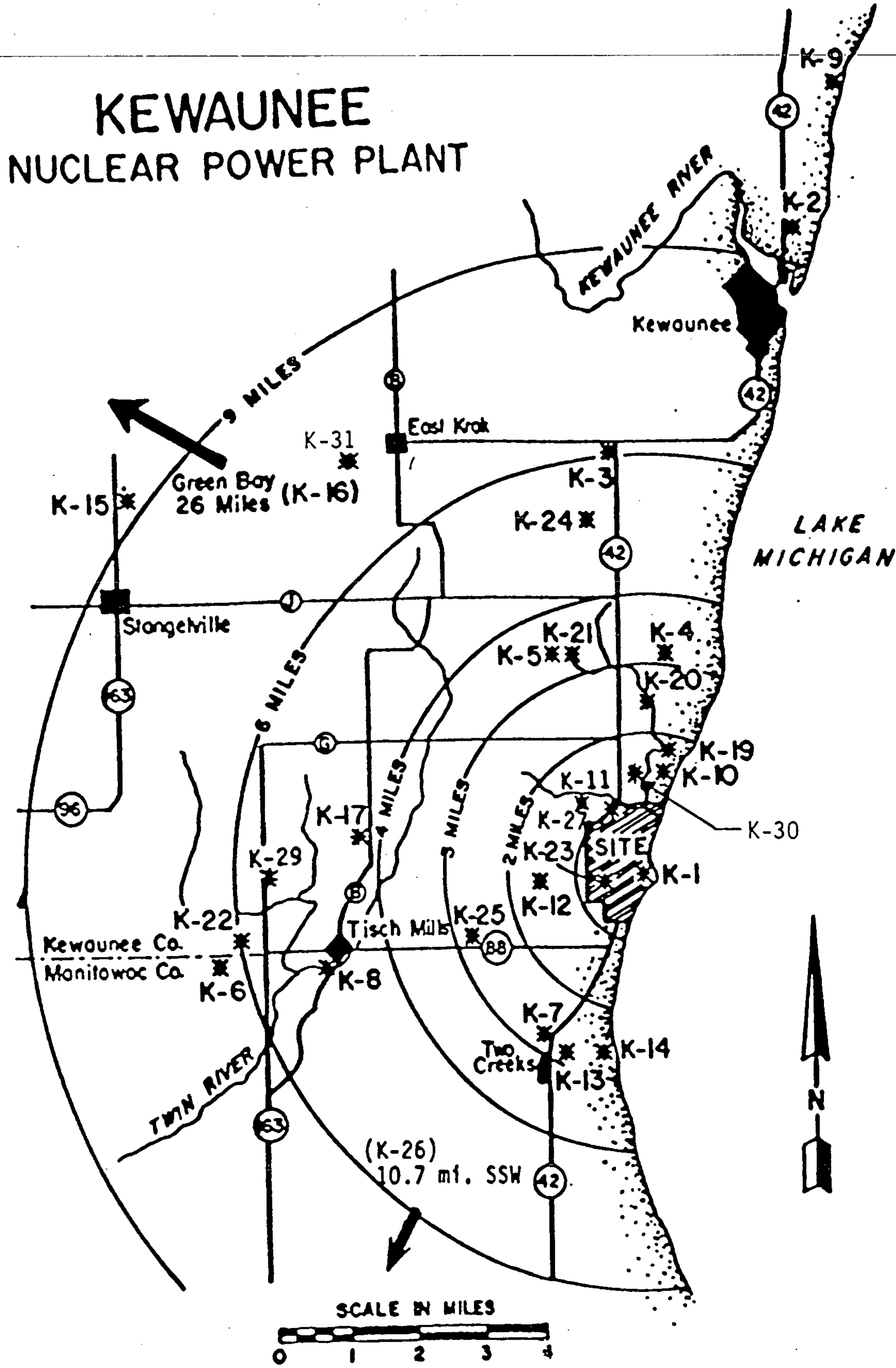

Figure 1. Sampling locations, Kewaunee Nuclear Power Plant

Table 1. Sampling locations, Kewaunee Nuclear Power Plant.

Code	Type[a]	Distance (miles)[b] and Sector	Location
K-1			Onsite
K-1a	I	0.62 N	North Creek
K-1b	I	0.12 N	Middle Creek
K-1c	I	0.10 N	500' north of condenser discharge
K-1d	I	0.10 E	Condenser discharge
K-1e	I	0.12 S	South Creek
K-1f	I	0.12 S	Meteorological Tower
K-1g	I	0.06 W	South Well
K-1h	I	0.12 NW	North Well
K-1j	I	0.10 S	500' south of condenser discharge
K-1k	I	0.60 SW	Drainage Pond
K-2	C	9.5 NNE	WPS Operations Building in Kewaunee
K-3	C	6.0 N	Lyle and John Siegmund Farm, Route 1, Kewaunee
K-4	I	3.0 N	Tom Stangel Farm, Route 1, Kewaunee
K-5	I	3.5 NNW	Ed Paplham Farm, Route 1, Kewaunee
K-6	C	6.7 WSW	Novitsky Farm
K-7	I	2.75 SSW	Ron Zimmerman Farm, Route 3, Two Rivers
K-8	C	5.0 WSW	Saint Mary's Church, Tisch Mills
K-9	C	11.5 NNE	Rostok Water Intake for Green Bay, Wisconsin, two miles north of Kewaunee
K-10	I	1.5 NNE	Turner Farm, Kewaunee site
K-11	I	1.0 NW	Harlan Ihlenfeld Farm
K-12	I	1.5 WSW	Lecaptain Farm, one mile west of site
K-13	C	3.0 SSW	Rand's General Store
K-14	I	2.5 S	Two Creeks Park, 2.5 miles south of site
K-15	C	9.25 NW	Gas Substation, 1.5 miles north of Stangelville
K-16	C	26 NW	WPS Division Office Building, Green Bay, Wisconsin
K-17	I	4.25 W	Jansky's Farm, Route 1, Kewaunee
K-19	I	1.75 NNE	Wayne Paral Farm, Route 1, Kewaunee
K-20	I	2.5 N	Carl Struck Farm, Route 1, Kewaunee
K-23	I	0.5 W	0.5 miles west of plant, Kewaunee site
K-24	C	5.45 N	Fectum Farm, Route 1, Kewaunee
K-25	C	2.75 WSW	Wotachek Farm, Route 1, Denmark
K-26	C	10.7 SSW	Bertler's Fruit Stand (8.0 miles south of "BB")
K-27	I	1.5 NW	Schlies Farm, 0.5 miles west of K-11
K-28	C	26 NW	Hansen Dairy, Green Bay, Wisconsin
K-29	I	5.75 W	Kunesh Farm, Route 1, Kewaunee
K-30	I	1.00 N	End of site boundary
K-31	C	6.25 NNW	E. Krok Substation
K-32	C	11.5 mi. N	Piggly Wiggly Foods, 931 Marquette Dr., Kewaunee

[a] I= indicator; C = control.

[b] Distances are measured from reactor stack.

Table 2. Type and frequency of collection.

Location	Weekly	Biweekly	Monthly	Quarterly	Semiannually	Annually
				Frequency		
K-1a			SW		SL	
K-1b			SW	GR[a]	SL	
K-1c					BS[b]	
K-1d			SW	FI	BS[b], SL	
K-1e			SW		SL	
K-1f	AP	AI		GR[a], TLD	SO	
K-1g				WW		
K-1h				WW		
K-1j					BS[b]	
K-1k			SW		SL	
K-2	AP	AI		TLD		
K-3			MI[c]	GR[a], TLD, CF[d]	SO	
K-4			MI[c]	GR[a], TLD, CF[d]	SO	
K-5			MI[c]	GR[a], TLD, CF[d]	SO	
K-6			MI[c]	GR[a], TLD, CF[d]	SO	
K-7	AP	AI		TLD		
K-8	AP	AI		TLD		
K-9			SW		BS[b], SL	
K-10				WW		
K-11			PR	WW		
K-12			MI[c]	GR[a], CF[d], WW	SO	
K-13				WW		
K-14			SW		BS[b], SL	
K-15[e]				TLD		
K-16	AP	AI		TLD		
K-17				TLD		VE
K-19			MI[c]	GR[a], CF[d]	SO	
K-20						DM
K-23						GRN
K-24				EG		DM
K-26						VE
K-27				TLD, EG		DM
K-28			MI[c]			
K-29						DM
K-30				TLD		
K-31	AP	AI		TLD		
K-32						DM

[a] Three times a year, second (April, May, June), third (July, August, September), and fourth (October, November, December) quarters.
[b] To be collected in May and November.
[c] Monthly from November through April; semimonthly May through October.
[d] First quarter (January, February, March) only.
[e] Air sampler moved to K-31, September, 1997.

Table 3. Sample codes used in Table 2.

Code	Description
AP	Airborne Particulate
AI	Airborne Iodine
TLD	Thermoluminescent Dosimeter
PR	Precipitation
MI	Milk
WW	Well Water
DM	Domestic Meat
EG	Eggs
VE	Vegetables
GRN	Grain
GR	Grass
CF	Cattlefeed
SO	Soil
SW	Surface Water
FI	Fish
SL	Slime
BS	Bottom Sediments

KEWAUNEE

GROSS BETA

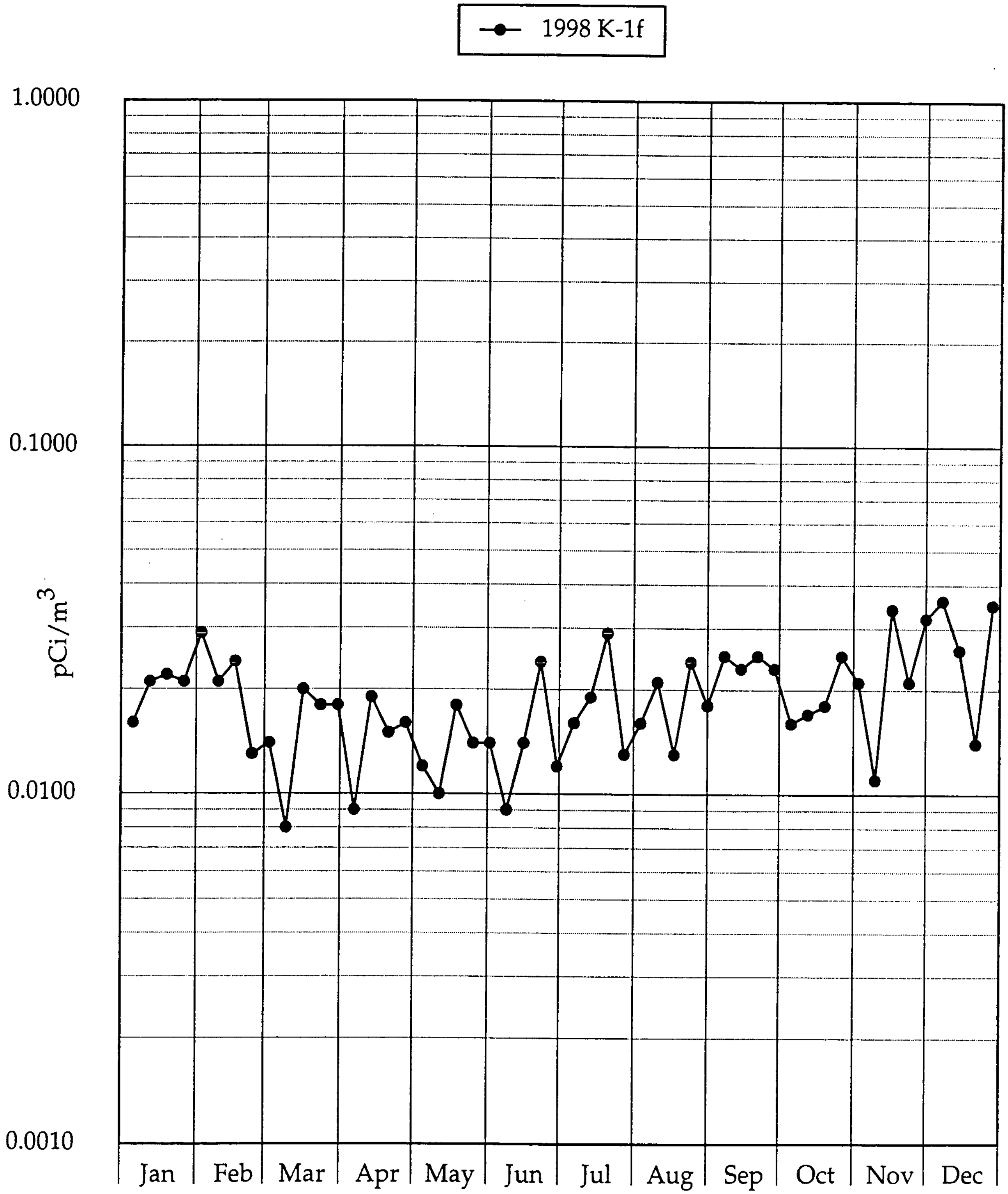

Figure 2. Airborne particulates. Location K-1f (weekly averages). A break in plot indicates missing data.

GROSS BETA

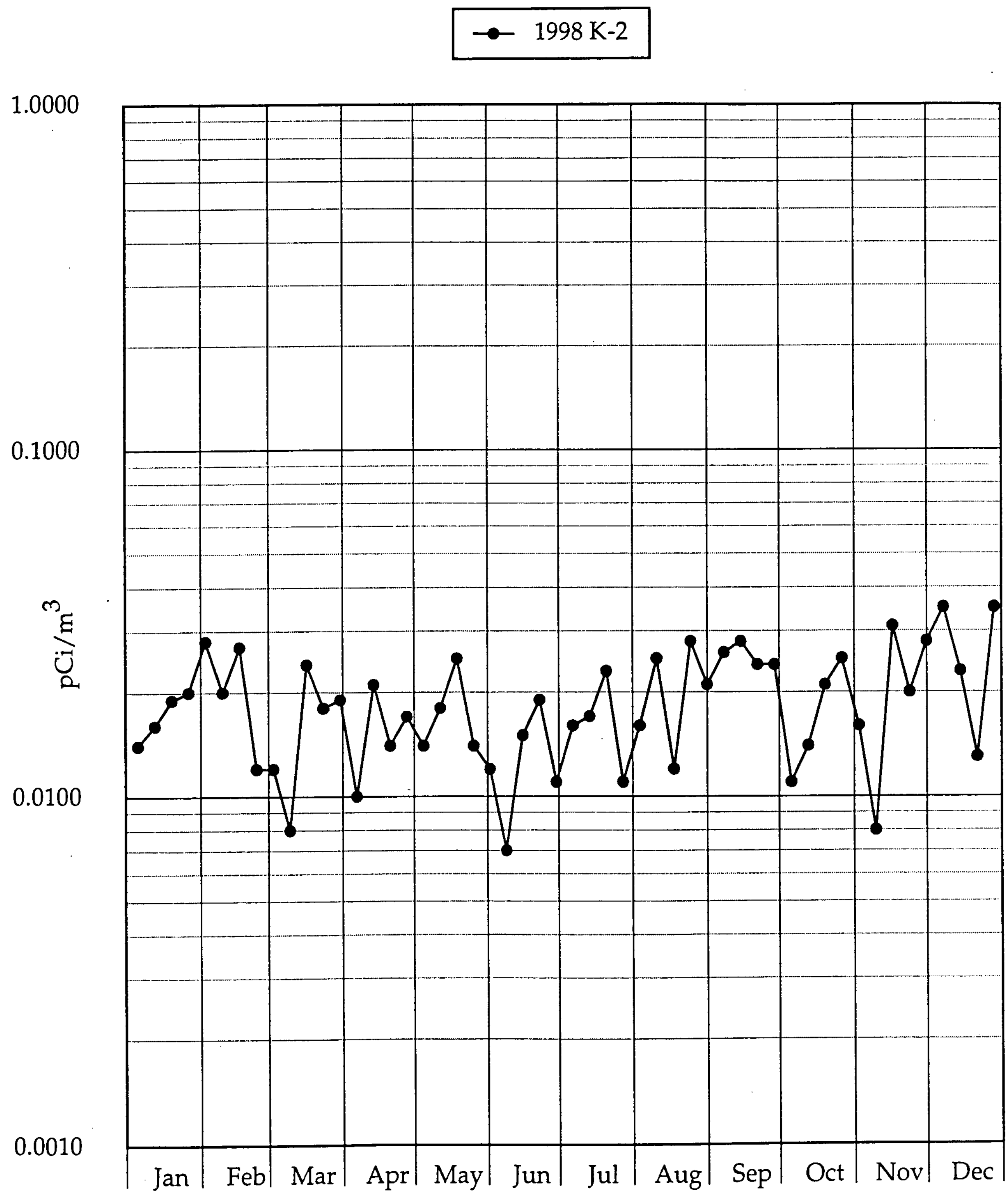

Figure 3. Airborne particulates. Location K-2 (weekly Averages). A break in plot indicates missing data.

GROSS BETA

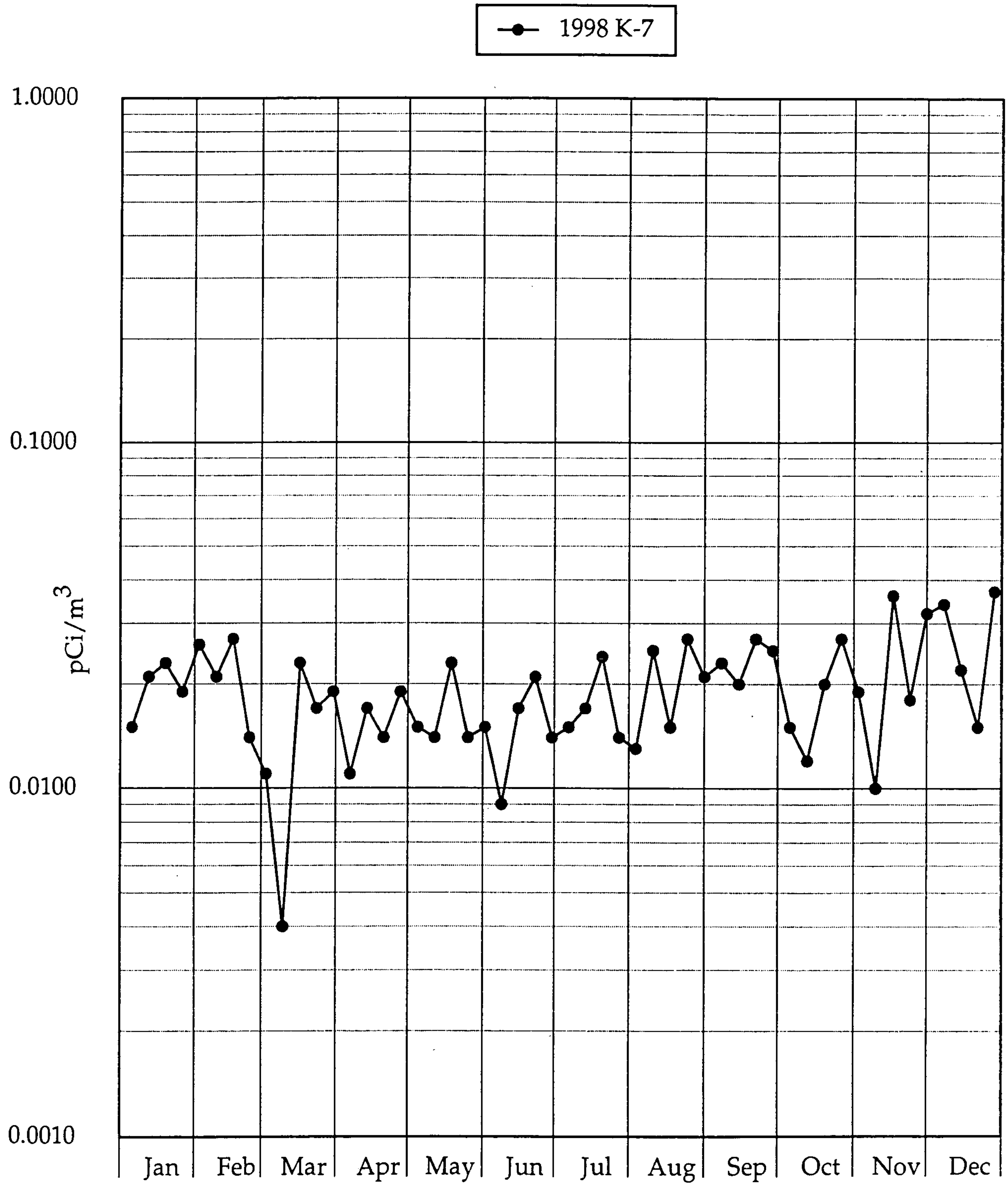

Figure 4. Airborne particulates. Location K-7 (weekly averages). A break in plot indicates missing data.

GROSS BETA

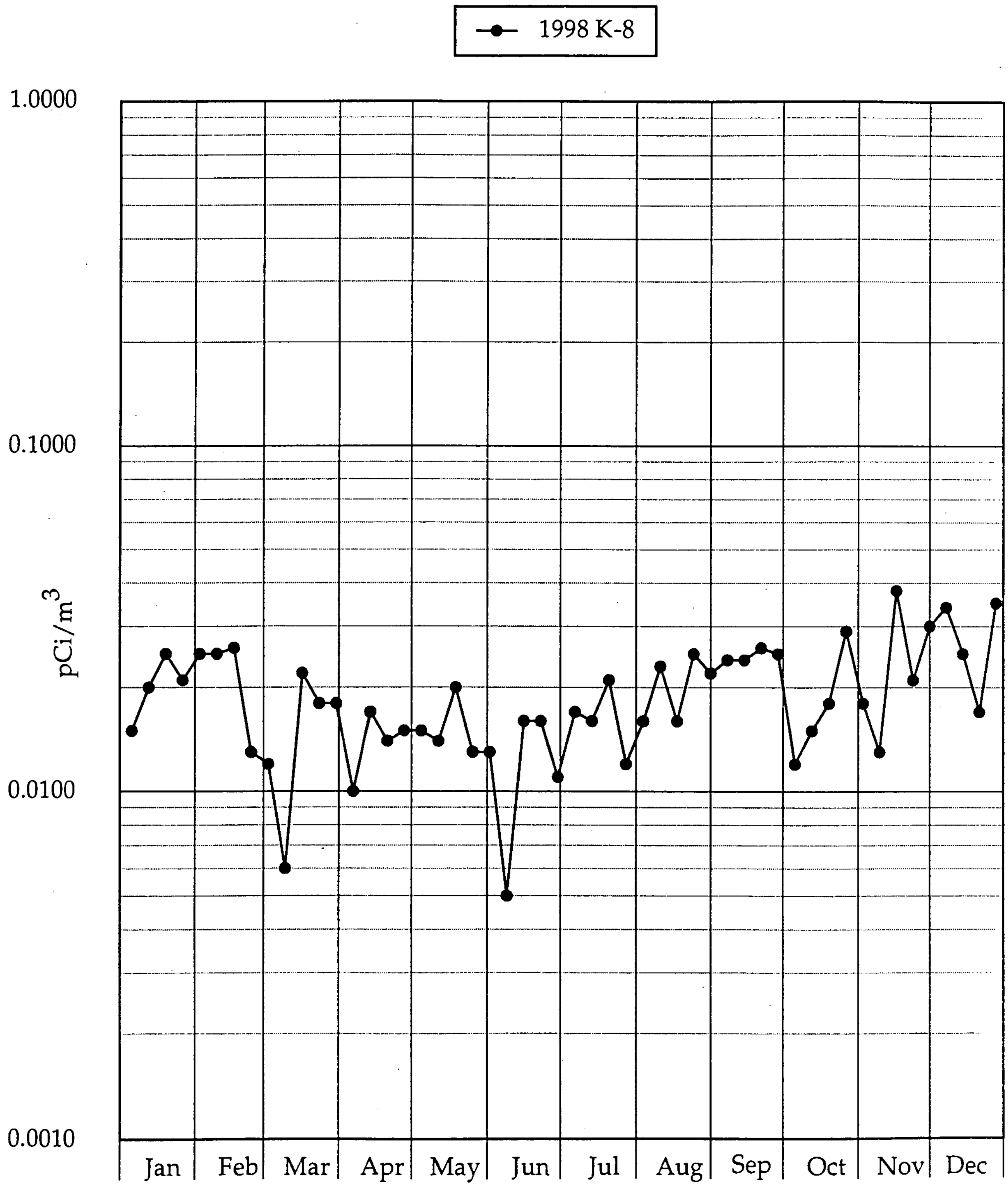

Figure 5. Airborne particulates. Location K-8 (weekly averages). A break in plot indicates missing data.

GROSS BETA

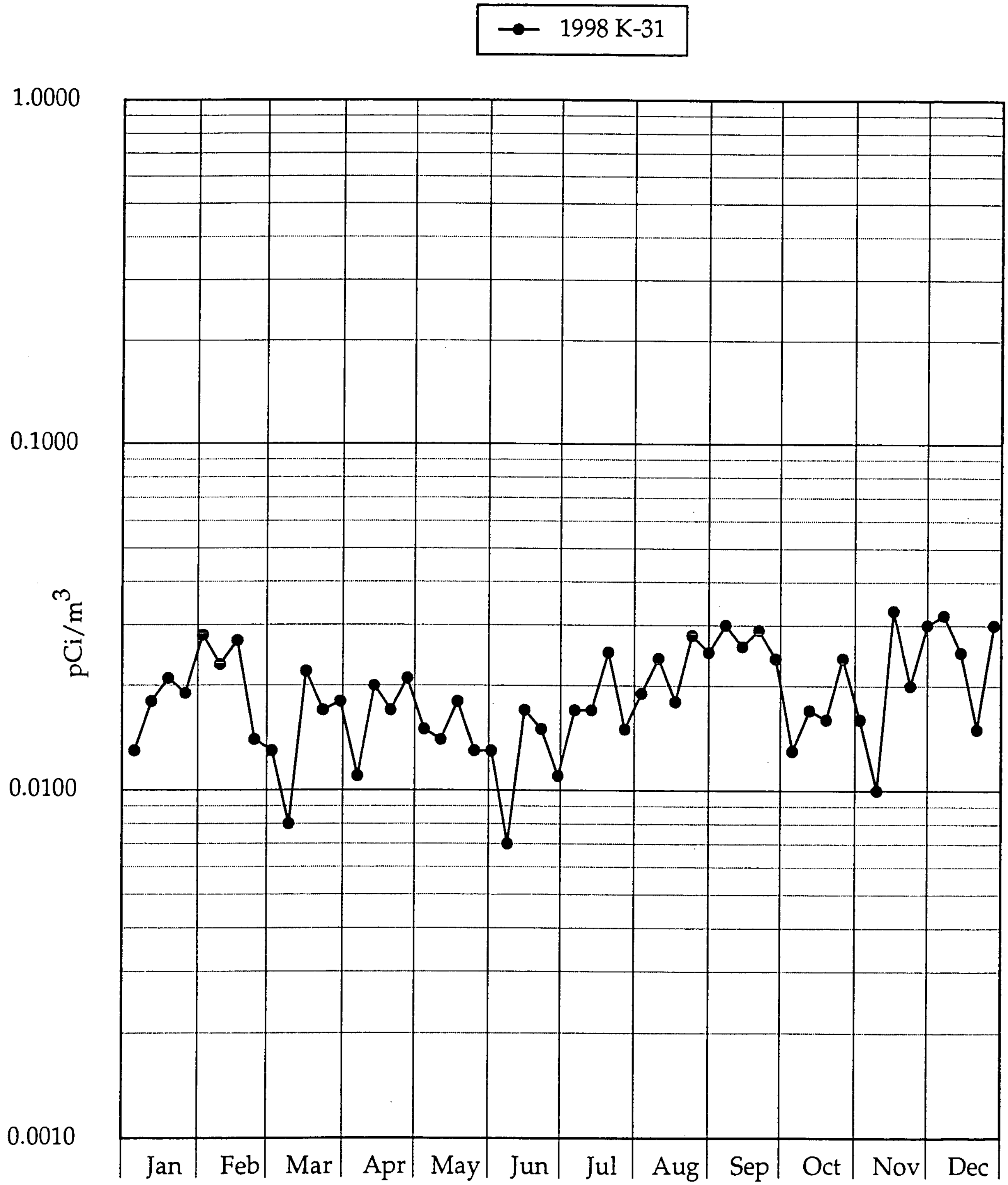

Figure 6. Airborne particulates. Location K-31 (weekly averages). A break in plot indicates missing data.

GROSS BETA

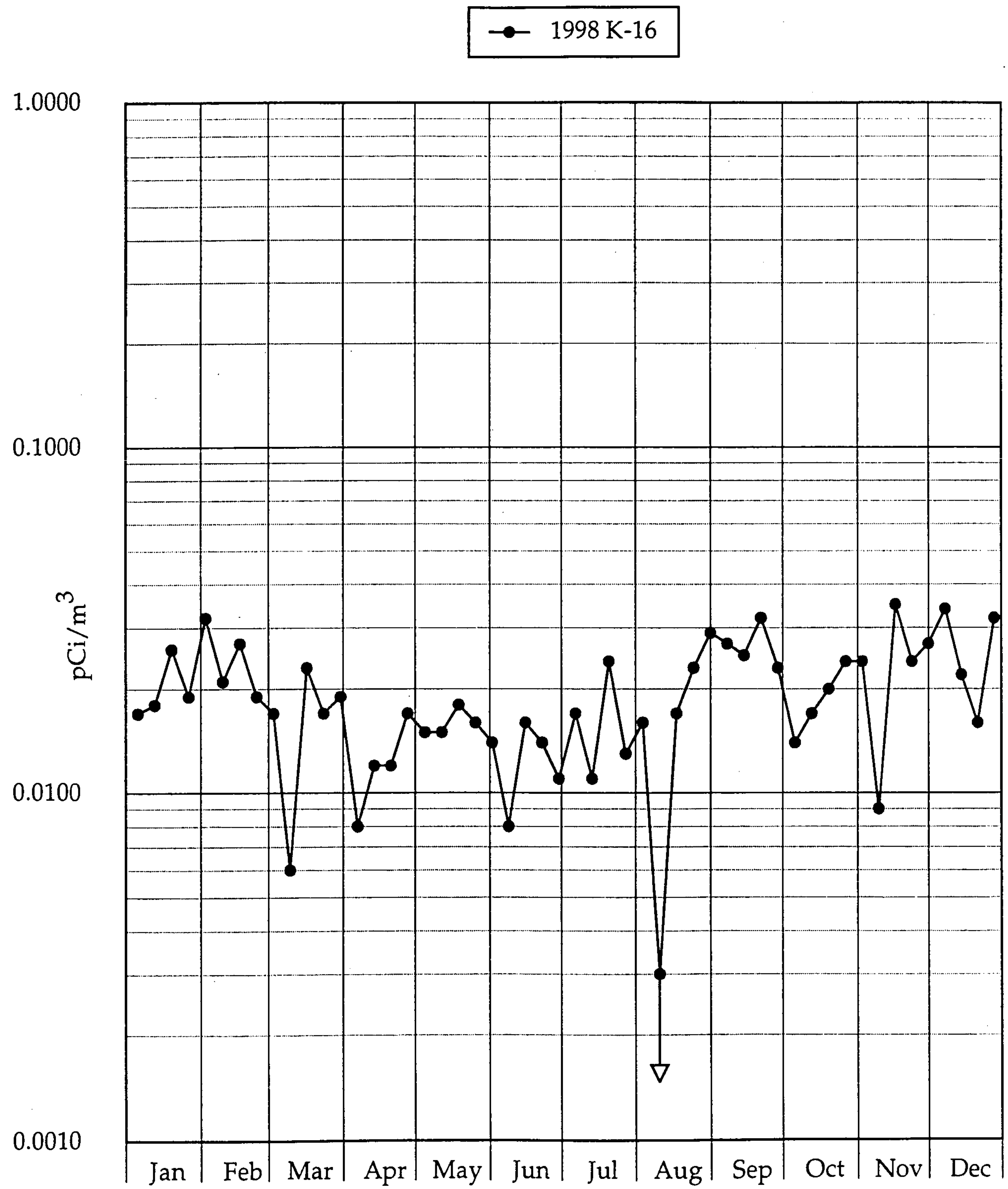

Figure 7. Airborne particulates. Location K-16 (weekly averages). A break in plot indicates missing data.

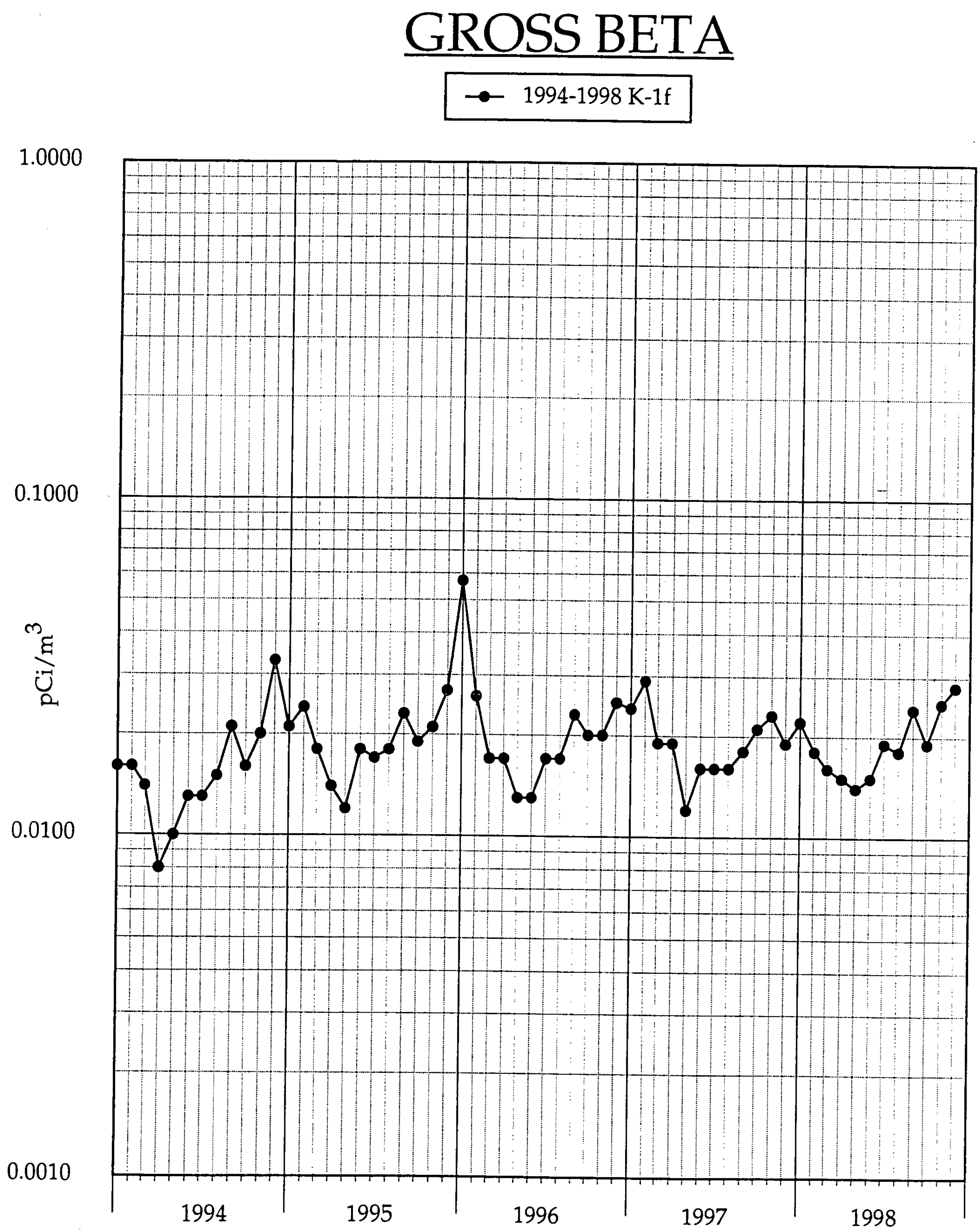

Figure 8. Monthly averages of airborne particulates collected weekly at location K-1f. A break in plot indicates missing data.

GROSS BETA

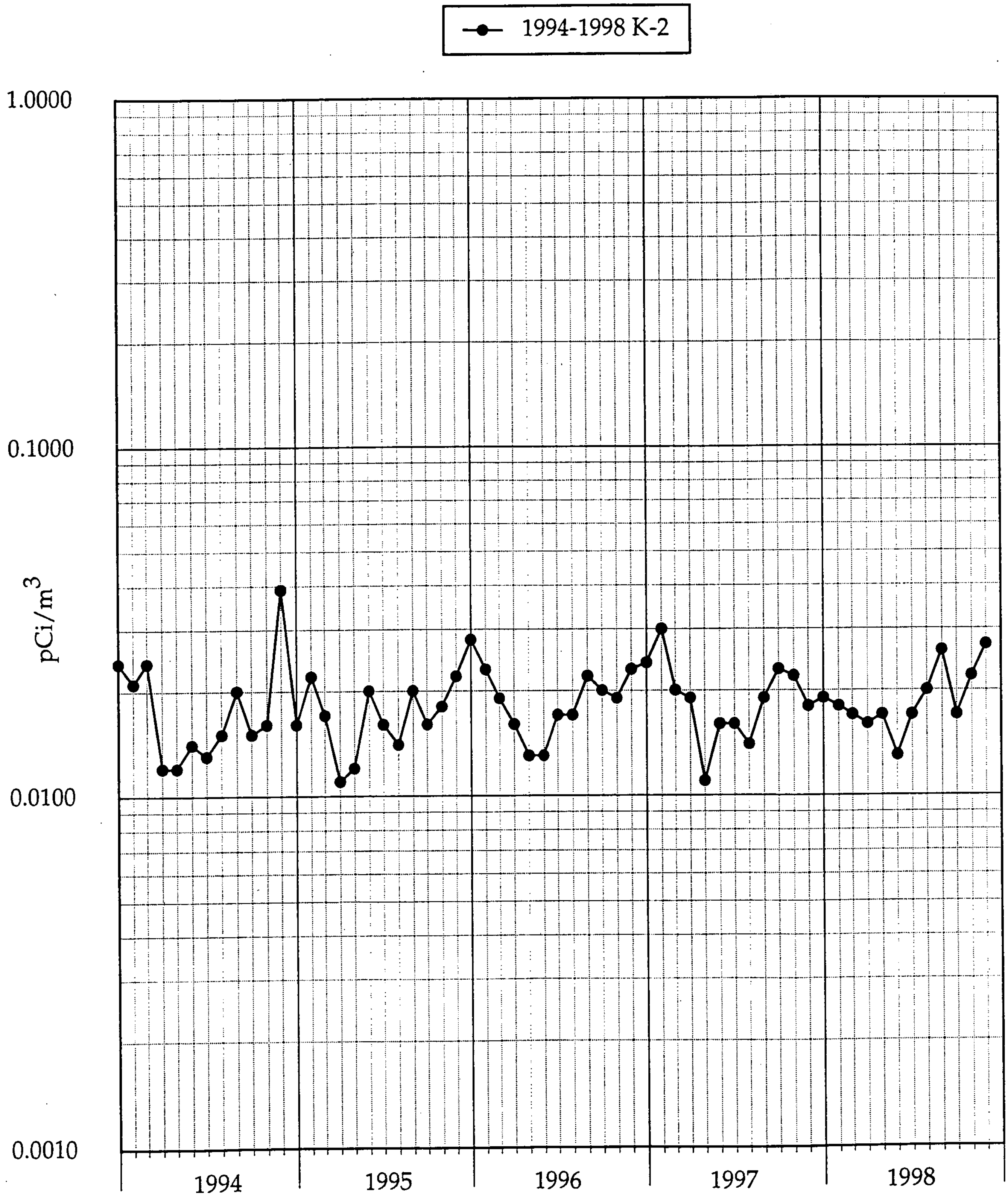

Figure 9. Monthly averages of airborne particulates collected weekly at location K-2. A break in plot indicates missing data.

GROSS BETA

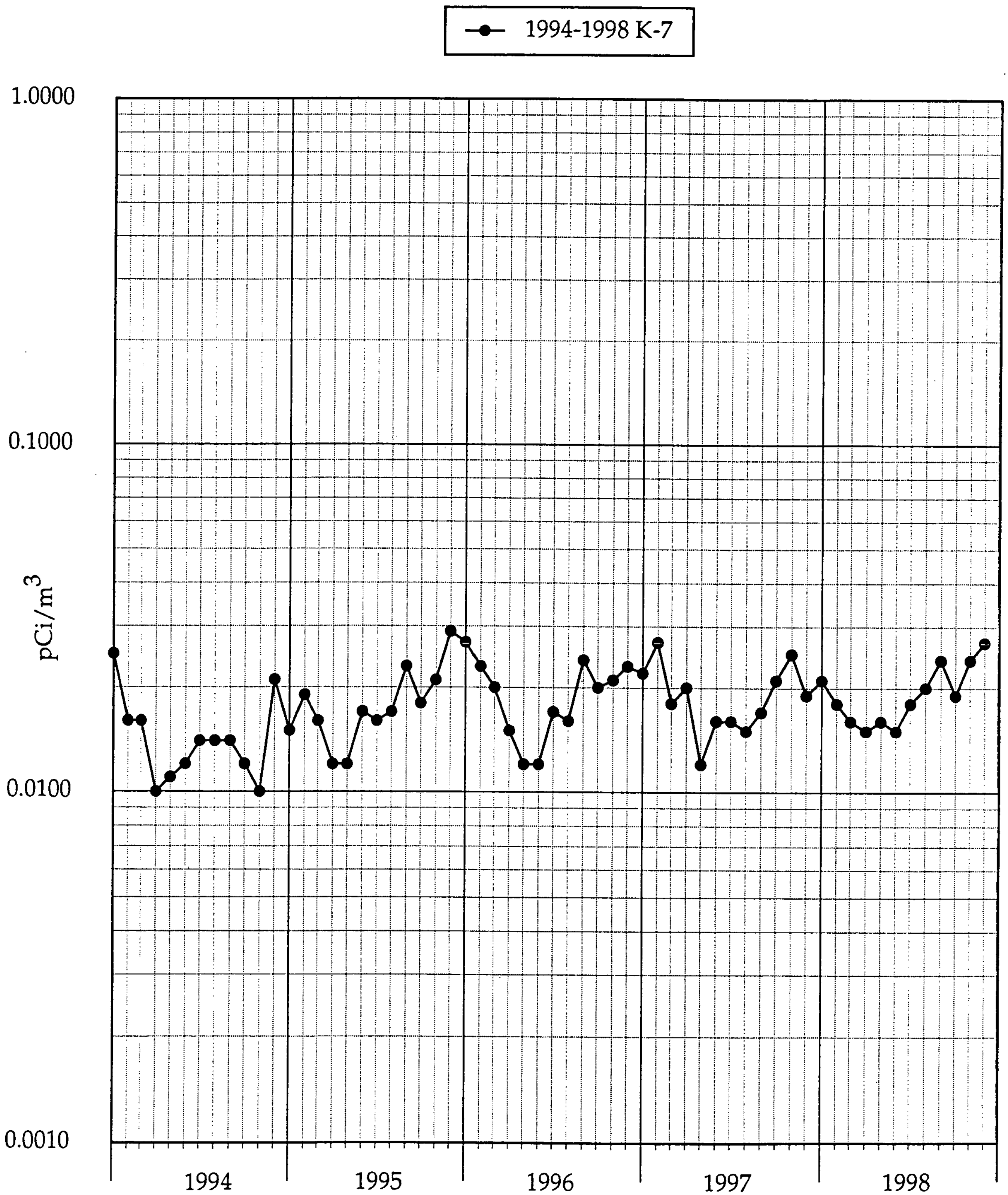

Figure 10. Monthly averages of airborne particulates collected weekly at location K-7. A break in plot indicates missing data.

GROSS BETA

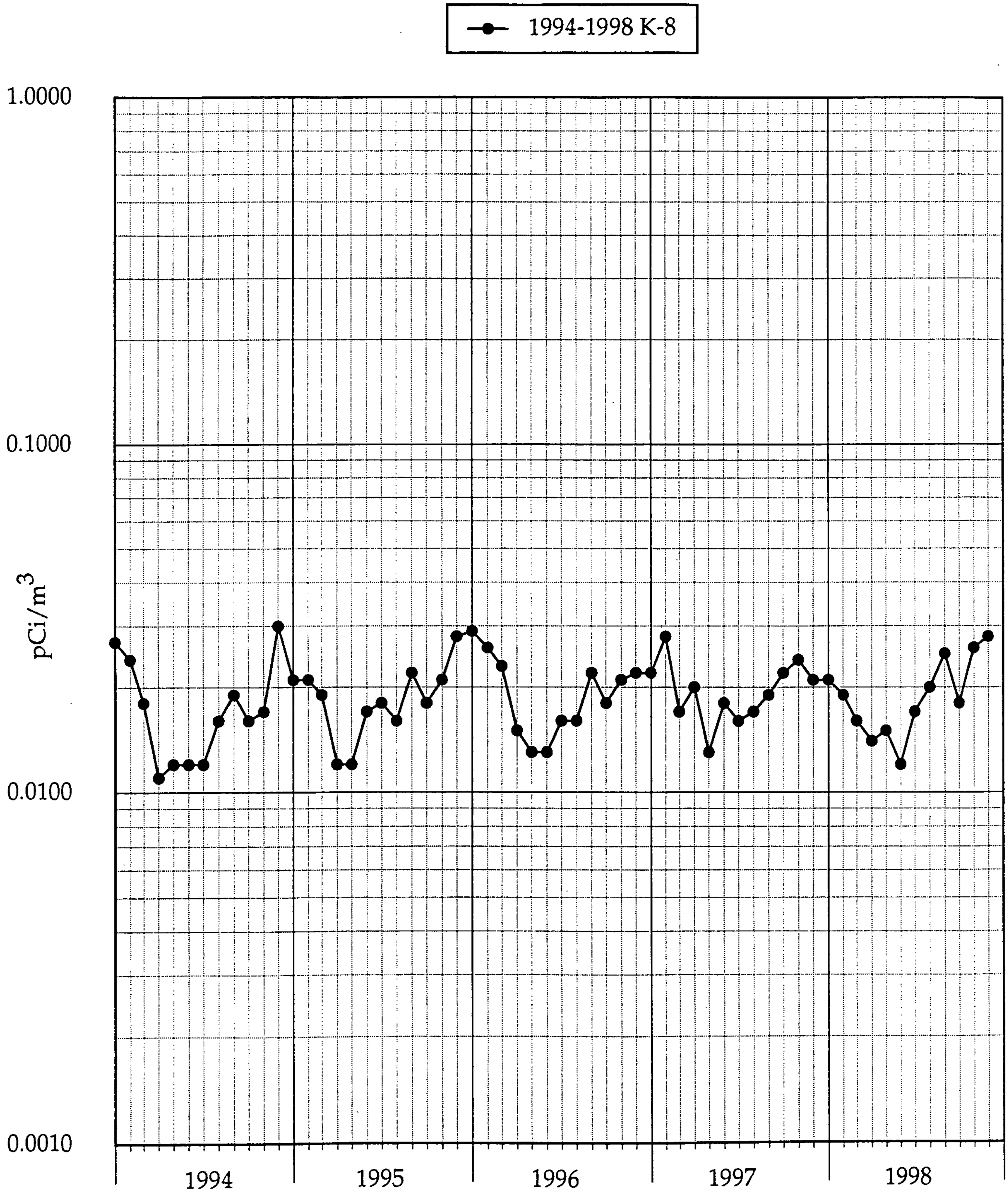

Figure 11. Monthly averages of airborne particulates collected weekly at location K-8. A break in plot indicates missing data.

GROSS BETA

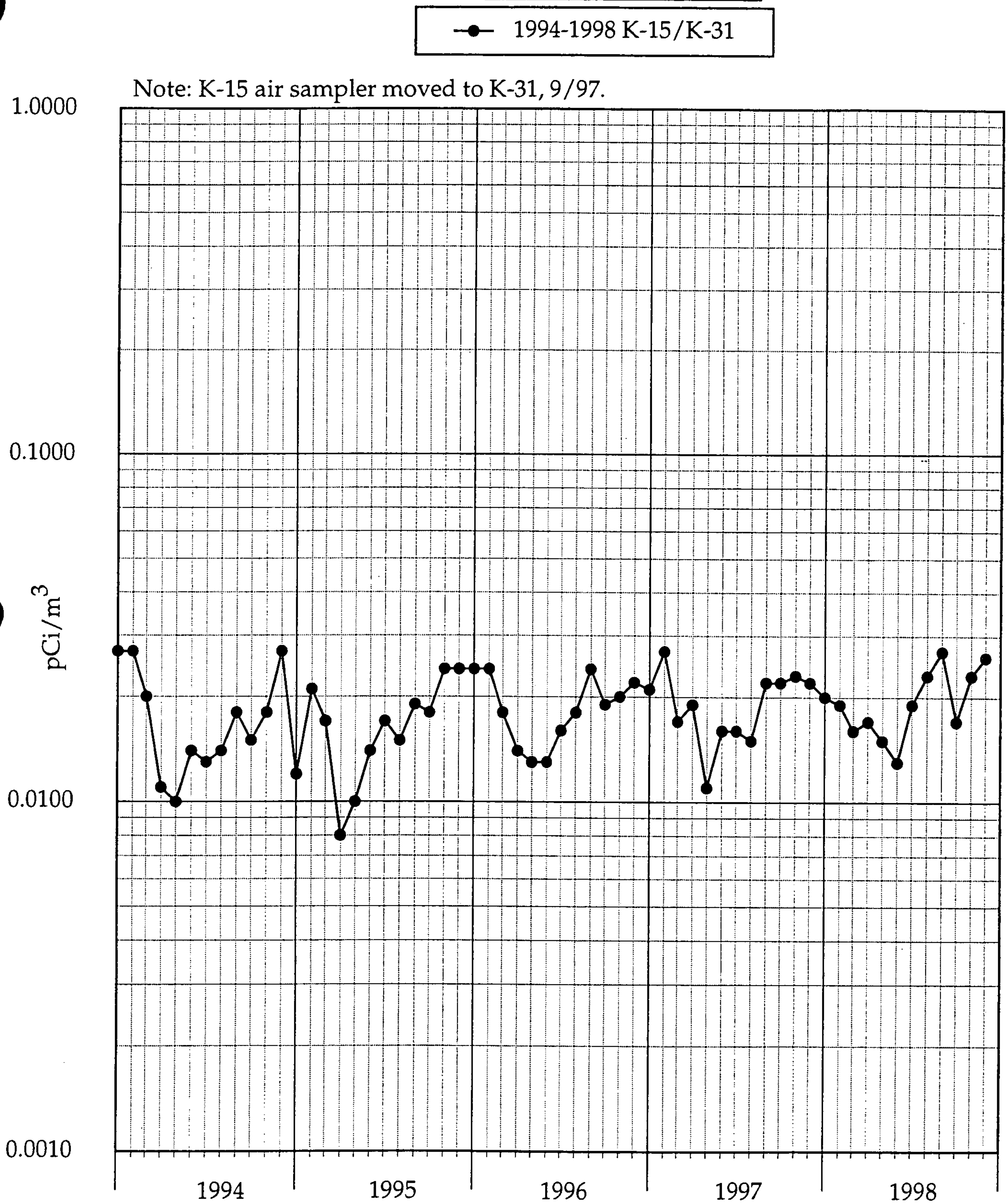

Figure 12. Monthly averages of airborne particulates collected weekly at location K-31. A break in plot indicates missing data.

GROSS BETA

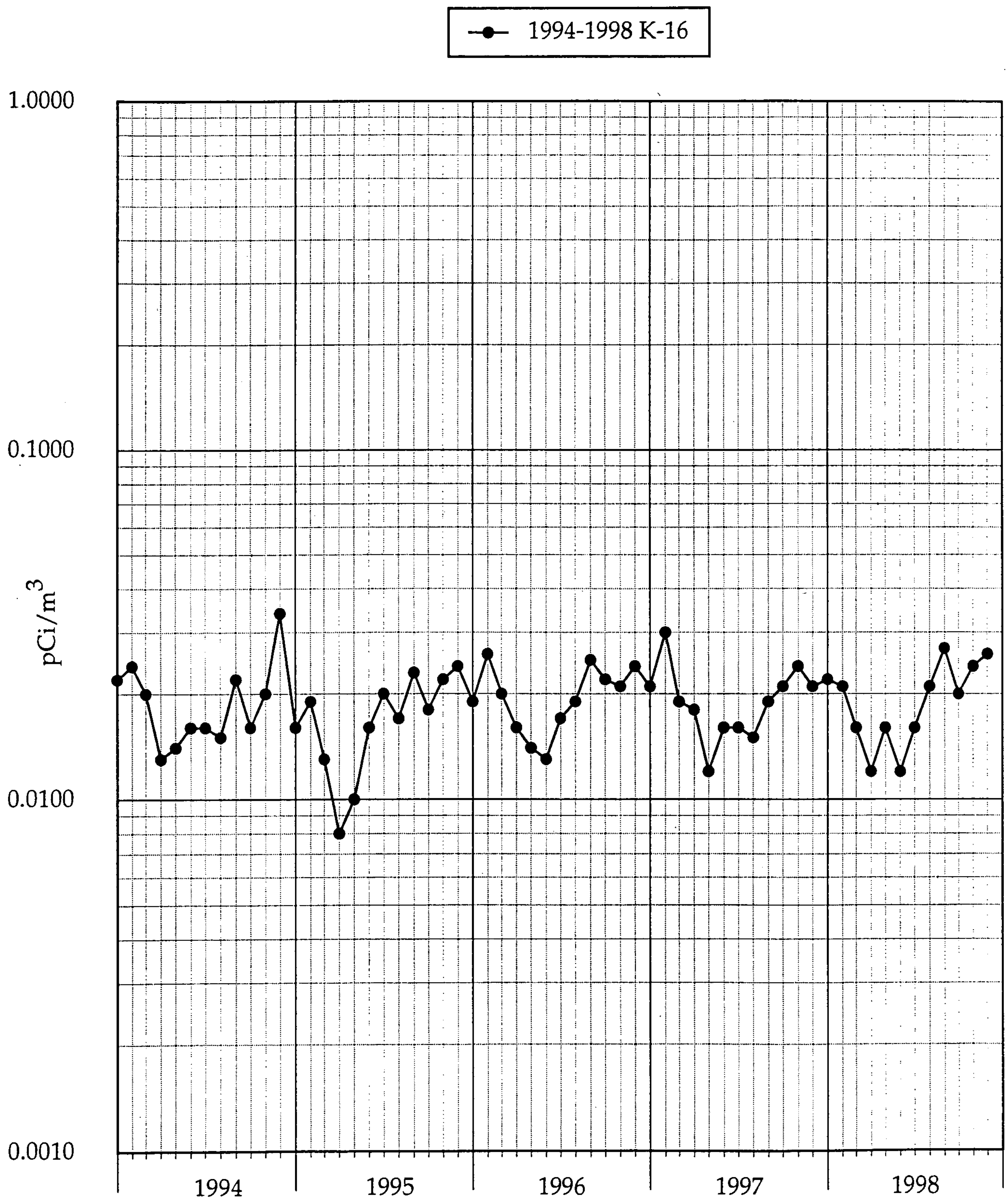

Figure 13. Monthly averages of airborne particulates collected weekly at location K-16. A break in plot indicates missing data.

GROSS ALPHA

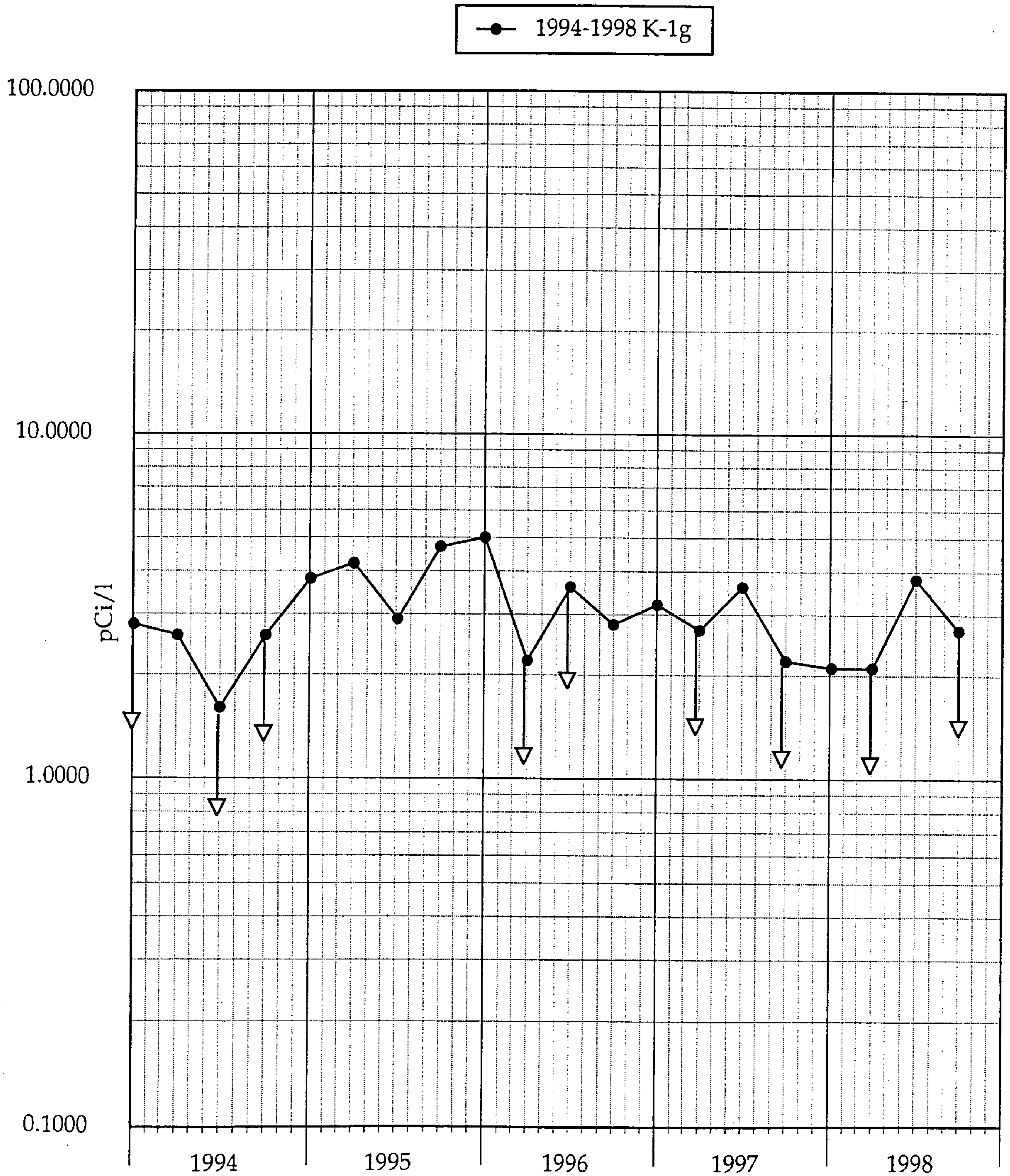

Figure 14. Well water samples. Location K-1g. (Total residue)

GROSS ALPHA

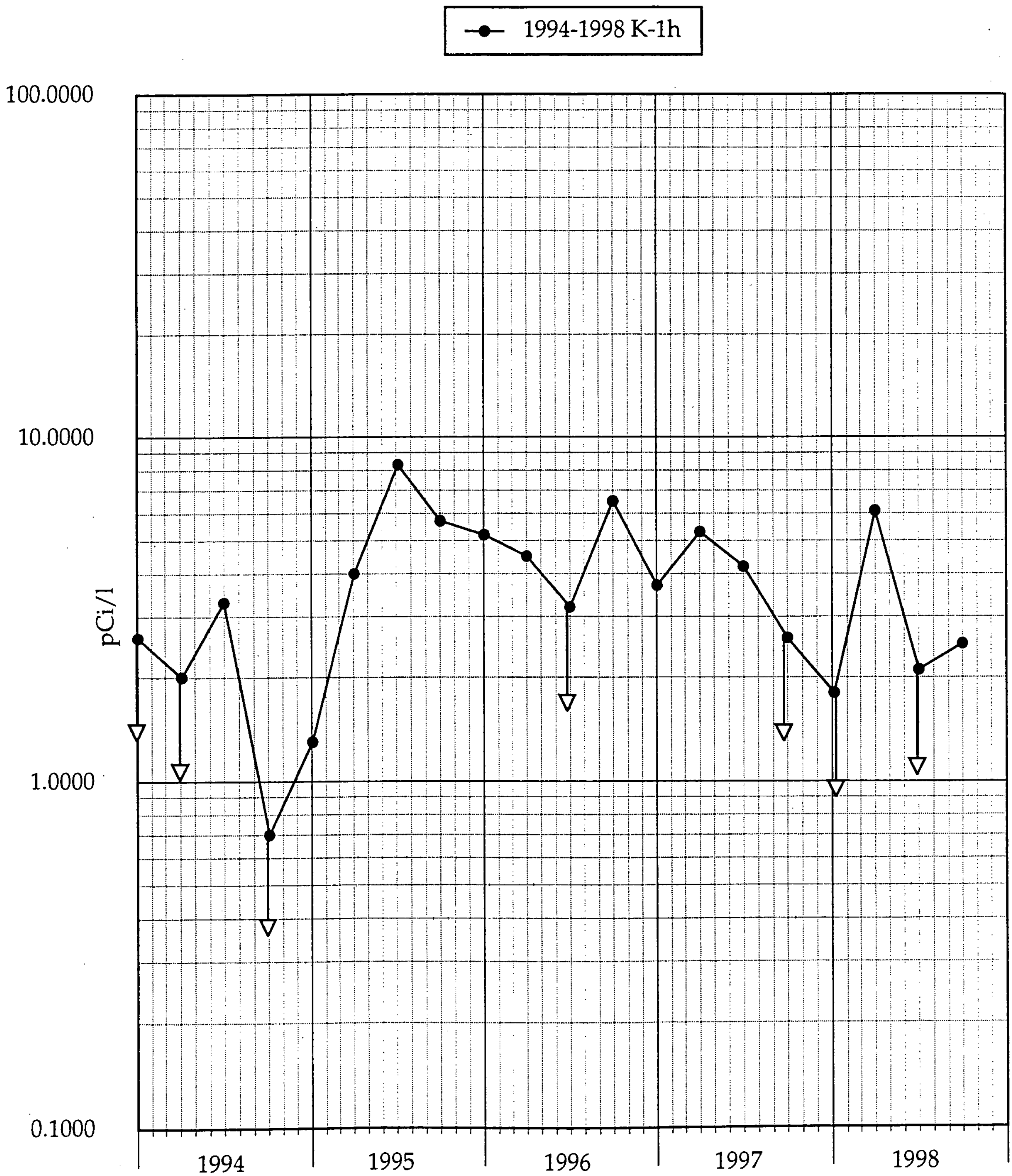

Figure 15. Well water samples. Location K-1h. (Total residue)

GROSS BETA

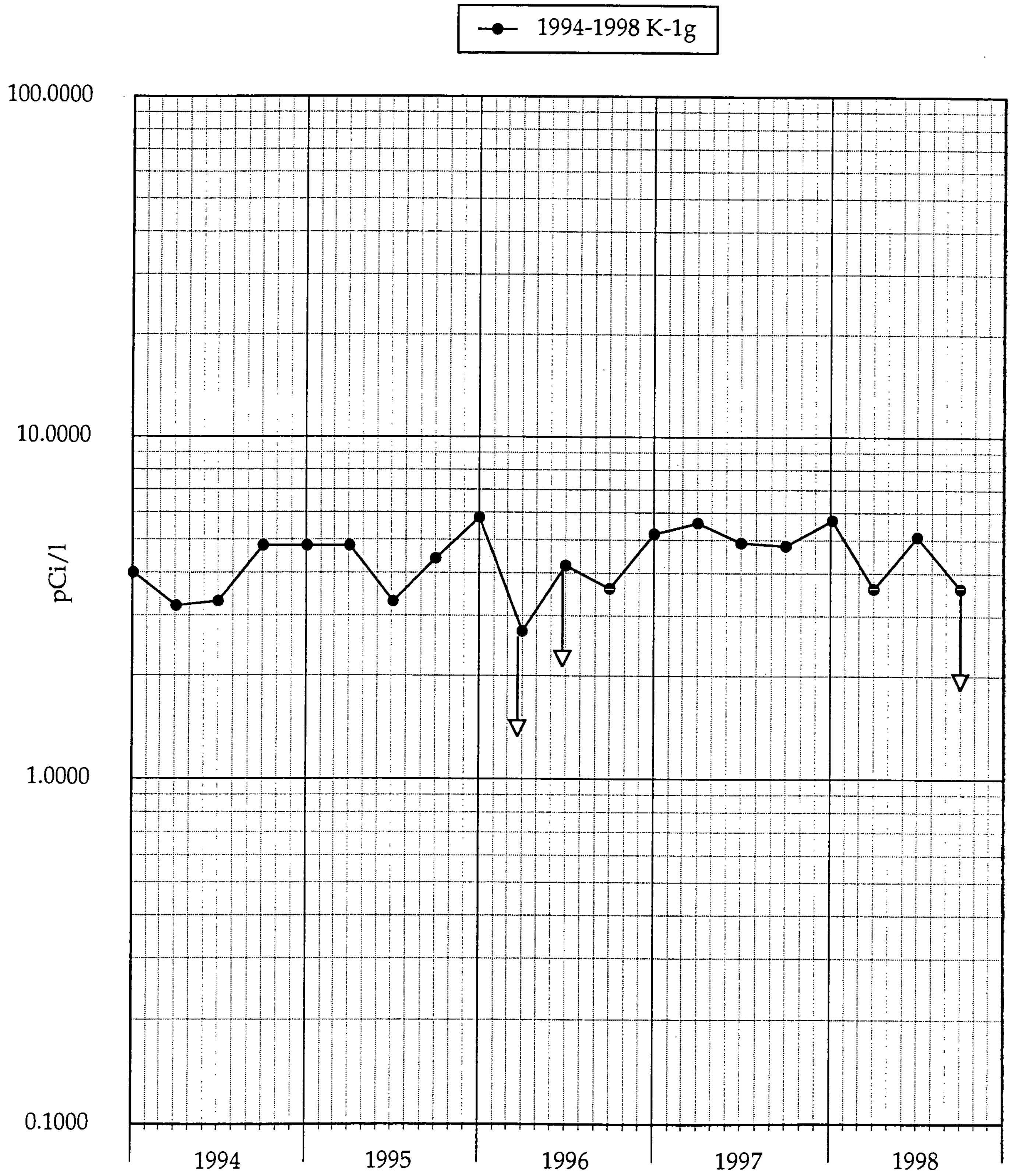

Figure 16. Well water samples. Location K-1g. (Total residue).

GROSS BETA

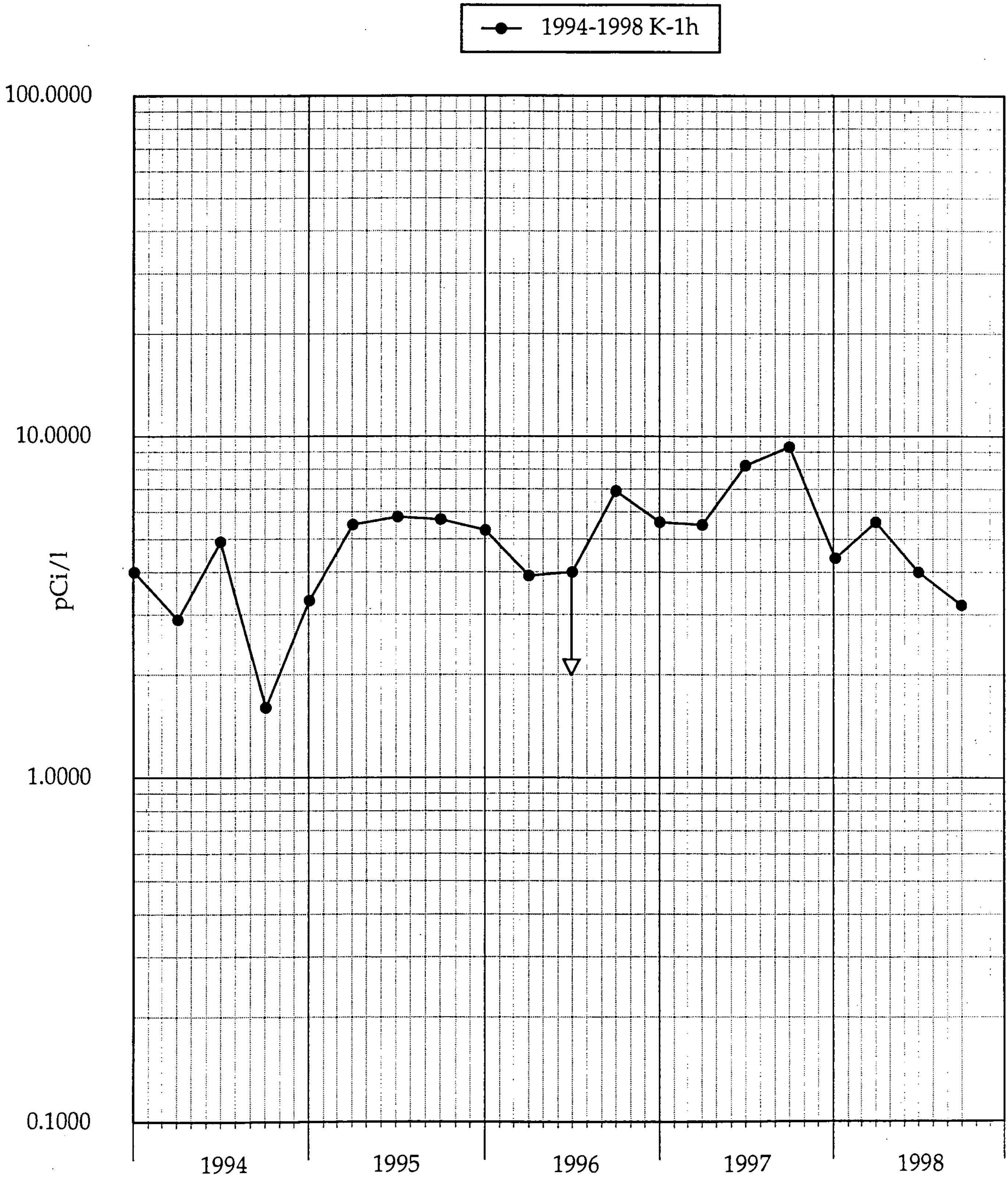

Figure 17. Well water samples. Location K-1h. (Total residue)

GROSS BETA

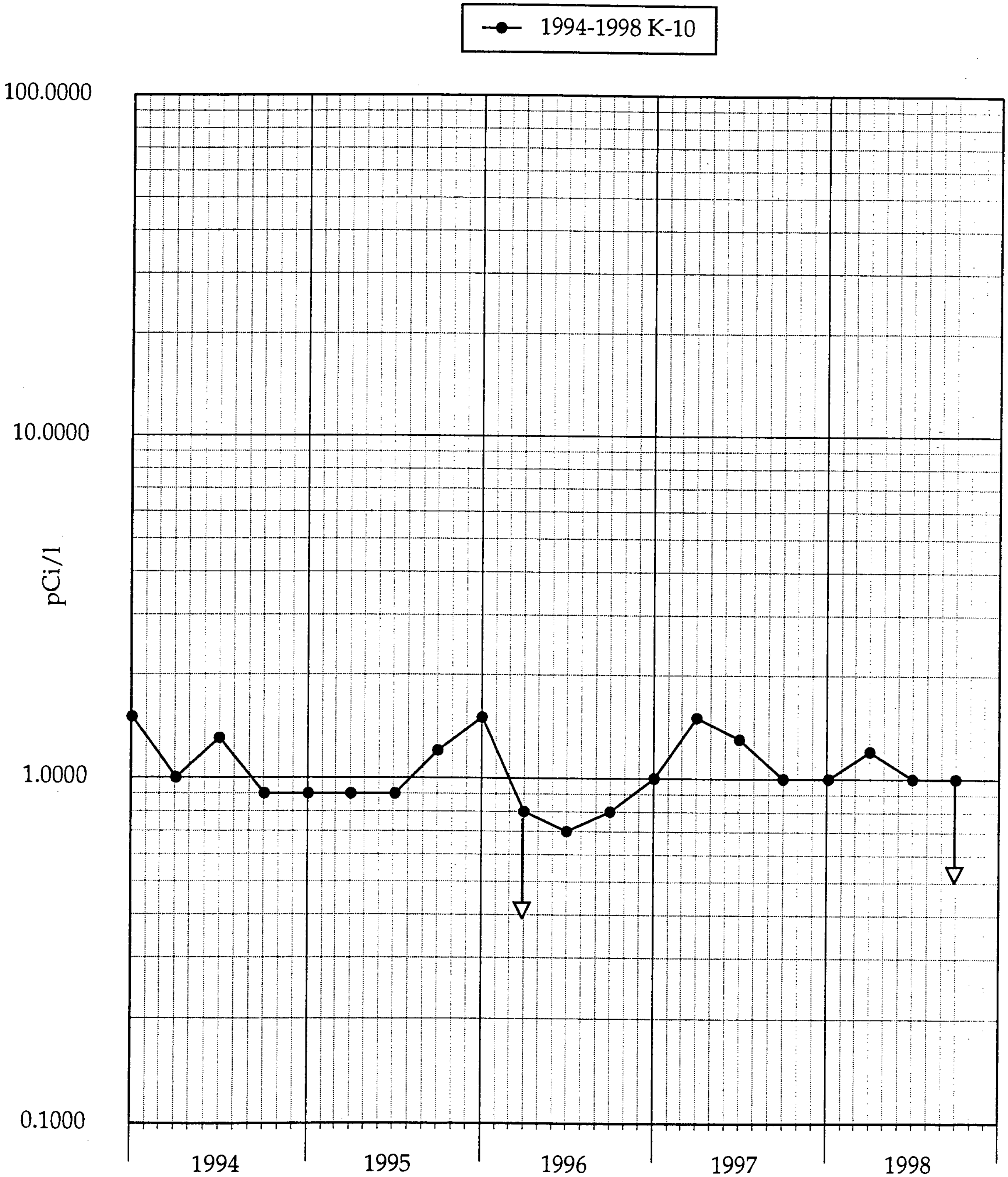

Figure 18. Well water samples. Location K-10. (Total residue)

GROSS BETA

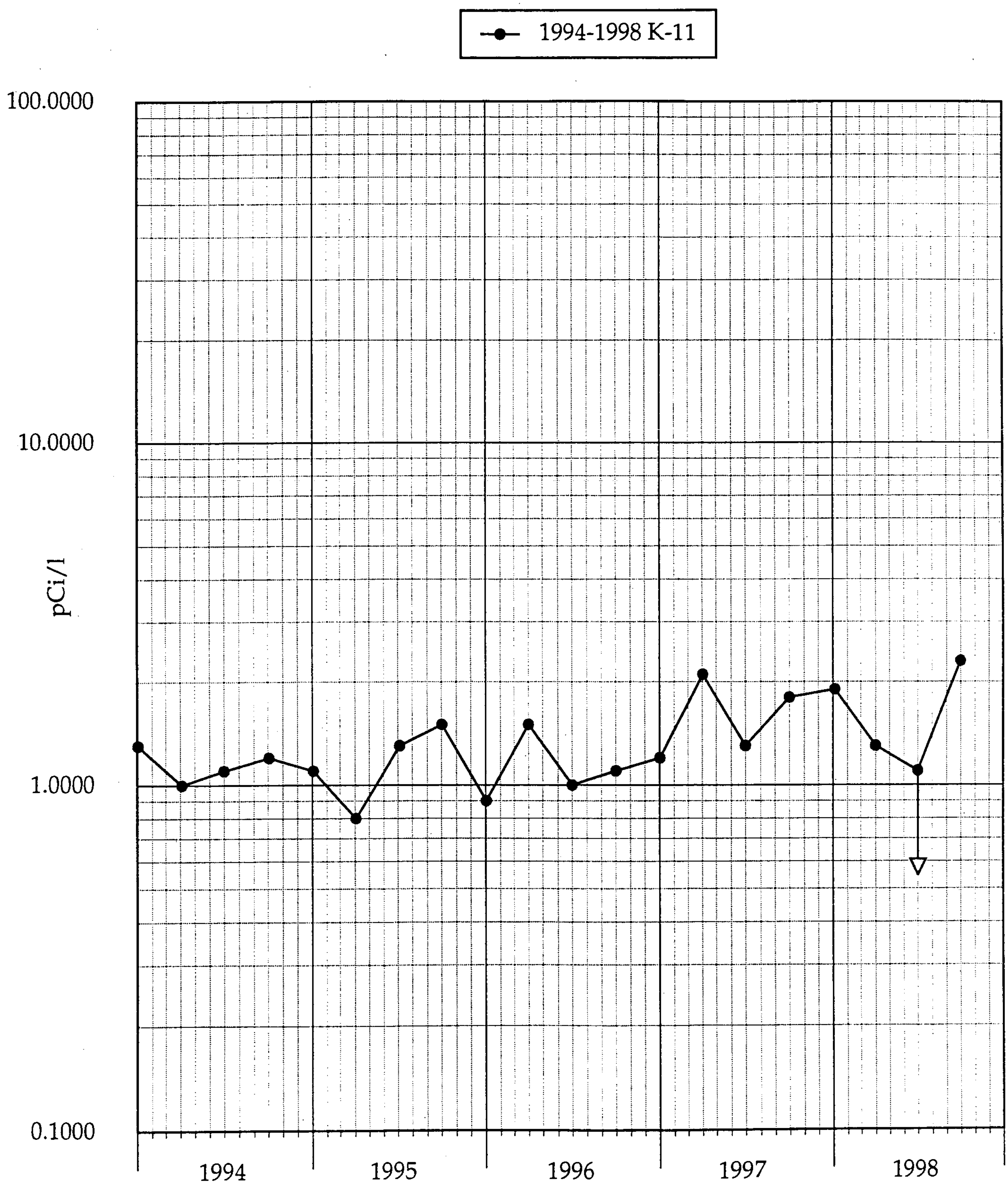

Figure 19. Well water samples. Location K-11. (Total residue)

GROSS BETA

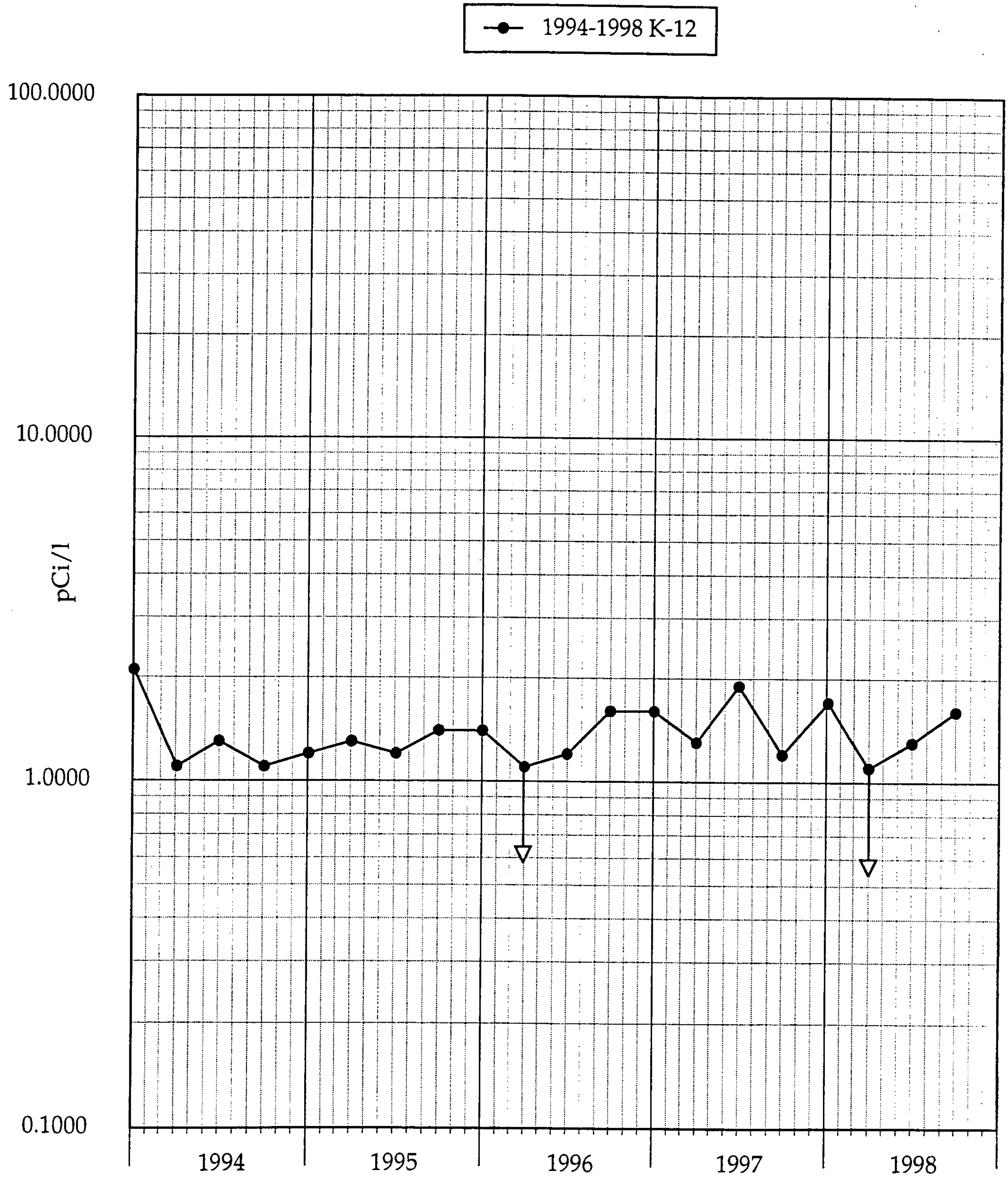

Figure 20. Well water samples. Location K-12. (Total residue)

GROSS BETA

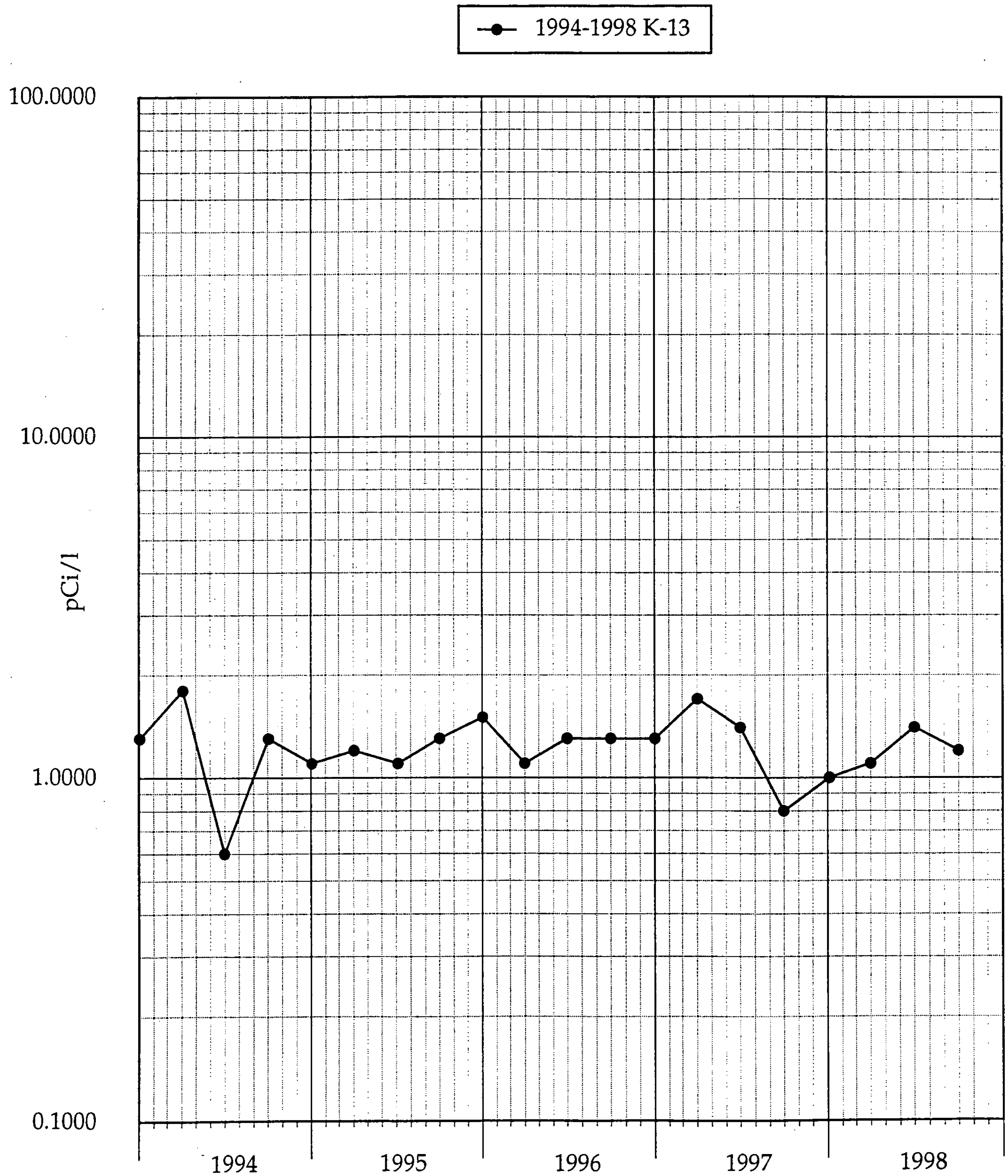

Figure 21. Well water samples. Location K-13. (Total residue)

STRONTIUM-90

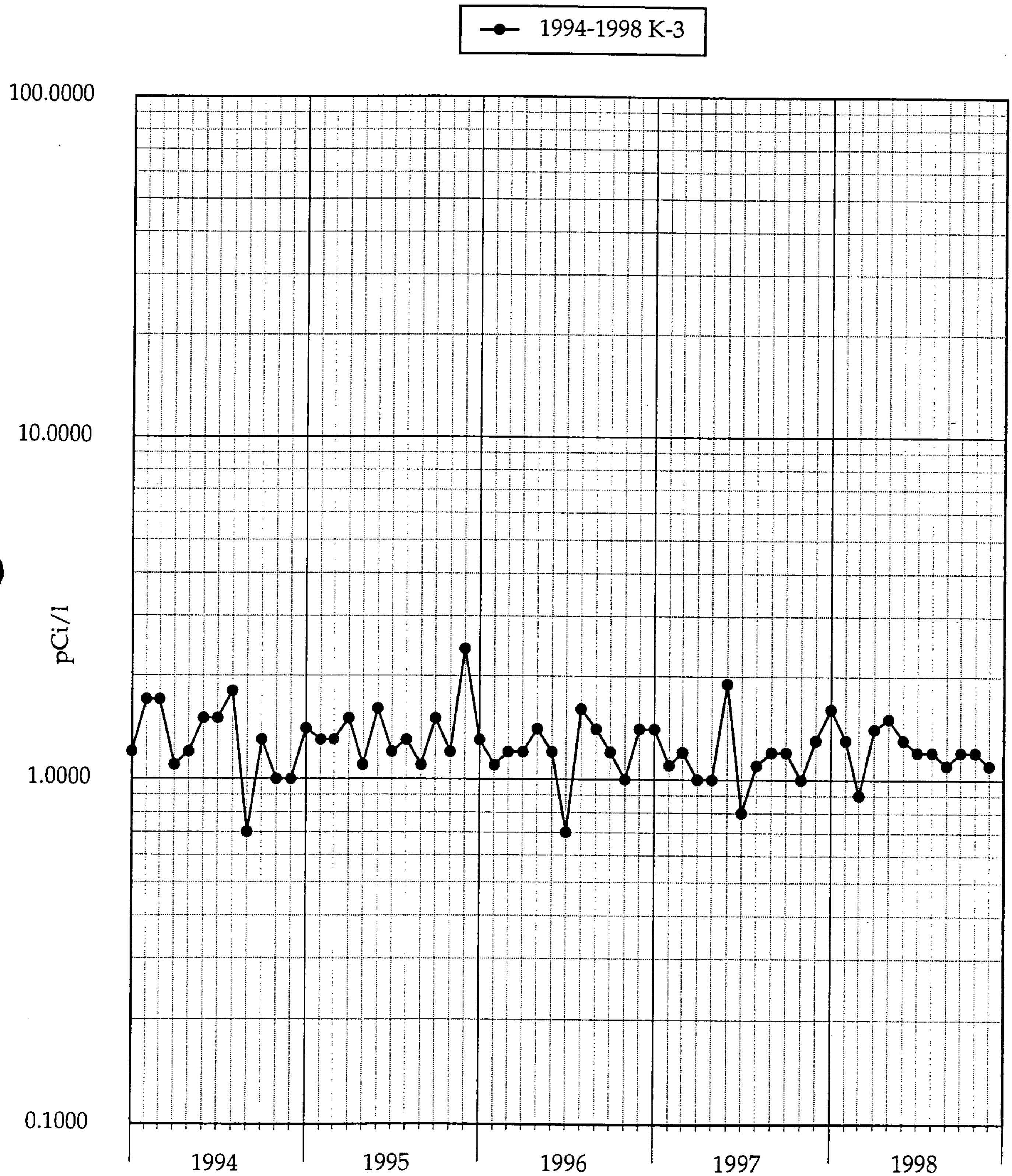

Figure 22. Milk samples. (Location K-3)

STRONTIUM-90

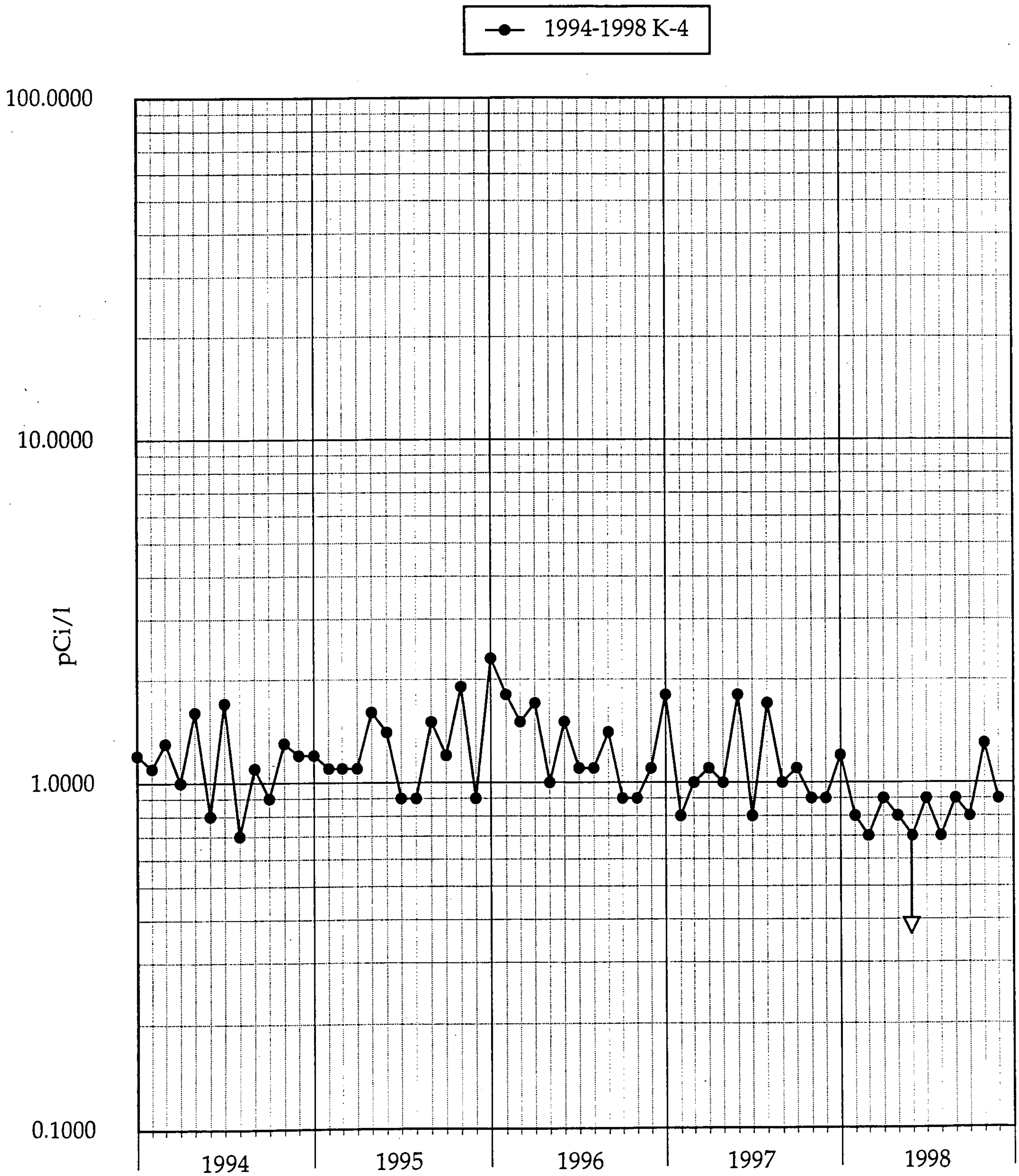

Figure 23. Milk samples. (Location K-4)

STRONTIUM-90

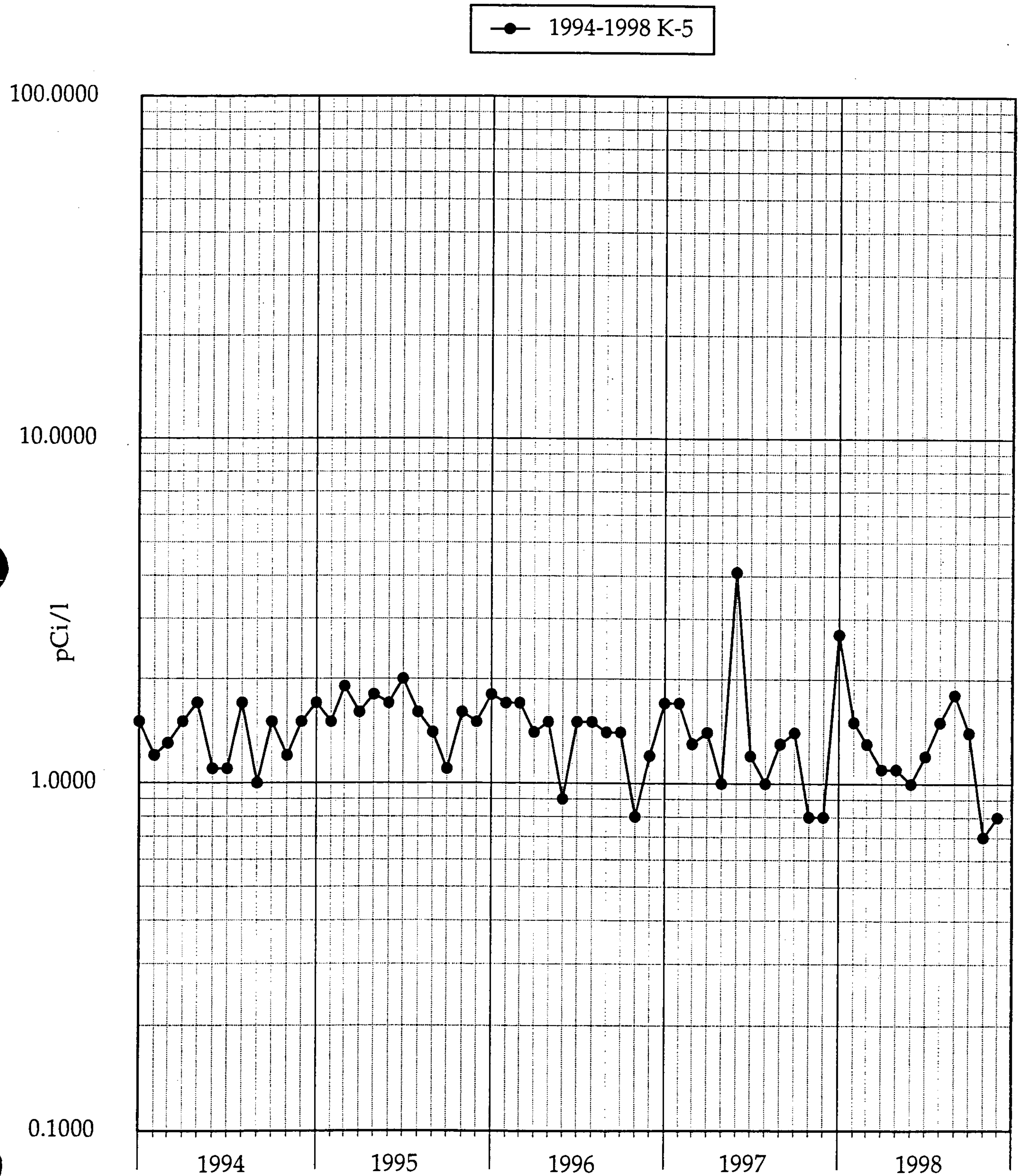

Figure 24. Milk samples. (Location K-5)

STRONTIUM-90

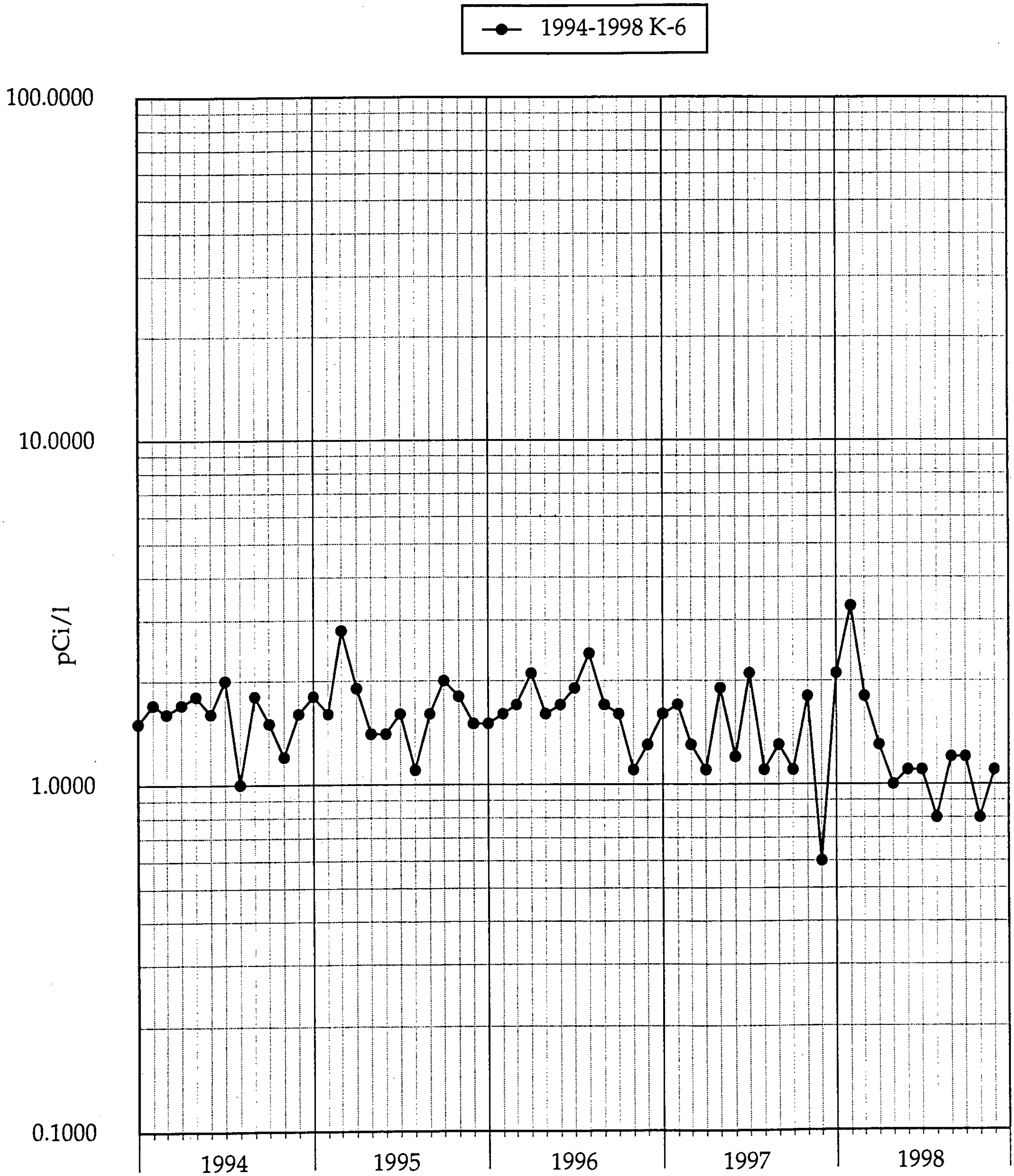

Figure 25. Milk samples. (Location K-6)

STRONTIUM-90

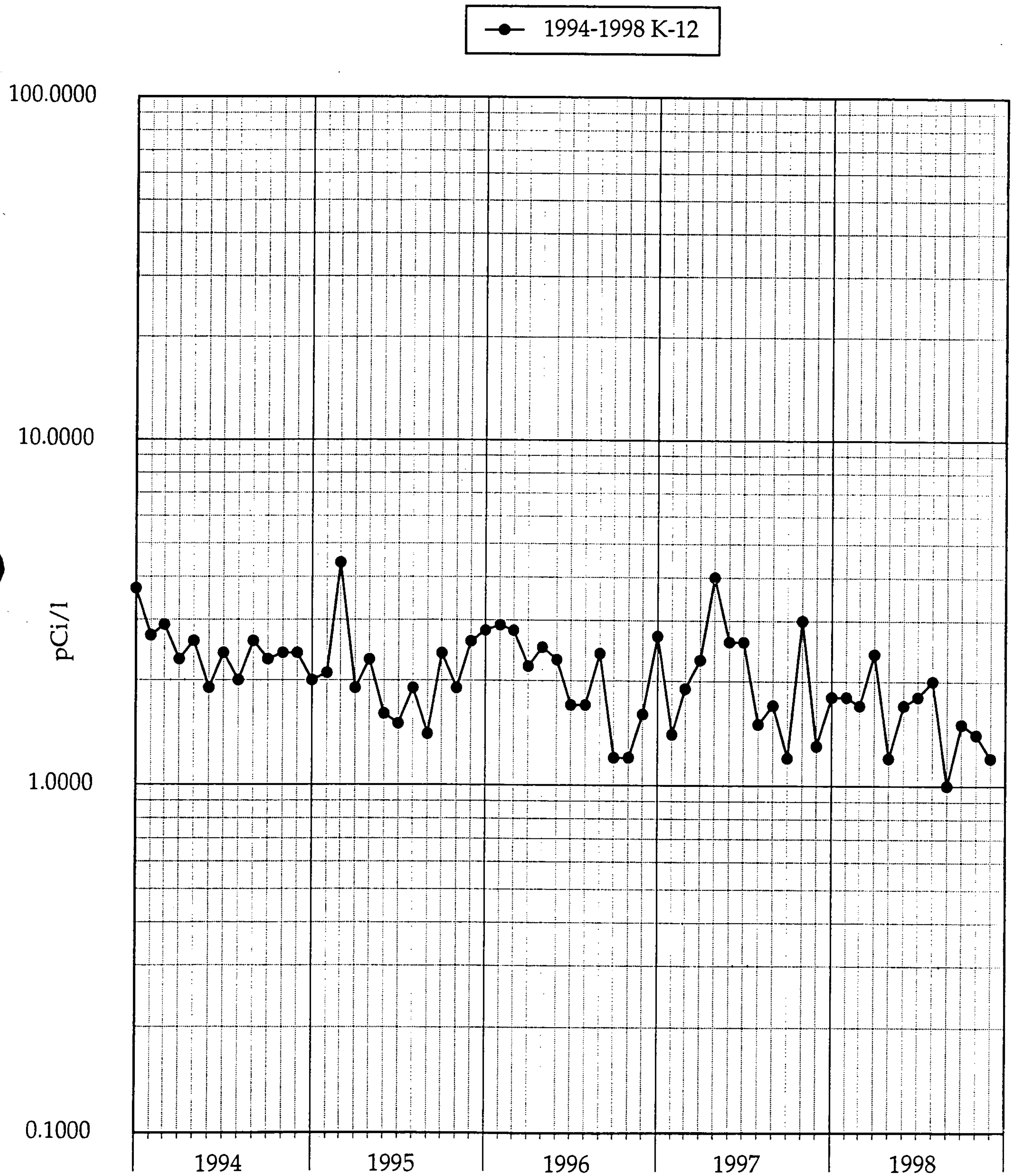

Figure 26. Milk samples. (Location K-12)

STRONTIUM-90

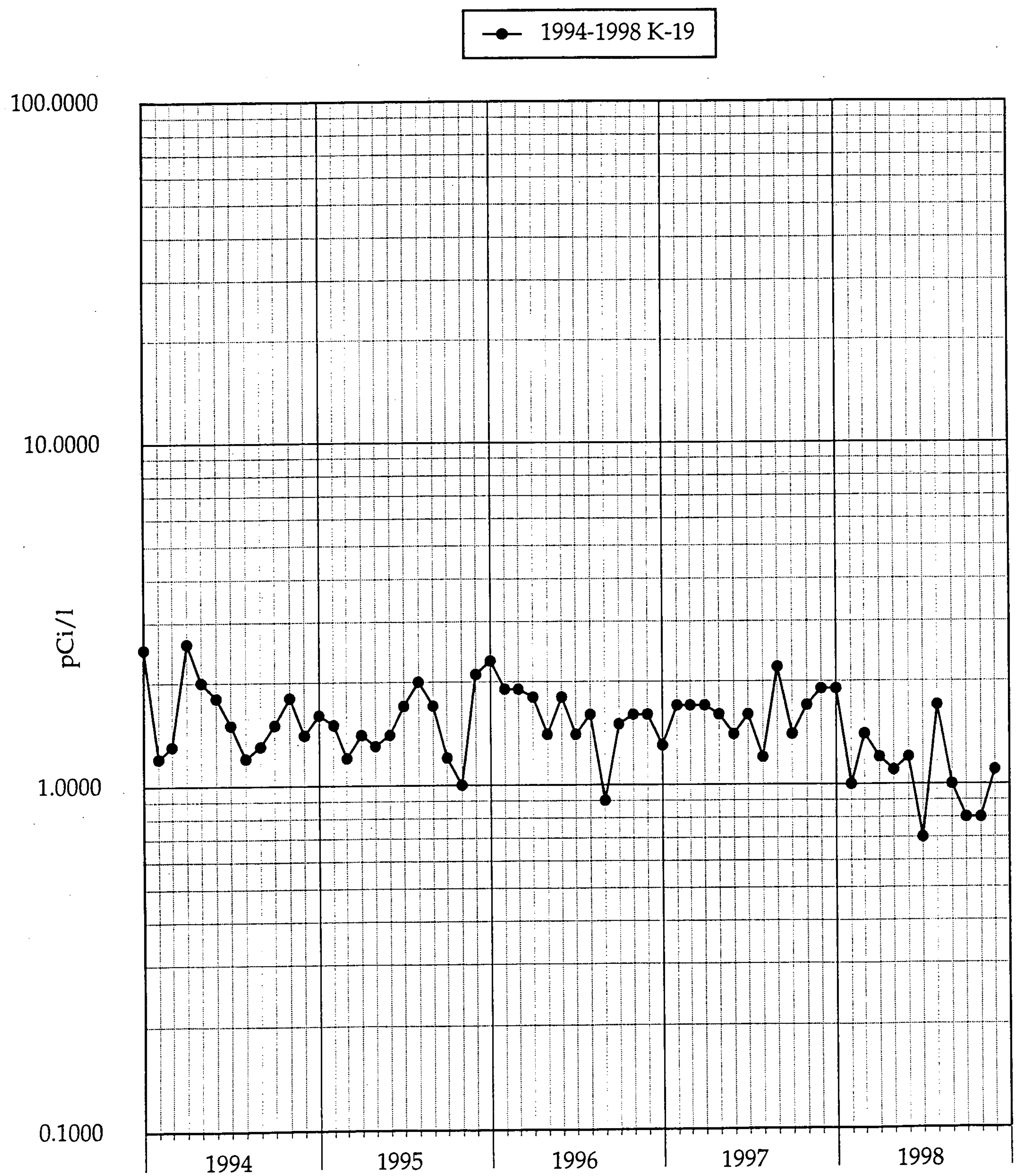

Figure 27. Milk samples. (Location K-19)

STRONTIUM-90

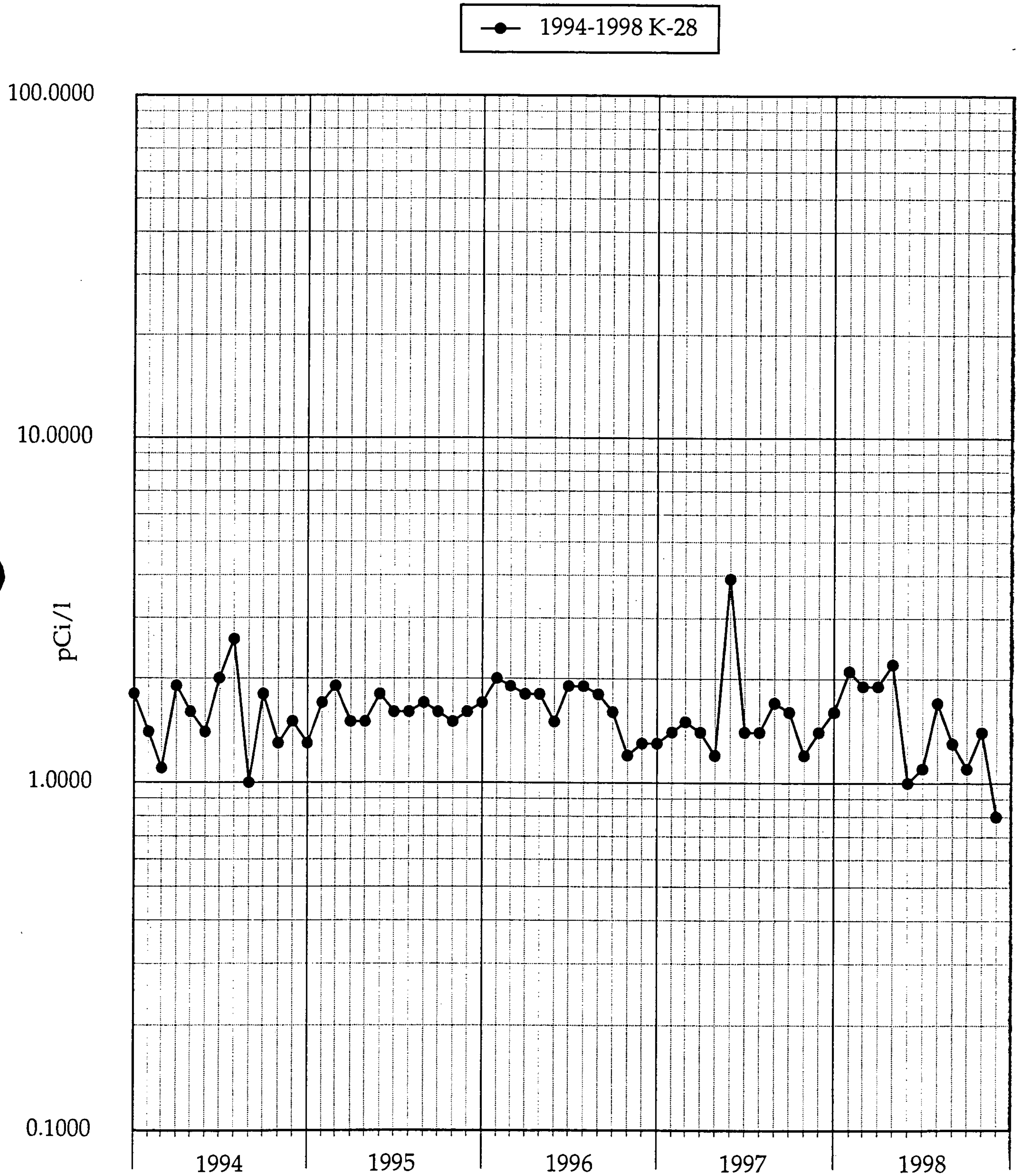

Figure 28. Milk samples. (Location K-28)

GROSS BETA

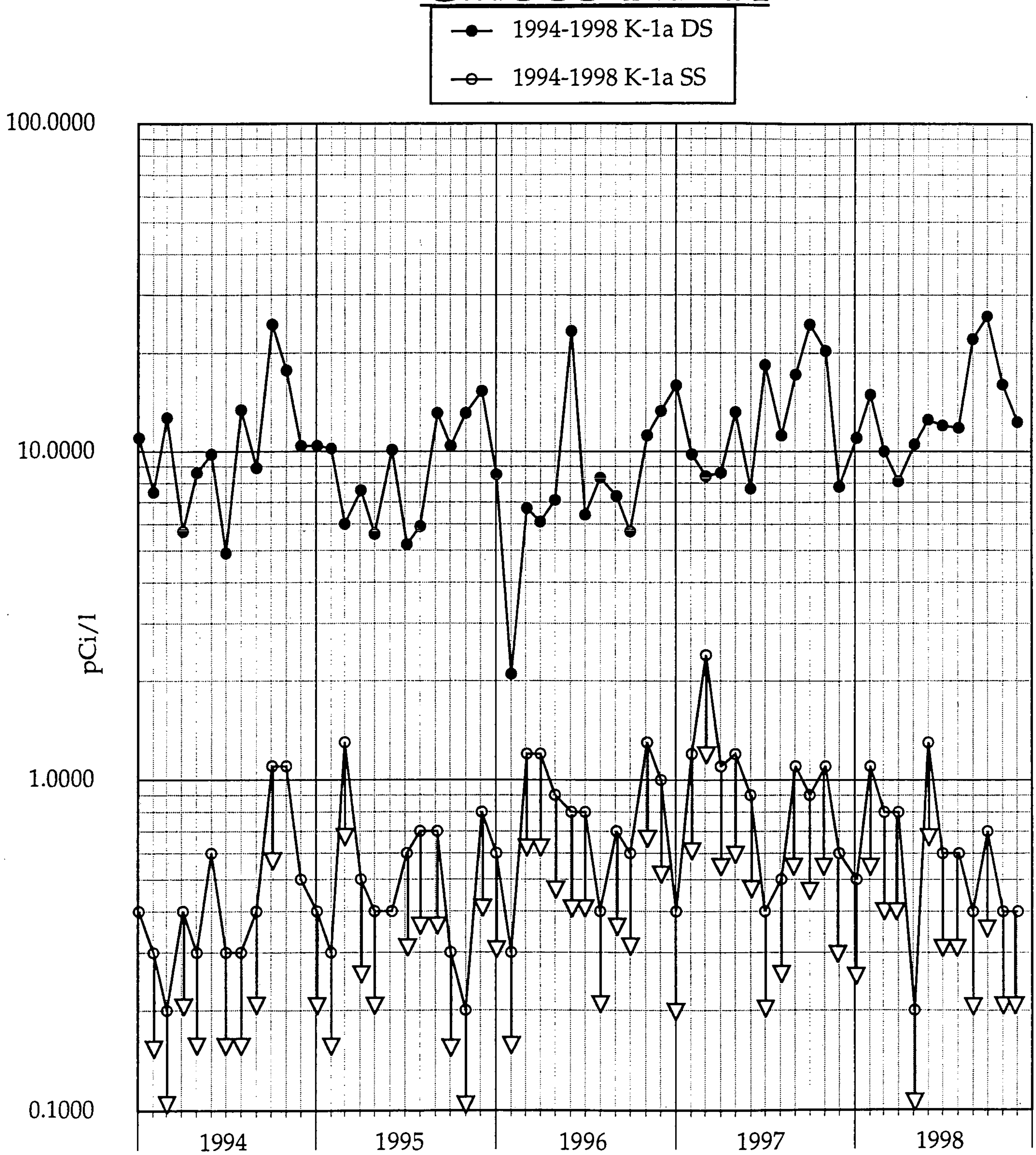

Figure 29. Surface water samples. Collected at North Creek onsite. (Location K-1a)

GROSS BETA

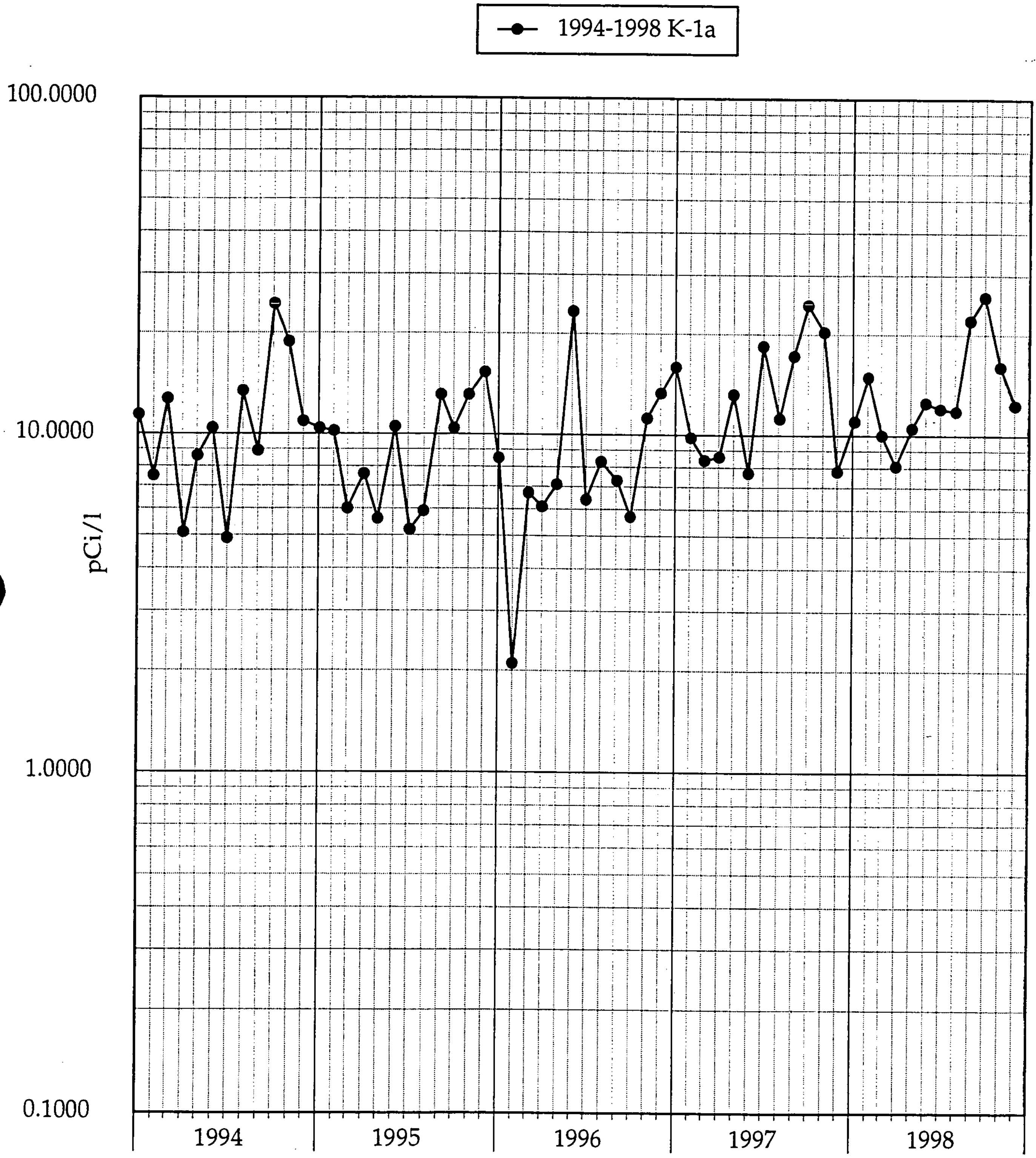

Figure 30. Surface water samples. Collected at North Creek onsite. Total Residue. (Location K-1a)

GROSS BETA

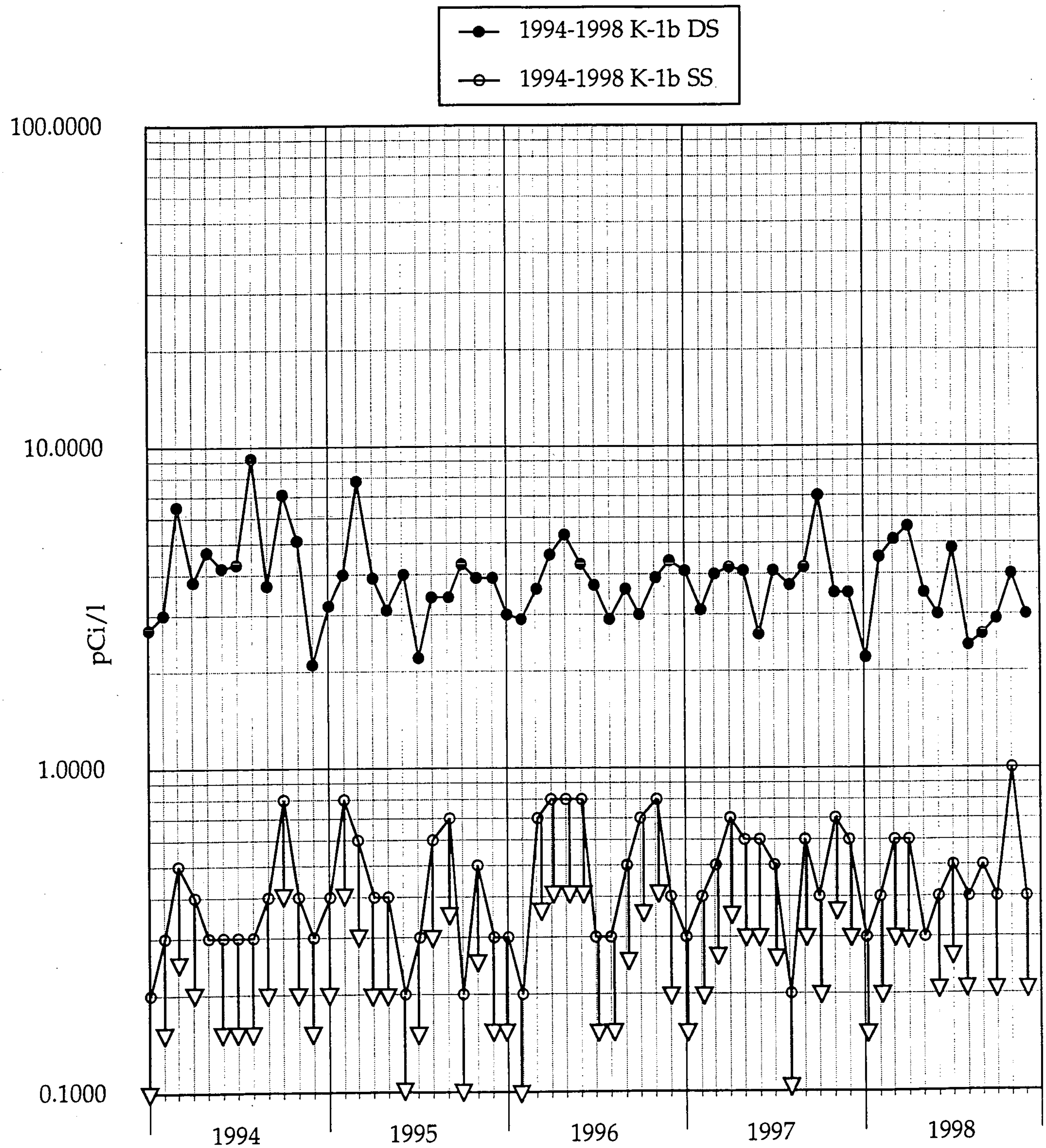

Figure 31. Surface water samples. Collected at Middle Creek onsite. (Location K-1b).

GROSS BETA

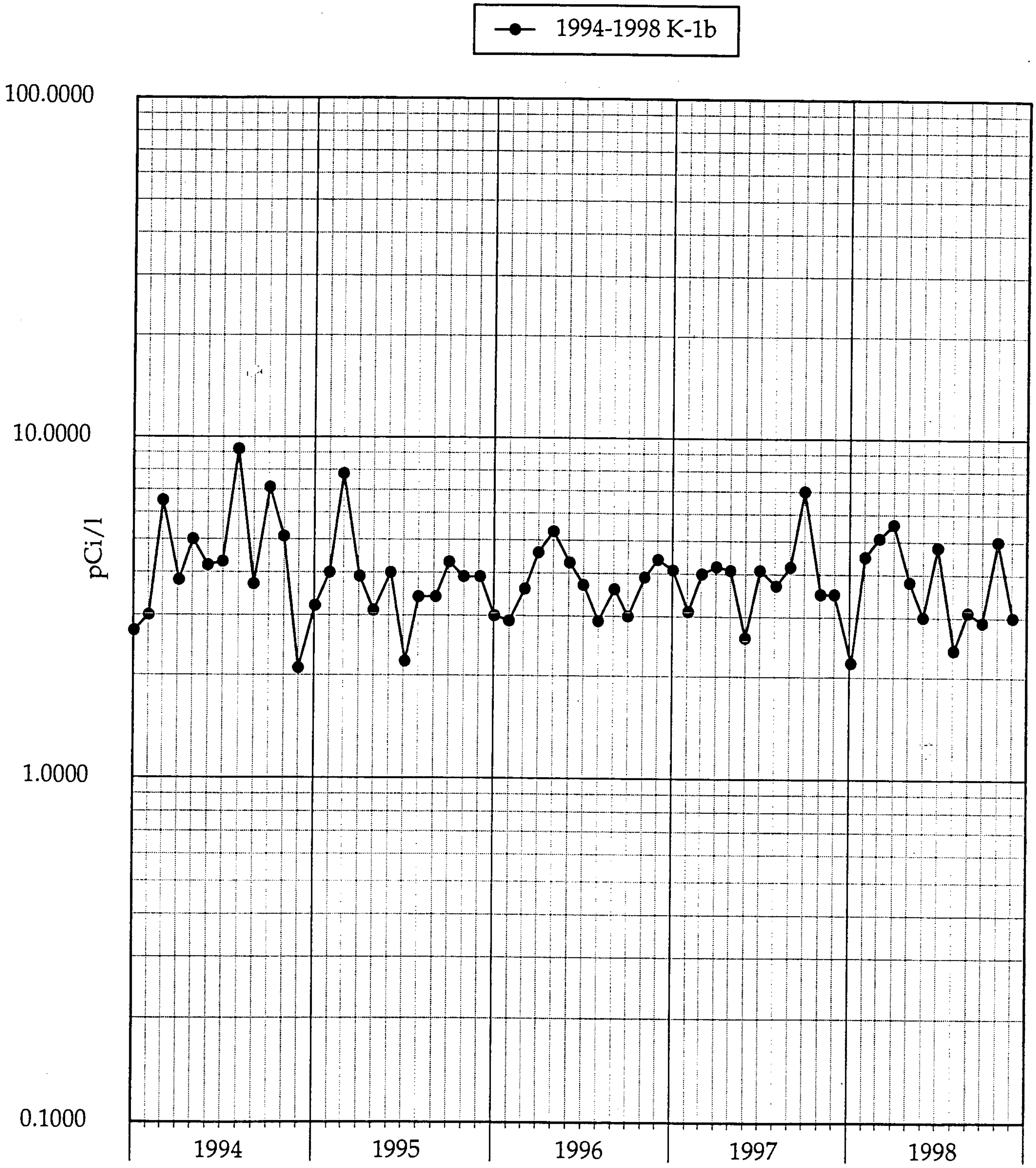

Figure 32. Surface water samples. Collected at Middle Creek onsite. Total residue. (Location K-1b)

GROSS BETA

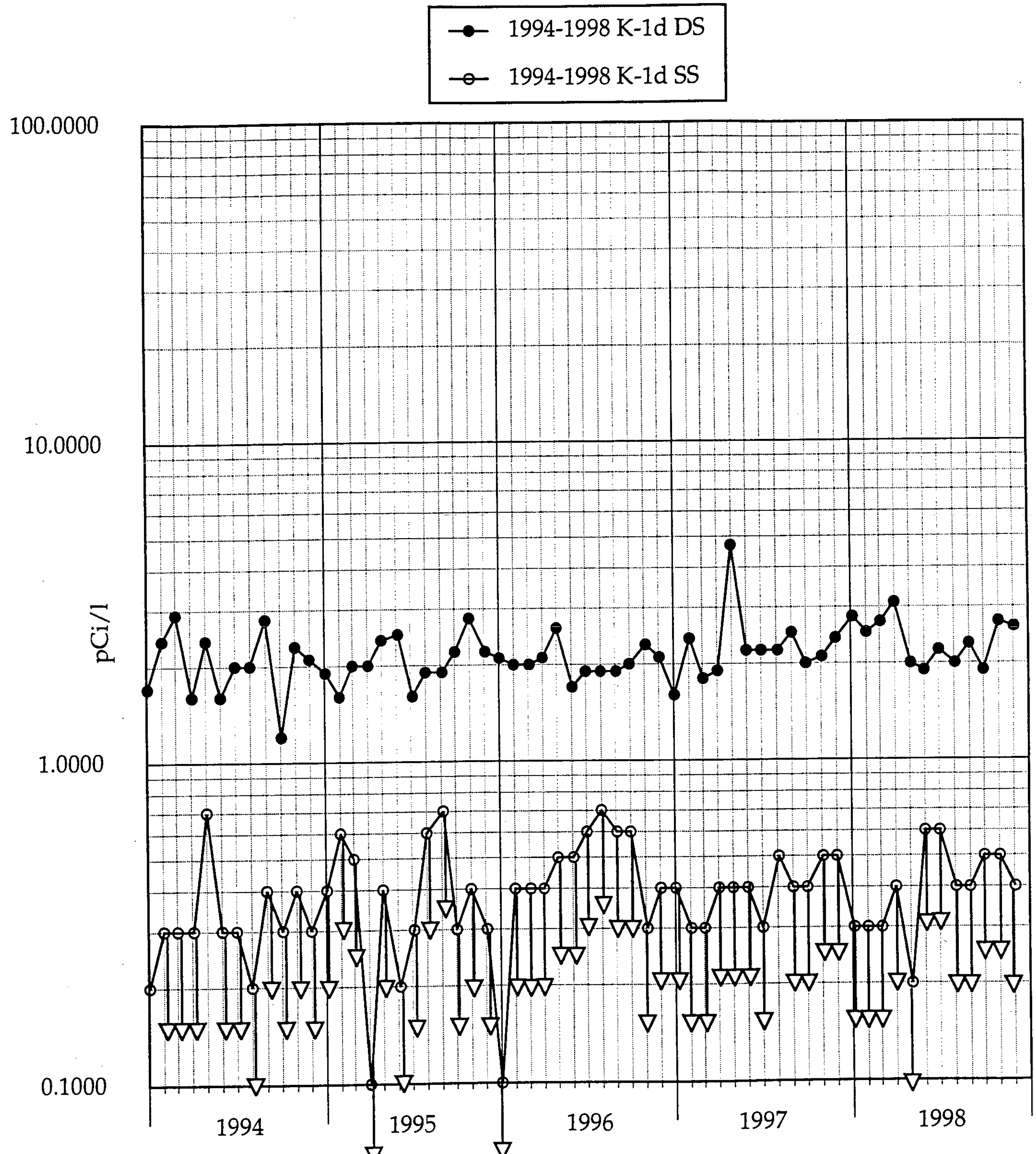

Figure 33. Surface water samples. Collected at the Lake Michigan condenser discharge onsite. (Location K-1d)

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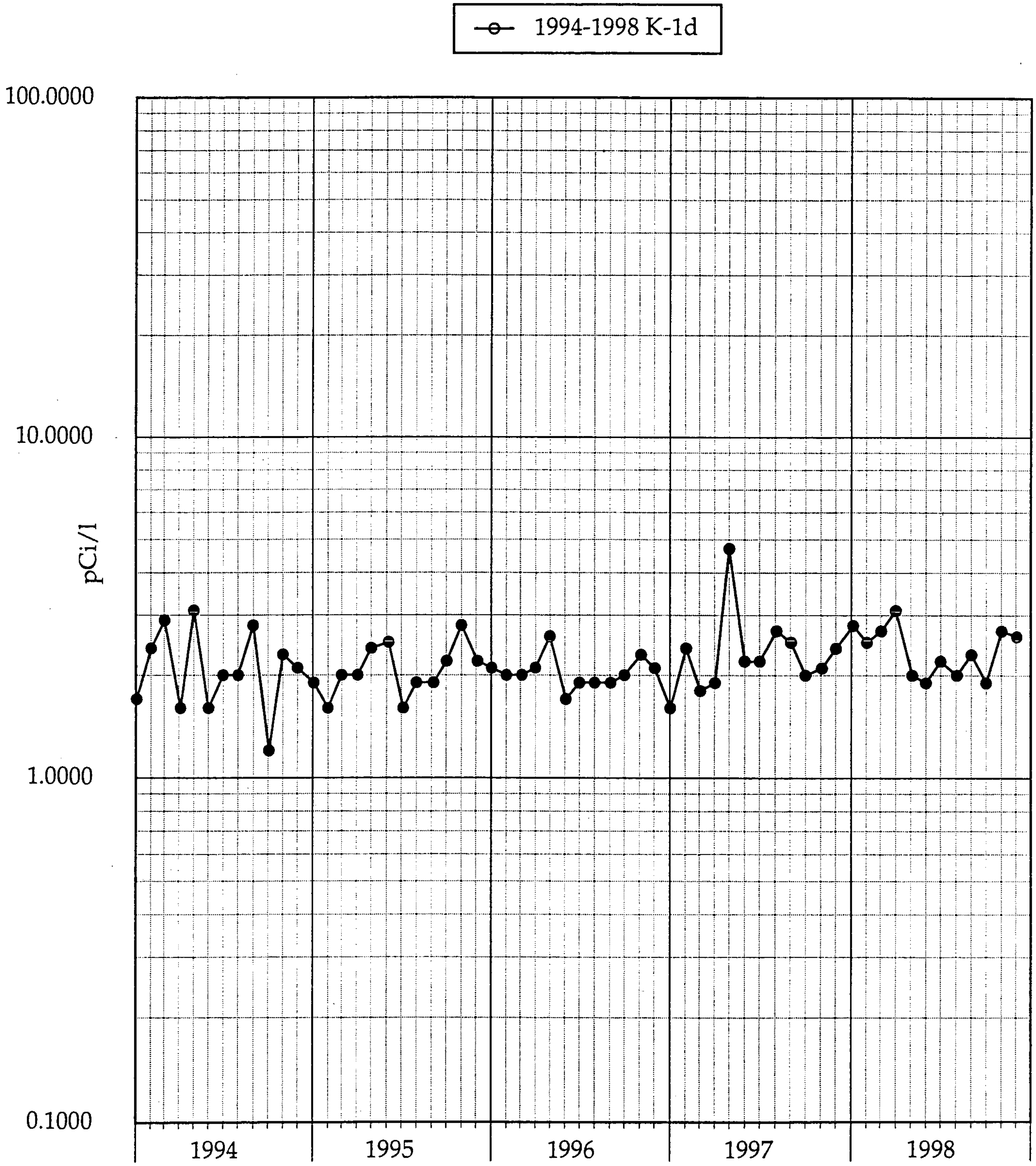

Figure 34. Surface water samples. Collected at the Lake Michigan condenser discharge onsight. Total residue (Location K-1d).

GROSS BETA

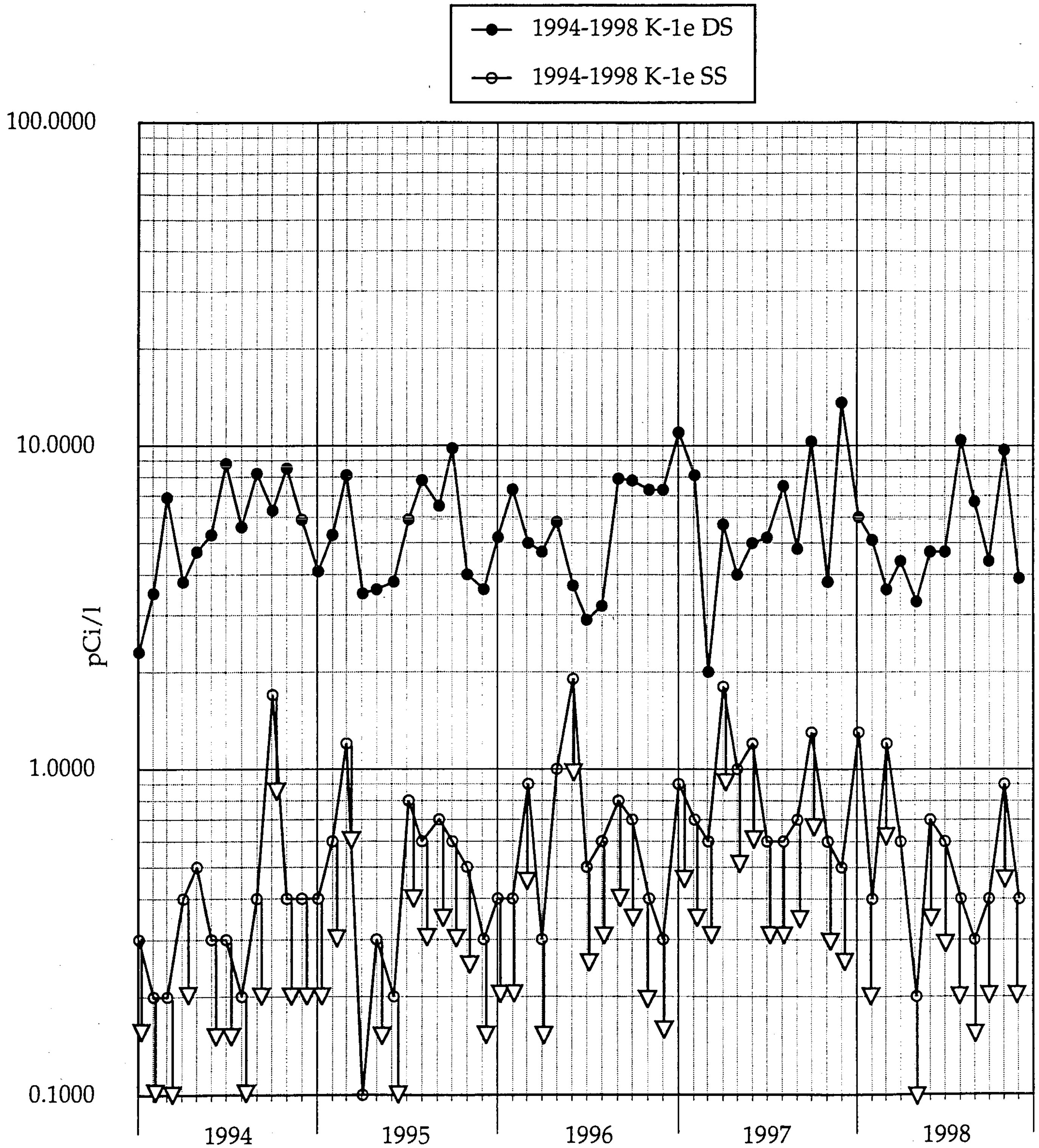

Figure 35. Surface water samples. Collected at South Creek onsite. (Location K-1e).

GROSS BETA

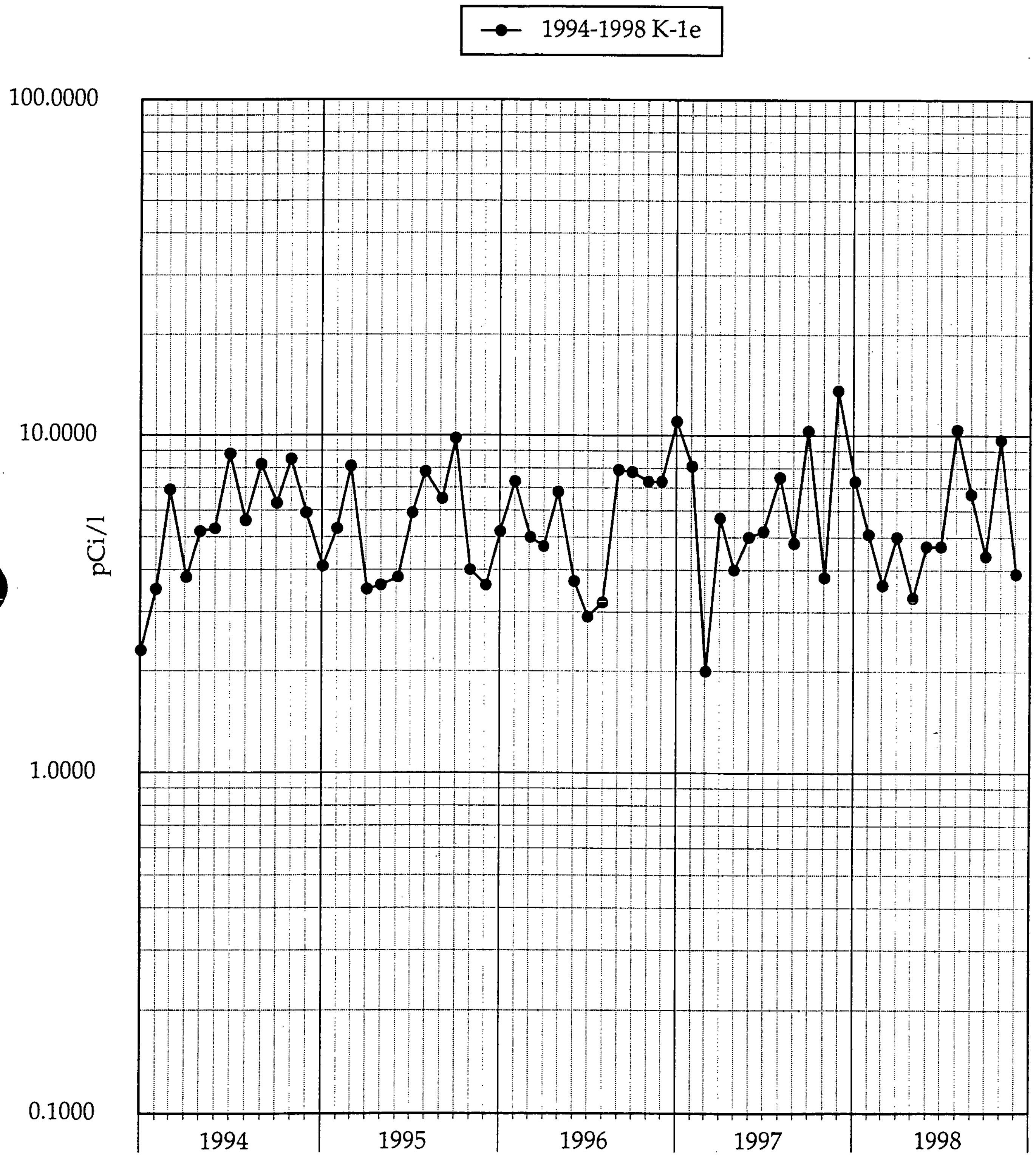

Figure 36. Surface water samples. Collected at South Creek onsite. Total residue (Location K-1e).

GROSS BETA

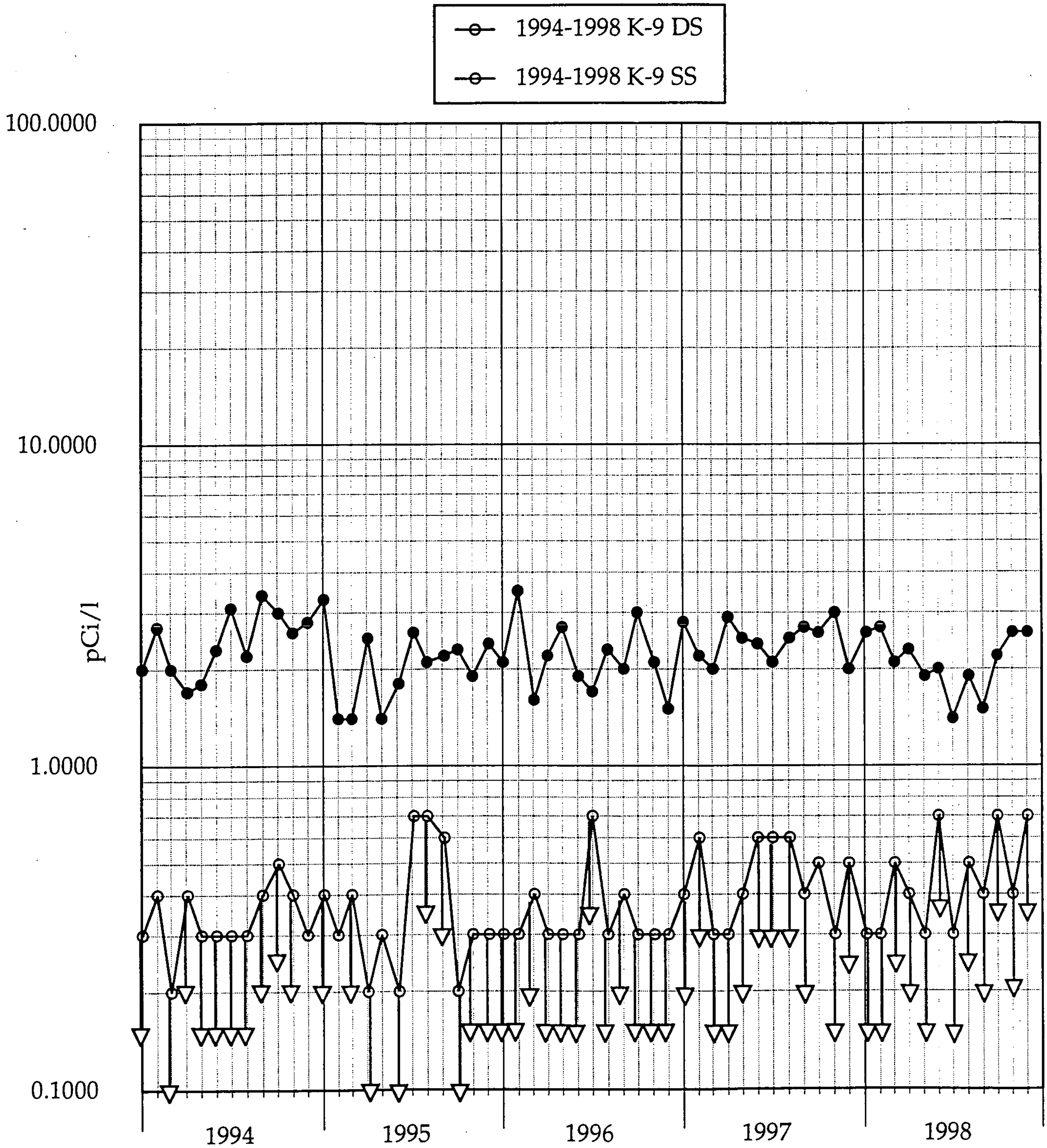

Figure 37. Surface water (raw) samples. Collected at Lake Michigan Rostok intake. (Location K-9)

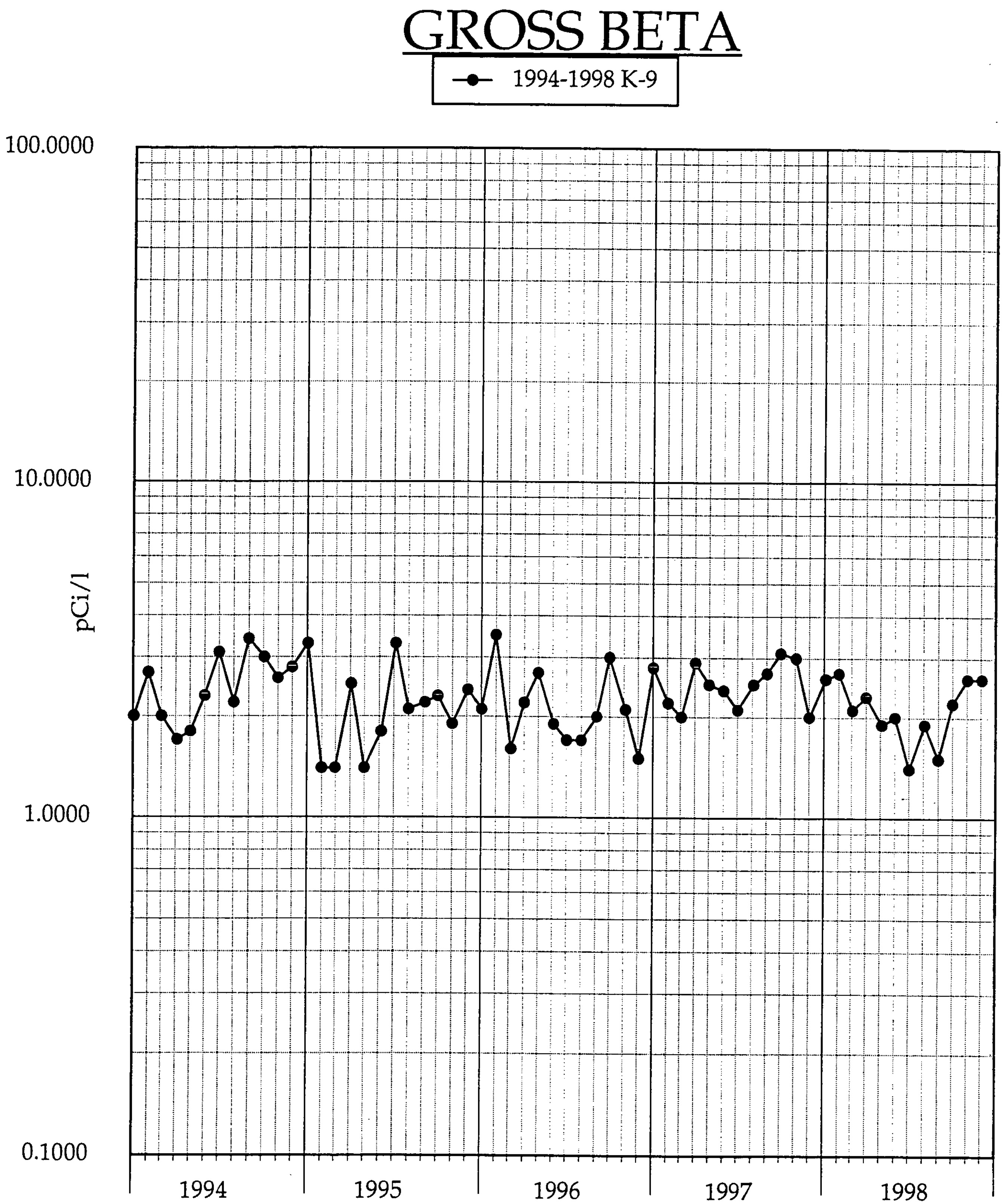

Figure 38. Surface water (raw) samples. Collected at the Lake Michigan Rostok intake. Total residue (Location K-9).

GROSS BETA

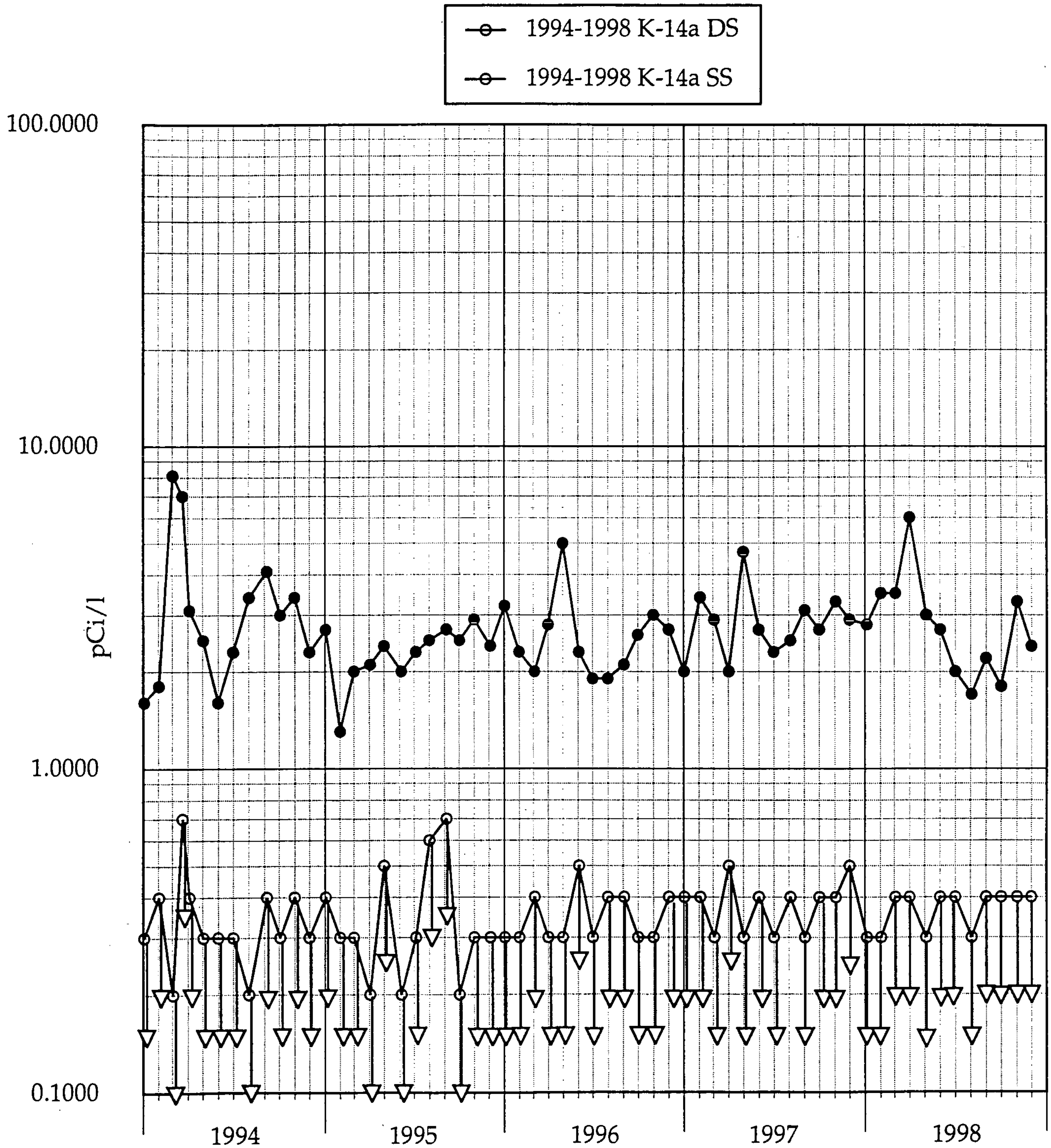

Figure 39. Surface water samples. Collected at Lake Michigan Two Creeks Park. (Location K-14a).

GROSS BETA

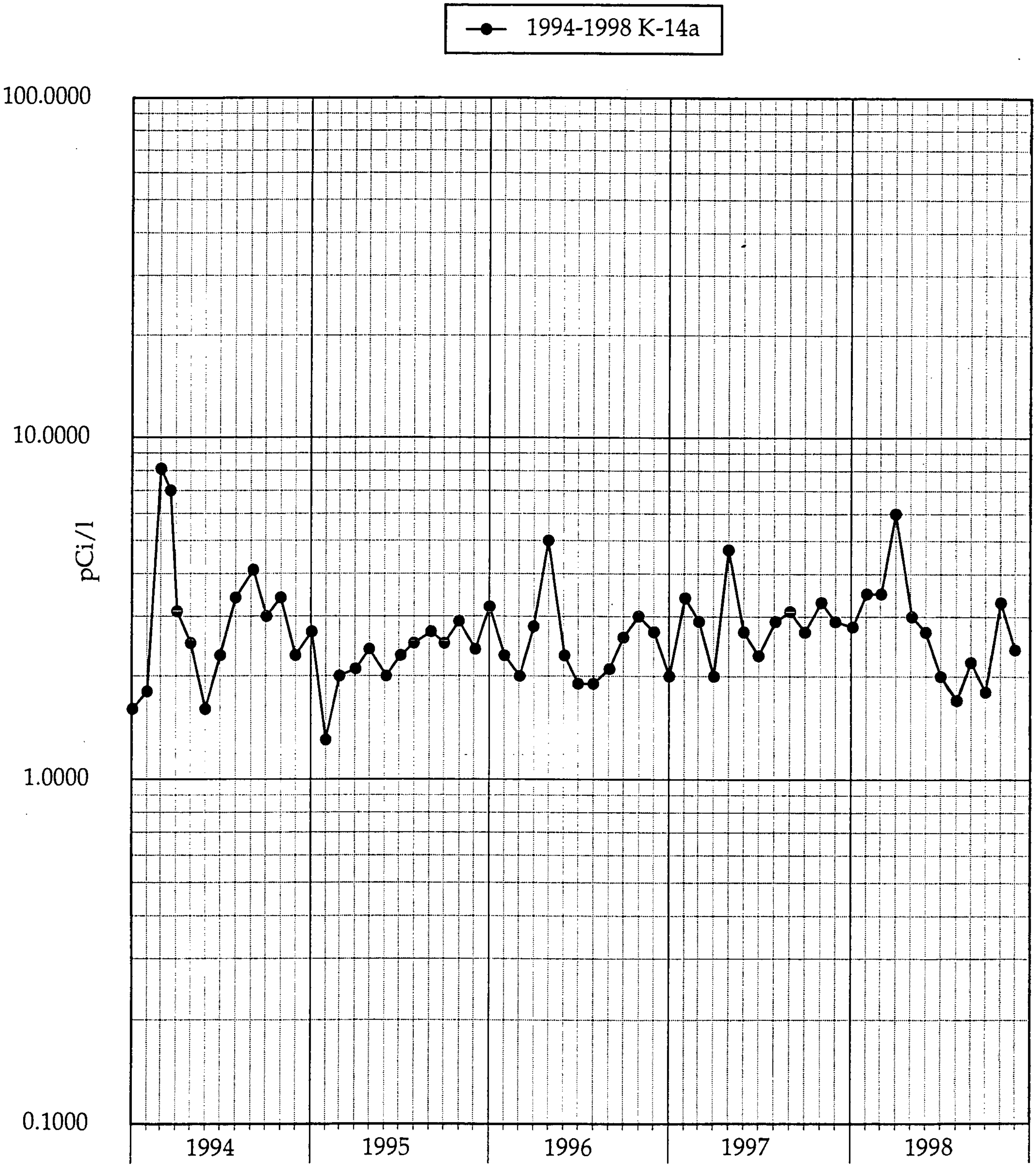

Figure 40. Surface water samples. Collected at the Lake Michigan Two Creeks Park. Total residue (Location K-14a).

GROSS BETA

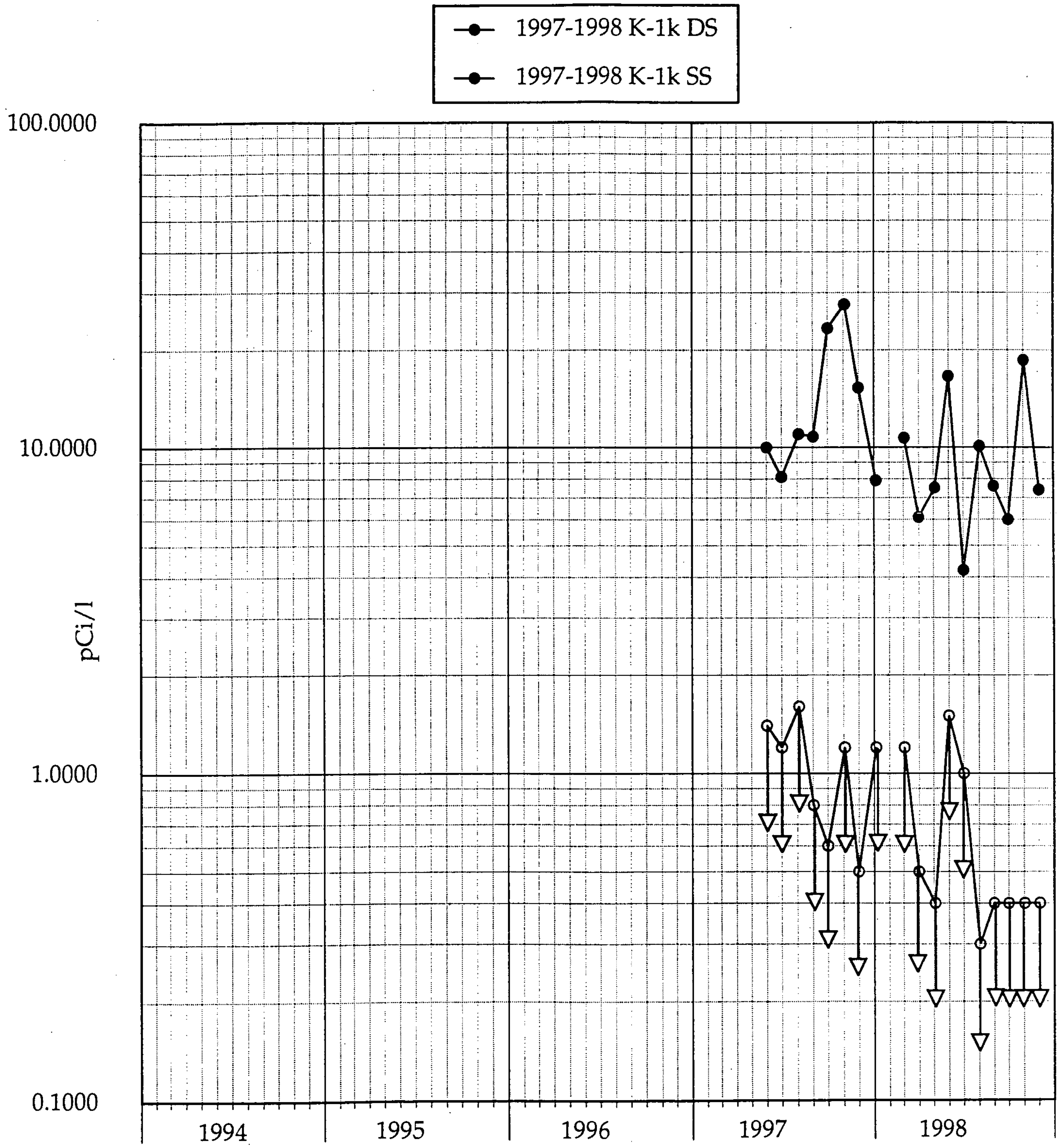

Figure 40a. Surface water samples. Collected at School Forest Pond. (Location K-1k).

GROSS BETA

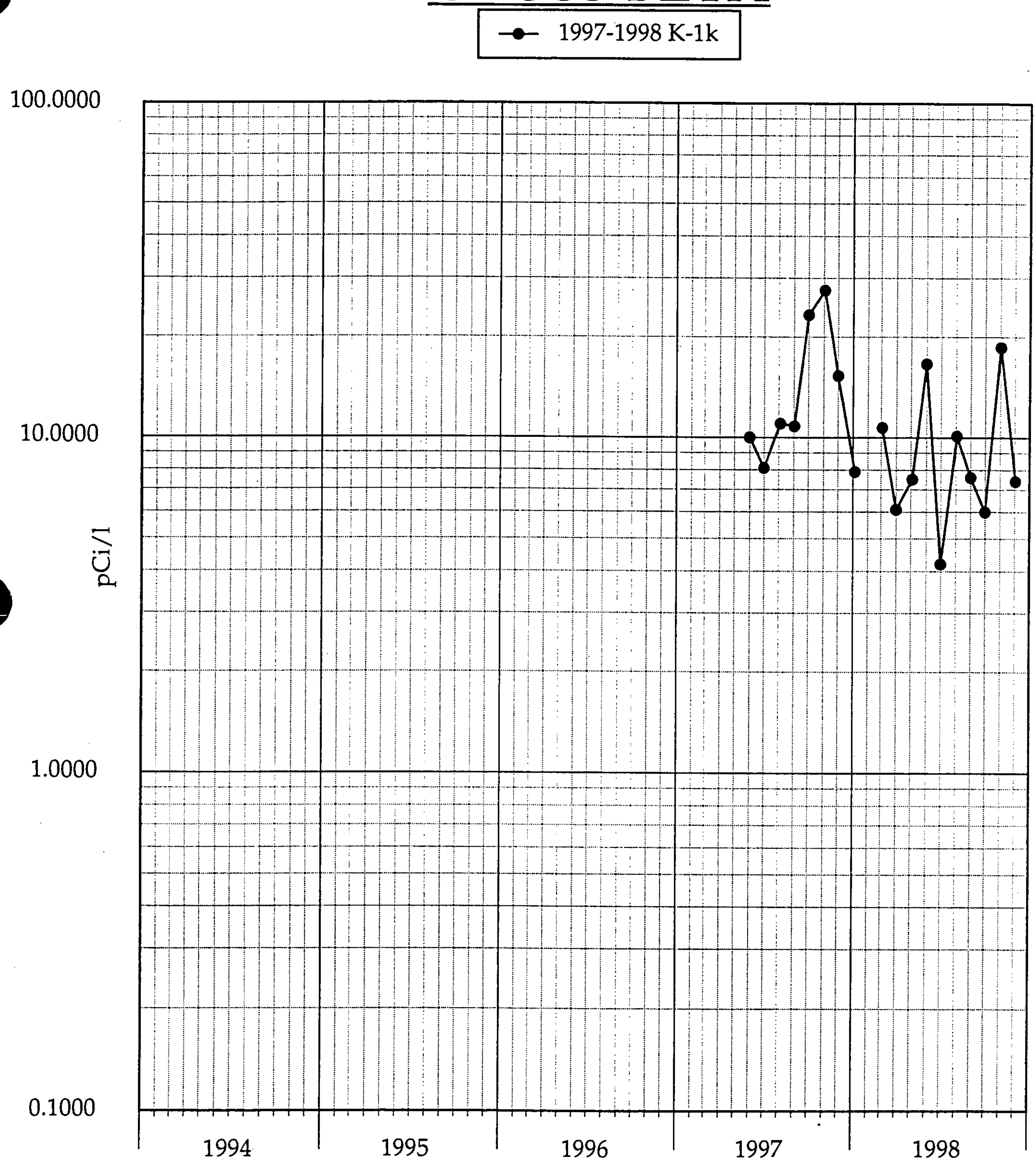

Figure 40b. Surface water samples. Collected at School Forest Pond. Total residue (Location K-1k).

TRITIUM

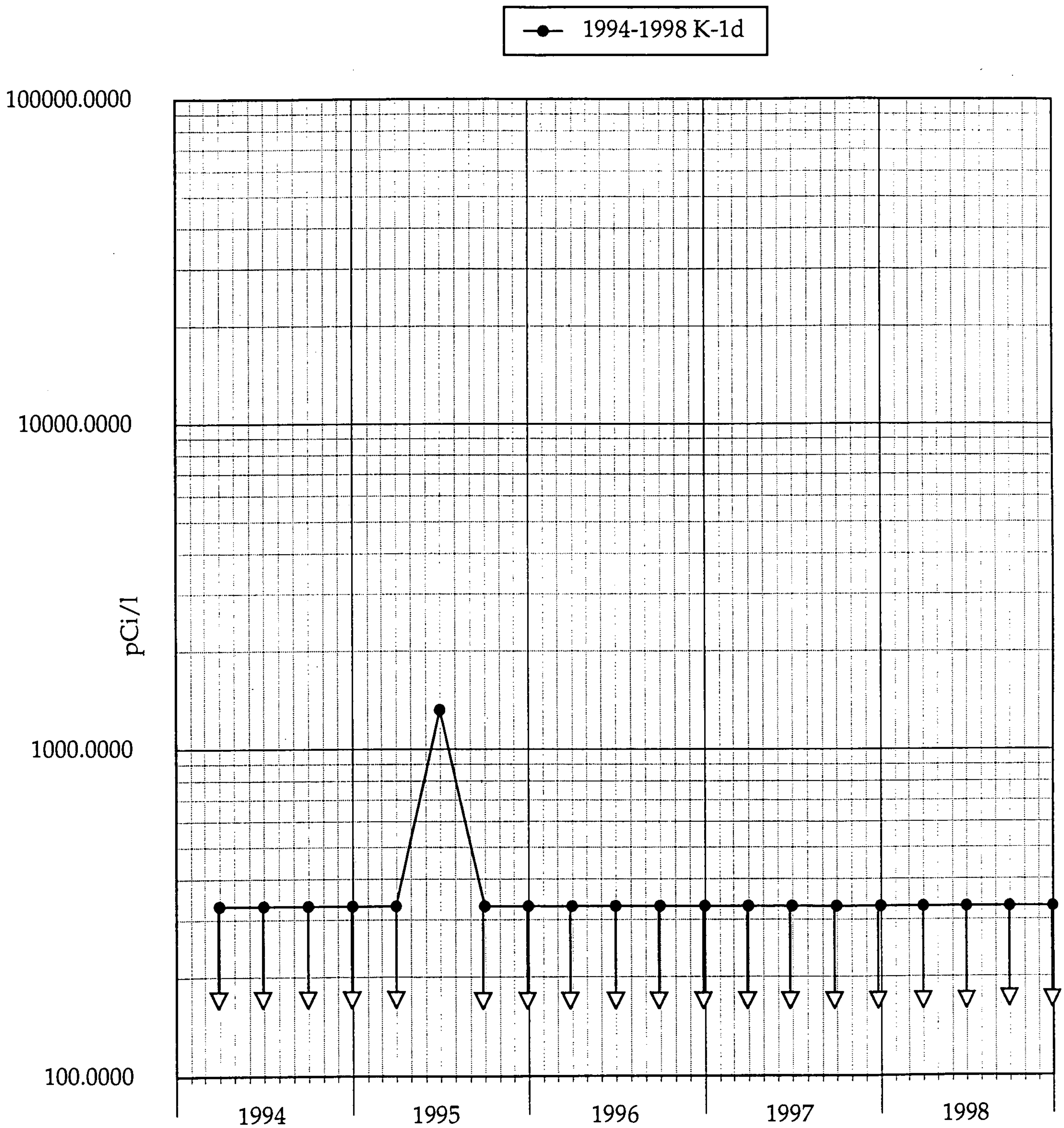

Figure 41. Surface water samples. Collected at the Lake Michigan condenser discharge onsite. (Location K-1d).

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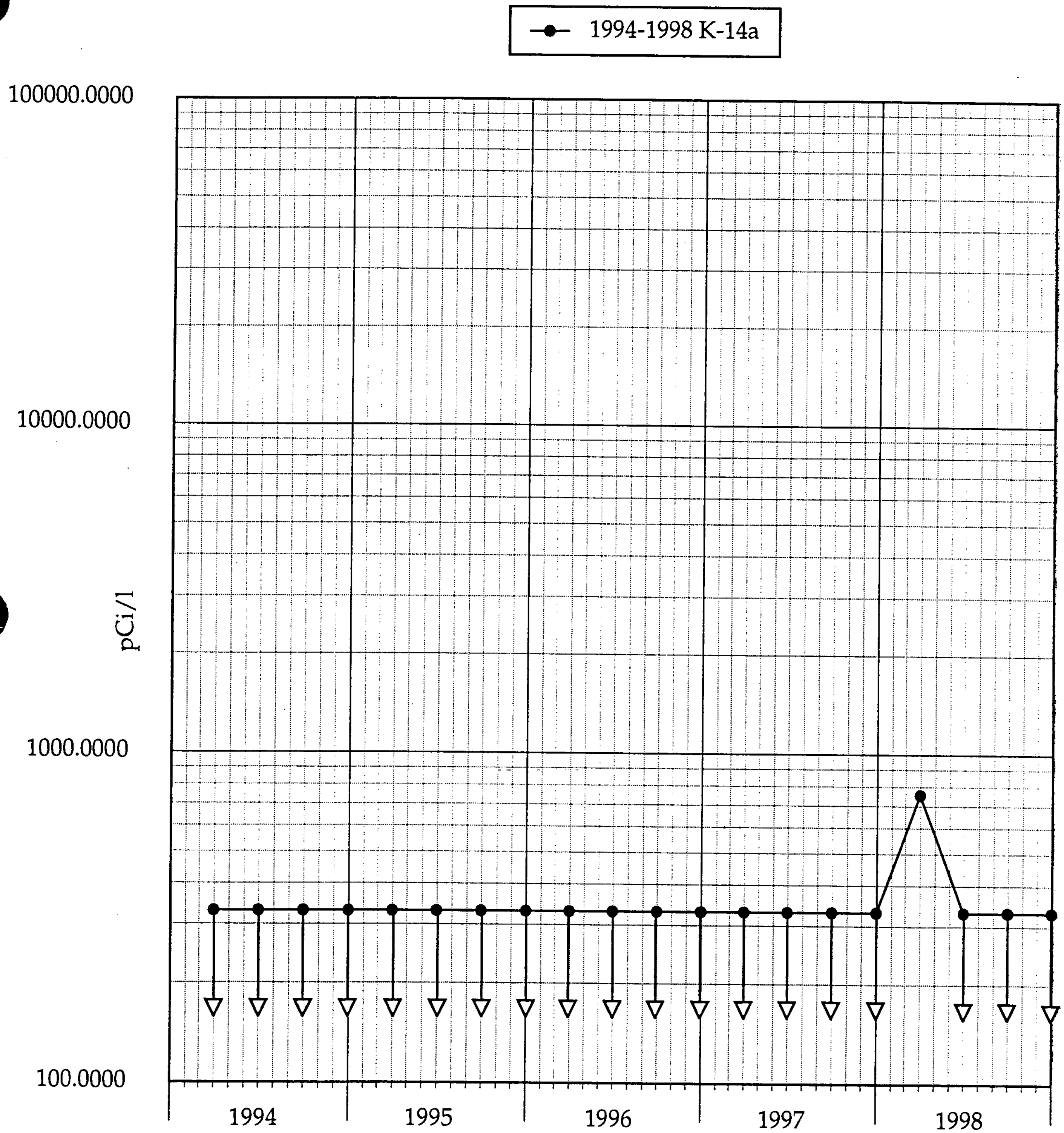

Figure 42. Surface water samples. Collected at Lake Michigan Two Creeks Park. (Location K-14a).

TRITIUM

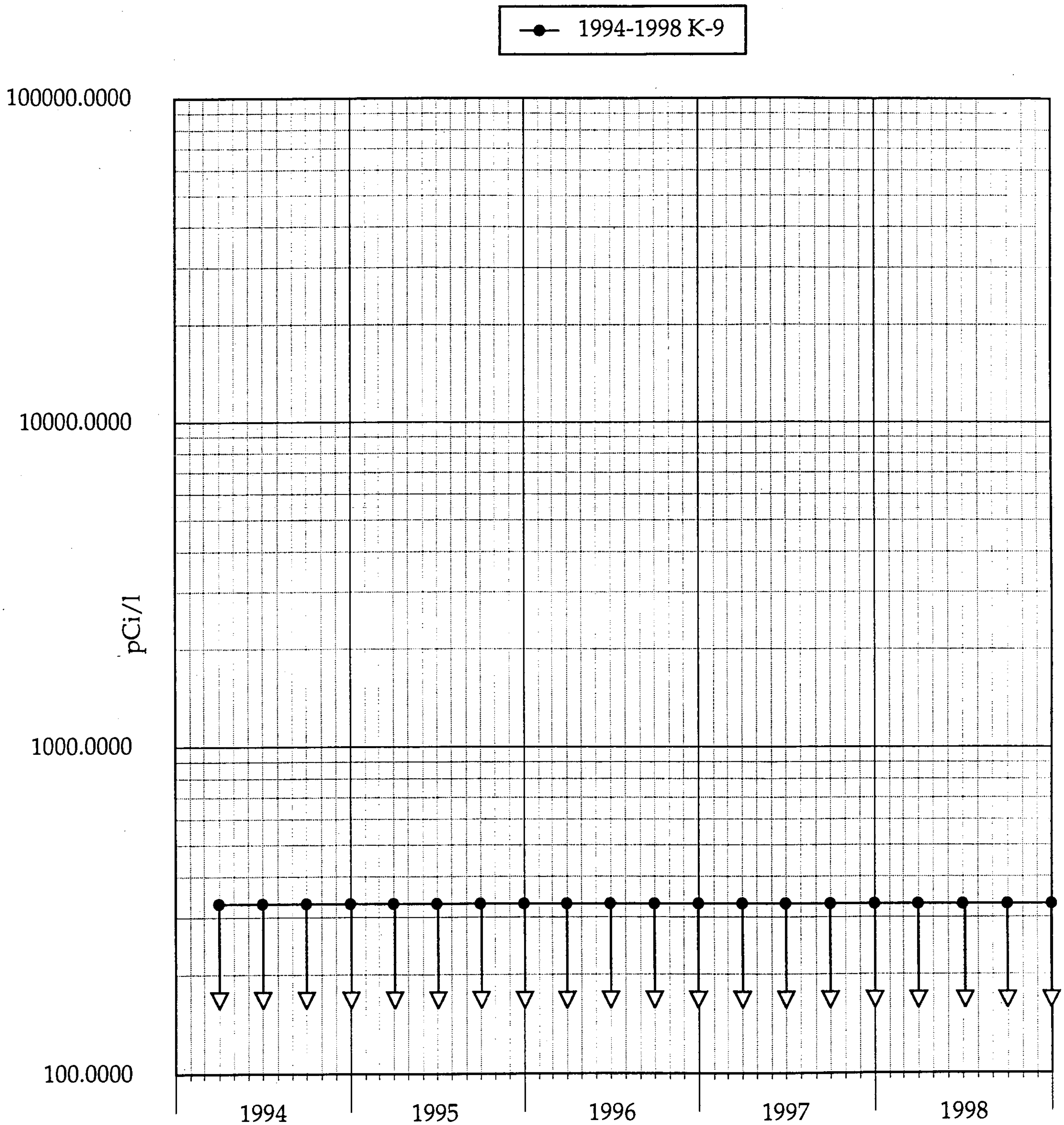

Figure 43. Surface water (raw) samples. Collected at Lake Michigan Rostok intake. (Location K-9).

6.0 DATA TABULATIONS

Table 4. Airborne particulates and charcoal canisters, analyses for gross beta and iodine-131[a].
Location: K-1f
Units: pCi/m^3
Collection: Continuous, weekly exchange.

Date Collected	Volume (m^3)	Gross Beta	Date Collected	Volume (m^3)	Gross Beta
Required LLD		0.010			0.010
01-06-98	284	0.016 ± 0.003	07-07-98	255	0.016 ± 0.003
01-13-98	283	0.021 ± 0.003	07-14-98	252	0.019 ± 0.004
01-20-98	284	0.022 ± 0.003	07-21-98	274	0.029 ± 0.004
01-27-98	283	0.021 ± 0.003	07-28-98	278	0.013 ± 0.003
02-03-98	284	0.029 ± 0.004			
			08-04-98	284	0.016 ± 0.003
02-10-98	285	0.021 ± 0.004	08-11-98	294	0.021 ± 0.003
02-17-98	283	0.024 ± 0.003	08-18-98	302	0.013 ± 0.003
02-24-98	292	0.013 ± 0.003	08-25-98	305	0.024 ± 0.003
03-03-98	306	0.014 ± 0.003	09-01-98	294	0.018 ± 0.003
03-10-98	292	0.008 ± 0.002	09-08-98	280	0.025 ± 0.003
03-17-98	350	0.020 ± 0.003	09-15-98	251	0.023 ± 0.004
03-24-98	335	0.018 ± 0.003	09-22-98	256	0.025 ± 0.004
03-31-98	360	0.018 ± 0.003	09-29-98	263	0.023 ± 0.004
1st Quarter Mean ± s.d.		0.019 ± 0.005	3rd Quarter Mean ± s.d.		0.020 ± 0.005
04-07-98	278	0.009 ±0.003	10-06-98	274	0.016 ± 0.003
04-14-98	273	0.019 ±0.004	10-13-98	287	0.017 ± 0.003
04-21-98	274	0.015 ±0.003	10-20-98	295	0.018 ± 0.003
04-28-98	268	0.016 ±0.003	10-27-98	285	0.025 ± 0.004
			11-03-98	284	0.021 ± 0.004
05-05-98	285	0.012 ±0.003			
05-12-98	304	0.010 ±0.002	11-10-98	284	0.011 ± 0.003
05-19-98	303	0.018 ±0.003	11-17-98	282	0.034 ± 0.004
05-26-98	295	0.014 ±0.003	11-24-98	273	0.021 ± 0.004
06-02-98	267	0.014 ±0.003	12-01-98	273	0.032 ± 0.004
06-09-98	255	0.009 ±0.003	12-08-98	274	0.036 ± 0.004
06-16-98	281	0.014 ±0.003	12-15-98	273	0.026 ± 0.004
06-23-98	267	0.024 ±0.004	12-22-98	275	0.014 ± 0.003
06-30-98	252	0.012 ±0.003	12-29-98	272	0.035 ± 0.004
2nd Quarter Mean ± s.d.		0.014 ±0.004	4th Quarter Mean ± s.d.		0.024 ± 0.009
			Cumulative Average		0.019
			Previous Annual Average		0.019

[a] Iodine-131 is sampled biweekly. Concentrations are <0.03 pCi/m^3 unless otherwise noted.

Table 5. Airborne particulates and charcoal canisters, analyses for gross beta and iodine-131[a].
Location: K-2
Units: pCi/m^3
Collection: Continuous, weekly exchange.

Date Collected	Volume (m^3)	Gross Beta	Date Collected	Volume (m^3)	Gross Beta
Required LLD		0.010			0.010
01-06-98	304	0.014 ± 0.003	07-07-98	306	0.016 ± 0.003
01-13-98	304	0.016 ± 0.003	07-14-98	301	0.017 ± 0.003
01-20-98	304	0.019 ± 0.003	07-21-98	312	0.023 ± 0.003
01-27-98	303	0.020 ± 0.003	07-28-98	298	0.011 ± 0.002
02-03-98	304	0.028 ± 0.004			
			08-04-98	306	0.016 ± 0.003
02-10-98	306	0.020 ± 0.003	08-11-98	302	0.025 ± 0.003
02-17-98	303	0.027 ± 0.003	08-18-98	300	0.012 ± 0.003
02-24-98	302	0.012 ± 0.003	08-25-98	310	0.028 ± 0.003
03-03-98	308	0.012 ± 0.003	09-01-98	301	0.021 ± 0.003
03-10-98	305	0.008 ± 0.003	09-08-98	280	0.026 ± 0.004
03-17-98	302	0.024 ± 0.003	09-15-98	261	0.028 ± 0.004
03-24-98	304	0.018 ± 0.003	09-22-98	310	0.024 ± 0.004
03-31-98	306	0.019 ± 0.003	09-29-98	302	0.024 ± 0.003
1st Quarter Mean ± s.d.		0.018 ± 0.006	3rd Quarter Mean ± s.d.		0.021 ± 0.006
04-07-98	303	0.010 ±0.002	10-06-98	304	0.011 ± 0.003
04-14-98	302	0.021 ±0.003	10-13-98	300	0.014 ± 0.003
04-21-98	304	0.014 ±0.003	10-20-98	307	0.021 ± 0.003
04-28-98	305	0.017 ±0.003	10-27-98	306	0.025 ± 0.003
			11-03-98	304	0.016 ± 0.003
05-05-98	305	0.014 ±0.003			
05-12-98	252	0.018 ±0.003	11-10-98	305	0.009 ± 0.003
05-19-98	250	0.025 ±0.004	11-17-98	305	0.031 ± 0.003
05-26-98	282	0.014 ±0.003	11-24-98	303	0.020 ± 0.003
06-02-98	302	0.012 ±0.003	12-01-98	304	0.028 ± 0.003
06-09-98	307	0.007 ±0.002	12-08-98	274	0.035 ± 0.004
06-16-98	297	0.015 ±0.003	12-15-98	304	0.023 ± 0.004
06-23-98	308	0.019 ±0.003	12-22-98	306	0.013 ± 0.003
06-30-98	301	0.011 ±0.003	12-29-98	302	0.035 ± 0.004
2nd Quarter Mean ± s.d.		0.015 ±0.005	4th Quarter Mean ± s.d.		0.022 ± 0.009

Cumulative Average	0.019
Previous Annual Average	0.019

[a] Iodine-131 is sampled biweekly. Concentrations are <0.03 pCi/m^3 unless otherwise noted.

Table 6. Airborne particulates and charcoal canisters, analyses for gross beta and iodine-131[a].
Location: K-7
Units: pCi/m^3
Collection: Continuous, weekly exchange.

Date Collected	Volume (m^3)	Gross Beta	Date Collected	Volume (m^3)	Gross Beta
Required LLD		0.010			0.010
01-06-98	304	0.015 ± 0.003	07-07-98	255	0.015 ± 0.003
01-13-98	303	0.021 ± 0.003	07-14-98	252	0.017 ± 0.004
01-20-98	305	0.023 ± 0.003	07-21-98	259	0.024 ± 0.004
01-27-98	303	0.019 ± 0.003	07-28-98	248	0.014 ± 0.004
02-03-98	305	0.026 ± 0.004			
			08-04-98	253	0.013 ± 0.003
02-10-98	306	0.021 ± 0.003	08-11-98	255	0.025 ± 0.004
02-17-98	303	0.027 ± 0.003	08-18-98	250	0.015 ± 0.004
02-24-98	305	0.014 ± 0.003	08-25-98	283	0.027 ± 0.004
03-03-98	302	0.011 ± 0.003	09-01-98	278	0.021 ± 0.004
03-10-98	300	0.004 ± 0.002	09-08-98	270	0.023 ± 0.003
03-17-98	256	0.023 ± 0.004	09-15-98	251	0.020 ± 0.004
03-24-98	306	0.017 ± 0.003	09-22-98	280	0.027 ± 0.004
03-31-98	279	0.019 ± 0.003	09-29-98	320	0.025 ± 0.003
1st Quarter Mean ± s.d.		0.018 ± 0.006	3rd Quarter Mean ± s.d.		0.020 ± 0.005
04-07-98	258	0.011 ±0.003	10-06-98	334	0.015 ± 0.003
04-14-98	267	0.017 ±0.003	10-13-98	330	0.012 ± 0.003
04-21-98	253	0.014 ±0.003	10-20-98	338	0.020 ± 0.003
04-28-98	251	0.019 ±0.004	10-27-98	334	0.027 ± 0.003
			11-03-98	330	0.019 ± 0.003
05-05-98	255	0.015 ±0.003			
05-12-98	254	0.014 ±0.003	11-10-98	316	0.010 ± 0.003
05-19-98	250	0.023 ±0.004	11-17-98	315	0.036 ± 0.004
05-26-98	256	0.014 ±0.003	11-24-98	323	0.018 ± 0.003
06-02-98	252	0.015 ±0.003	12-01-98	328	0.031 ± 0.003
06-09-98	254	0.009 ±0.003	12-08-98	337	0.034 ± 0.003
06-16-98	256	0.017 ±0.003	12-15-98	354	0.022 ± 0.003
06-23-98	252	0.021 ±0.004	12-22-98	357	0.015 ± 0.003
06-30-98	253	0.014 ±0.003	12-29-98	340	0.037 ± 0.004
2nd Quarter Mean ± s.d.		0.016 ±0.004	4th Quarter Mean ± s.d.		0.023 ± 0.009
			Cumulative Average		0.019
			Previous Annual Average		0.019

[a] Iodine-131 is sampled biweekly. Concentrations are <0.03 pCi/m^3 unless otherwise noted.

Table 7. Airborne particulates and charcoal canisters, analyses for gross beta and iodine-131[a].
Location: K-8
Units: pCi/m^3
Collection: Continuous, weekly exchange.

Date Collected	Volume (m^3)	Gross Beta	Date Collected	Volume (m^3)	Gross Beta
Required LLD		0.010			0.010
01-06-98	294	0.015 ± 0.003	07-07-98	285	0.017 ± 0.003
01-13-98	284	0.020 ± 0.003	07-14-98	292	0.016 ± 0.003
01-20-98	284	0.025 ± 0.003	07-21-98	311	0.021 ± 0.003
01-27-98	282	0.021 ± 0.003	07-28-98	298	0.012 ± 0.002
02-03-98	284	0.025 ± 0.004			
			08-04-98	294	0.016 ± 0.003
02-10-98	295	0.025 ± 0.004	08-11-98	294	0.023 ± 0.003
02-17-98	303	0.026 ± 0.003	08-18-98	300	0.016 ± 0.003
02-24-98	305	0.013 ± 0.003	08-25-98	308	0.025 ± 0.003
03-03-98	303	0.012 ± 0.003	09-01-98	304	0.022 ± 0.003
03-10-98	294	0.006 ± 0.002	09-08-98	305	0.024 ± 0.003
03-17-98	256	0.022 ± 0.003	09-15-98	301	0.024 ± 0.003
03-24-98	305	0.018 ± 0.003	09-22-98	306	0.026 ± 0.004
03-31-98	303	0.018 ± 0.003	09-29-98	305	0.025 ± 0.003
1st Quarter Mean ± s.d.		0.019 ± 0.006	3rd Quarter Mean ± s.d.		0.021 ± 0.005
04-07-98	303	0.010 ±0.002	10-06-98	304	0.012 ± 0.003
04-14-98	303	0.017 ±0.003	10-13-98	300	0.015 ± 0.003
04-21-98	305	0.014 ±0.003	10-20-98	302	0.018 ± 0.003
04-28-98	302	0.015 ±0.003	10-27-98	304	0.029 ± 0.004
			11-03-98	306	0.018 ± 0.003
05-05-98	305	0.015 ±0.003			
05-12-98	305	0.014 ±0.003	11-10-98	305	0.013 ± 0.003
05-19-98	301	0.020 ±0.003	11-17-98	305	0.038 ± 0.004
05-26-98	307	0.013 ±0.003	11-24-98	303	0.021 ± 0.003
06-02-98	302	0.013 ±0.003	12-01-98	307	0.030 ± 0.003
06-09-98	304	0.005 ±0.002	12-08-98	302	0.034 ± 0.004
06-16-98	307	0.016 ±0.003	12-15-98	313	0.025 ± 0.004
06-23-98	303	0.016 ±0.003	12-22-98	326	0.017 ± 0.003
06-30-98	293	0.011 ±0.003	12-29-98	322	0.035 ± 0.004
2nd Quarter Mean ± s.d.		0.014 ±0.004	4th Quarter Mean ± s.d.		0.023 ± 0.009

Cumulative Average	0.019
Previous Annual Average	0.020

[a] Iodine-131 is sampled biweekly. Concentrations are <0.03 pCi/m^3 unless otherwise noted.

Table 8. Airborne particulates and charcoal canisters, analyses for gross beta and iodine-131[a].
Location: K-31
Units: pCi/m^3
Collection: Continuous, weekly exchange.

Date Collected	Volume (m^3)	Gross Beta	Date Collected	Volume (m^3)	Gross Beta
Required LLD		0.010			0.010
01-06-98	365	0.013 ± 0.002	07-07-98	276	0.017 ± 0.003
01-13-98	398	0.018 ± 0.003	07-14-98	270	0.017 ± 0.003
01-20-98	397	0.021 ± 0.003	07-21-98	282	0.025 ± 0.003
01-27-98	403	0.019 ± 0.003	07-28-98	268	0.015 ± 0.004
02-03-98	407	0.028 ± 0.003			
			08-04-98	275	0.019 ± 0.003
02-10-98	407	0.023 ± 0.003	08-11-98	273	0.024 ± 0.004
02-17-98	405	0.027 ± 0.003	08-18-98	285	0.018 ± 0.003
02-24-98	404	0.014 ± 0.002	08-25-98	283	0.028 ± 0.004
03-03-98	335	0.013 ± 0.002	09-01-98	252	0.025 ± 0.004
03-10-98	402	0.008 ± 0.002	09-08-98	255	0.030 ± 0.004
03-17-98	408	0.022 ± 0.003	09-15-98	249	0.026 ± 0.004
03-24-98	405	0.017 ± 0.002	09-22-98	284	0.029 ± 0.004
03-31-98	403	0.018 ± 0.002	09-29-98	318	0.024 ± 0.003
1st Quarter Mean ± s.d.		0.019 ± 0.006	3rd Quarter Mean ± s.d.		0.023 ± 0.005
04-07-98	341	0.011 ±0.002	10-06-98	333	0.013 ± 0.003
04-14-98	273	0.020 ±0.004	10-13-98	282	0.017 ± 0.003
04-21-98	274	0.017 ±0.003	10-20-98	338	0.016 ± 0.003
04-28-98	274	0.021 ±0.004	10-27-98	331	0.024 ± 0.003
			11-03-98	324	0.016 ± 0.003
05-05-98	289	0.015 ±0.003			
05-12-98	303	0.014 ±0.003	11-10-98	325	0.010 ± 0.002
05-19-98	300	0.018 ±0.003	11-17-98	314	0.033 ± 0.003
05-26-98	308	0.013 ±0.003	11-24-98	303	0.020 ± 0.003
06-02-98	302	0.013 ±0.003	12-01-98	304	0.030 ± 0.003
06-09-98	306	0.007 ±0.002	12-08-98	306	0.032 ± 0.004
06-16-98	276	0.017 ±0.003	12-15-98	314	0.025 ± 0.004
06-23-98	298	0.015 ±0.003	12-22-98	326	0.015 ± 0.003
06-30-98	281	0.011 ±0.003	12-29-98	320	0.030 ± 0.004
2nd Quarter Mean ± s.d.		0.015 ±0.004	4th Quarter Mean ± s.d.		0.022 ± 0.008
			Cumulative Average		0.019
			Previous Annual Average		0.019

[a] Iodine-131 is sampled biweekly. Concentrations are <0.03 pCi/m^3 unless otherwise noted.

Table 9. Airborne particulates and charcoal canisters, analyses for gross beta and iodine-131[a].
Location: K-16
Units: pCi/m^3
Collection: Continuous, weekly exchange.

Date Collected	Volume (m^3)	Gross Beta	Date Collected	Volume (m^3)	Gross Beta
Required LLD		0.010			0.010
01-05-98	304	0.017 ± 0.003	07-06-98	254	0.017 ± 0.003
01-12-98	304	0.018 ± 0.003	07-13-98	253	0.011 ± 0.003
01-19-98	305	0.026 ± 0.003	07-20-98	254	0.024 ± 0.004
01-26-98	304	0.019 ± 0.003	07-27-98	259	0.013 ± 0.004
02-02-98	303	0.032 ± 0.004			
			08-03-98	259	0.016 ± 0.003
02-10-98	304	0.021 ± 0.003	08-10-98	258	< 0.003[b]
02-16-98	305	0.027 ± 0.003	08-17-98	278	0.017 ± 0.003
02-23-98	303	0.019 ± 0.003	08-24-98	280	0.023 ± 0.003
03-02-98	304	0.017 ± 0.003	08-31-98	254	0.029 ± 0.003
03-09-98	304	0.006 ± 0.002	09-08-98	289	0.027 ± 0.003
03-16-98	304	0.023 ± 0.003	09-14-98	218	0.025 ± 0.004
03-23-98	304	0.017 ± 0.003	09-21-98	278	0.032 ± 0.004
03-30-98	304	0.019 ± 0.003	09-28-98	304	0.023 ± 0.003
1st Quarter Mean ± s.d.		0.020 ± 0.006	3rd Quarter Mean ± s.d.		0.021 ± 0.007
04-06-98	302	0.008 ±0.002	10-05-98	304	0.014 ± 0.003
04-13-98	278	0.012 ±0.003	10-12-98	304	0.017 ± 0.003
04-20-98	254	0.012 ±0.003	10-20-98	304	0.020 ± 0.003
04-27-98	254	0.017 ±0.004	10-26-98	306	0.024 ± 0.003
			11-02-98	304	0.024 ± 0.004
05-04-98	252	0.015 ±0.003			
05-11-98	253	0.015 ±0.003	11-09-98	303	0.009 ± 0.003
05-18-98	254	0.018 ±0.003	11-16-98	304	0.035 ± 0.004
05-26-98	289	0.016 ±0.003	11-23-98	304	0.024 ± 0.004
06-01-98	217	0.014 ±0.004	11-30-98	305	0.027 ± 0.003
06-08-98	254	0.008 ±0.003	12-07-98	302	0.034 ± 0.004
06-15-98	253	0.016 ±0.003	12-14-98	305	0.022 ± 0.004
06-22-98	254	0.014 ±0.003	12-21-98	304	0.016 ± 0.003
06-29-98	253	0.011 ±0.003	12-28-98	304	0.032 ± 0.004
2nd Quarter Mean ± s.d.		0.014 ±0.003	4th Quarter Mean ± s.d.		0.023 ± 0.008
			Cumulative Average		0.019
			Previous Annual Average		0.019

[a] Iodine-131 is sampled biweekly. Concentrations are <0.03 pCi/m^3 unless otherwise noted.
[b] Filter light.

Table 7. Airborne particulate data, gross beta analyses, monthly averages, minima and maxima.

January

Location	Average	Minima	Maxima
Indicators	0.021	0.015	0.029
K-1f	0.022	0.016	0.029
K-7	0.021	0.015	0.026
Controls	0.021	0.013	0.032
K-2	0.019	0.014	0.028
K-8	0.021	0.015	0.025
K-31	0.020	0.013	0.028
K-16	0.022	0.017	0.032

April

Location	Average	Minima	Maxima
Indicators	0.015	0.009	0.019
K-1f	0.015	0.009	0.019
K-7	0.015	0.011	0.019
Controls	0.015	0.008	0.021
K-2	0.016	0.010	0.021
K-8	0.014	0.010	0.017
K-31	0.017	0.011	0.021
K-16	0.012	0.008	0.017

February

Location	Average	Minima	Maxima
Indicators	0.018	0.011	0.027
K-1f	0.018	0.013	0.024
K-7	0.018	0.011	0.027
Controls	0.019	0.012	0.027
K-2	0.018	0.012	0.027
K-8	0.019	0.012	0.026
K-31	0.019	0.013	0.027
K-16	0.021	0.017	0.027

May

Location	Average	Minima	Maxima
Indicators	0.015	0.010	0.023
K-1f	0.014	0.010	0.018
K-7	0.016	0.014	0.023
Controls	0.015	0.012	0.025
K-2	0.017	0.012	0.025
K-8	0.015	0.013	0.020
K-31	0.015	0.013	0.018
K-16	0.016	0.014	0.018

March

Location	Average	Minima	Maxima
Indicators	0.016	0.004	0.023
K-1f	0.016	0.008	0.020
K-7	0.016	0.004	0.023
Controls	0.016	0.006	0.024
K-2	0.017	0.008	0.024
K-8	0.016	0.006	0.022
K-31	0.016	0.008	0.022
K-16	0.016	0.006	0.023

June

Location	Average	Minima	Maxima
Indicators	0.015	0.009	0.024
K-1f	0.015	0.009	0.024
K-7	0.015	0.009	0.021
Controls	0.012	0.005	0.019
K-2	0.013	0.007	0.019
K-8	0.012	0.005	0.016
K-31	0.013	0.007	0.017
K-16	0.012	0.008	0.016

Note: unless otherwise specified, samples collected on the first, second or third day of the month are grouped with data of the previous month.

Table 7. Airborne particulate data,gross beta analyses, monthly averages, minima and maxima.

July

Location	Average	Minima	Maxima
Indicators	0.018	0.013	0.029
K-1f	0.019	0.013	0.029
K-7	0.018	0.014	0.024
Controls	0.017	0.011	0.025
K-2	0.017	0.011	0.023
K-8	0.017	0.012	0.021
K-31	0.019	0.015	0.025
K-16	0.016	0.011	0.024

August

Location	Average	Minima	Maxima
Indicators	0.019	0.013	0.027
K-1f	0.018	0.013	0.024
K-7	0.020	0.013	0.027
Controls	0.021	0.012	0.029
K-2	0.020	0.012	0.028
K-8	0.020	0.016	0.025
K-31	0.023	0.018	0.028
K-16	0.021	0.016	0.029

September

Location	Average	Minima	Maxima
Indicators	0.024	0.020	0.027
K-1f	0.024	0.023	0.025
K-7	0.024	0.020	0.027
Controls	0.026	0.023	0.032
K-2	0.026	0.024	0.028
K-8	0.025	0.024	0.026
K-31	0.027	0.024	0.030
K-16	0.027	0.023	0.032

October

Location	Average	Minima	Maxima
Indicators	0.019	0.012	0.027
K-1f	0.019	0.016	0.025
K-7	0.019	0.012	0.027
Controls	0.018	0.011	0.029
K-2	0.017	0.011	0.025
K-8	0.018	0.012	0.029
K-31	0.017	0.013	0.024
K-16	0.020	0.014	0.024

November

Location	Average	Minima	Maxima
Indicators	0.024	0.010	0.036
K-1f	0.025	0.011	0.034
K-7	0.024	0.010	0.036
Controls	0.024	0.009	0.038
K-2	0.022	0.009	0.031
K-8	0.026	0.013	0.038
K-31	0.023	0.010	0.033
K-16	0.024	0.009	0.035

December

Location	Average	Minima	Maxima
Indicators	0.027	0.014	0.037
K-1f	0.028	0.014	0.036
K-7	0.027	0.015	0.037
Controls	0.026	0.013	0.035
K-2	0.027	0.013	0.035
K-8	0.028	0.017	0.035
K-31	0.026	0.015	0.032
K-16	0.026	0.016	0.034

Note: unless otherwise specified, samples collected on the first, second or third day of the month are grouped with data of the previous month.

Table 11. Airborne particulate samples, quarterly composites of weekly samples, analysis for gamma-emitting isotopes.

	Sample Description and Concentration (pCi/m^3)			
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Indicator				
K-1f				
Lab Code	KAP-2187	KAP-5187	KAP-8117	KAP-11170
Volume (m^3)	3921	3602	3588	3631
Be-7	0.072 ± 0.012	0.079 ± 0.015	0.067 ± 0.018	0.055 ± 0.014
Nb-95	< 0.0011	< 0.0005	< 0.0020	< 0.0015
Zr-95	< 0.0019	< 0.0016	< 0.0025	< 0.0028
Ru-103	< 0.0011	< 0.0007	< 0.0010	< 0.0009
Ru-106	< 0.0056	< 0.0048	< 0.010	< 0.0072
Cs-134	< 0.0006	< 0.0014	< 0.0007	< 0.0009
Cs-137	< 0.0007	< 0.0008	< 0.0012	< 0.0008
Ce-141	< 0.0008	< 0.0018	< 0.0029	< 0.0015
Ce-144	< 0.0046	< 0.0033	< 0.0082	< 0.0053
K-7				
Lab Code	KAP-2189	KAP-5190	KAP-8120	KAP-11172
Volume (m^3)	3877	3311	3454	4336
Be-7	0.066 ± 0.014	0.089 ± 0.019	0.072 ± 0.016	0.054 ± 0.012
Nb-95	< 0.0017	< 0.0006	< 0.0020	< 0.0010
Zr-95	< 0.0013	< 0.0025	< 0.0036	< 0.0011
Ru-103	< 0.0013	< 0.0003	< 0.0010	< 0.0004
Ru-106	< 0.0089	< 0.0057	< 0.012	< 0.0029
Cs-134	< 0.0008	< 0.0005	< 0.0008	< 0.0006
Cs-137	< 0.0011	< 0.0007	< 0.0011	< 0.0005
Ce-141	< 0.0020	< 0.0024	< 0.0030	< 0.0012
Ce-144	< 0.0057	< 0.0044	< 0.0074	< 0.0017

Table 11. Airborne particulate samples, quarterly composites of weekly samples, analysis for gamma-emitting isotopes, (continued).

	Sample Description and Concentration (pCi/m^3)			
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Control				
K-2				
Lab Code	KAP-2188	KAP-5188,89	KAP-8118,9	KAP-11171
Volume (m^3)	3955	3818	3889	3924
Be-7	0.064 ± 0.009	0.079 ± 0.010	0.073 ± 0.012	0.057 ± 0.011
Nb-95	< 0.0007	< 0.0009	< 0.0003	< 0.0006
Zr-95	< 0.0010	< 0.0009	< 0.0015	< 0.0021
Ru-103	< 0.0003	< 0.0004	< 0.0008	< 0.0006
Ru-106	< 0.0064	< 0.0052	< 0.0060	< 0.0094
Cs-134	< 0.0005	< 0.0004	< 0.0009	< 0.0007
Cs-137	< 0.0005	< 0.0005	< 0.0006	< 0.0005
Ce-141	< 0.0007	< 0.0009	< 0.0009	< 0.0013
Ce-144	< 0.0029	< 0.0045	< 0.0025	< 0.0051
K-8				
Lab Code	KAP-2190	KAP-5191	KAP-8121	KAP-11173
Volume (m^3)	3792	3940	3903	3999
Be-7	0.071 ± 0.010	0.083 ± 0.013	0.083 ± 0.014	0.054 ± 0.013
Nb-95	< 0.0006	< 0.0004	< 0.0014	< 0.0010
Zr-95	< 0.0009	< 0.0012	< 0.0014	< 0.0010
Ru-103	< 0.0007	< 0.0009	< 0.0006	< 0.0008
Ru-106	< 0.0063	< 0.0027	< 0.0025	< 0.0080
Cs-134	< 0.0007	< 0.0014	< 0.0003	< 0.0008
Cs-137	< 0.0004	< 0.0008	< 0.0007	< 0.0005
Ce-141	< 0.0006	< 0.0019	< 0.0007	< 0.0017
Ce-144	< 0.0029	< 0.0044	< 0.0025	< 0.0042

Table 11. Airborne particulate samples, quarterly composites of weekly samples, analysis for gamma-emitting isotopes, (continued).

	Sample Description and Concentration (pCi/m³)			
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Control				
K-31				
Lab Code	KAP-2191	KAP-5192	KAP-8122	KAP-11174
Volume (m^3)	5139	3825	3570	4120
Be-7	0.071 ± 0.011	0.072 ± 0.010	0.091 ± 0.014	0.054 ± 0.009
Nb-95	< 0.0008	< 0.0009	< 0.0008	< 0.0011
Zr-95	< 0.0009	< 0.0004	< 0.0023	< 0.0012
Ru-103	< 0.0009	< 0.0004	< 0.0007	< 0.0008
Ru-106	< 0.0029	< 0.0044	< 0.0080	< 0.0058
Cs-134	< 0.0007	< 0.0007	< 0.0005	< 0.0006
Cs-137	< 0.0006	< 0.0006	< 0.0004	< 0.0005
Ce-141	< 0.0009	< 0.0015	< 0.0011	< 0.0009
Ce-144	< 0.0024	< 0.0025	< 0.0030	< 0.0026
K-16				
Lab Code	KAP-2192	KAP-5193	KAP-8123	KAP-11175
Volume (m^3)	3952	3367	3438	3953
Be-7	0.079 ± 0.015	0.082 ± 0.015	0.085 ± 0.020	0.047 ± 0.011
Nb-95	< 0.0016	< 0.0009	< 0.0023	< 0.0008
Zr-95	< 0.0021	< 0.0024	< 0.0014	< 0.0016
Ru-103	< 0.0009	< 0.0004	< 0.0016	< 0.0010
Ru-106	< 0.0081	< 0.0045	< 0.0088	< 0.0064
Cs-134	< 0.0009	< 0.0017	< 0.0015	< 0.0008
Cs-137	< 0.0013	< 0.0012	< 0.0008	< 0.0004
Ce-141	< 0.0014	< 0.0014	< 0.0014	< 0.0013
Ce-144	< 0.0064	< 0.0033	< 0.0089	< 0.0026

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Table 12. Ambient gamma radiation (TLD), quarterly exposure.

	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	
Date Placed	01-05-98	04-01-98	07-01-98	10-01-98	
Date Removed	04-01-98	07-01-98	10-01-98	01-06-99	
	mR/91 days[a]				
Indicator					Mean±s.d.
K-1f	14.2 ± 0.2	12.3 ± 0.2	14.5 ± 0.1	12.7 ± 0.1	13.4 ± 1.1
K-4	15.6 ± 0.1	14.0 ± 0.1	15.0 ± 0.2	14.4 ± 0.1	14.8 ± 0.7
K-5	14.2 ± 0.2	15.3 ± 0.1	16.1 ± 0.3	15.6 ± 0.2	15.3 ± 0.8
K-7	17.1 ± 0.1	18.3 ± 0.1	20.4 ± 0.1	18.7 ± 0.3	18.6 ± 1.4
K-17	19.1 ± 0.3	16.9 ± 0.3	20.3 ± 0.2	17.1 ± 0.1	18.4 ± 1.6
K-27	15.8 ± 0.1	13.6 ± 0.1	15.4 ± 0.1	13.9 ± 0.1	14.7 ± 1.1
K-30	17.4 ± 0.3	16.4 ± 0.2	18.2 ± 0.1	17.2 ± 0.1	17.3 ± 0.7
Mean ± s.d.	16.2 ± 1.8	15.3 ± 2.1	17.1 ± 2.5	15.7 ± 2.1	16.1 ± 0.8
Control					
K-2	13.8 ± 0.2	13.6 ± 0.1	14.1 ± 0.2	13.6 ± 0.1	13.8 ± 0.2
K-3	17.1 ± 0.1	17.9 ± 0.1	18.8 ± 0.1	17.9 ± 0.1	17.9 ± 0.7
K-6	NS[b]	13.8 ± 0.1[c]	14.2 ± 0.1	13.6 ± 0.1	13.9 ± 0.3
K-8	16.7 ± 0.2	16.5 ± 0.2	17.7 ± 0.2	16.7 ± 0.1	16.9 ± 0.5
K-15	16.1 ± 0.1	15.7 ± 0.2	17.6 ± 0.3	16.3 ± 0.1	16.4 ± 0.8
K-16	15.8 ± 0.1	13.5 ± 0.1	16.1 ± 0.1	13.9 ± 0.1	14.8 ± 1.3
K-31	15.1 ± 0.1	13.5 ± 0.6	15.2 ± 0.3	13.5 ± 0.3	14.3 ± 1.0
Mean ± s.d.	15.8 ± 1.2	14.9 ± 1.8	16.2 ± 1.8	15.1 ± 1.8	15.5 ± 0.6

[a] The uncertainty for each location corresponds to the two-standard deviation error of the average dose of eight dosimeters placed at this location.

[b] NS=No sample; TLD lost due to power line pole replacement.

[c] Removed 8-3-98.

Table 13. Precipitation samples collected at Location K-11; analysis for tritium, January through December, 1998.

Month Collected	Lab Code	H-3 pCi/L	H-3 T.U. (100 T.U. = 320 pCi/L)
January	KP -10041	< 330	< 103
February	-683	< 330	< 103
March	-1411	< 330	< 103
April	-2144	< 330	< 103
May	-3000	< 330	< 103
June	-4183,4	< 330	< 103
July	-4876	< 330	< 103
August	-6150	< 330	< 103
September	-6995	< 330	< 103
October	-7887	< 330	< 103
November	-9469	< 330	< 103
December	-10299	< 330	< 103

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Table 14. Milk, analyses for iodine-131 and gamma-emitting isotopes.
Collection: Semimonthly during grazing season, monthly at other times.

Collection Date	Lab Code	Concentration (pCi/L)				
		I-131	Cs-134	Cs-137	Ba-La-140	K-40
Indicators						
K-4						
01-06-98	KMI - 6	< 0.5	< 10	< 10	< 15	1490 ± 160
02-02-98	- 578	< 0.5	< 10	< 10	< 15	1240 ± 150
03-03-98	- 1280	< 0.5	< 10	< 10	< 15	1490 ± 130
04-02-98	- 1960	< 0.5	< 10	< 10	< 15	1290 ± 130
05-05-98	- 2937	< 0.5	< 10	< 10	< 15	1360 ± 100
05-19-98	- 3607	< 0.5	< 10	< 10	< 15	1400 ± 180
06-02-98	- 4002	< 0.5	< 10	< 10	< 15	1240 ± 180
06-16-98	- 4373	< 0.5	< 10	< 10	< 15	1280 ± 140
07-01-98	- 4802	< 0.5	< 10	< 10	< 15	1410 ± 120
07-14-98	- 5288	< 0.5	< 10	< 10	< 15	1390 ± 110
08-04-98	- 5915	< 0.5	< 10	< 10	< 15	1080 ± 140
08-18-98	- 6429	< 0.5	< 10	< 10	< 15	1330 ± 160
09-02-98	- 6839	< 0.5	< 10	< 10	< 15	1410 ± 120
09-15-98	- 7528	< 0.5	< 10	< 10	< 15	1400 ± 190
10-02-98	- 7821	< 0.5	< 10	< 10	< 15	1240 ± 160
10-13-98	- 8330	< 0.5	< 10	< 10	< 15	1200 ± 150
11-03-98	- 9332	< 0.5	< 10	< 10	< 15	1370 ± 160
12-02-98	- 10148	< 0.5	< 10	< 10	< 15	1540 ± 170
K-5						
01-06-98	KMI - 7	< 0.5	< 10	< 10	< 15	1460 ± 180
02-02-98	- 579	< 0.5	< 10	< 10	< 15	1540 ± 160
03-03-98	- 1281	< 0.5	< 10	< 10	< 15	1430 ± 120
04-02-98	- 1961	< 0.5	< 10	< 10	< 15	1210 ± 180
05-05-98	- 2938	< 0.5	< 10	< 10	< 15	1370 ± 170
05-19-98	- 3608	< 0.5	< 10	< 10	< 15	1400 ± 130
06-02-98	- 4003	< 0.5	< 10	< 10	< 15	1320 ± 100
06-16-98	- 4374	< 0.5	< 10	< 10	< 15	1470 ± 180
07-01-98	- 4803	< 0.5	< 10	< 10	< 15	1400 ± 180
07-14-98	- 5289	< 0.5	< 10	< 10	< 15	1470 ± 170
08-04-98	- 5916	< 0.5	< 10	< 10	< 15	1340 ± 150
08-18-98	- 6430	< 0.5	< 10	< 10	< 15	1330 ± 170
09-02-98	- 6840	< 0.5	< 10	< 10	< 15	1270 ± 110
09-15-98	- 7529	< 0.5	< 10	< 10	< 15	1730 ± 200
10-02-98	- 7822	< 0.5	< 10	< 10	< 15	1350 ± 160
10-13-98	- 8331	< 0.5	< 10	< 10	< 15	1380 ± 170
11-03-98	- 9333	< 0.5	< 10	< 10	< 15	1340 ± 160
12-02-98	- 10149	< 0.5	< 10	< 10	< 15	1350 ± 160

Table 14. Milk, analyses for iodine-131 and gamma-emitting isotopes (continued).

Collection Date	Lab Code	Concentration (pCi/L)				
		I-131	Cs-134	Cs-137	Ba-La-140	K-40
Indicators						
K-12						
01-05-98	KMI - 9	< 0.5	< 10	< 10	< 15	1440 ± 170
02-02-98	- 581	< 0.5	< 10	< 10	< 15	1500 ± 120
03-03-98	- 1283	< 0.5	< 10	< 10	< 15	1640 ± 180
04-01-98	- 1963	< 0.5	< 10	< 10	< 15	1530 ± 130
05-04-98	- 2940	< 0.5	< 10	< 10	< 15	1420 ± 180
05-19-98	- 3610	< 0.5	< 10	< 10	< 15	1340 ± 110
06-02-98	- 4005	< 0.5	< 10	< 10	< 15	1340 ± 160
06-16-98	- 4376	< 0.5	< 10	< 10	< 15	1490 ± 160
07-01-98	- 4805	< 0.5	< 10	< 10	< 15	1680 ± 190
07-14-98	- 5291	< 0.5	< 10	< 10	< 15	1410 ± 100
08-04-98	- 5918	< 0.5	< 10	< 10	< 15	1320 ± 170
08-18-98	- 6432	< 0.5	< 10	< 10	< 15	1370 ± 120
09-01-98	- 6842	< 0.5	< 10	< 10	< 15	1260 ± 150
09-15-98	- 7531	< 0.5	< 10	< 10	< 15	1600 ± 150
10-01-98	- 7824	< 0.5	< 10	< 10	< 15	1530 ± 200
10-13-98	- 8333	< 0.5	< 10	< 10	< 15	1390 ± 120
11-02-98	- 9335	< 0.5	< 10	< 10	< 15	1500 ± 190
12-02-98	- 10151	< 0.5	< 10	< 10	< 15	1580 ± 180
K-19						
01-06-98	KMI - 10	< 0.5	< 10	< 10	< 15	1240 ± 160
02-02-98	- 582	< 0.5	< 10	< 10	< 15	1270 ± 150
03-03-98	- 1284	< 0.5	< 10	< 10	< 15	1420 ± 150
04-02-98	- 1964	< 0.5	< 10	< 10	< 15	1390 ± 130
05-04-98	- 2940,1	< 0.5	< 10	< 10	< 15	1320 ± 120
05-19-98	- 3611	< 0.5	< 10	< 10	< 15	1160 ± 140
06-02-98	- 4006	< 0.5	< 10	< 10	< 15	1430 ± 170
06-16-98	- 4377	< 0.5	< 10	< 10	< 15	1290 ± 150
07-01-98	- 4806	< 0.5	< 10	< 10	< 15	1600 ± 170
07-14-98	- 5292	< 0.5	< 10	< 10	< 15	1310 ± 160
08-04-98	- 5919	< 0.5	< 10	< 10	< 15	1380 ± 170
08-18-98	- 6433	< 0.5	< 10	< 10	< 15	1310 ± 160
09-01-98	- 6843	< 0.5	< 10	< 10	< 15	1420 ± 120
09-15-98	- 7532	< 0.5	< 10	< 10	< 15	1550 ± 170
10-01-98	- 7825	< 0.5	< 10	< 10	< 15	1390 ± 160
10-13-98	- 8334	< 0.5	< 10	< 10	< 15	1390 ± 100
11-02-98	- 9336	< 0.5	< 10	< 10	< 15	1400 ± 150
12-02-98	- 10152	< 0.5	< 10	< 10	< 15	1440 ± 160

Table 14. Milk, analyses for iodine-131 and gamma-emitting isotopes (continued).

Collection Date	Lab Code	Concentration (pCi/L)				
		I-131	Cs-134	Cs-137	Ba-La-140	K-40
Control						
K-3						
01-06-98	KMI - 5	< 0.5	< 10	< 10	< 15	1580 ± 160
02-02-98	- 577	< 0.5	< 10	< 10	< 15	1510 ± 110
03-03-98	- 1279	< 0.5	< 10	< 10	< 15	1650 ± 210
04-02-98	- 1959	< 0.5	< 10	< 10	< 15	1480 ± 160
05-05-98	- 2936	< 0.5	< 10	< 10	< 15	1330 ± 120
05-19-98	- 3606	< 0.5	< 10	< 10	< 15	1420 ± 120
06-02-98	- 4001	< 0.5	< 10	< 10	< 15	1410 ± 180
06-16-98	- 4372	< 0.5	< 10	< 10	< 15	1410 ± 150
07-01-98	- 4801	< 0.5	< 10	< 10	< 15	1450 ± 190
07-14-98	- 5287	< 0.5	< 10	< 10	< 15	1400 ± 140
08-04-98	- 5914	< 0.5	< 10	< 10	< 15	1390 ± 150
08-18-98	- 6428	< 0.5	< 10	< 10	< 15	1340 ± 170
09-02-98	- 6838	< 0.5	< 10	< 10	< 15	1260 ± 160
09-15-98	- 7527	< 0.5	< 10	< 10	< 15	1560 ± 150
10-02-98	- 7820	< 0.5	< 10	< 10	< 15	1410 ± 160
10-13-98	- 8329	< 0.5	< 10	< 10	< 15	1390 ± 130
11-03-98	- 9331	< 0.5	< 10	< 10	< 15	1310 ± 190
12-02-98	-10146,7	< 0.5	< 10	< 10	< 15	1390 ± 120
K-6						
01-05-98	KMI - 8	< 0.5	< 10	< 10	< 15	1360 ± 100
02-02-98	- 580	< 0.5	< 10	< 10	< 15	1470 ± 170
03-03-98	- 1282	< 0.5	< 10	< 10	< 15	1300 ± 160
04-02-98	- 1962	< 0.5	< 10	< 10	< 15	1130 ± 120
05-04-98	- 2939	< 0.5	< 10	< 10	< 15	1200 ± 160
05-19-98	- 3609	< 0.5	< 10	< 10	< 15	1180 ± 150
06-02-98	- 4004	< 0.5	< 10	< 10	< 15	1260 ± 110
06-16-98	- 4375	< 0.5	< 10	< 10	< 15	1180 ± 110
07-01-98	- 4804	< 0.5	< 10	< 10	< 15	1100 ± 150
07-14-98	- 5290	< 0.5	< 10	< 10	< 15	1170 ± 180
08-04-98	- 5917	< 0.5	< 10	< 10	< 15	1070 ± 160
08-18-98	- 6431	< 0.5	< 10	< 10	< 15	1180 ± 120
09-01-98	- 6841	< 0.5	< 10	< 10	< 15	1330 ± 130
09-15-98	- 7530	< 0.5	< 10	< 10	< 15	1410 ± 170
10-01-98	- 7823	< 0.5	< 10	< 10	< 15	1340 ± 120
10-13-98	- 8332	< 0.5	< 10	< 10	< 15	1340 ± 160
11-02-98	- 9334	< 0.5	< 10	< 10	< 15	1310 ± 160
12-01-98	- 10150	< 0.5	< 10	< 10	< 15	1290 ± 160

Table 14. Milk, analyses for iodine-131 and gamma-emitting isotopes (continued).

Collection Date	Lab Code	Concentration (pCi/L)				
		I-131	Cs-134	Cs-137	Ba-La-140	K-40
Control						
K-28						
01-06-98	KMI - 11	< 0.5	< 10	< 10	< 15	1470 ± 180
02-02-98	- 583	< 0.5	< 10	< 10	< 15	1380 ± 170
03-03-98	- 1285	< 0.5	< 10	< 10	< 15	1490 ± 160
04-02-98	- 1965	< 0.5	< 10	< 10	< 15	1130 ± 160
05-04-98	- 2943	< 0.5	< 10	< 10	< 15	1270 ± 140
05-19-98	- 3612	< 0.5	< 10	< 10	< 15	1390 ± 180
06-02-98	- 4007	< 0.5	< 10	< 10	< 15	1480 ± 170
06-16-98	- 4378	< 0.5	< 10	< 10	< 15	1240 ± 170
07-01-98	- 4807	< 0.5	< 10	< 10	< 15	1260 ± 150
07-14-98	- 5293	< 0.5	< 10	< 10	< 15	1300 ± 180
08-04-98	- 5920	< 0.5	< 10	< 10	< 15	1440 ± 170
08-18-98	- 6434	< 0.5	< 10	< 10	< 15	1290 ± 160
09-02-98	- 6844	< 0.5	< 10	< 10	< 15	1470 ± 180
09-15-98	- 7533	< 0.5	< 10	< 10	< 15	1560 ± 150
10-01-98	- 7826	< 0.5	< 10	< 10	< 15	1300 ± 140
10-13-98	- 8335	< 0.5	< 10	< 10	< 15	1300 ± 130
11-03-98	- 9337	< 0.5	< 10	< 10	< 15	1200 ± 170
12-02-98	- 10153	< 0.5	< 10	< 10	< 15	1440 ± 180

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Table 15. Milk, analyses for strontium-89, strontium-90, stable potassium, stable calcium, and ratios of strontium-90 per gram of calcium and cesium-137 per gram of potassium. Collection: Monthly composites.

Collection Period	Lab Code	Concentration Sr-89 (pCi/L)	Concentration Sr-90 (pCi/L)	Concentration K (g/L)	Ca (g/L)	Ratios Sr-90 (pCi/L) per gram Ca	Ratios Cs-137 (pCi/L) per gram K
Indicators							
K-4							
January	KMI -6	< 0.9	1.2 ± 0.6	1.72 ± 0.18	0.85	1.41	<5.81
February	-578	< 0.7	0.8 ± 0.4	1.43 ± 0.17	0.91	0.88	<6.98
March	-1280	< 0.8	0.7 ± 0.3	1.72 ± 0.15	0.99	0.71	<5.81
April	-1960	< 0.7	0.9 ± 0.4	1.49 ± 0.15	0.78	1.15	<6.71
May	-3614	< 1.1	0.8 ± 0.3	1.60 ± 0.12	0.88	0.91	<6.27
June	-4380	< 1.0	< 0.7	1.46 ± 0.13	0.86	<0.81	<6.87
July	-5316	< 1.2	0.9 ± 0.4	1.62 ± 0.06	0.80	1.13	<6.18
August	-6436	< 1.1	0.7 ± 0.3	1.39 ± 0.12	0.77	0.91	<7.18
September	-7535	< 0.9	0.9 ± 0.4	1.62 ± 0.13	0.80	1.13	<6.16
October	-8339	< 1.0	0.8 ± 0.4	1.43 ± 0.18	0.87	0.92	<6.98
November	-9332	< 1.0	1.3 ± 0.4	1.58 ± 0.18	0.89	1.46	<6.31
December	-10148	< 1.1	0.9 ± 0.5	1.78 ± 0.20	0.89	1.01	<5.62
K-5							
January	KMI -7	< 0.8	2.7 ± 0.7	1.69 ± 0.21	0.84	3.21	<5.92
February	-579	< 0.7	1.5 ± 0.5	1.78 ± 0.18	0.89	1.69	<5.62
March	-1281	< 0.9	1.3 ± 0.4	1.65 ± 0.14	1.03	1.26	<6.05
April	-1961	< 0.8	1.1 ± 0.4	1.40 ± 0.21	0.71	1.55	<7.15
May	-3615	< 0.6	1.1 ± 0.3	1.60 ± 0.14	0.83	1.33	<6.25
June	-4381	< 0.9	1.0 ± 0.4	1.61 ± 0.12	0.96	1.04	<6.20
July	-5317	< 1.1	1.2 ± 0.4	1.66 ± 0.14	0.88	1.36	<6.03
August	-6437	< 0.9	1.5 ± 0.4	1.54 ± 0.13	0.98	1.53	<6.48
September	-7536	< 1.0	1.8 ± 0.5	1.73 ± 0.13	0.85	2.12	<5.77
October	-8340	< 0.8	1.4 ± 0.4	1.58 ± 0.13	0.89	1.57	<6.34
November	-9333	< 0.9	0.7 ± 0.3	1.55 ± 0.18	0.86	0.81	<6.46
December	-10149	< 1.1	0.8 ± 0.4	1.56 ± 0.18	0.70	1.14	<6.41

Table 15. Milk, analyses for strontium-89, strontium-90, stable potassium, stable calcium, and ratios of strontium-90 per gram of calcium and cesium-137 per gram of potassium (continued).

Collection Period	Lab Code	Concentration Sr-89 (pCi/L)	Sr-90 (pCi/L)	K (g/L)	Ca (g/L)	Ratios Sr-90 (pCi/L) per gram Ca	Cs-137 (pCi/L) per gram K
Indicators							
K-12							
January	KMI -9	< 0.7	1.8 ± 0.6	1.66 ± 0.20	0.80	2.25	<6.01
February	-581	< 0.7	1.8 ± 0.5	1.73 ± 0.14	0.90	2.00	<5.77
March	-1283	< 0.7	1.7 ± 0.5	1.90 ± 0.21	1.00	1.70	<5.27
April	-1963	< 0.8	2.4 ± 0.5	1.77 ± 0.15	0.87	2.76	<5.65
May	-3617	< 0.6	1.2 ± 0.4	1.60 ± 0.12	0.93	1.29	<6.27
June	-4383	< 0.7	1.7 ± 0.4	1.64 ± 0.13	0.96	1.77	<6.11
July	-5319	< 1.0	1.8 ± 0.4	1.79 ± 0.06	0.80	2.25	<5.60
August	-6439	< 1.1	2.0 ± 0.4	1.55 ± 0.12	0.82	2.44	<6.43
September	-7538	< 1.0	1.0 ± 0.4	1.65 ± 0.12	0.85	1.18	<6.05
October	-8342	< 0.8	1.5 ± 0.4	1.69 ± 0.13	0.78	1.92	<5.92
November	-9335	< 1.0	1.4 ± 0.4	1.73 ± 0.22	0.75	1.87	<5.77
December	-10151	< 1.0	1.2 ± 0.5	1.83 ± 0.21	0.90	1.33	<5.47
K-19							
January	KMI -10	< 0.8	1.9 ± 0.5	1.43 ± 0.18	0.80	2.38	<6.98
February	-582	< 0.7	1.0 ± 0.4	1.47 ± 0.17	0.89	1.12	<6.81
March	-1284	< 0.7	1.4 ± 0.4	1.64 ± 0.17	0.90	1.56	<6.09
April	-1964	< 0.7	1.2 ± 0.3	1.61 ± 0.15	0.89	1.35	<6.22
May	-3618	< 0.5	1.1 ± 0.3	1.43 ± 0.10	0.87	1.26	<6.98
June	-4384	< 1.0	1.2 ± 0.5	1.57 ± 0.13	0.82	1.46	<6.36
July	-5320	< 1.1	0.7 ± 0.3	1.68 ± 0.13	0.94	0.74	<5.95
August	-6440	< 1.2	1.7 ± 0.4	1.55 ± 0.13	0.84	2.02	<6.43
September	-7539	< 0.8	1.0 ± 0.3	1.72 ± 0.12	0.88	1.14	<5.82
October	-8343	< 0.8	0.8 ± 0.4	1.61 ± 0.11	0.76	1.05	<6.22
November	-9336	< 1.0	0.8 ± 0.4	1.62 ± 0.17	0.78	1.03	<6.18
December	-10152	< 0.9	1.1 ± 0.4	1.66 ± 0.18	0.80	1.38	<6.01

Table 15. Milk, analyses for strontium-89, strontium-90, stable potassium, stable calcium, and ratios of strontium-90 per gram of calcium and cesium-137 per gram of potassium (continued).

Collection Period	Lab Code	Concentration Sr-89 (pCi/L)	Concentration Sr-90 (pCi/L)	Concentration K (g/L)	Ca (g/L)	Ratios Sr-90 (pCi/L) per gram Ca	Ratios Cs-137 (pCi/L) per gram K
Control							
K-3							
January	KMI -5	< 0.8	1.6 ± 0.6	1.83 ± 0.18	1.08	1.48	<5.47
February	-577	< 0.8	1.3 ± 0.5	1.75 ± 0.13	0.87	1.49	<5.73
March	-1279	< 0.8	0.9 ± 0.4	1.91 ± 0.24	0.95	0.95	<5.24
April	-1959	< 0.8	1.4 ± 0.5	1.71 ± 0.18	0.87	1.61	<5.84
May	-3613	< 0.7	1.5 ± 0.4	1.59 ± 0.10	0.93	1.61	<6.29
June	-4379	< 1.4	1.3 ± 0.5	1.63 ± 0.14	0.96	1.35	<6.13
July	-5315	< 1.2	1.2 ± 0.4	1.65 ± 0.14	0.82	1.46	<6.07
August	-6435	< 1.1	1.2 ± 0.4	1.58 ± 0.13	0.90	1.33	<6.34
September	-7534	< 0.9	1.1 ± 0.4	1.63 ± 0.13	0.86	1.28	<6.13
October	-8338	< 0.9	1.2 ± 0.4	1.62 ± 0.12	0.89	1.35	<6.18
November	-9331	< 1.1	1.2 ± 0.4	1.51 ± 0.22	0.75	1.60	<6.60
December	-10146,7	< 1.1	1.1 ± 0.5	1.61 ± 0.14	0.78	1.41	<6.22
K-6							
January	KMI -8	< 0.8	2.1 ± 0.6	1.57 ± 0.12	0.98	2.14	<6.36
February	-580	< 0.7	3.3 ± 0.6	1.70 ± 0.20	1.02	3.24	<5.88
March	-1282	< 0.8	1.8 ± 0.4	1.50 ± 0.18	1.03	1.75	<6.65
April	-1962	< 0.7	1.3 ± 0.4	1.31 ± 0.14	1.00	1.30	<7.65
May	-3616	< 0.7	1.0 ± 0.4	1.38 ± 0.13	0.97	1.03	<7.27
June	-4382	< 0.8	1.1 ± 0.4	1.41 ± 0.09	0.90	1.22	<7.09
July	-5318	< 1.1	1.1 ± 0.4	1.31 ± 0.14	1.07	1.03	<7.62
August	-6438	< 1.2	0.8 ± 0.4	1.30 ± 0.14	0.99	0.81	<7.69
September	-7537	< 0.9	1.2 ± 0.4	1.58 ± 0.12	0.92	1.30	<6.31
October	-8341	< 0.9	1.2 ± 0.4	1.55 ± 0.12	1.05	1.14	<6.46
November	-9334	< 0.9	0.8 ± 0.3	1.51 ± 0.18	0.87	0.92	<6.60
December	-10150	< 1.1	1.1 ± 0.4	1.49 ± 0.18	0.90	1.22	<6.71

Table 15. Milk, analyses for strontium-89, strontium-90, stable potassium, stable calcium, and ratios of strontium-90 per gram of calcium and cesium-137 per gram of potassium (continued).

Collection Period	Lab Code	Concentration: Sr-89 (pCi/L)	Concentration: Sr-90 (pCi/L)	Concentration: K (g/L)	Ca (g/L)	Ratios: Sr-90 (pCi/L) per gram Ca	Ratios: Cs-137 (pCi/L) per gram K
Control							
K-28							
January	KMI -11	< 0.8	1.6 ± 0.5	1.70 ± 0.21	0.89	1.80	<5.88
February	-583	< 0.8	2.1 ± 0.5	1.60 ± 0.20	0.88	2.39	<6.27
March	-1285	< 0.7	1.9 ± 0.6	1.72 ± 0.18	0.90	2.11	<5.81
April	-1965	< 0.7	1.9 ± 0.4	1.31 ± 0.18	0.85	2.24	<7.65
May	-3619	< 0.7	2.2 ± 0.5	1.54 ± 0.13	1.10	2.00	<6.50
June	-4385	< 1.0	1.0 ± 0.5	1.57 ± 0.14	0.80	1.25	<6.36
July	-5321	< 1.1	1.1 ± 0.4	1.48 ± 0.14	0.81	1.36	<6.76
August	-6441	< 1.0	1.7 ± 0.4	1.58 ± 0.13	0.89	1.91	<6.34
September	-7540	< 0.8	1.3 ± 0.4	1.75 ± 0.14	0.82	1.59	<5.71
October	-8344	< 0.9	1.1 ± 0.4	1.50 ± 0.11	0.88	1.25	<6.65
November	-9337	< 1.1	1.4 ± 0.5	1.39 ± 0.20	0.84	1.67	<7.21
December	-10153	< 1.0	0.8 ± 0.3	1.66 ± 0.21	0.76	1.05	<6.01

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Table 16. Well water samples, analyses for gross alpha[a], gross beta, potassium-40, and gamma-emitting isotopes.
Collection: Quarterly.

Sample Description and Concentration (pCi/L)

Indicator

K-1g

Date Collected	01-05-98	04-01-98	07-01-98	10-01-98
Lab Code	KWW-35	KWW-1977	KWW-4817	KWW-7862
Gross alpha	2.1 ± 1.7	< 2.1	3.8 ± 2.1	< 2.7
Gross beta	5.7 ± 1.4	3.6 ± 2.8	5.1 ± 2.6	< 3.6
K-40 (flame photometry)	2.68	2.25	2.77	2.60
Mn-54	<15	<15	<15	<15
Fe-59	<30	<30	<30	<30
Co-58	<15	<15	<15	<15
Co-60	<15	<15	<15	<15
Zr-Nb-95	<15	<15	<15	<15
Cs-134	<10	<10	<10	<10
Cs-137	<10	<10	<10	<10
Ba-La-140	<15	<15	<15	<15

K-1h

Date Collected	01-05-98	04-01-98	07-01-98	10-01-98
Lab Code	KWW-36	KWW-1978	KWW-4818	KWW-7863
Gross alpha	< 1.8	6.1 ± 1.6	< 2.1	2.5 ± 1.7
Gross beta	4.4 ± 1.2	5.6 ± 1.4	4.0 ± 1.6	3.2 ± 1.6
K-40 (flame photometry)	2.60	2.25	2.68	2.60
Mn-54	<15	<15	<15	<15
Fe-59	<30	<30	<30	<30
Co-58	<15	<15	<15	<15
Co-60	<15	<15	<15	<15
Zr-Nb-95	<15	<15	<15	<15
Cs-134	<10	<10	<10	<10
Cs-137	<10	<10	<10	<10
Ba-La-140	<15	<15	<15	<15

[a] Gross Alpha analyses required on samples from K-1g and K-1h only.

Table 16. Well water samples, analyses for gross alpha, gross beta, potassium-40, and gamma-emitting isotopes (continued).

Sample Description and Concentration (pCi/L)

Indicator

K-10

Date Collected	01-05-98	04-01-98	07-01-98	10-01-98
Lab Code	KWW-37	KWW-1979	KWW-4819,20	KWW-7864
Gross beta	1.0 ± 0.4	1.2 ± 0.3	1.0 ± 0.4	< 1.0
K-40 (flame photometry)	<0.87	<0.87	0.91	0.87
Mn-54	<15	<15	<15	<15
Fe-59	<30	<30	<30	<30
Co-58	<15	<15	<15	<15
Co-60	<15	<15	<15	<15
Zr-Nb-95	<15	<15	<15	<15
Cs-134	<10	<10	<10	<10
Cs-137	<10	<10	<10	<10
Ba-La-140	<15	<15	<15	<15

K-11

Date Collected	01-05-98	04-01-98	07-01-98	10-01-98
Lab Code	KWW-38	KWW-1980	KWW-4821	KWW-7865
Gross beta	1.9 ± 0.6	1.3 ± 0.3	< 1.1	2.3 ± 0.3
K-40 (flame photometry)	0.87	<0.87	1.04	0.95
Mn-54	<15	<15	<15	<15
Fe-59	<30	<30	<30	<30
Co-58	<15	<15	<15	<15
Co-60	<15	<15	<15	<15
Zr-Nb-95	<15	<15	<15	<15
Cs-134	<10	<10	<10	<10
Cs-137	<10	<10	<10	<10
Ba-La-140	<15	<15	<15	<15

Table 16. Well water samples, analyses for gross alpha, gross beta, potassium-40, and gamma-emitting isotopes (continued).

Sample Description and Concentration (pCi/L)

Indicator (continued)

K-12

Date Collected	01-05-98	04-01-98	07-01-98	10-01-98
Lab Code	KWW-39	KWW-1981	KWW-4822	KWW-7866
Gross beta	1.7 ± 0.6	< 1.1	1.3 ± 0.7	1.6 ± 0.3
K-40 (flame photometry)	1.04	0.95	1.12	1.21
Mn-54	<15	<15	<15	<15
Fe-59	<30	<30	<30	<30
Co-58	<15	<15	<15	<15
Co-60	<15	<15	<15	<15
Zr-Nb-95	<15	<15	<15	<15
Cs-134	<10	<10	<10	<10
Cs-137	<10	<10	<10	<10
Ba-La-140	<15	<15	<15	<15

Control

K-13

Date Collected	01-05-98	04-01-98	07-01-98	10-01-98
Lab Code	KWW-40	KWW-1982	KWW-4823	KWW-7867
Gross beta	1.0 ± 0.4	1.1 ± 0.4	1.4 ± 0.5	1.2 ± 0.2
K-40 (flame photometry)	0.95	0.95	1.04	0.95
Mn-54	<15	<15	<15	<15
Fe-59	<30	<30	<30	<30
Co-58	<15	<15	<15	<15
Co-60	<15	<15	<15	<15
Zr-Nb-95	<15	<15	<15	<15
Cs-134	<10	<10	<10	<10
Cs-137	<10	<10	<10	<10
Ba-La-140	<15	<15	<15	<15

Table 17. Well water samples from K-1g , analyses for tritium, strontium-89, and strontium-90. Collection: Quarterly.

Date Collected	Lab Code	Concentration (pCi/L)		
		H-3	Sr-89	Sr-90
01-05-98	KWW -35	< 330	< 0.7	< 0.4
04-01-98	-1977	< 330	< 0.7	0.5 ± 0.2
07-01-98	-4817	< 330	< 2.2	< 0.5
10-01-98	-7862	< 330	< 0.8	< 0.5

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Table 18. Domestic meat samples (chickens), analyses of flesh for gross alpha, gross beta, and gamma-emitting isotopes.
Collection: Annually.

Sample Description and Concentration (pCi/g wet)

	Indicator			Control
Location	K-24	K-27	K-29	K-32
Date Collected	09-01-98	NS[a]	09-01-98	09-01-98
Lab Code	KME-6864	-	KME-6865	KME-6866
Gross Alpha	0.10 ± 0.06	-	< 0.04	0.05 ± 0.03
Gross beta	2.52 ± 0.13	-	1.76 ± 0.09	3.00 ± 0.09
Be-7	< 0.41	-	< 0.31	< 0.094
K-40	3.06 ± 0.42	-	2.76 ± 0.30	2.19 ± 0.16
Nb-95	< 0.083	-	< 0.039	< 0.013
Zr-95	< 0.042	-	< 0.060	< 0.011
Ru-103	< 0.032	-	< 0.022	< 0.012
Ru-106	< 0.23	-	< 0.16	< 0.057
Cs-134	< 0.021	-	< 0.020	< 0.006
Cs-137	< 0.021	-	< 0.018	< 0.006
Ce-141	< 0.063	-	< 0.057	< 0.018
Ce-144	< 0.11	-	< 0.13	< 0.032

[a] NS = No sample; sample not available from this location.

Table 19. Eggs, analyses for gross beta, strontium-89, strontium-90 and gamma emitting isotopes.

Collection:

Sample Description and Concentration (pCi/g wet)

Location	K-24			
Date Collected	01-05-98	04-01-98	08-04-98	10-01-98
Lab Code	KE-12	KE-1966, 7	KE-5921	KE-7876
Gross beta	1.15 ± 0.04	1.16 ± 0.04	1.22 ± 0.06	1.23 ± 0.06
Sr-89	< 0.004	< 0.010	< 0.006	< 0.006
Sr-90	< 0.003	< 0.003	0.004 ± 0.001	0.002 ± 0.001
Be-7	< 0.036	< 0.038	< 0.088	< 0.092
K-40	1.25 ± 0.13	1.32 ± 0.11	1.11 ± 0.21	1.31 ± 0.21
Nb-95	< 0.008	< 0.004	< 0.009	< 0.013
Zr-95	< 0.007	< 0.015	< 0.022	< 0.011
Ru-103	< 0.005	< 0.004	< 0.006	< 0.006
Ru-106	< 0.048	< 0.057	< 0.041	< 0.045
Cs-134	< 0.005	< 0.003	< 0.006	< 0.007
Cs-137	< 0.005	< 0.006	< 0.009	< 0.006
Ce-141	< 0.013	< 0.008	< 0.012	< 0.023
Ce-144	< 0.040	< 0.042	< 0.039	< 0.059

Location		K-32		
Date Collected		05-04-98	07-02-98	10-01-98
Lab Code		KE-2953	KE-4824	KE-7877
Gross beta		1.16 ± 0.04	2.07 ± 0.09	1.31 ± 0.06
Sr-89		< 0.007	< 0.004	< 0.002
Sr-90		< 0.003	< 0.002	< 0.001
Be-7		< 0.058	< 0.091	< 0.082
K-40		1.48 ± 0.20	1.46 ± 0.21	1.20 ± 0.22
Nb-95		< 0.014	< 0.009	< 0.020
Zr-95		< 0.020	< 0.014	< 0.017
Ru-103		< 0.011	< 0.011	< 0.013
Ru-106		< 0.099	< 0.055	< 0.040
Cs-134		< 0.009	< 0.008	< 0.009
Cs-137		< 0.011	< 0.006	< 0.011
Ce-141		< 0.021	< 0.022	< 0.022
Ce-144		< 0.039	< 0.047	< 0.063

Table 20. Vegetable and grain samples, analyses for gross beta, strontium-89, strontium-90, and gamma-emitting isotopes.
Collection: Annually

Sample Description and Concentration (pCi/g wet)

	Indicator		
Location	K-17	K-17	K-17
Date Collected	09-01-98	09-01-98	09-01-98
Lab Code	KVE-6867	KVE-6868	KVE-6869
Type	Tomatoes	Squash	Cucumbers
Gross beta	2.11 ± 0.07	3.48 ± 0.13	1.17 ± 0.04
Sr-89	< 0.004	< 0.004	< 0.001
Sr-90	< 0.002	< 0.002	< 0.001
Be-7	< 0.065	< 0.096	< 0.034
K-40	2.02 ± 0.24	2.77 ± 0.30	1.05 ± 0.17
Nb-95	< 0.009	< 0.015	< 0.004
Zr-95	< 0.016	< 0.015	< 0.009
Ru-103	< 0.008	< 0.012	< 0.007
Ru-106	< 0.067	< 0.056	< 0.050
Cs-134	< 0.008	< 0.013	< 0.010
Cs-137	< 0.009	< 0.008	< 0.007
Ce-141	< 0.019	< 0.013	< 0.014
Ce-144	< 0.067	< 0.069	< 0.032

	Control			
Location	K-26	K-26	K-26	K-26
Date Collected	09-01-98	09-01-98	09-01-98	10-01-98
Lab Code	KVE-6870	KVE-6871	KVE-6872	KVE-7886
Type	Corn	Cauliflower	Cabbage	Pumpkin
Gross beta	3.75 ± 0.11	2.23 ± 0.07	2.16 ± 0.08	1.93 ± 0.05
Sr-89	0.014	< 0.002	< 0.003	< 0.001
Sr-90	0.006	< 0.001	< 0.002	< 0.001
Be-7	< 0.16	< 0.037	< 0.077	< 0.086
K-40	2.58 ± 0.37	2.09 ± 0.18	2.12 ± 0.27	1.94 ± 0.25
Nb-95	< 0.019	< 0.007	< 0.012	< 0.006
Zr-95	< 0.016	< 0.017	< 0.024	< 0.025
Ru-103	< 0.012	< 0.004	< 0.011	< 0.012
Ru-106	< 0.055	< 0.065	< 0.051	< 0.056
Cs-134	< 0.010	< 0.007	< 0.010	< 0.006
Cs-137	< 0.018	< 0.007	< 0.008	< 0.011
Ce-141	< 0.017	< 0.009	< 0.012	< 0.019
Ce-144	< 0.066	< 0.040	< 0.046	< 0.057

Table 20. Vegetable and grain samples, analyses for gross beta, strontium-89, strontium-90, and gamma-emitting isotopes (continued).

Sample Description and Concentration (pCi/g wet)

	Indicator	
Location	K-23	K-23
Date Collected	08-04-98	08-04-98
Lab Code	KVE-5926 A	KVE-5926 B
Type	Oats	Clover
Gross beta	8.46 ± 0.35	4.92 ± 0.19
Sr-89	< 0.043	< 0.021
Sr-90	< 0.022	0.016 ± 0.007
Be-7	0.86 ± 0.32	0.97 ± 0.32
K-40	9.23 ± 0.79	4.55 ± 0.52
Nb-95	< 0.031	< 0.011
Zr-95	< 0.078	< 0.029
Ru-103	< 0.037	< 0.022
Ru-106	< 0.26	< 0.17
Cs-134	< 0.021	< 0.016
Cs-137	< 0.028	< 0.021
Ce-141	< 0.060	< 0.042
Ce-144	< 0.10	< 0.18

Location
Date Collected
Lab Code
Type
Gross beta
Sr-89
Sr-90
Be-7
K-40
Nb-95
Zr-95
Ru-103
Ru-106
Cs-134
Cs-137
Ce-141
Ce-144

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Table 21. Cattlefeed samples, analyses for gross beta, strontium-89, strontium-90, and gamma-emitting isotopes.
Collection: First Quarter.

Sample Description and Concentration (pCi/g wet)		
	Control	
Location	K-3	K-3
Date Collected	01-06-98	01-06-98
Lab Code	KCF-13	KCF-14
Type	Hay	Silage
Gross beta	11.94 ± 0.37	3.79 ± 0.13
Sr-89	<0.005	<0.005
Sr-90	0.013±0.003	0.003±0.002
Be-7	< 0.20	0.44 ± 0.20
K-40	10.03 ± 0.76	4.66 ± 0.50
Nb-95	< 0.027	< 0.024
Zr-95	< 0.056	< 0.048
Ru-103	< 0.011	< 0.015
Ru-106	< 0.19	< 0.15
Cs-134	< 0.020	< 0.021
Cs-137	< 0.009	< 0.016
Ce-141	< 0.041	< 0.041
Ce-144	< 0.14	< 0.12
Location	K-6	K-6
Date Collected	01-06-98	01-06-98
Lab Code	KCF-19	KCF-20
Type	Hay	Silage
Gross beta	10.39 ± 0.38	10.50 ± 0.36
Sr-89	<0.013	<0.009
Sr-90	0.060±0.010	0.050±0.008
Be-7	1.23 ± 0.16	0.93 ± 0.29
K-40	9.73 ± 0.38	10.38 ± 0.77
Nb-95	< 0.011	< 0.022
Zr-95	< 0.020	< 0.047
Ru-103	< 0.014	< 0.013
Ru-106	< 0.10	< 0.18
Cs-134	< 0.015	< 0.028
Cs-137	< 0.017	< 0.022
Ce-141	< 0.033	< 0.031
Ce-144	< 0.093	< 0.089

Table 21. Cattlefeed samples, analyses for gross beta, strontium-89, strontium-90, and gamma-emitting isotopes (continued).

Sample Description and Concentration (pCi/g wet)				
	Indicator			
Location	K-4	K-4	K-5	K-5
Date Collected	01-06-98	01-06-98	01-06-98	01-06-98
Lab Code	KCF-15	KCF-16	KCF-17	KCF-18
Type	Hay	Silage	Hay	Silage
Gross beta	23.62 ± 0.77	5.68 ± 0.14	20.07 ± 0.49	9.23 ± 0.29
Sr-89	< 0.012	< 0.004	< 0.018	< 0.010
Sr-90	0.029 ± 0.006	0.007 ± 0.002	0.035 ± 0.010	0.017 ± 0.006
Be-7	0.65 ± 0.30	< 0.10	< 0.17	0.38 ± 0.13
K-40	26.79 ± 0.99	5.07 ± 0.29	22.26 ± 0.84	9.66 ± 0.44
Nb-95	< 0.043	< 0.013	< 0.042	< 0.012
Zr-95	< 0.044	< 0.023	< 0.070	< 0.018
Ru-103	< 0.018	< 0.007	< 0.029	< 0.010
Ru-106	< 0.23	< 0.069	< 0.25	< 0.11
Cs-134	< 0.033	< 0.008	< 0.029	< 0.012
Cs-137	< 0.033	< 0.009	< 0.025	< 0.013
Ce-141	< 0.047	< 0.023	< 0.067	< 0.015
Ce-144	< 0.20	< 0.052	< 0.19	< 0.073
Location	K-12	K-12	K-19	K-19
Date Collected	01-06-98	01-06-98	01-06-98	01-06-98
Lab Code	KCF-21,22	KCF-23	KCF-24	KCF-25
Type	Hay	Silage	Hay	Silage
Gross beta	17.59 ± 0.41	2.07 ± 0.08	14.72 ± 0.49	6.90 ± 0.23
Sr-89	< 0.016	< 0.003	< 0.027	< 0.007
Sr-90	0.030 ± 0.006	0.003 ± 0.001	0.027 ± 0.010	0.007 ± 0.003
Be-7	0.40 ± 0.13	0.22 ± 0.12	0.67 ± 0.24	0.49 ± 0.19
K-40	21.02 ± 0.50	1.97 ± 0.28	14.83 ± 0.65	6.97 ± 0.64
Nb-95	< 0.027	< 0.010	< 0.024	< 0.022
Zr-95	< 0.058	< 0.021	< 0.062	< 0.037
Ru-103	< 0.015	< 0.008	< 0.015	< 0.014
Ru-106	< 0.14	< 0.051	< 0.21	< 0.076
Cs-134	< 0.015	< 0.016	< 0.022	< 0.021
Cs-137	< 0.017	< 0.011	< 0.023	< 0.019
Ce-141	< 0.035	< 0.026	< 0.037	< 0.041
Ce-144	< 0.13	< 0.051	< 0.075	< 0.11

Table 22. Grass, analyses for gross beta, strontium-89, strontium-90, and gamma-emitting isotopes.
Collection: Quarterly, April through December
Units: pCi/g wet

Sample Description and Concentration

	Indicator			Control
Location	K-1b	K-1f	K-4	K-3
Date Collected	05-04-98	05-04-98	05-04-98	05-04-98
Lab Code	KG-2955	KG-2954	KG-2957	KG-2956
Gross beta	11.83 ± 0.41	7.30 ± 0.39	6.72 ± 0.21	11.98 ± 0.39
Sr-89	< 0.008	< 0.016	< 0.009	< 0.007
Sr-90	< 0.004	< 0.008	< 0.005	< 0.004
Be-7	1.94 ± 0.19	2.89 ± 0.13	1.65 ± 0.23	0.88 ± 0.18
K-40	7.71 ± 0.42	6.33 ± 0.26	7.27 ± 0.52	6.89 ± 0.47
Mn-54	< 0.007	< 0.007	< 0.020	< 0.009
Co-58	< 0.011	< 0.011	< 0.016	< 0.013
Co-60	< 0.019	< 0.013	< 0.021	< 0.018
Nb-95	< 0.015	< 0.013	< 0.020	< 0.008
Zr-95	< 0.033	< 0.015	< 0.035	< 0.025
Ru-103	< 0.012	< 0.007	< 0.019	< 0.008
Ru-106	< 0.092	< 0.092	< 0.20	< 0.12
Cs-134	< 0.013	< 0.009	< 0.024	< 0.013
Cs-137	< 0.017	< 0.010	< 0.020	< 0.016
Ce-141	< 0.026	< 0.015	< 0.021	< 0.017
Ce-144	< 0.13	< 0.035	< 0.12	< 0.11
Location	K-5	K-12	K-19	K-6
Date Collected	05-04-98	05-04-98	05-04-98	06-01-98
Lab Code	KG-2958	KG-2959	KG-2960	KG-4029
Gross beta	7.02 ± 0.24	5.51 ± 0.18	6.42 ± 0.21	6.84 ± 0.24
Sr-89	< 0.011	< 0.016	< 0.009	< 0.014
Sr-90	< 0.004	0.010 ± 0.004	< 0.004	< 0.008
Be-7	0.70 ± 0.20	0.34 ± 0.13	1.65 ± 0.23	0.70 ± 0.19
K-40	8.11 ± 0.50	6.16 ± 0.41	6.46 ± 0.43	8.19 ± 0.44
Mn-54	< 0.009	< 0.009	< 0.019	< 0.019
Co-58	< 0.017	< 0.006	< 0.018	< 0.020
Co-60	< 0.016	< 0.013	< 0.021	< 0.018
Nb-95	< 0.017	< 0.008	< 0.019	< 0.022
Zr-95	< 0.033	< 0.023	< 0.040	< 0.043
Ru-103	< 0.007	< 0.012	< 0.016	< 0.009
Ru-106	< 0.10	< 0.092	< 0.13	< 0.075
Cs-134	< 0.015	< 0.015	< 0.019	< 0.018
Cs-137	< 0.015	< 0.015	< 0.017	< 0.018
Ce-141	< 0.029	< 0.022	< 0.028	< 0.031
Ce-144	< 0.12	< 0.069	< 0.068	< 0.10

Table 22. Grass samples, analyses for gross beta, strontium-89, strontium-90, and gamma-emitting isotopes (continued).

Sample Description and Concentration

	Indicator			Control
Location	K-1b	K-1f	K-4	K-3
Date Collected	07-01-98	07-01-98	07-01-98	07-01-98
Lab Code	KG-4825	KG-4826	KG-4828	KG-4827
Gross beta	5.63 ± 0.22	7.09 ± 0.21	6.41 ± 0.22	6.63 ± 0.21
Sr-89	< 0.009	< 0.013	< 0.006	< 0.007
Sr-90	0.005 ± 0.002	< 0.006	0.005 ± 0.002	0.005 ± 0.002
Be-7	1.31 ± 0.42	1.45 ± 0.38	2.57 ± 0.37	2.41 ± 0.40
K-40	5.30 ± 0.71	5.22 ± 0.88	5.65 ± 0.73	6.34 ± 0.78
Mn-54	< 0.025	< 0.025	< 0.020	< 0.030
Co-58	< 0.014	< 0.020	< 0.011	< 0.012
Co-60	< 0.033	< 0.027	< 0.038	< 0.031
Nb-95	< 0.047	< 0.042	< 0.039	< 0.033
Zr-95	< 0.075	< 0.049	< 0.029	< 0.053
Ru-103	< 0.031	< 0.035	< 0.031	< 0.025
Ru-106	< 0.28	< 0.15	< 0.10	< 0.18
Cs-134	< 0.018	< 0.038	< 0.014	< 0.014
Cs-137	< 0.031	< 0.017	< 0.022	< 0.027
Ce-141	< 0.066	< 0.042	< 0.052	< 0.046
Ce-144	< 0.23	< 0.11	< 0.22	< 0.097
Location	K-5	K-12	K-19	K-6
Date Collected	07-01-98	07-01-98	07-01-98	07-01-98
Lab Code	KG-4829	KG-4831	KG-4832	KG-4830
Gross beta	7.65 ± 0.26	6.15 ± 0.21	5.49 ± 0.21	6.26 ± 0.23
Sr-89	< 0.008	< 0.008	< 0.014	< 0.013
Sr-90	< 0.004	< 0.004	0.008 ± 0.004	< 0.007
Be-7	2.47 ± 0.38	1.22 ± 0.22	3.21 ± 0.52	1.92 ± 0.24
K-40	7.17 ± 0.54	5.86 ± 0.45	6.72 ± 0.86	6.21 ± 0.44
Mn-54	< 0.011	< 0.010	< 0.035	< 0.014
Co-58	< 0.008	< 0.015	< 0.039	< 0.012
Co-60	< 0.021	< 0.014	< 0.039	< 0.020
Nb-95	< 0.015	< 0.020	< 0.056	< 0.011
Zr-95	< 0.030	< 0.030	< 0.039	< 0.020
Ru-103	< 0.013	< 0.022	< 0.041	< 0.009
Ru-106	< 0.16	< 0.12	< 0.15	< 0.11
Cs-134	< 0.030	< 0.028	< 0.051	< 0.013
Cs-137	< 0.018	< 0.014	< 0.044	< 0.019
Ce-141	< 0.042	< 0.016	< 0.084	< 0.031
Ce-144	< 0.14	< 0.074	< 0.38	< 0.17

Table 22. Grass samples, analyses for gross beta, strontium-89, strontium-90, and gamma-emitting isotopes (continued).

Sample Description and Concentration (pCi/g wet)

	Indicator			Control
Location	K-1b	K-1f	K-4	K-3
Date Collected	10-01-98	10-01-98	10-01-98	10-01-98
Lab Code	KG-7868	KG-7869	KG-7871	KG-7870
Gross beta	4.99 ± 0.24	5.88 ± 0.28	5.48 ± 0.22	6.65 ± 0.24
Sr-89	< 0.004	< 0.004	< 0.002	< 0.005
Sr-90	0.004 ± 0.001	0.005 ± 0.001	0.001 ± 0.001	0.002 ± 0.001
Be-7	3.46 ± 0.52	3.94 ± 0.53	3.69 ± 0.50	2.92 ± 0.44
K-40	4.31 ± 0.68	4.44 ± 0.70	5.79 ± 0.73	6.45 ± 0.77
Mn-54	< 0.026	< 0.013	< 0.017	< 0.011
Co-58	< 0.016	< 0.031	< 0.020	< 0.031
Co-60	< 0.045	< 0.037	< 0.040	< 0.023
Nb-95	< 0.042	< 0.041	< 0.039	< 0.044
Zr-95	< 0.059	< 0.034	< 0.082	< 0.053
Ru-103	< 0.024	< 0.022	< 0.017	< 0.039
Ru-106	< 0.29	< 0.25	< 0.33	< 0.17
Cs-134	< 0.024	< 0.043	< 0.031	< 0.035
Cs-137	< 0.029	< 0.027	< 0.036	< 0.027
Ce-141	< 0.068	< 0.053	< 0.070	< 0.039
Ce-144	< 0.23	< 0.17	< 0.17	< 0.18
Location	K-5	K-12	K-19	K-6
Date Collected	10-01-98	10-01-98	10-01-98	10-01-98
Lab Code	KG-7872	KG-7874	KG-7875	KG-7873
Gross beta	6.36 ± 0.20	7.17 ± 0.24	4.86 ± 0.21	5.29 ± 0.18
Sr-89	< 0.002	< 0.003	< 0.004	< 0.002
Sr-90	0.002 ± 0.001	< 0.001	0.006 ± 0.001	< 0.001
Be-7	1.94 ± 0.41	1.63 ± 0.34	3.26 ± 0.58	1.23 ± 0.29
K-40	7.21 ± 0.75	7.37 ± 0.75	5.51 ± 0.89	6.08 ± 0.62
Mn-54	< 0.018	< 0.019	< 0.015	< 0.023
Co-58	< 0.026	< 0.028	< 0.044	< 0.019
Co-60	< 0.020	< 0.034	< 0.039	< 0.020
Nb-95	< 0.053	< 0.029	< 0.031	< 0.027
Zr-95	< 0.034	< 0.046	< 0.068	< 0.029
Ru-103	< 0.028	< 0.019	< 0.043	< 0.032
Ru-106	< 0.28	< 0.16	< 0.37	< 0.089
Cs-134	< 0.016	< 0.033	< 0.048	< 0.021
Cs-137	< 0.031	< 0.030	< 0.034	< 0.029
Ce-141	< 0.074	< 0.037	< 0.042	< 0.049
Ce-144	< 0.21	< 0.11	< 0.25	< 0.17

Table 23. Soil samples, analyses for gross alpha, gross beta, strontium-89, strontium-90, an(gamma-emitting isotopes.
Collection: Semiannually

Sample Description and Concentration (pCi/g dry)

	Indicator		
Location	K-1f	K-4	K-5
Date Collected	05-04-98	05-04-98	05-04-98
Lab Code	KSO-2961	KSO-2964	KSO-2965
Gross alpha	4.92 ± 2.73	9.73 ± 3.46	14.41 ± 4.12
Gross beta	22.42 ± 2.69	27.68 ± 2.85	35.57 ± 3.21
Sr-89	< 0.032	< 0.030	< 0.034
Sr-90	< 0.016	0.016 ± 0.008	0.094 ± 0.016
Be-7	< 0.22	< 0.19	< 0.27
K-40	18.93 ± 0.74	18.85 ± 0.75	26.28 ± 0.93
Nb-95	< 0.041	< 0.015	< 0.016
Zr-95	< 0.047	< 0.044	< 0.054
Ru-103	< 0.029	< 0.023	< 0.021
Ru-106	< 0.19	< 0.19	< 0.26
Cs-134	< 0.048	< 0.046	< 0.040
Cs-137	< 0.020	0.067 ± 0.027	0.28 ± 0.041
Ce-141	< 0.050	< 0.043	< 0.040
Ce-144	< 0.14	< 0.093	< 0.12
Location	K-1f	K-4	K-5
Date Collected	10-01-98	10-01-98	10-01-98
Lab Code	KSO-7878,9	KSO-7881	KSO-7882
Gross alpha	< 5.80	< 6.95	9.28 ± 4.98
Gross beta	21.32 ± 2.92	24.65 ± 4.36	30.66 ± 4.56
Sr-89	< 0.072	< 0.065	< 0.062
Sr-90	< 0.023	< 0.019	< 0.018
Be-7	< 0.15	< 0.22	< 0.24
K-40	17.28 ± 0.71	17.68 ± 0.83	19.36 ± 0.75
Nb-95	< 0.015	< 0.024	< 0.025
Zr-95	< 0.025	< 0.048	< 0.015
Ru-103	< 0.015	< 0.020	< 0.026
Ru-106	< 0.071	< 0.082	< 0.17
Cs-134	< 0.042	< 0.051	< 0.046
Cs-137	< 0.021	0.10 ± 0.029	0.047 ± 0.019
Ce-141	< 0.019	< 0.056	< 0.038
Ce-144	< 0.10	< 0.093	< 0.075

Table 23. Soil samples, analyses for gross alpha, gross beta, strontium-89, strontium-90, and gamma-emitting isotopes (continued).

Sample Description and Concentration (pCi/g dry)

	Indicator	
Location	K-12	K-19
Date Collected	05-04-98	05-04-98
Lab Code	KSO-2967	KSO-2968
Gross alpha	4.86 ± 1.69	4.49 ± 1.82
Gross beta	20.04 ± 1.86	17.30 ± 1.69
Sr-89	< 0.027	< 0.038
Sr-90	0.088 ± 0.017	0.080 ± 0.017
Be-7	< 0.30	< 0.21
K-40	19.59 ± 1.46	16.45 ± 0.88
Nb-95	< 0.051	< 0.021
Zr-95	< 0.12	< 0.043
Ru-103	< 0.038	< 0.013
Ru-106	< 0.27	< 0.19
Cs-134	< 0.058	< 0.034
Cs-137	0.27 ± 0.062	0.25 ± 0.038
Ce-141	< 0.067	< 0.036
Ce-144	< 0.26	< 0.17
Location	K-12	K-19
Date Collected	10-01-98	10-01-98
Lab Code	KSO-7884	KSO-7885
Gross alpha	< 6.93	< 6.57
Gross beta	14.84 ± 3.54	14.98 ± 4.57
Sr-89	< 0.069	< 0.060
Sr-90	0.024 ± 0.012	0.051 ± 0.014
Be-7	0.47 ± 0.21	< 0.18
K-40	12.78 ± 0.57	14.86 ± 0.64
Nb-95	< 0.021	< 0.022
Zr-95	< 0.013	< 0.030
Ru-103	< 0.011	< 0.017
Ru-106	< 0.16	< 0.078
Cs-134	< 0.036	< 0.042
Cs-137	< 0.017	0.10 ± 0.025
Ce-141	< 0.018	< 0.024
Ce-144	< 0.071	< 0.072

Table 23. Soil samples, analyses for gross alpha, gross beta, strontium-89, strontium-90, and gamma-emitting isotopes (continued).

Sample Description and Concentration (pCi/g dry)

	Control	
Location	K-3	K-6
Date Collected	05-04-98	05-04-98
Lab Code	KSO-2962,3	KSO-2966
Gross alpha	10.05 ± 2.49	8.83 ± 3.35
Gross beta	29.35 ± 2.08	25.65 ± 2.80
Sr-89	< 0.034	< 0.055
Sr-90	0.041 ± 0.009	0.079 ± 0.021
Be-7	< 0.21	< 0.28
K-40	22.37 ± 0.71	21.43 ± 0.98
Nb-95	< 0.021	< 0.024
Zr-95	< 0.046	< 0.032
Ru-103	< 0.017	< 0.032
Ru-106	< 0.13	< 0.24
Cs-134	< 0.050	< 0.040
Cs-137	0.15 ± 0.026	0.18 ± 0.037
Ce-141	< 0.053	< 0.065
Ce-144	< 0.087	< 0.24
Location	K-3	K-6
Date Collected	10-01-98	10-01-98
Lab Code	KSO-7880	KSO-7883
Gross alpha	7.01 ± 4.50	7.06 ± 4.44
Gross beta	25.00 ± 4.10	25.31 ± 4.35
Sr-89	< 0.049	< 0.052
Sr-90	0.042 ± 0.011	0.075 ± 0.014
Be-7	< 0.21	< 0.18
K-40	21.19 ± 0.76	18.88 ± 0.72
Nb-95	< 0.012	< 0.027
Zr-95	< 0.017	< 0.028
Ru-103	< 0.024	< 0.028
Ru-106	< 0.15	< 0.093
Cs-134	< 0.049	< 0.053
Cs-137	0.19 ± 0.032	0.14 ± 0.027
Ce-141	< 0.044	< 0.028
Ce-144	< 0.11	< 0.14

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Table 24. Surface water samples, analyses for gross beta, potassium-40, and gamma-emitting isotopes.
Collection: Monthly

Sample Description and Concentration (pCi/L)

Indicator

K-1a

Date Collected	01-05-98	02-02-98	03-03-98
Lab Code	KSW-26	KSW-584	KSW-1286,7
Gross beta			
Suspended Solids	< 0.5	< 1.1	< 0.8
Dissolved Solids	11.0 ± 0.9	14.9 ± 1.4	10.0 ± 0.8
Total Residue	11.0 ± 0.9	14.9 ± 1.4	10.0 ± 0.8
K-40 (flame photometry)	8.65	9.52	7.05
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15

K-1b

Date Collected	01-05-98	02-02-98	03-03-98
Lab Code	KSW-27	KSW-585	KSW-1288
Gross beta			
Suspended Solids	< 0.3	< 0.4	< 0.6
Dissolved Solids	2.2 ± 0.4	4.5 ± 0.7	5.1 ± 0.7
Total Residue	2.2 ± 0.4	4.5 ± 0.7	5.1 ± 0.7
K-40 (flame photometry)	0.87	2.08	2.16
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15

Table 24. Surface water samples, analyses for gross beta, potassium-40, and gamma-emitting isotopes (continued).

Sample Description and Concentration (pCi/L)			
Indicator			
K-1a			
Date Collected	04-01-98	05-04-98	06-01-98
Lab Code	KSW-1968	KSW-2944	KSW-4018
Gross beta			
Suspended Solids	< 0.8	< 0.2	<1.3
Dissolved Solids	8.1 ± 1.1	10.5 ± 1.2	12.5 ± 1.8
Total Residue	8.1 ± 1.1	10.5 ± 1.2	12.5 ± 1.8
K-40 (flame photometry)	5.97	8.65	9.52
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15
K-1b			
Date Collected	04-01-98	05-04-98	06-01-98
Lab Code	KSW-1969	KSW-2945	KSW-4019
Gross beta			
Suspended Solids	< 0.6	0.3 ± 0.2	<0.4
Dissolved Solids	5.6 ± 0.7	3.5 ± 0.8	3.0 ± 0.9
Total Residue	5.6 ± 0.7	3.8 ± 0.8	3.0 ± 0.9
K-40 (flame photometry)	3.29	2.42	1.90
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15

Table 24. Surface water samples, analyses for gross beta, potassium-40, and gamma-emitting isotopes (continued).

Sample Description and Concentration (pCi/L)

Indicator

K-1a

Date Collected	07-01-98	08-03-98	09-01-98
Lab Code	KSW-4808	KSW-5929	KSW-6852
Gross beta			
Suspended Solids	< 0.6	< 0.6	< 0.4
Dissolved Solids	12.0 ± 1.3	11.8 ± 1.0	22.0 ± 1.5
Total Residue	12.0 ± 1.3	11.8 ± 1.0	22.0 ± 1.5
K-40 (flame photometry)	8.48	11.25	21.63
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15

K-1b

Date Collected	07-01-98	08-03-98	09-01-98
Lab Code	KSW-4809	KSW-5928	KSW-6853
Gross beta			
Suspended Solids	< 0.5	< 0.4	0.5 ± 0.2
Dissolved Solids	4.8 ± 0.8	2.4 ± 0.8	2.6 ± 0.8
Total Residue	4.8 ± 0.8	2.4 ± 0.8	3.1 ± 0.8
K-40 (flame photometry)	2.16	2.08	1.82
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15

Table 24. Surface water samples, analyses for gross beta, potassium-40, and gamma-emitting isotopes (continued).

Sample Description and Concentration (pCi/L)

Indicator

K-1a

Date Collected	10-01-98	11-02-98	12-01-98
Lab Code	KSW-7852	KSW-9338	KSW-10154
Gross beta			
Suspended Solids	< 0.7	< 0.4	< 0.4
Dissolved Solids	25.8 ± 2.4	16.0 ± 1.4	12.3 ± 1.2
Total Residue	25.8 ± 2.4	16.0 ± 1.4	12.3 ± 1.2
K-40 (flame photometry)	22.49	13.84	9.52
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15

K-1b

Date Collected	10-01-98	11-02-98	12-01-98
Lab Code	KSW-7853	KSW-9339	KSW-10155
Gross beta			
Suspended Solids	< 0.4	1.0 ± 0.3	< 0.4
Dissolved Solids	2.9 ± 0.7	4.0 ± 0.7	3.0 ± 0.8
Total Residue	2.9 ± 0.7	5.0 ± 0.8	3.0 ± 0.8
K-40 (flame photometry)	2.25	1.47	1.90
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15

Table 24. Surface water samples, analyses for gross beta, potassium-40, and gamma-emitting isotopes (continued).

Sample Description and Concentration (pCi/L)

Indicator

K-1d

Date Collected	01-05-98	02-02-98	03-03-98
Lab Code	KSW-28	KSW-586	KSW-1289
Gross beta			
Suspended Solids	< 0.3	< 0.3	< 0.3
Dissolved Solids	2.8 ± 0.4	2.5 ± 0.5	2.7 ± 0.5
Total Residue	2.8 ± 0.4	2.5 ± 0.5	2.7 ± 0.5
K-40 (flame photometry)	1.21	0.95	1.04
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15

K-1e

Date Collected	01-05-98	02-02-98	03-03-98
Lab Code	KSW-29	KSW-587	KSW-1290
Gross beta			
Suspended Solids	1.3 ± 0.4	< 0.4	< 1.2
Dissolved Solids	6.0 ± 1.0	5.1 ± 1.3	3.6 ± 1.1
Total Residue	7.3 ± 1.1	5.1 ± 1.3	3.6 ± 1.1
K-40 (flame photometry)	4.67	2.60	2.16
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15

Table 24. Surface water samples, analyses for gross beta, potassium-40, and gamma-emitting isotopes (continued).

Sample Description and Concentration (pCi/L)			
Indicator			
K-1d			
Date Collected	04-01-98	05-04-98	06-01-98
Lab Code	KSW-1970	KSW-2946	KSW-4020,1
Gross beta			
Suspended Solids	< 0.4	< 0.2	< 0.6
Dissolved Solids	3.1 ± 0.5	2.0 ± 0.5	1.9 ± 0.4
Total Residue	3.1 ± 0.5	2.0 ± 0.5	1.9 ± 0.4
K-40 (fp)	1.47	1.21	1.04
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15
K-1e			
Date Collected	04-01-98	05-04-98	06-01-98
Lab Code	KSW-1971	KSW-2947	KSW-4022
Gross beta			
Suspended Solids	0.6 ± 0.3	< 0.2	< 0.7
Dissolved Solids	4.4 ± 1.1	3.3 ± 1.2	4.7 ± 1.6
Total Residue	5.0 ± 1.1	3.3 ± 1.2	4.7 ± 1.6
K-40 (fp)	2.60	2.68	2.94
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15

Table 24. Surface water samples, analyses for gross beta, potassium-40, and gamma-emitting isotopes (continued).

Sample Description and Concentration (pCi/L)

Indicator

K-1d

Date Collected	07-01-98	08-03-98	09-01-98
Lab Code	KSW-4810	KSW-5930	KSW-6854
Gross beta			
Suspended Solids	< 0.6	< 0.4	< 0.4
Dissolved Solids	2.2 ± 0.4	2.0 ± 0.4	2.3 ± 0.5
Total Residue	2.2 ± 0.4	2.0 ± 0.4	2.3 ± 0.5
K-40 (flame photometry)	1.12	1.21	1.21
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15

K-1e

Date Collected	07-01-98	08-03-98	09-01-98
Lab Code	KSW-4811	KSW-5931	KSW-6855
Gross beta			
Suspended Solids	< 0.6	< 0.4	< 0.3
Dissolved Solids	4.7 ± 1.2	10.4 ± 1.5	6.7 ± 1.6
Total Residue	4.7 ± 1.2	10.4 ± 1.5	6.7 ± 1.6
K-40 (flame photometry)	3.72	9.52	8.65
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15

Table 24. Surface water samples, analyses for gross beta, potassium-40, and gamma-emitting isotopes (continued).

Sample Description and Concentration (pCi/L)

Indicator

K-1d

Date Collected	10-01-98	11-02-98	12-01-98
Lab Code	KSW-7854	KSW-9340	KSW-10156
Gross beta			
Suspended Solids	< 0.5	< 0.5	< 0.4
Dissolved Solids	1.9 ± 0.4	2.7 ± 0.4	2.6 ± 0.6
Total Residue	1.9 ± 0.4	2.7 ± 0.4	2.6 ± 0.6
K-40 (flame photometry)	1.04	1.30	1.12
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15

K-1e

Date Collected	10-01-98	11-02-98	12-01-98
Lab Code	KSW-7855	KSW-9341	KSW-10157
Gross beta			
Suspended Solids	< 0.4	< 0.9	< 0.4
Dissolved Solids	4.4 ± 1.3	9.7 ± 1.5	3.9 ± 1.4
Total Residue	4.4 ± 1.3	9.7 ± 1.5	3.9 ± 1.4
K-40 (flame photometry)	3.11	8.56	2.16
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15

Table 24. Surface water samples, analyses for gross beta, potassium-40, and gamma-emitting isotopes (continued).

Sample Description and Concentration (pCi/L)

Indicator

K-14a

Date Collected	01-05-98	02-02-98	03-03-98
Lab Code	KSW-33	KSW-591	KSW-1294
Gross beta			
Suspended Solids	< 0.3	< 0.3	< 0.4
Dissolved Solids	2.8 ± 0.7	3.5 ± 0.7	3.5 ± 0.7
Total Residue	2.8 ± 0.7	3.5 ± 0.7	3.5 ± 0.7
K-40 (flame photometry)	1.30	1.21	1.73
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15

K-14b

Date Collected	01-05-98	02-02-98	03-03-98
Lab Code	KSW-34	KSW-592	KSW-1295
Gross beta			
Suspended Solids	< 0.3	< 0.3	< 0.4
Dissolved Solids	3.6 ± 0.7	3.3 ± 0.7	2.9 ± 0.6
Total Residue	3.6 ± 0.7	3.3 ± 0.7	2.9 ± 0.6
K-40 (flame photometry)	1.38	1.21	1.73
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15

Table 24. Surface water samples, analyses for gross beta, potassium-40, and gamma-emitting isotopes (continued).

Sample Description and Concentration (pCi/L)			
Indicator			
K-14a			
Date Collected	04-01-98	05-04-98	06-01-98
Lab Code	KSW-1975	KSW-2951	KSW-4026
Gross beta			
Suspended Solids	< 0.4	< 0.3	< 0.4
Dissolved Solids	6.0 ± 0.8	3.0 ± 0.7	2.7 ± 0.6
Total Residue	6.0 ± 0.8	3.0 ± 0.7	2.7 ± 0.6
K-40 (fp)	2.94	2.16	1.12
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15
K-14b			
Date Collected	04-01-98	05-04-98	06-01-98
Lab Code	KSW-1976	KSW-2952	KSW-4027
Gross beta			
Suspended Solids	< 0.4	< 0.3	< 0.5
Dissolved Solids	5.8 ± 0.8	2.2 ± 0.7	3.3 ± 0.7
Total Residue	5.8 ± 0.8	2.2 ± 0.7	3.3 ± 0.7
K-40 (fp)	2.94	2.16	1.12
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15

Table 24. Surface water samples, analyses for gross beta, potassium-40, and gamma-emitting isotopes (continued).

	Sample Description and Concentration (pCi/L)		
Indicator			
K-14a			
Date Collected	07-01-98	08-03-98	09-01-98
Lab Code	KSW-4815	KSW-5935	KSW-6859
Gross beta			
Suspended Solids	< 0.4	< 0.3	< 0.4
Dissolved Solids	2.0 ± 0.6	1.7 ± 0.6	2.2 ± 0.6
Total Residue	2.0 ± 0.6	1.7 ± 0.6	2.2 ± 0.6
K-40 (flame photometry)	1.21	1.30	1.12
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15
K-14b			
Date Collected	07-01-98	08-03-98	09-01-98
Lab Code	KSW-4816	KSW-5936	KSW-6860
Gross beta			
Suspended Solids	< 0.4	< 0.4	< 0.4
Dissolved Solids	2.3 ± 0.6	2.8 ± 0.6	1.7 ± 0.5
Total Residue	2.3 ± 0.6	2.8 ± 0.6	1.7 ± 0.5
K-40 (flame photometry)	1.21	1.21	1.38
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15

Table 24. Surface water samples, analyses for gross beta, potassium-40, and gamma-emitting isotopes (continued).

Sample Description and Concentration (pCi/L)

Indicator

K-14a

Date Collected	10-01-98	11-02-98	12-01-98
Lab Code	KSW-7860	KSW-9345	KSW-10161
Gross beta			
Suspended Solids	< 0.4	< 0.4	< 0.4
Dissolved Solids	1.8 ± 0.6	3.2 ± 0.6	2.1 ± 0.7
Total Residue	1.8 ± 0.6	3.2 ± 0.6	2.1 ± 0.7
K-40 (flame photometry)	1.12	1.21	1.04
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15

K-14b

Date Collected	10-01-98	11-02-98	12-01-98
Lab Code	KSW-7861	KSW-9346	KSW-10162
Gross beta			
Suspended Solids	< 0.4	< 0.4	< 0.4
Dissolved Solids	1.8 ± 0.6	3.3 ± 0.6	2.4 ± 0.7
Total Residue	1.8 ± 0.6	3.3 ± 0.6	2.4 ± 0.7
K-40 (flame photometry)	1.21	1.21	1.12
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15

Table 24. Surface water samples, analyses for gross beta, potassium-40, and gamma-emitting isotopes (continued).

Sample Description and Concentration (pCi/L)

Control

K-9

Date Collected	01-05-98		02-02-98		03-03-98	
Lab Code	KSW-31 (Raw)	KSW-32 (Tap)	KSW-588, 9 (Raw)	KSW-590 (Tap)	KSW-1292 (Raw)	KSW-1293 (Tap)
Gross beta						
Suspended Solids	<0.3	< 0.3	<0.3	< 0.3	<0.5	< 0.3
Dissolved Solids	2.6 ± 0.8	2.1 ± 0.4	2.7 ± 0.6	1.9 ± 0.4	2.1 ± 0.7	2.2 ± 0.5
Total Residue	2.6 ± 0.8	2.1 ± 0.4	2.7 ± 0.6	1.9 ± 0.4	2.1 ± 0.7	2.2 ± 0.5
K-40 (fp)	1.12	1.12	0.99	1.04	1.04	1.04
Mn-54	<15	<15	<15	<15	<15	<15
Fe-59	<30	<30	<30	<30	<30	<30
Co-58	<15	<15	<15	<15	<15	<15
Co-60	<15	<15	<15	<15	<15	<15
Zr-Nb-95	<15	<15	<15	<15	<15	<15
Cs-134	<10	<10	<10	<10	<10	<10
Cs-137	<10	<10	<10	<10	<10	<10
Ba-La-140	<15	<15	<15	<15	<15	<15

Date Collected	04-01-98		05-04-98		06-01-98	
Lab Code	KSW-1973 (Raw)	KSW-1974 (Tap)	KSW-2949 (Raw)	KSW-2950 (Tap)	KSW-4024 (Raw)	KSW-4025 (Tap)
Gross beta						
Suspended Solids	< 0.4	< 0.4	< 0.3	< 0.4	< 0.7	< 0.4
Dissolved Solids	2.3 ± 0.8	1.9 ± 0.4	1.9 ± 0.8	2.4 ± 0.4	2.0 ± 0.7	2.5 ± 0.5
Total Residue	2.3 ± 0.8	1.9 ± 0.4	1.9 ± 0.8	2.4 ± 0.4	2.0 ± 0.7	2.5 ± 0.5
K-40 (fp)	0.95	0.95	1.12	1.12	1.04	1.12
Mn-54	<15	<15	<15	<15	<15	<15
Fe-59	<30	<30	<30	<30	<30	<30
Co-58	<15	<15	<15	<15	<15	<15
Co-60	<15	<15	<15	<15	<15	<15
Zr-Nb-95	<15	<15	<15	<15	<15	<15
Cs-134	<10	<10	<10	<10	<10	<10
Cs-137	<10	<10	<10	<10	<10	<10
Ba-La-140	<15	<15	<15	<15	<15	<15

Table 24. Surface water samples, analyses for gross beta, potassium-40, and gamma-emitting isotopes (continued).

Sample Description and Concentration (pCi/L)

Control

K-9

Date Collected	07-01-98		08-03-98		09-01-98	
Lab Code	KSW-4813 (Raw)	KSW-4814 (Tap)	KSW-5933 (Raw)	KSW-5934 (Tap)	KSW-6857 (Raw)	KSW-6858 (Tap)
Gross beta						
Suspended Solids	< 0.3	< 0.4	<0.5	<0.4	<0.4	<0.3
Dissolved Solids	1.4 ± 0.7	2.1 ± 0.4	1.9 ± 0.7	1.7 ± 0.4	1.5 ± 0.8	2.2 ± 0.5
Total Residue	1.4 ± 0.7	2.1 ± 0.4	1.9 ± 0.7	1.7 ± 0.4	1.5 ± 0.8	2.2 ± 0.5
K-40 (fp)	1.12	1.12	1.21	1.21	1.38	1.12
Mn-54	<15	<15	<15	<15	<15	<15
Fe-59	<30	<30	<30	<30	<30	<30
Co-58	<15	<15	<15	<15	<15	<15
Co-60	<15	<15	<15	<15	<15	<15
Zr-Nb-95	<15	<15	<15	<15	<15	<15
Cs-134	<10	<10	<10	<10	<10	<10
Cs-137	<10	<10	<10	<10	<10	<10
Ba-La-140	<15	<15	<15	<15	<15	<15

K-9

Date Collected	10-01-98		11-02-98		12-01-98	
Lab Code	KSW-7857,8 (Raw)	KSW-7859 (Tap)	KSW-9343 (Raw)	KSW-9344 (Tap)	KSW-10159 (Raw)	KSW-10160 (Tap)
Gross beta						
Suspended Solids	<0.7	<0.4	<0.4	<0.4	<0.7	<0.4
Dissolved Solids	2.2 ± 0.5	1.7 ± 0.4	2.6 ± 0.7	2.3 ± 0.4	2.6 ± 0.9	1.6 ± 0.5
Total Residue	2.2 ± 0.5	1.7 ± 0.4	2.6 ± 0.7	2.3 ± 0.4	2.6 ± 0.9	1.6 ± 0.5
K-40 (fp)	1.04	1.12	1.12	1.12	1.04	1.04
Mn-54	<15	<15	<15	<15	<15	<15
Fe-59	<30	<30	<30	<30	<30	<30
Co-58	<15	<15	<15	<15	<15	<15
Co-60	<15	<15	<15	<15	<15	<15
Zr-Nb-95	<15	<15	<15	<15	<15	<15
Cs-134	<10	<10	<10	<10	<10	<10
Cs-137	<10	<10	<10	<10	<10	<10
Ba-La-140	<15	<15	<15	<15	<15	<15

Table 24. Surface water samples, analyses for gross beta, potassium-40, and gamma-emitting isotopes (continued).

Sample Description and Concentration (pCi/L)

Indicator

K-1k

Date Collected	01-05-98	02-02-98	03-03-98
Lab Code	KSW-30	NS[a]	KSW-1291
Gross beta			
Suspended Solids	< 1.2	-	< 1.2
Dissolved Solids	7.9 ± 1.4	-	10.7 ± 1.5
Total Residue	7.9 ± 1.4	-	10.7 ± 1.5
K-40 (fp)	4.67	-	6.83
Mn-54	<15	-	<15
Fe-59	<30	-	<30
Co-58	<15	-	<15
Co-60	<15	-	<15
Zr-Nb-95	<15	-	<15
Cs-134	<10	-	<10
Cs-137	<10	-	<10
Ba-La-140	<15	-	<15

K-1k

Date Collected	04-01-98	05-04-98	06-01-98
Lab Code	KSW-1972	KSW-2948	KSW-4023
Gross beta			
Suspended Solids	< 0.5	< 0.4	< 1.5
Dissolved Solids	6.1 ± 1.3	7.5 ± 1.4	16.6 ± 1.8
Total Residue	6.1 ± 1.3	7.5 ± 1.4	16.6 ± 1.8
K-40 (fp)	4.15	7.44	7.61
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15

a NS= No sample; sample not available; pond frozen.

Table 24. Surface water samples, analyses for gross beta, potassium-40, and gamma-emitting isotopes (continued).

Sample Description and Concentration (pCi/L)

Indicator

K-1k

Date Collected	07-01-98	08-03-98	09-01-98
Lab Code	KSW-4812	KSW-5932	KSW-6856
Gross beta			
Suspended Solids	< 1.0	< 0.3	< 0.4
Dissolved Solids	4.2 ± 1.2	10.1 ± 1.5	7.6 ± 1.5
Total Residue	4.2 ± 1.2	10.1 ± 1.5	7.6 ± 1.5
K-40 (flame photometry)	3.03	8.65	7.70
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15

K-1k

Date Collected	10-01-98	11-02-98	12-01-98
Lab Code	KSW-7856	KSW-9342	KSW-10158
Gross beta			
Suspended Solids	< 0.4	< 0.4	< 0.4
Dissolved Solids	6.0 ± 1.3	18.6 ± 1.7	7.4 ± 1.6
Total Residue	6.0 ± 1.3	18.6 ± 1.7	7.4 ± 1.6
K-40 (flame photometry)	5.36	7.18	6.49
Mn-54	<15	<15	<15
Fe-59	<30	<30	<30
Co-58	<15	<15	<15
Co-60	<15	<15	<15
Zr-Nb-95	<15	<15	<15
Cs-134	<10	<10	<10
Cs-137	<10	<10	<10
Ba-La-140	<15	<15	<15

Table 25. Surface water, analyses for tritium, strontium-89 and strontium-90.
Collection: Quarterly composites of monthly samples.

Location and Collection Period	Lab Code	Concentration pCi/L H-3	Sr-89	Sr-90
Indicator				
K-1a				
1st Quarter	KSW -1901	< 330	< 0.9	0.7 ± 0.3
2nd Quarter	-4616	< 330	< 0.8	< 0.5
3rd Quarter	-7753	< 330	< 1.4	< 0.5
4th Quarter	-11029	< 330	< 1.0	0.7 ± 0.3
Annual mean ± s.d.		< 330	< 1.4	0.7 ± 0.0
K-1b				
1st Quarter	KSW -1902	< 330	< 0.9	< 0.5
2nd Quarter	-4617	< 330	< 0.9	< 0.5
3rd Quarter	-7754	< 330	< 1.4	< 0.7
4th Quarter	-11030	< 330	< 1.0	0.7 ± 0.3
Annual mean ± s.d.		< 330	< 1.4	0.7
K-1d				
1st Quarter	KSW -1903	< 330	< 1.0	0.6 ± 0.3
2nd Quarter	-4618	< 330	< 0.9	< 0.5
3rd Quarter	-7755	< 330	< 1.4	< 0.6
4th Quarter	-11031	< 330	< 1.0	0.7 ± 0.3
Annual mean ± s.d.		< 330	< 1.4	0.7 ± 0.1
K-1e				
1st Quarter	KSW -1904	< 330	< 0.9	< 0.5
2nd Quarter	-4619	< 330	< 0.8	< 0.5
3rd Quarter	-7756	< 330	< 1.4	0.4 ± 0.3
4th Quarter	-11032	< 330	< 0.9	< 0.5
Annual mean ± s.d.		< 330	< 1.4	0.4

Table 25. Surface water, analyses for tritium, strontium-89 and strontium-90 (continued).

Location and Collection Period		Concentration pCi/L H-3	Sr-89	Sr-90
Indicator				
K-14a				
1st Quarter[a]	KSW -1908	755 ± 109[a]	< 0.9	0.9 ± 0.3
January	-33	< 330	-	-
February	-591	547 ± 102	-	-
March	-1294	1322 ± 126	-	-
2nd Quarter	-4623	< 330	< 1.1	< 0.6
3rd Quarter	-7760	< 330	< 1.5	< 0.5
4th Quarter	-11036	< 330	< 0.8	0.8 ± 0.3
Annual mean ± s.d.		755	< 1.4	0.9 ± 0.1
K-14b				
1st Quarter[a]	KSW -1909	694 ± 107[a]	< 0.9	< 0.6
January	-34	< 330	-	-
February	-592	552 ± 101	-	-
March	-1295	1348 ± 127	-	-
2nd Quarter	-4624	< 330	< 1.4	< 0.6
3rd Quarter	-7761	< 330	< 1.4	< 0.6
4th Quarter	-11037	< 330	< 0.8	< 0.4
Annual mean ± s.d.		694	< 1.4	< 0.6
K-1k				
1st Quarter	KSW -1905	< 330	< 0.9	0.7 ± 0.3
2nd Quarter	-4620	< 330	< 0.8	0.6 ± 0.3
3rd Quarter	-7757	< 330	< 1.4	0.6 ± 0.4
4th Quarter	-11033	< 330	< 0.8	0.8 ± 0.3
Annual mean ± s.d.		< 330	< 1.4	0.7 ± 0.1
Control				
K-9				
1st Quarter	KSW -1906 (Raw)	< 330	< 1.0	0.9 ± 0.3
	-1907 (Tap)	< 330	< 1.1	1.0 ± 0.4
2nd Quarter	-4621 (Raw)	< 330	< 1.5	< 0.6
	-4622 (Tap)	< 330	< 1.3	0.7 ± 0.3
3rd Quarter	-7758 (Raw)	< 330	< 0.9	< 0.5
	-7759 (Tap)	< 330	< 1.4	0.6 ± 0.3
4th Quarter	-11034 (Raw)	< 330	< 1.1	< 0.6
	-11035(Tap)	< 330	< 1.0	0.7 ± 0.3
Annual mean ± s.d.		< 330	< 1.1	0.8 ± 0.2

[a] Results of reanalyses; KSW-1908, 665±105 pCi/L, KSW-1909, 600±103 pCi/L.
Monthly analyses for tritium by client request.

Table 26. Fish samples collected at K-1d, analyses for gross beta, strontium-89, strontium-90, and gamma-emitting isotopes.
Collection: Three times a year

Sample Description and Concentration (pCi/g wet)

Date Collected	04-02-98		04-02-98	
Lab Code	KF-3516		KF-3517	
Type	Lake Trout		Sucker	
Portion	Flesh	Bones	Flesh	Bones
Gross beta	2.59 ± 0.11	1.94 ± 0.58	2.34 ± 0.11	1.78 ± 0.45
Sr-89	NA[a]	< 0.10	NA[a]	< 0.11
Sr-90	NA	0.086 ±0.032	NA[a]	0.079 ±0.034
K-40	2.49 ± 0.49	NA[a]	2.28 ± 0.41	NA[a]
Mn-54	< 0.023	NA	< 0.011	NA
Fe-59	< 0.074	NA	< 0.068	NA
Co-58	< 0.025	NA	< 0.017	NA
Co-60	< 0.017	NA	< 0.014	NA
Cs-134	< 0.020	NA	< 0.020	NA
Cs-137	0.029 ± 0.018	NA	0.085 ± 0.025	NA

Date Collected	07-04-98		10-07-98		10-29-98	
Lab Code	KF-5927		KF-10145		KF-9353	
Type	Dogfish		Catfish		Salmon	
Portion	Flesh	Bones	Flesh	Bones	Flesh	Bones
Gross beta	2.10 ± 0.05	2.38 ± 0.40	2.26 ± 0.11	2.88 ± 0.74	4.49 ± 0.17	0.85 ± 0.27
Sr-89	NA[a]	< 0.08	NA[a]	< 0.18	NA[a]	< 0.06
Sr-90	NA	0.28 ± 0.027	NA	0.22 ± 0.045	NA	0.050 ± 0.024
K-40	2.52 ± 0.39	NA[a]	2.15 ± 0.29	NA[a]	3.50 ± 0.45	NA[a]
Mn-54	< 0.014	NA	< 0.011	NA	< 0.022	NA
Fe-59	< 0.081	NA	< 0.072	NA	< 0.079	NA
Co-58	< 0.023	NA	< 0.015	NA	< 0.020	NA
Co-60	< 0.013	NA	< 0.014	NA	< 0.028	NA
Cs-134	< 0.015	NA	< 0.012	NA	< 0.009	NA
Cs-137	0.15 ± 0.026	NA	0.058 ± 0.016	NA	0.054 ± 0.021	NA

[a] NA = Not analyzed; analyses not required.

Table 27. Slime samples, analyses for gross beta, strontium-89, strontium-90, and gamma-emitting isotopes.
Collection: Semiannually

Sample Description and Concentration

	Indicators			Control
Location	K-1a	K-1b	K-1d	K-9
Date Collected	06-01-98	06-01-98	06-01-98	06-01-98
Lab Code	KSL-4030	KSL-4031	KSL-4032	KSL-4035
Gross beta	4.61 ± 0.15	5.47 ± 0.19	3.27 ± 0.66	2.64 ± 0.10
Sr-89	< 0.010	< 0.012	< 0.13	< 0.004
Sr-90	< 0.006	< 0.007	< 0.08	< 0.002
Be-7	0.31 ± 0.14	< 0.24	0.69 ± 0.25	< 0.20
K-40	5.00 ± 0.39	5.31 ± 0.59	2.67 ± 0.46	2.57 ± 0.44
Mn-54	< 0.012	< 0.006	< 0.012	< 0.015
Co-58	< 0.007	< 0.018	< 0.022	< 0.013
Co-60	< 0.013	< 0.016	< 0.018	< 0.014
Nb-95	< 0.011	< 0.028	< 0.023	< 0.024
Zr-95	< 0.014	< 0.020	< 0.026	< 0.017
Ru-103	< 0.016	< 0.021	< 0.022	< 0.012
Ru-106	< 0.11	< 0.19	< 0.12	< 0.18
Cs-134	< 0.009	< 0.021	< 0.022	< 0.021
Cs-137	< 0.015	< 0.023	< 0.021	< 0.021
Ce-141	< 0.023	< 0.032	< 0.043	< 0.023
Ce-144	< 0.10	< 0.099	< 0.090	< 0.15

Location	K-1e	K-1k	K-14
Date Collected	06-01-98	06-01-98	06-01-98
Lab Code	KSL-4033	KSL-4034	KSL-4036
Gross beta	4.58 ± 0.15	5.24 ± 0.17	3.93 ± 0.14
Sr-89	< 0.004	< 0.010	< 0.010
Sr-90	< 0.003	< 0.006	< 0.006
Be-7	< 0.20	< 0.23	0.53 ± 0.17
K-40	4.72 ± 0.46	5.38 ± 0.68	3.93 ± 0.33
Mn-54	< 0.018	< 0.026	< 0.014
Co-58	< 0.016	< 0.023	< 0.018
Co-60	< 0.009	< 0.011	< 0.020
Nb-95	< 0.019	< 0.035	< 0.018
Zr-95	< 0.053	< 0.053	< 0.019
Ru-103	< 0.025	< 0.033	< 0.018
Ru-106	< 0.16	< 0.14	< 0.11
Cs-134	< 0.021	< 0.024	< 0.018
Cs-137	< 0.025	< 0.025	< 0.016
Ce-141	< 0.041	< 0.032	< 0.013
Ce-144	< 0.16	< 0.15	< 0.050

Table 27. Slime samples, analyses for gross beta, strontium-89, strontium-90, and gamma-emitting isotopes.
Collection: Semiannually

Sample Description and Concentration

	Indicators			Control
Location	K-1a	K-1b	K-1d	K-9
Date Collected	08-04-98	08-04-98	09-01-98	09-01-98
Lab Code	KSL-5922	KSL-5923	KSL-6861	KSL-6862
Gross beta	3.56 ± 0.13	4.87 ± 0.21	3.55 ± 0.51	1.81 ± 0.09
Sr-89	< 0.007	< 0.011	< 0.11	< 0.003
Sr-90	0.007 ± 0.002	< 0.005	< 0.046	< 0.002
Be-7	< 0.24	0.88 ± 0.28	0.87 ± 0.12	0.35 ± 0.20
K-40	3.42 ± 0.54	4.57 ± 0.68	2.32 ± 0.21	2.06 ± 0.33
Mn-54	< 0.027	< 0.023	< 0.007	< 0.009
Co-58	< 0.026	< 0.006	0.022 ± 0.010	< 0.020
Co-60	< 0.027	< 0.037	< 0.008	< 0.015
Nb-95	< 0.018	< 0.032	< 0.008	< 0.021
Zr-95	< 0.032	< 0.032	< 0.011	< 0.041
Ru-103	< 0.019	< 0.025	< 0.013	< 0.013
Ru-106	< 0.16	< 0.19	< 0.045	< 0.18
Cs-134	< 0.032	< 0.018	< 0.017	< 0.016
Cs-137	< 0.023	< 0.023	0.033 ± 0.010	< 0.021
Ce-141	< 0.054	< 0.024	< 0.023	< 0.033
Ce-144	< 0.094	< 0.18	< 0.057	< 0.16

Location	K-1e	K-1k	K-14
Date Collected	08-04-98	08-04-98	09-01-98
Lab Code	KSL-5924	KSL-5925	KSL-6863
Gross beta	3.09 ± 0.37	3.72 ± 0.13	3.09 ± 0.34
Sr-89	< 0.038	< 0.006	< 0.044
Sr-90	< 0.017	0.012 ± 0.003	< 0.019
Be-7	1.22 ± 0.15	< 0.26	0.92 ± 0.21
K-40	1.55 ± 0.21	2.95 ± 0.53	0.94 ± 0.23
Mn-54	< 0.005	< 0.022	< 0.011
Co-58	0.048 ± 0.015	< 0.017	< 0.018
Co-60	< 0.014	< 0.019	< 0.011
Nb-95	< 0.006	< 0.035	< 0.020
Zr-95	< 0.024	< 0.054	< 0.016
Ru-103	< 0.011	< 0.023	< 0.008
Ru-106	< 0.090	< 0.15	< 0.038
Cs-134	< 0.012	< 0.016	< 0.024
Cs-137	0.033 ± 0.017	< 0.028	< 0.016
Ce-141	< 0.011	< 0.040	< 0.022
Ce-144	< 0.078	< 0.15	< 0.094

Table 28. Bottom sediment samples, analyses for gross beta, strontium-89, strontium-90, and gamma-emitting isotopes
Collection: May and November

Sample Description and Concentration (pCi/g dry)

	Indicator				Control
Location	K-1c	K-1d	K-1j	K-14	K-9
Collection Date	05-04-98	05-04-98	05-04-98	05-04-98	05-04-98
Lab Code	KBS-2969	KBS-2970	KBS-2971	KBS-2973	KBS-2972
Gross beta	8.84 ± 2.16	7.73 ± 1.90	4.18 ± 1.75	6.42 ± 1.86	5.15 ± 1.69
Sr-89	< 0.034	< 0.037	< 0.033	< 0.031	< 0.031
Sr-90	< 0.018	< 0.019	< 0.021	< 0.019	< 0.018
K-40	7.45 ± 0.41	5.23 ± 0.35	4.87 ± 0.32	7.09 ± 0.42	5.71 ± 0.36
Co-58	< 0.015	< 0.014	< 0.016	< 0.013	< 0.016
Co-60	< 0.018	< 0.013	< 0.012	< 0.017	< 0.013
Cs-134	< 0.025	< 0.027	< 0.026	< 0.031	< 0.023
Cs-137	< 0.014	0.033 ± 0.014	< 0.012	< 0.015	< 0.012
Location	K-1c	K-1d	K-1j	K-14	K-9
Collection Date	11-02-98	11-02-98	11-02-98	11-02-98	11-02-98
Lab Code	KBS-9348	KBS-9347	KBS-9349,50	KBS-9352	KBS-9351
Gross beta	6.07 ± 2.06	8.50 ± 2.22	7.46 ± 1.51	8.77 ± 2.24	7.64 ± 2.16
Sr-89	< 0.038	< 0.027	< 0.031	< 0.028	< 0.029
Sr-90	< 0.014	< 0.010	< 0.012	< 0.011	< 0.010
K-40	5.79 ± 0.58	6.30 ± 0.57	6.70 ± 0.31	8.22 ± 0.65	6.24 ± 0.45
Co-58	< 0.023	< 0.031	< 0.019	< 0.020	< 0.020
Co-60	< 0.015	< 0.024	< 0.018	< 0.031	< 0.020
Cs-134	< 0.038	< 0.038	< 0.029	< 0.036	< 0.031
Cs-137	< 0.023	0.037 ± 0.019	0.026 ± 0.011	< 0.025	< 0.023

7.0 STATISTICAL ANALYSES

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Table 29. Air particulate samples, gross beta, quarterly and annual means and standard deviations.

Location	Gross Beta (pCi/m^3)				
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual
Indicator					
K-1f	0.019 ± 0.005	0.014 ± 0.004	0.020 ± 0.005	0.024 ± 0.009	0.019 ±0.007
K-7	0.018 ± 0.006	0.016 ± 0.004	0.020 ± 0.005	0.023 ± 0.009	0.019 ±0.007
Mean ± s.d.	0.019 ± 0.006	0.015 ± 0.004	0.020 ± 0.005	0.023 ± 0.009	0.019 ±0.007
Control					
K-2	0.018 ± 0.006	0.015 ± 0.005	0.021 ± 0.006	0.022 ± 0.009	0.019 ±0.007
K-8	0.019 ± 0.006	0.014 ± 0.004	0.021 ± 0.005	0.023 ± 0.009	0.019 ±0.007
K-15	0.019 ± 0.006	0.015 ± 0.004	0.023 ± 0.005	0.022 ± 0.008	0.019 ±0.006
K-16	0.020 ± 0.006	0.014 ± 0.003	0.021 ± 0.007	0.023 ± 0.008	0.019 ±0.007
Mean ± s.d.	0.019 ± 0.006	0.014 ± 0.004	0.021 ± 0.005	0.022 ± 0.008	0.019 ±0.007

NOTE: All means and standard deviations are calculated by using individual results.

Table 30. Milk samples, strontium-90, quarterly and annual means and standard deviations.

Location	Strontium-90 (pCi/L)				
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual
Indicator					
K-4	0.9 ± 0.3	0.9 ± 0.1	0.8 ± 0.1	1.0 ± 0.3	0.9 ± 0.2
K-5	1.8 ± 0.8	1.1 ± 0.1	1.5 ± 0.3	1.0 ± 0.4	1.3 ± 0.5
K-12	1.8 ± 0.1	1.8 ± 0.6	1.6 ± 0.5	1.4 ± 0.2	1.6 ± 0.4
K-19	1.4 ± 0.5	1.2 ± 0.1	1.1 ± 0.5	0.9 ± 0.2	1.2 ± 0.4
Mean ± s.d.	1.5 ± 0.6	1.2 ± 0.4	1.3 ± 0.5	1.1 ± 0.3	1.3 ± 0.5
Control					
K-3	1.3 ± 0.4	1.4 ± 0.1	1.2 ± 0.1	1.2 ± 0.1	1.3 ± 0.2
K-6	2.4 ± 0.8	1.1 ± 0.2	1.0 ± 0.2	1.0 ± 0.2	1.4 ± 0.7
K-28	1.9 ± 0.3	1.7 ± 0.6	1.4 ± 0.3	1.1 ± 0.3	1.5 ± 0.5
Mean ± s.d.	1.8 ± 0.7	1.4 ± 0.4	1.2 ± 0.2	1.1 ± 0.2	1.4 ± 0.5

NOTE: All means and standard deviations are calculated by using individual results.

KEWAUNEE

Table 31. Milk samples, potassium-40, quarterly and annual means and standard deviations.

Location	K-40 (pCi/L)				
	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual
Indicator					
K-4	1410 ± 140	1310 ± 60	1340 ± 130	1340 ± 150	1340 ± 120
K-5	1480 ± 60	1350 ± 100	1420 ± 160	1360 ± 20	1400 ± 110
K-12	1530 ± 100	1420 ± 90	1440 ± 160	1500 ± 80	1460 ± 120
K-19	1310 ± 100	1320 ± 100	1430 ± 120	1410 ± 20	1370 ± 110
Mean ± s.d.	1430 ± 120	1350 ± 90	1410 ± 140	1400 ± 100	1390 ± 120
Control					
K-3	1580 ± 70	1410 ± 50	1400 ± 100	1380 ± 40	1430 ± 100
K-6	1380 ± 90	1190 ± 50	1210 ± 130	1320 ± 20	1260 ± 110
K-28	1450 ± 60	1300 ± 140	1390 ± 120	1310 ± 100	1360 ± 120
Mean ± s.d.	1470 ± 110	1300 ± 120	1330 ± 140	1340 ± 70	1350 ± 130

NOTE 1: All means and standard deviations are calculated by using individual results.

Table 32. Grass samples, gross beta, potassium-40 and strontium-90, annual means and standard deviations.

Location	Concentration (pCi/L)		
	Gross Beta	Potassium-40	Strontium-90
Indicator			
K-1b	7.48 ± 3.78	5.77 ± 1.75	0.005 ± 0.001
K-1f	6.76 ± 0.77	5.33 ± 0.95	0.005
K-4	6.20 ± 0.65	6.24 ± 0.90	0.003 ± 0.003
K-5	7.01 ± 0.65	7.50 ± 0.53	0.002
K-12	6.28 ± 0.84	6.46 ± 0.80	0.010
K-19	5.59 ± 0.78	6.23 ± 0.64	0.007 ± 0.001
Mean ± s.d.	6.55 ± 1.55	6.26 ± 1.09	0.005 ± 0.003
Control			
K-3	8.42 ± 3.08	6.56 ± 0.29	0.004 ± 0.002
K-6	6.13 ± 0.78	6.83 ± 1.18	- -
Mean ± s.d.	7.28 ± 2.37	6.69 ± 0.78	0.004 ± 0.002

NOTE 1: All means and standard deviations are calculated by using individual results.

Table 33. Soil samples, gross alpha, gross beta, potassium-40, strontium-90 and cesium-137, annual means and standard deviations.

Location	Concentration (pCi/L)				
	gross alpha	gross beta	potassium-40	strontium-90	cesium-137
Indicator					
K-1f	4.92	21.87 ± 0.78	18.11 ± 1.17	- -	- -
K-4	9.73	26.17 ± 2.14	18.27 ± 0.83	0.016	0.08 ± 0.02
K-5	11.85 ± 3.63	33.12 ± 3.47	22.82 ± 4.89	0.094	0.16 ± 0.16
K-12	4.86	17.44 ± 3.68	16.19 ± 4.82	0.056 ± 0.045	0.27
K-19	4.49	16.14 ± 1.64	15.66 ± 1.12	0.066 ± 0.021	0.18 ± 0.11
Mean ± s.d.	7.95 ± 3.93	22.95 ± 6.80	18.21 ± 3.56	0.059 ± 0.034	0.16 ± 0.10
Control					
K-3	8.53 ± 2.15	27.18 ± 3.08	21.78 ± 0.83	0.042 ± 0.001	0.17 ± 0.03
K-6	7.95 ± 1.25	25.48 ± 0.24	20.16 ± 1.80	0.077 ± 0.003	0.16 ± 0.03
Mean ± s.d.	8.24 ± 1.48	26.33 ± 2.03	20.97 ± 1.48	0.059 ± 0.021	0.17 ± 0.02

NOTE: All means and standard deviations are calculated by using individual results.

Table 34. Surface water samples, gross beta in total residue, quarterly and annual means and standard deviations.

Location	pCi/L 1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual
Indicator					
K1a	12.0 ± 2.6	10.4 ± 2.2	15.3 ± 5.8	18.0 ± 7.0	13.9 ± 3.4
K1b	3.9 ± 1.5	4.1 ± 1.3	3.4 ± 1.2	3.6 ± 1.2	3.8 ± 0.3
K-1d	2.7 ± 0.2	2.3 ± 0.7	2.2 ± 0.2	2.4 ± 0.4	2.4 ± 0.2
K-1e	5.3 ± 1.9	4.3 ± 0.9	7.3 ± 2.9	6.0 ± 3.2	5.7 ± 1.2
K-1k	9.3 ± 2.0	10.1 ± 5.7	7.3 ± 3.0	10.7 ± 6.9	9.3 ± 1.5
K-14a	3.3 ± 0.4	3.9 ± 1.8	2.0 ± 0.3	2.4 ± 0.7	2.9 ± 0.9
K-14b	3.3 ± 0.4	3.8 ± 1.8	2.3 ± 0.6	2.5 ± 0.8	3.0 ± 0.7
Mean ± s.d.	5.7 ± 3.6	5.6 ± 3.2	5.7 ± 4.8	6.5 ± 5.9	5.9 ± 0.4
Control					
K-9 (Raw)	2.5 ± 0.3	2.1 ± 0.2	1.6 ± 0.3	2.5 ± 0.2	2.2 ± 0.4
(Tap)	2.1 ± 0.2	2.3 ± 0.3	2.0 ± 0.3	1.9 ± 0.4	2.1 ± 0.2

NOTE 1: All means and standard deviations are calculated by using individual results.

Table 35. Bottom sediment samples, gross beta, potassium-40, and cesium-137, annual means and standard deviations.

Location	pCi/g dry		
	gross beta	potassium-40	cesium-137
Indicator			
K-1c	7.46 ± 1.96	6.62 ± 1.17	- -
K-1d	8.12 ± 0.54	5.77 ± 0.76	0.035 ± 0.003
K-1j	5.82 ± 2.32	5.79 ± 1.29	0.026
K-14	7.60 ± 1.66	7.66 ± 0.80	- -
Mean ± s.d.	7.25 ± 0.99	6.46 ± 0.89	0.031 ± 0.006
Control			
K-9	6.40 ± 1.76	5.98 ± 0.37	- -

NOTE: All means and standard deviations are calculated by using individual results.

APPENDIX A

RADIOCHEMICAL ANALYTICAL PROCEDURES

TELEDYNE
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ENVIRONMENTAL SERVICES
MIDWEST LABORATORY

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ANALYTICAL PROCEDURES MANUAL

TELEDYNE BROWN ENGINEERING ENVIRONMENTAL SERVICES
MIDWEST LABORATORY

PREPARED FOR

WISCONSIN PUBLIC SERVICE CORPORATION

NOTE: Only procedures applicable to the WPS Radiological Environmental Monitoring Program are included in this manual.

Approved by: ____________________
Bronia Grob, M.S.
Technical Lead

Revised 21 July 1998

WPS

List of Procedures

Procedure Number		Revision Number	Revision Date
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SAMPLE PREPARATION

PROCEDURE NO. TIML-SP-01

Prepared by

Teledyne Isotopes Midwest Laboratory

Copy No. ___________

Revision #	Date	Pages	Prepared by	Approved by
0	07-02-86	11	[signature]	[signature]
1	08-14-92	11	[signature]	[signature]
2	06-20-95	12	[signature]	[signature]
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SAMPLE PREPARATION

Principle of Method

Different classes of samples require different preparations. In general, food products are prepared as for home use, while others are dried and ashed as received.

Reagents

Formaldehyde

Apparatus

Balance
Ceramic Dishes
Counting Containers
Cutting Board
Drying Oven
Drying Pans
Grinder
High Temperature Marking Pen
Knives
Muffle Furnace
Plastic Bags
Pulverizer
Scissors
Spatulas

Procedure for Packing Standard Calibrated Counting Containers

A. 1.0L, 2.0L, 3.5L: Pour 1.0, 2.0, or 3.5 liters of water into corresponding container. Mark the level and empty the container. Fill with the sample to the mark, except for grass.

B. 250mL, and 500mL: Fill to the rim on the inside wall, which is 1/4" from the top. 2

C. 4 oz.: Fill to the 100mL mark.

Pack the sample tightly. When filling with soil and bottom sediments, make sure it is level.

NOTE 1: For ComEd samples use a NEW counting container for each sample.

NOTE 2: For Illinois Power (Clinton) samples keep a set of counting containers MARKED "Clinton". 2

A. Vegetables and Fruits

1. Wash and prepare vegetables and fruits as for eating.

2. Cut up vegetables and hard fruits into small pieces (about 1/4" cubes). Mash soft fruits.

3. Transfer the sample to a standard calibrated container. Use the largest size possible for the amount of sample available. DO NOT FILL ABOVE THE MARK. Record the wet weight.

4. Add a few cc of formaldehyde to prevent spoilage.

5. Seal with cover. Attach paper tape on top of the cover and write sample number, net weight, and date and time collected.

6. Submit to the counting room for gamma spectroscopic analysis without delay or store in a cooler until counting (for short period).

   NOTE: If I-131 analysis is required, it is imperative that the sample be prepared and submitted to the counting room immediately. Mark "I-131" on the tape.

7. After gamma scanning is completed, transfer the sample to a drying pan and dry at 110°C.

   NOTE 1.: If only gamma scan is required, skip drying and ashing (Steps 7 through 11). Transfer the sample to a plastic bag, seal, label, and store in a cooler until disposal.

   NOTE 2: If there is sufficient quantity, use surplus sample for drying and ashing instead of waiting for gamma scanning to be completed.

8. Cool, weigh, and record dry weight. Grind.

9. Weigh out accurately in tared ceramic dish 100-120g of the ground sample. Record the weight. (If sample weight is more than 100g, use two dishes; mark one as "A" and the second one as "B.") Ash in a muffle furnace by gradually increasing the temperature to 600°C. Ash overnight.

   NOTE: If ashing is incomplete (black carbon remains), cool the dish, crush the ash with spatula, and continue ashing overnight at 600°C. At this stage, it is not necessary to increase the temperature gradually. Set the temperature for 600°C and turn on the furnace.

10. Cool and weigh the ashed sample and record the ash weight. Grind to pass a 30 mesh screen. Transfer to a 4 oz. container, seal, and write sample number, weight, analysis required, and date and time of collection. The sample is now ready for analysis.

11. Store remaining ground sample in a plastic bag for possible future rechecking.

   NOTE: USEcology, Inc. samples: Weigh and record the total weight received. 2

B. Grass, Green Leafy Vegetation and Cattle Feed

1. Take enough sample to fill 3.5L or 2.0L Marinelli beaker to the top.

2. Cut up grass and green leafy vegetation into approximately 1-2" long stems and pack into a 3.5L or 2.0L container. Pack cattle feed and silage as is. Use larger container if sufficient amount of sample is available. FILL TO THE TOP OF THE CONTAINER. Record the wet weight. 1

3. Add a few cc of formaldehyde to prevent spoilage.

4. Seal with cover. Attach paper tape on top of the cover and label with sample number, net weight, and date and time collected.

5. Submit to the counting room for gamma spectroscopic analysis or store in a cooler until counting (for a short period) without delay.

   NOTE: If I-131 analysis is required, it is imperative that the sample be prepared and submitted to the counting room immediately. Mark "I-131" on the tape.

6. After gamma scanning is completed, transfer the sample to a drying pan and dry at 110°C.

   NOTE 1: If only gamma scan is required, skip drying and ashing (Steps 6 through 10). Transfer the sample to a plastic bag, seal, label, and store in the cooler until disposal.

   NOTE 2: If there is sufficient quantity, use surplus sample for drying and ashing instead of waiting for gamma scanning to be completed.

7. Cool, weigh, and record dry weight. Grind.

8. Weigh out accurately in a tared ceramic dish 100-120g of the ground sample. Record the weight. (If sample weight is more than 100g, use two dishes; mark one as "A" and the second one as "B.") Ash in a muffle furnace by gradually increasing the temperature to 600°C. Ash overnight.

   NOTE: If ashing is incomplete (black carbon remains), cool the dish, crush the ash with spatula, and continue ashing overnight at 600°C. At this stage, it is not necessary to increase the temperature gradually. Set the temperature at 600°C and turn on the furnace.

9. Cool and weigh the ashed sample and record the ash weight. Grind to pass a 30 mesh screen. Transfer to 4 oz. container, seal, and write sample number, weight, analyses required, and date and time of collection. The sample is now ready for analyses.

10. Store the remaining ground sample in a plastic bag for possible future rechecking.

C. Fish

1. Wash the fish.

2. Fillet and pack the fish immediately (to prevent moisture loss) in a 250mL, 500 mL, or 4 oz. standard calibrated container. Use 500 mL size if enough sample is available. DO NOT FILL ABOVE THE RIM. Record the wet weight. 2

3. Add a few cc of formaldehyde.

4. Seal with cover. Attach paper tape on top of the cover and label with sample number, weight, and date and time of collection.

   NOTE: If bones are to be analyzed, boil remaining fish in water for about 1 hour. Clean the bones. Air dry, weigh, and record as wet weight. Dry at 110°C. Record dry weight. Ash at 800°C, cool, weigh, and record the ash weight. Grind to a homogeneous sample. The sample is ready for analysis.

5. Submit to the counting room for gamma spectroscopic analysis without delay or store in a refrigerator until counting.

   NOTE: If I-131 analysis is required, it is imperative that the sample be prepared and submitted to the counting room immediately. Mark "I-131" on the tape.

6. After gamma spectroscopic analysis is completed, transfer the sample to a drying pan and dry at 110°C.

   NOTE 1: If only gamma scan is required, skip drying and ashing (Steps 5 through 9). Transfer the sample to a plastic bag, seal, label, and store in the freezer until disposal.

   NOTE 2: If there is sufficient quantity, use surplus flesh for drying and ashing instead of waiting for gamma scanning to be completed.

7. Cool, weigh, and record dry weight.

8. Transfer to a tared ceramic dish. Record dry weight for ashing.

9. Ash in a muffle furnace by gradually increasing the temperature to 450°C. If considerable amount of carbon remains after overnight ashing, the ash should be crushed with a spatula and placed back in the muffle furnace until ashing is completed.

10. Cool and weigh the ashed sample and record the ash weight. Grind to pass a 30 mesh screen. Transfer to a 4 oz. container, seal, and write sample number, weight, analyses required, and date and time of collection. The sample is now ready for analysis.

D. Waterfowl, Meat, and Wildlife

1. Skin and clean the animal. Remove a sufficient amount of flesh to fill an appropriate standard calibrated container (500mL, 250mL, or 4 oz). Weigh without delay (to prevent moisture loss). DO NOT FILL ABOVE THE RIM. Record the wet weight.

2. Add a few cc of formaldehyde.

   NOTE: If bones are to be analyzed, boil remaining flesh and bones in water for about 1 hour. Clean the bones. Air dry, weigh, and record as wet weight. Dry at 110°C. Record dry weight. Ash at 800°C, cool, weigh, and record the ash weight. Grind to a homogeneous sample. The sample is ready for analysis. 2

3. Seal with the cover. Attach paper tape on top of the cover and label with sample number, wet weight, and date and time of collection.

4. Submit to the counting room for gamma spectroscopic analysis without delay or store in a refrigerator until counting (for short period).

   NOTE: If I-131 analysis is required, it is IMPERATIVE that the sample be prepared and submitted to the counting room IMMEDIATELY. Mark "I-131" on the tape.

5. After the gamma scanning is completed, transfer the sample to a drying pan and dry at 110°C.

6. Cool, weigh, and record dry weight.

7. Transfer to a tared ceramic dish. Record dry weight for ashing.

8. Ash in a muffle furnace by gradually increasing the temperature to 450°C. If considerable amounts of carbon remain after overnight ashing, the sample should be crushed with a spatula and placed back in the muffle furnace until ashing is completed.

9. Cool and weigh the ashed sample and record the ash weight. Grind to pass a 30 mesh screen. Transfer to a 4 oz container. Seal and write sample number, weight, analyses required, and date and time of collection. the sample is now ready for analysis.

E. Eggs

1. Remove the egg shells and mix the eggs with a spatula. Use about one (1) dozen eggs. 1

2. Transfer the mixed eggs to a standard calibrated 500 mL container. Record the wet weight. DO NOT FILL ABOVE THE RIM.

3. Add a few cc of formaldehyde.

4. Seal with cover. Attach paper tape on top of the cover and label with sample number, wet weight, and date and time of collection.

5. Submit to the counting room for gamma spectroscopic analysis without delay or store in a refrigerator until counting (for short period).

6. After gamma spectroscopic analysis is completed, transfer the sample to a plastic bag, seal, label, and store in a freezer until disposal.

   NOTE: If only a gamma scan is required, skip Steps 7 through 11.

7. Weigh the rest of the sample, record wet weight, and dry in an oven at 110°C.

8. Cool, weigh, and record dry weight.

9. Weigh out accurately 100-120g of the sample in a tared ceramic dish. Record the weight. Ash in a muffle furnace by gradually increasing the temperature to 550°C. If a considerable amount of carbon remains after overnight ashing, the sample should be crushed and placed back in the muffle furnace until ashing is completed.

10. Cool and weigh the ashed sample and record the weight. Grind to pass a 30 mesh screen. Transfer to a 4 oz container, seal, and write sample number, weight, analyses required, and date and time of collection. The sample is now ready for analysis.

11. Store the remaining ground sample in a plastic bag for possible future rechecking.

F. Slime and Aquatic Vegetation

1. Remove foreign materials.

2. Place the sample in a sieve pan and wash until all sand and dirt is removed (turn the sample over several times).

3. Squeeze out the water by hand.

4. Place the sample in a standard calibrated 500mL, 250mL, or 4 oz container. Weigh and record wet weight. Use 500mL container if enough sample is available. DO NOT FILL ABOVE THE RIM. 2

5. Add a few cc of formaldehyde.

6. Seal with cover. Attach paper tape on top of the cover and label with sample number, weight, and date and time of collection.

7. Submit to the counting room without delay. Slime decomposes quickly even with formaldehyde. If gamma scanning must be delayed, freeze.

   NOTE: If I-131 analysis is required, it is IMPERATIVE that the sample be prepared and analyzed IMMEDIATELY. Mark "I-131" on the tape.

8. After gamma scanning is completed, transfer the sample to a drying pan and dry at 110°C.

   NOTE: If only gamma scan is required, skip drying and ashing (Steps 8 through 11). Transfer the sample to a plastic bag, seal, label, and store in the freezer until disposal.

9. Cool, weigh, and record dry weight.

10. Transfer to a tared ceramic dish, and record dry weight for ashing. Ash in a muffle furnace by gradually increasing the temperature to 600°C.

    NOTE: If ashing is incomplete (black carbon remains), cool the dish, crush the ash with spatula, and continue ashing overnight at 600°C. At this stage, it is not necessary to increase the temperature gradually. Set the temperature at 600°C and turn on the furnace.

11. Cool and weigh the ashed sample and record ash weight. Grind to pass a 30 mesh screen. Transfer to a 4 oz container, seal, and label with sample number, weight, analyses required, and date and time of collection. The sample is now ready for analyses.

G. Bottom Sediments and Soil

1. Remove rocks, roots, and any other foreign materials.
2. Place approximately 1 kg of sample on the drying pan and dry at 110°C. (See NOTES 1 and 2) 2
3. Seal, label, and save remaining sample.
4. Grind or pulverize the dried sample and sieve through a No. 20 mesh screen.
5. For gamma spectroscopic analysis, transfer sieved sample to a standard calibrated 500mL, 250mL, or 4 ounce container. DO NOT FILL ABOVE THE RIM. Record dry weight.
6. Seal with cover. Attach paper tape on top of the cover and write sample number, weight, and date and time of collection.
7. Submit to the counting room for gamma spectroscopic analysis without delay.
8. For gross alpha and beta analysis transfer 1-2g of sample to a 4oz container, seal and label with the sample number. For other analysis (eg, radiostrontium, transuranics etc.,) transfer to a ceramic dish and ash in a muffler furnance at 600°C. Cool and transfer to a 4oz container, seal and label with the sample number. 2
9. Store the remaining sieved sample in a plastic bag for possible future rechecking.
10. After the gamma scanning is completed, transfer the sample to a plastic bag, seal, label, and store until disposal.

NOTE 1: For tritium analysis transfer approximately 100g of wet sample to a 4oz container, label with the sample number and seal.

NOTE 2: USEcology, Inc. samples: Record total weight received, and record wet and dry weights. 2

H. Milk

1. Transfer 25mL of milk for gross alpha and beta analysis or 100-1000mL for other analyis into a glass beaker.

2. Dry at 110°C.

3. Ash in the muffler furnance by gradually increasing the temperature to 600°C. If a considerable amount of carbon remains (black) cool the beaker, crush the ash with a spatula and continue ashing until ashing is completed (white or light gray).

4. Cool and weigh the ashed sample and record the ash weight. Grind and transfer to a 4oz container, seal and write the sample number. The sample is now ready for analysis.

I. Feces

NOTE: Perform Transfer operation in the hood. Wear new plastic gloves and face mask.

1. Take 600mL beaker, clean acid etched area and write sample # using HI-Temp marker.
2. Cover the beaker with parafilm and weigh. Record the weight.
3. Transfer the whole sample to the beaker using a new plastic spoon.
4. Cover the beaker with the same parafilm and weigh. Record total weight.
5. Transfer the beaker to the drying oven, turn the oven on, remove parafilm and dry the sample overnight at 110°C.
6. In the morning, turn the heater off and let the exhaust fan run until the samples is cooled to room temperature.
7. Transfer the beaker to the muffler furnace. Set temperature to 175°C. Gradually increase the temperature to 450°C and ash the sample overnight.

   NOTE: In the morning, carefully open the door and visually inspect the sample. Do not touch or remove the beaker from the furnace. If ashing in incomplete (black carbon remains) continue ashing for another 24 hours or until the ash is grey-white.

8. When ashing is complete, turn the temperature dial down. Let the exhaust fan run until beaker is cool.
9. Remove the beaker form the furnace and cover with parafilm. The sample is ready for analyses.

   NOTE: Digest the whole ash sample in the same beaker before taking aliquot for analysis. Do not weigh the beaker.

J. Bottom Sediments and Soil, Analysis for Ra-226 by Gamma Spectroscopy

1. Remove rocks, roots and any other foreign materials.
2. Place approximately 1 kg of sample on the drying pan and dry at 110°C.
3. Seal, label and save remaining sample.
4. Grind or pulverize the dried sample and sieve through a No. 20 mesh screen.
5. Transfer sieved sample to a standard calibrated 500mL or 250mL container. DO NOT FILL ABOVE THE RIM. Record dry weight.
6. Seal with cover and electric tape. Attach paper tape on top of the cover and write sample number, weight, date and time of collection and date and time the container was sealed.
7. Store sealed sample for a minimum of 25 days to allow for Pb-214 to come to equilibrium with Ra-226..
8. Submit to counting room for gamma spectroscopic analysis. Use Pb-214 peak to calculate Ra-226 concentration.
9. Store the remaining sieved sample in a plastic bag for possible future rechecking.
10. After the gamma scanning is completed, transfer the sample to a plastic bag, seal, label and store until disposal.

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PREPARATION AND READOUT of TELEDYNE ISOTOPES TLD CARDS

PROCEDURE NO. TIML-TLD-01

Prepared by

Teledyne Isotopes Midwest Laboratory

Copy No. _____ _____

Revision #	Date	Pages	Prepared by	Approved by
0	05-08-85	4	[signature]	[signature]
1	05-15-85	5	[signature]	[signature]
2	08-04-86	5	[signature]	[signature]
3	04-27-88	5	[signature]	[signature]
4	12-27-88	5	[signature]	[signature]
5	01-08-90	6	[signature]	[signature]
6	04-24-95	6	[signature]	[signature]

Principle of Method

The cards are spread out in a single layer on a perforated metal tray and annealed for two hours at 250-260 °C. After annealing, the cards are packaged and sent to the field. 5

Once the cards are returned from the field they are read as soon as possible. After reading, several cards are chosen annealed and irradiated with a known dose using Ra-226 source encapsulated in an iridium needle to calculate efficiency. The net exposure is calculated by the computer after in-transit exposure is subtracted.

Equipment & Materials:

TLD Reader: Teledyne Isotopes Model 8300

TLD Cards impregnated with $CaSO_4$:Dy phosphor

TLD Card Holder with copper shielding

Annealing oven

Forceps

Black Plastic bags (pouches)

Transparent plastic bags: 8oz and 6oz puncture proof Whirl-Pak

Heat sealer

Scotch tape

Labeles

Recording sheet

Ra-226 Needle: "American Radium" No. 37852 6

Turntable

I. Receiving Procedure

To avoid accidental exposure of TLDs to radioactive sources in the receiving area follow this receiving procedure:

1. If TLDs are delivered to the front office (regular mail), write the date received on the package and deliver them DIRECTLY to the TLD room.

2. If TLDs are delivered to the receiving area (UPS, air freight, etc.), write the date received on the package and deliver them IMMEDIATELY to the TLD room.

Preparation and Readout of Teledyne Isotopes TLD Cards

II. Preparation Procedure

1. Fill out readout recording sheet by entering location I.D., dosimeter (card) number, and date annealed.

   NOTE : Make sure to include at least two (2) cards for in-transit and two (2) cards for spares.

2. Spread the cards in single layer on the perforated tray.
3. Preheat the annealing oven to 250-260 °C
4. Open the oven and quickly insert the tray. Close the door.
5. Wait until temperature reaches preset temperature (250-260 °C).
6. Set the alarm for two (2) hours.
7. After two (2) hours, remove the tray from the oven and let it cool. 5
8. Place each card in a black plastic bag (pouch), seal the flap with scotch tape, and place in the card holder.
9. Attach the labels identifying the station, location, and exposure period to the holders.
10. Place the holders into the transparent plastic bags and heat seal.
11. Ship without delay.

    NOTE: Make sure to place a "Do Not X-Ray" stickers on the mailing container.

Preparation and Readout of Teledyne Isotopes TLD Cards(Continued)

III. Readout Procedure

1. Reader Calibration

1.1: Adjust the nitrogen flow control to 6 SCF per hour.

1.2: Open the drawer.

1.3: Turn "FUNTION" switch to "CALIBRATE"

1.4: "WAIT" sign will be illuminated and the reading will change every three (3) seconds. The reading should be 1000±10 . If it is not, adjust the "CALIBRATE" knob. 6

1.5: Turn "FUNCTION" switch to "OPERATE".

1.6: Press "START" button. When "READ" sign appears, the reading should be as posted on the reader. If it is not, adjust "Sensitivity" knob. (Turn the knob clockwise if the reading is low and counterclockwise if the reading is high).

1.7: Wait until "START" button lights up.

1.8: Press "START" button again. Continue adjusting "SENSITIVITY" knob and taking reading until the reading is as posted on the reader. Make and record 5 readings.

1.9: Wait until "START" button lights up.

1.10: Push in card drawer to position No. 3.

1.11: Press "START" button. Wait until "READ" sign lights up and record the reading.

1.12: When "START " button lights up, press it again. Repeat this step four (4) more times (take a total of five (5) readings) and record the results.

NOTE: The reading should be as posted on the reader. If it is not, notify the Lab supervisor.

III. Readout Procedure (Continued)

2. Readout

2.1: When "START" button lights up, pull out card drawer. Take the card out of the card holder and insert in the drawer with printed card number facing down and to the back (away from you).

2.2: Push drawer into position No. 1. Push "START" button.

2.3: When "READ" sign appears, record the reading.

2.4: When "START" button lights up, push the drawer to position No. 2. Push "START" button. Repeat steps 2.3 and 2.4 until all positions are read out.

2.5: Read out and record the reading for the rest of the cards in the same manner. 5

III. Readout Procedure (Continued)

3. Irradiation (Efficiency Determination)

NOTE: Perform efficiency calibration after each field cycle. (This means that TLDs from each project are to be calibrated every time they are returned
to the lab and after they are read out.). 5

3.1: After all the cards are read out, select at random two (2) to three (3) cards.

3.2: Anneal and package them as described in Part II, Steps 2 thru 8.

3.3: Mount the holder (with freshly annealed cards) on the irradiation turntable using clips.

3.4: Start rotation. Attach Ra-226 needle to the holder in the middle. Record the time.

3.5: Irradiate overnight.

3.6: Remove the needle, record the time, and read out the cards as in Part III.

3.7: Average all the readings of irradiated cards, and subtract average dark current reading (Part III, Step 1.12).

3.8: Calculate efficiency (light response) as follows:

$$\text{Efficiency} = \frac{\text{Net Average Reading (from step 3.7)}}{\text{Hours of exposure} \times 2.097}$$

3.9: Submit the field data and efficiency data sheets to data clerk for calculations.

NOTE: The computer program will automatically subtract in-transit exposure and prorate exposure to a selected number of days
(usually 30 or 91). Occasionally, some TLDs are placed 5
and/or removed at different times resulting in a different number of exposure days in the field. Exposure will be prorated for the selected number of days.

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DETERMINATION OF GROSS ALPHA AND/OR GROSS BETA IN AIR PARTICULATE FILTERS

PROCEDURE NO. TIML-AP-02

Prepared by

Teledyne Isotopes Midwest Laboratory

Copy No. ________

Revised Pages	Revision No.	Date	Pages	Prepared by	Approved by
	0	07-11-86	3	B. Grob	L. G. Huebner
2	1	07-15-91	3	B. Grob	L. G. Huebner

DETERMINATION OF GROSS ALPHA AND/OR GROSS BETA IN AIR PARTICULATE FILTERS

Principle of Method

Air particulate filters are stored for at least 72 hours to allow for the decay of short-lived radon and thoron daughters and then counted in the proportional counter. 1

Apparatus

Forceps
Loading Sheet
Proportional Counter
Stainless Steel Planchets (standard 2" x 1/8")

Procedure

1. Store the filters for at least 72 hours from the day of collection. 1

2. Place filters on a stainless steel planchet.

3. Fill out a sample loading sheet. Fill in the date, counter number, counting time, sample identification number, sample collection date, and initials.

   NOTES: When loading samples in the holder, load blanks (unexposed filter paper) in positions 1, 12, 23, 34, 45, etc.

   If filters from more than one project are loaded, make sure that the appropriate blanks are loaded with each batch. Load the counter blank planchet as a last sample.

4. Count in a proporational counter long enough to obtain the required LLDs.

5. After counting is completed, return the filters to the original envelopes.

6. Submit the counter printout, field collection sheet, and the loading sheet to the data clerk for calculations.

Calculations

Gross alpha (beta) concentration:

$$(\text{pCi/liter}) = \frac{A}{B \times C \times 2.22} \pm \frac{2\sqrt{E_{sb}^2 + E_b^2}}{B \times C \times 2.22}$$

Where:

A = Net alpha (beta) count (cpm)

B = Efficiency for counting alpha (beta) activity (cpm/dpm)

C = Volume of sample

E_{sb} = Counting error of sample plus background

E_b = Counting error of background

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PROCEDURE FOR COMPOSITING AIR PARTICULATE FILTERS

FOR GAMMA SPECTROSCOPIC ANALYSIS

PROCEDURE NO. TIML-AP-03

Prepared by

Teledyne Brown Engineering Environmental Services
Midwest Laboratory

Copy No. ____________

Revision #	Date	Pages	Prepared by	Approved by
0	12-15-89	3	B. Grob	L. Huebner
1	03-21-95	3	B. Grob	L. Huebner
2	07-21-98	3	A. Faymacin	B. Grob

PROCEDURE FOR COMPOSITING AIR PARTICULATE FILTERS FOR GAMMA SPECTROSCOPIC ANALYSIS

Principle of Method

AP filters are placed in a Petri dish in chronological order, labeled and submitted to counting room for analysis.

Materials

Tweezers (long)
Blank filter paper
Small Petri dish (50 x 9 mm)
Scotch Tape

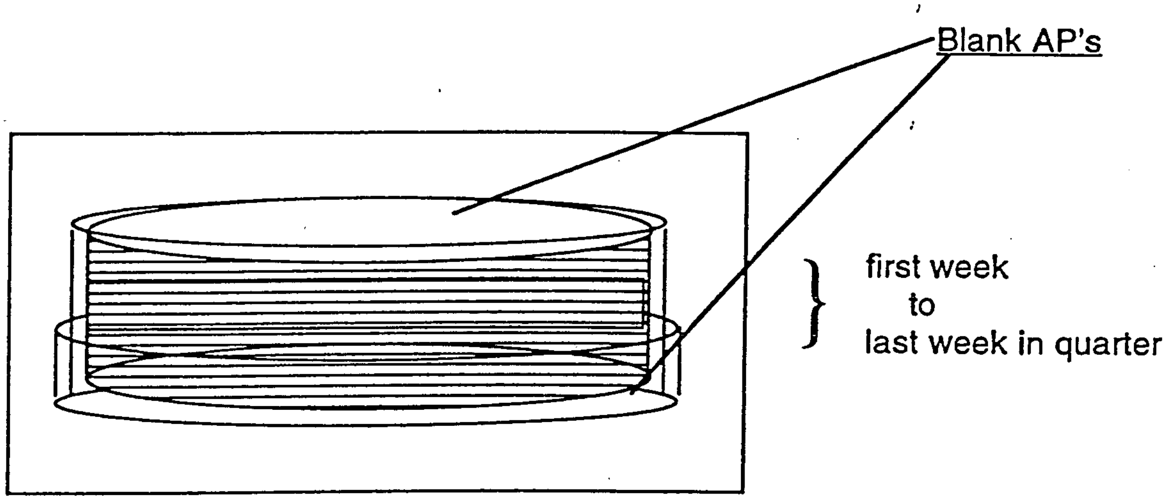
Procedure

1. In the Recording Book enter:
   - Sample ID (project)
   - Sample No.
   - Location
   - Collection period
   - Date composited
2. Obtain sample numbers from Recieving Clerk.
3. Stack the envelopes with APs from each location in chronological order, starting with the earliest collection date on the bottom. After you are done, flip the stack over.
4. Place blank filter paper, "fluffy" side down, in deep half of petri dish.
5. Beginning from the top of the stack, remove each AP from its envelope and place in the Petri dish with the deposit facing down.
6.. Continue transferring all of the AP's from envelopes into the Petri dish. 2
7. Place blank filter paper, "fluffy"side down, on top of APs.
8. Cap the Petri dish using the shallow half (you may use scotch tape to hold cap in place, if needed). Turn the petri dish over.
9. On the Petri dish and each stack of glassine envelopes (each location kept together by either paperclips or rubber bands) using a black marker write:
   - Sample ID
   - Sample No.
   - Last date of collection
   - Collection period
10. Submit the samples to the counting room.
11. After counting, samples are stored in the warehouse, according to client's requirements.

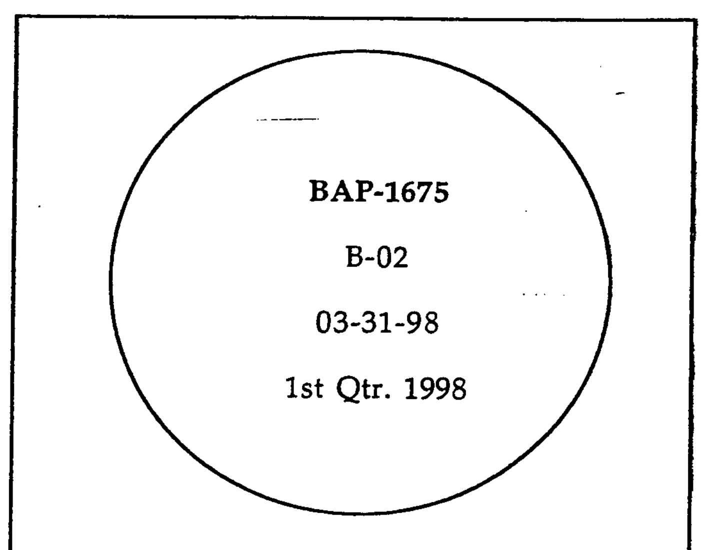
PROCEDURE FOR COMPOSITING AIR PARTICULATE FILTERS FOR GAMMA SPECTROSCOPIC ANALYSIS

Example

- Sample ID/Project: BAP
- Location: 2
- Sample No.: 1675
- Last Collection Date: 03-31-98
- Collection period: 1st Qtr. 1998



Side View



Top View

TELEDYNE BROWN ENGINEERING
ENVIRONMENTAL SERVICES
MIDWEST LABORATORY

DETERMINATION OF GROSS ALPHA AND/OR GROSS BETA IN WATER

(DISSOLVED SOLIDS OR TOTAL RESIDUE)

PROCEDURE NO. TIML-W(DS)-01

Prepared by

Teledyne Brown Engineering Environmental Services
Midwest Laboratory

Copy No. ___________

Revision #	Date	Pages	Prepared by	Approved by
0	11-25-85	4	B. Grob	L.G. Huebner
1	02-28-91	4	B. Grob	L.G. Huebner
2	05-03-91	4	B. Grob	L.G. Huebner
3	08-14-92	4	B. Grob	L.G. Huebner
4	07-21-98	4	D. Rieter	B. Grob

DETERMINATION OF GROSS ALPHA AND/OR GROSS BETA IN WATER

(Dissolved Solids or Total Residue)[a]

Principle of Method

Water samples containing suspended matter are filtered through a membrane filter and the filtrate is analyzed. The filtered water sample is evaporated and the residue is transferred to a tared planchet for counting gross alpha and gross beta activity.

Reagents

All chemicals should be of "reagent-grade" or equivalent whenever they are commercially available.

Lucite: 0.5 mg/ml in acetone
Nitric acid, HNO_3: 16 N (concentrated), 1 N (62 ml of N HNO_3 diluted to 1 liter)

Apparatus

Filter, membrane Type AA, 0.08
Filtration equipment
Planchets (Standard 2"x1/8" stainless steel , ringed planchet)
Electric hotplate
Heat lamp
Drying oven
Muffle furnace
Analytical Balance
Dessicator
Proportional counter

Procedure

1. Filter a volume of sample containing not more than 100 mg of dissolved solids for alpha assay, or not more than 200 mg of dissolved solids for beta assay.[a]

   NOTE: For gross alpha and gross beta assay in the same sample, limit the amount of solids to 100 mg.

2. Filter sample through a membrane filter. Wash the sides of the funnel with deionized (D. I.) water. Discard the filter, unless determining suspended solids also. See procedure TIML-W(SS-)02.

3. Evaporate the filtrate to NEAR dryness on a hot plate.

4. Add 20 ml of concentrated HNO_3 and evaporate to NEAR dryness again.

   NOTE: If water samples are known or suspected to contain chloride salts, these chloride salts should be converted to nitrate salts before the sample residue is transferred to a stainless steel planchet. (Chlorides will attack stainless steel and increase the sample solids. No correction can be made for these added solids.) Chloride salts can be converted to nitrate salts by adding concentrated HNO^3 and evaporating to near dryness.

5. Transfer quantitatively the residue to a TARED PLANCHET, using an unused plastic disposable pipette for each sample, (not more than 1 or 2 ml at a time) evaporating each portion to dryness under the lamp. Spread residue uniformly on the planchet.

   NOTE: Non-uniformity of the sample residue in the counting planchet interferes with the accuracy and precision of the method.

6. Wash the beaker with DI water several times and combine the washings and the residue in the planchet, using the rubber policeman to wash the walls. Evaporate to dryness.

   NOTE: Rinse the rubber policeman with DI water between samples.

7. Bake in muffle furnace at 400 ° C for 45 minutes, cool and weigh.

   NOTE: If the sample is very powdery, add a few drops (6-7) of the Lucite solution and dry under the infrared lamp for 10-20 minutes.

8. Store the sample in a dessicator until ready to count since vapors from the moist residue can damage the detector and the window and can cause erratic measurements.

9. Count the gross alpha and/or the gross beta activity in a low background proportional counter.

   NOTE: If the gas-flow internal proportional counter does not discriminate for the higher energy alpha pulses at the beta plateau, the activity must be subtracted from the beta plus alpha activity. This is particularly important for samples with high alpha activity.

   Samples may be counted for beta activity immediately after baking; alpha counting should be delayed at least 72 hours (until equilibrium has occurred).

[a] For analysis of total residue (for clear water), proceed as described above but do not filter the water. Measure out the appropriate amount and proceed to Step 3.

Calculations

Gross alpha (beta) activity:

$$pCi/L = \frac{A}{B \times C \times D \times 2.22} \pm \frac{2\sqrt{E^2_{sb}+E^2_b}}{B \times C \times D \times 2.22}$$

Where:

A	= Net alpha (beta) count (cpm)
B	= Efficiency for counting alpha (beta) activity (cpm/dpm)
C	=Volume of sample (liters)
D	= Correction factor for self-absorption (See Proc. TIML-AB-02)
E_{sb}	=Counting error of sample plus background
E_b	= Counting error of background

References: Radio assay Procedures for Environmental Samples, US. Department of Health, Education and Welfare. Environmental Health Series, Jan. 1967.

EPA Prescribed Procedures for Measurement of Radioactivity in Drinking Water. August 1980

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DETERMINATION OF GROSS ALPHA AND/OR GROSS BETA IN WATER

(SUSPENDED SOLIDS)

PROCEDURE NO. TIML-W(SS)-02

Prepared by

Teledyne Brown Engineering Environmental Services
Midwest Laboratory

Copy No. ____________

Revision #	Date	Pages	Prepared by	Approved by
0	10-21-86	4	L.G. Huebner	L.G. Huebner
1	08-14-92	4	B. Grob	L.G. Huebner
2	07-21-98	3		B Grob

DETERMINATION OF GROSS ALPHA AND/OR GROSS BETA IN WATER (SUSPENDED SOLIDS)

Principle of Method

The sample is filtered through a tared membrane filter. The filter containing the solids is placed on a ringless, stainless steel planchet and air dried, then placed in a dessicator until ready for weighing. The gross alpha and gross beta activities are measured in a low background internal proportional counter.

Reagent

Acetone

Apparatus

Filter, membrane Type AA 0.08
Filtration equipment
Planchets (Standard 2"x1/8" stainless steel , ringless planchet)
Heat lamp
Analytical Balance
Dessicator
Proportional counter

Procedure

1. Filter one liter of sample through a TARED membrane filter. Wash the sides of the funnel with deionized water.

   NOTE: If the sample contains sand, place it in the separatory funnel, allow the sand to settle for 30 minutes, then drain off the sand at the bottom. Shake the funnel and repeat as above two (2) more times.

2. Place the filter on a ringless planchet and air dry for 24 hours.

3. Dry under the infrared lamp for 20-30 minutes. Desiccate to constant weight and weigh.

4. Count for gross alpha and gross beta activity using a proportional counter.

5. Calculate the activity in pCi/L, using the computer program designed for this analysis.

Calculations

Gross alpha (beta) activity:

$$pCi/L = \frac{A}{B \times C \times D \times 2.22} \pm \frac{2\sqrt{E^2_{sb} + E^2_b}}{B \times C \times D \times 2.22}$$

Where:

A = Net alpha (beta) count (cpm)

B = Efficiency for counting alpha (beta) activity (cpm/dpm)

C = Volume of sample (liters)

D = Correction factor for self-absorption (See Proc. TIML-AB-02)

E_{sb} = Counting error of sample plus background

E_b = Counting error of background

References: Radio assay Procedures for Environmental Samples, U.S. Department of Health, Education and Welfare. Environmental Health Series, January 1967.

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DETERMINATION OF GROSS ALPHA AND/OR GROSS BETA IN SOLID SAMPLES

PROCEDURE NO. TIML-AB-01

Prepared by

Teledyne Isotopes Midwest Laboratory

Copy No. ________

Revision No.	Date	Pages	Prepared by	Approved by
0	08-04-86	5	B. Grob	L. G. Huebner
1	08-14-92	5	B. Grob	L. G. Huebner

OETERMINATION OF GROSS ALPHA AND/OR GROSS BETA IN SOLID SAMPLES

Principle of Method

100 mg to 200 mg of sample is distributed evenly on a 2" ringed planchet, counted in a proportional counter, and concentrations of gross alpha and/or gross beta are calculated.

Reagents

Lucite: 0.5 mg/ml in acetone

Appartus

Balance
Infrared lamp
Planchets (standard 2" x 1/8" ringed planchet)
Proportional counter

A. Gross Alpha and/or Gross Beta in Vegetation

Procedure

1. Weigh out accurately in a planchet no more than 100 mg of ashed or dried and ground sample for gross alpha assay and no more than 200 mg for gross beta assay.

   NOTE: If both gross alpha and gross beta analyses are required, do not use more than 100 mg.

2. Add a few drops of water and spread uniformly over the area of the planchet. Dry under the infrared lamp.

3. Add 2 - 3 drops of lucite solution in acetone and dry again under the infrared lamp.

4. Store the planchets in a desiccator until counting.

5. Count the gross alpha and gross beta activity in a low background proportional counter.

Calculations

Gross alpha (beta) concentration:

$$(pCi/g\ wet) = \frac{A}{B \times C \times D \times F \times 2.22} \pm \frac{2\sqrt{E_{sb}^2 + E_b^2}}{B \times C \times D \times F \times 2.22}$$

Where:

A = Net alpha (beta) count (cpm)

B = Efficiency for counting alpha (beta) activity (cpm/dpm)

C = Weight of sample (grams), ash or dry

D = Correction factor for self-absorption (See Proc. TIML-AB-02) |1

E_{sb} = Counting error of sample plus background

E_b = Counting error of background

F = Ratio of wet weight to ashed or dry weight

REFERENCE: Radioassay Procedures for Environmental Samples, U. S. Department of Health, Education and Welfare. Environmental Health Series, January 1967.

B. Gross Alpha and/or Gross Beta in Meat, Fish, and Wildlife

Procedure

1. Weigh out accurately in a planchet no more than 100 mg of ashed sample for gross alpha assay and no more than 200 mg for gross beta assay.

   NOTE: If both gross alpha and gross beta analyses are required, do not use more than 100 mg.

2. Add a few drops of water and spread uniformly over the area of the planchet. Dry under the infrared lamp.

3. Add 2 - 3 drops of lucite solution in acetone and dry again under the infrared lamp.

4. Store the planchets in a desiccator until counting.

5. Count the gross alpha and gross beta activity in a low background proportional counter.

Calculations

Gross alpha (beta) concentration:

$$(\text{pCi/g wet}) = \frac{A}{B \times C \times D \times F \times 2.22} \pm \frac{2\sqrt{E_{sb}^2 + E_b^2}}{B \times C \times D \times F \times 2.22}$$

Where:

- A = Net alpha (beta) count (cpm)
- B = Efficiency for counting alpha (beta) activity (cpm/dpm)
- C = Weight of sample (grams), ash
- D = Correction factor for self-absorption (See Proc. TIML-AB-02) |1
- E_{sb} = Counting error of sample plus background
- E_b = Counting error of background
- F = Ratio of wet weight to ashed weight

REFERENCE: Radioassay Procedures for Environmental Samples, U. S. Department of Health, Education and Welfare. Environmental Health Series, January 1967.

C. Gross Alpha and/or Gross Beta in Soil and Bottom Sediments

Procedure

1. Weigh out accurately in a planchet no more than 100 mg of a pulverized sample for gross alpha assay and no more than 200 mg for a gross beta assay.

   NOTE: If both gross alpha and gross beta analyses are required, do not use more than 100 mg.

2. Add a few drops of water and spread uniformly over the area of the planchet. Dry under the infrared lamp.

3. Add 2 - 3 drops of lucite solution in acetone and dry again under the infrared lamp.

4. Store the planchets in a desiccator until counting.

5. Count the gross alpha and gross beta activity in a low background proportional counter.

Calculations

Gross alpha (beta) concentration:

$$(\text{pCi/g dry}) = \frac{A}{B \times C \times D \times 2.22} \pm \frac{2\sqrt{E_{sb}^2 + E_b^2}}{B \times C \times D \times 2.22}$$

Where:

A = Net alpha (beta) count (cpm)

B = Efficiency for counting alpha (beta) activity (cpm/dpm)

C = Weight of sample (grams)

D = Correction factor for self-absorption (See Proc. TIML-AB-02) |1

E_{sb} = Counting error of sample plus background

E_b = Counting error of background

REFERENCE: Radioassay Procedures for Environmental Samples, U. S. Department of Health, Education and Welfare. Environmental Health Series, January 1967.

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DETERMINATION OF GAMMA EMITTERS
BY GAMMA SPECTROSCOPY
(GERMANIUM DETECTORS)

PROCEDURE NO. TIML-GS-01

Prepared by

Teledyne Isotopes Midwest Laboratory

Copy No. ___________

Revision #	Date	Pages	Prepared by	Approved by
0	07-21-86	5	B. Grob	L.G. Huebner
1	08-14-92	5	B. Grob	L.G. Huebner
2	07-01-98	5	[signature]	[signature]

DETERMINATION OF GAMMA EMITTERS
BY GAMMA SPECTROSCOPY
(GERMANIUM DETECTORS)

Principle of Method

The sample is placed in a calibrated container and counted for a length of time required to reach the client's technical requirements. The results are decay corrected to the sampling time, where appropriate, using a dedicated computer and software.

Apparatus

Counting Containers
Counting Equipment
Cylinders
Marking Pens
Recording Books

A. Milk, Water, and other Liquid Samples

1. Measure accurately 500 mL, 1.0 L, 2.0 L or 3.5 L of sample and put it in the calibrated counting container (Marinelli beaker). Always use largest volume if sample is of sufficient quantity.

2. Cover and attach a gummed label to the cover; write the sample number, volume and date and time of collection on the label. Mark "I-131" if analysis for I-131 is required by gamma spectroscopy.

3. Count without delay for estimated time required to meet the client's technical requirements. Record file number, sample identification number, date and time counting started, detector number, geometry, sample size, and date and time of collection.

4. Stop counting; transfer spectrum to the disk and print out the results.

5. Check results before taking the sample off. If the client's technical requirements are not met, continue counting.

6. After counting is completed, record the counting time.

7. Return the sample to the original container and mark with a red marker.

B. Airborne Particulates

1. Place air filters in a small Petrie dish following Procedure TIML-AP-03.

2. Place Petrie dish (with marked side up) on the detector and count long enough to meet the client's technical requirements. Record the file number, sample identification number, date and time counting started, detector number, geometry, sample size, and date and time collected.

NOTE: When counting an individual filter, place it in the Petrie dish with active (with deposit) side up. Mark the Petrie dish and place it on the detector with the active side up.

3. Stop counting and transfer spectrum to the disk. Print out and check the results before taking the sample off. If client's technical requirements are not met, continue counting.

4. After counting is completed, record the counting time.

5. Replace air filters in the original envelopes for storage or further analyses.

C. Other Samples

NOTE: Sample, e.g. soil, vegetation, fish, etc., are prepared in the prep lab and delivered to the counting room.

1. Place the sample on the detector and count long enough to meet the client's technical requirements. Record the file number, sample identification number, date and time counting started, detector number, geometry, sample size, and date and time of collection.

2. Stop counting and transfer spectrum to the disk. Print out the results and check the results before taking the sample off. If the client's technical requirements are not met, continue counting.

3. After counting is completed, record counting time. Mark the container with a red marker and return to the prep lab for transfer to a plastic bag for storage or further analyses.

D. Charcoal Cartridges

For counting charcoal cartridges, follow Procedures TIML-I-131-02 or TIML-I-131-04.

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DETERMINATION OF TRITIUM IN WATER

(DIRECT METHOD)

PROCEDURE NO. TIML-T-02

Prepared by

Teledyne Brown Engineering Environmental Services
Midwest Laboratory

Copy No. ___________

Revision #	Date	Pages	Prepared by	Approved by
0	11-22-85	5	B . Grob	L.G. Huebner
1	09-27-91	4	B . Grob	L.G. Huebner
2	04-24-95	4	B . Grob	L.G. Huebner
3	07-07-98	4	[illegible]	[illegible]

DETERMINATION OF TRITIUM IN WATER (DIRECT METHOD)

Principle of Method

The water sample is purified by distillation, a portion of the distillate is transferred to a counting vial and the scintillation fluid added. The contents of the vial are thoroughly mixed and counted in a liquid scintillation counter.

Reagents

Scintillation medium: Insta-Gel scintillator, Packard Instrument Company
Tritium standard solution
"Dead" water
Ethyl alcohol
Boiling chips
Sodium hydroxide: Pellets
Potassium, permanganate: Crystals 2

Apparatus

Boiling chips
Distillation apparatus
Liquid scintillation counter
Liquid scintillation counting vials
Kimwipes
Heating mantel 2
Pipetter 3
Disposable 5-10 ml pipette tips

Procedure

NOTE: All glassware must be <u>dry</u>. Dry it in the drying oven at 100-125°C.

1. Place 60-70 mL of the sample in a 250 mL distillation flask. Add a boiling chip to the flask. Add one NaOH pellet and about 0.02 g $KMnO_4$. Connect a side arm adapter and a condenser to the outlet of the flask. Place a receptacle at the outlet of the condenser. 3 Heat to boiling to distill. Discard the first 5-10 mL of distillate. Collect next 20-25 mL of distillate for analysis. Do not distill to dryness.

2. Mark the vial caps with the sample number. 2

   NOTE: Use the same type of vial for the whole batch (samples, background, and standard.)

3. Mark three (3) vial caps "Bkg 1", "Bkg 2", "Bkg 3", and date.

4. Mark three (3) vial caps "ST-1", "ST-2", "ST-3"; standard number, and date.

DETERMINATION OF TRITIUM IN WATER (DIRECT METHOD)

Procedure (Continued)

5. Dispense 13 mL of sample into marked vials and "dead" water into vials marked Bkg-1, 2, and 3.

   NOTE 1: Pipetter is set (and calibrated) to deliver 6.5 mL, so pipette twice into each vial. Use new tip for each sample and new tip (one) for three background samples .
   NOTE 2: Make sure the pipetter has not been reset. If it has been reset, or if you are not sure, do not use it; check with your supervisor.
   NOTE 3: Make sure the plastic tip is pushed all the way on the pipetter and is tight. If it is not, the air will be drawn in and the volume will be incorrect.

6. Dispense 13 mL (see Notes 1, 2, and 3, above) of "dead" water into each vial marked "ST-1", "ST-2", and "ST-3."

7. Take a 0.1 mL (100 µL) pipetter and withdraw 0.1 mL of water from each of the three standard vials. Discard this 0.1 mL of water.

8. Take a new 0.1 mL tip. Dispense 0.1 mL of standard into each of the three vials marked "ST-1," "ST-2," and "ST-3."

9. Take all vials containing samples, background, and standard to the counting room.

   NOTE: To avoid spurious counts, scintillator should not be added under fluorescent light.

10. Dispense 10 mL of Insta-Gel into each vial (one at a time), cap tightly, and shake VIGOROUSLY for at least 0.5 minutes. Recheck the cap for tightness.

11. Wet a Kimwipe with alcohol and wipe off each vial in the following order:

    Background
    Samples
    Standard

12. Load the vials in the following order:

    Bkg-1
    ST-1
    Samples
    Bkg-2*
    ST-2*
    Samples
    Bkg-3
    ST-3

*Bkg-2 and ST-2 should be placed in approximately the middle of each batch.

DETERMINATION OF TRITIUM IN WATER (DIRECT METHOD)

Procedure (Continued)

13. Let the vials dark- and temperature-adapt for about one hour.

    NOTE 1: To check if vials have reached counter temperature, inspect one vial (Bkg). The liquid should be transparent. If the temperature is too high (or too low), the liquid will be white and very viscous.

    NOTE 2: Temperature inside the counter should be between 10° and 14°C (check thermometer). In this temperature range, the liquid is transparent.

14. Fill out the loading sheet, being sure to indicate the date and time counting started, and your initials.

    NOTE: 1. Do not count prepared background and standard sets with another batch of samples if plastic vials are used. Prepare new backgrounds and standards for each batch.

    NOTE: 2. If glass vials are used, the prepared background and standard sets can be counted with other batches up to one (1) month after preparation, provided they are not taken out of the counter (not warmed up) and the same vial type from the same manufacturing batch (the same carton) is used. After one month prepare new sets of backgrounds and standards.

Calculations

$$pCi / L = \frac{\frac{A}{t_1} - \frac{B}{t_2}}{2.22 \times E \times V \times e^{-\lambda t_3}} \pm \frac{2\sqrt{\frac{A}{t_1^2} + \frac{B}{t_2^2}}}{2.22 \times E \times V \times e^{-\lambda t_3}}$$

Where:

- A = Total counts, sample
- B = Total counts, background
- E = Efficiency, (cpm/dpm)
- V = Volume (liter)
- e = Base of the natural logarithm = 2.71828
- λ = $\frac{0.693}{12.26} = 0.5652$
- t_1 = Counting time, sample
- t_2 = Counting time, background
- t_3 = Elapsed time from the time of collection to the time of counting (in years)

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DETERMINATION OF I-131 IN MILK BY ANION EXCHANGE (BATCH METHOD)

PROCEDURE NO. TIML-I-131-01

Prepared by

Teledyne Isotopes Midwest Laboratory

Copy No. ___________

Revised Pages	Revision #	Date	Pages	Prepared by	Approved by
	0	06-12-85	6	[signature]	[signature]
5	1	11-25-85	6	[signature]	[signature]
2,3,4,5	2	03-24-89	6	[signature]	[signature]
2,3,5	3	04-10-91	6	[signature]	[signature]
2	4	08-14-92	6	[signature]	[signature]
4	5	09-24-92	6	[signature]	[signature]

Determination of I-131 in Milk by Ion Exchange

(Batch Method)

Principle of Method

Iodine, as the iodide, is concentrated by adsorption on an anion resin. Following a NaCl wash, the iodine is eluted with sodium hypochlorite. Iodine in the iodate form is reduced to I_2 and the elemental iodine extracted into $CHCl_3$, back-extracted into water then finally precipitated as palladium iodide.

Chemical recovery of the added carrier is determined gravimetrically from the PdI_2 precipitate. I-131 is determined by beta counting the PdI_2.

Reagents

Anion Exchange Resin, Dowex 1-X8 (20-50 mesh) chloride form

Chloroform, $CHCl_3$ - reagent grade

Hydrochloric Acid, HCl, 1N

Hydrochloric Acid, HCl, 3N

Wash Solution: H_2O - HNO_3 - NH_2OH HCL, 50 mL H_2O; 10 mL 1M - NH_2OH-HCl; 10 mL conc. HNO_3

Hydroxylamine Hydrochloride, NH_2OH HCl - 1 M

Nitric Acid, HNO_3 - concentrated

Palladium Chloride, $PdCl_2$, 7.2 mg Pd^{++}/mL (1.2 g $PdCl_2$/100 mL of 6N HCl)

Sodium Bisulfite, $NaHSO_3$ - 1 M

Sodium Chloride, NaCl - 2M

Sodium Hypochlorite, NaOCl - 5% (Clorox)

Potassium Iodide, KI, ca 29 mg KI/mL (See Proc. TIML-CAR-01 for preparation) 4

Special Apparatus

Chromatographic Column, 20 mm x 150 mm (Reliance Glass Cat. #R2725T)

Vacuum Filter Holder, 2.5 cm^2 filter area

Filter Paper, Whatman #42, 21 mm

Mylar

Polyester Gummed Tape, 1 1/2", Scotch #853

Heat Lamp

Part A

Ion Exchange Procedure

1. Transfer 2 liters (if available) of sample to the beaker. Add 1.00 mL of standardized iodide carrier to each sample. 3

2. Add a clean magnetic stirring bar to each sample beaker. Stir each sample for 5 minutes or longer on a magnetic stirrer. Allow sample to equilibrate at least 1/2 hour. If a milk sample is curdled or lumpy, vacuum filter the sample through a Buchner funnel using a cheesecloth filter. Wash the curd thoroughly with deionized water, collecting the washings with the filtrate. Pour the filtrate back into the original washed and labeled 4 liter beaker and discard the curd.

3. Add approximately 45 grams of Dowex 1X8 (20-50 mesh) anion resin to each sample beaker and stir on a magnetic stirrer for at least 1 hour. Turn off the stirrer and allow the resin to settle for 10 minutes.

4. Gently decant and discard the milk or water sample taking care to retain as much resin as possible in the beaker. Add approximately 1 liter of deionized water to rinse the resin, allow to settle 2 minutes, and pour off the rinse. Repeat rinsing in the case of milk samples until all traces of milk are removed from the resin.

5. Using a deionized water wash bottle, transfer the resin to the column marked with the sample number. Allow resin to settle 2 minutes and drain the standing water. Wash the resin with 100 mL of 2M NaCl.

6. Measure 50 mL 5% sodium hypochlorite in a graduated cylinder. Add sodium hypochlorite to column in 10-20 mL increments, stirring resin as needed to eliminate gas bubbles and maintain flow rate of 2 mL/min. Collect eluate in 250 mL beaker and discard the resin.

Part B

Iodine Extraction Procedure

CAUTION: Perform following steps in the fume hood.

1. Acidify the eluate from Step 6 by adding ca. 15 mL of concentrated HNO_3 to make the sample 2-3 N in HNO_3 and transfer to 250 mL separatory funnel. (Add 5
the acid slowly with stirring until the vigorous reaction subsides).

2. Add 50 mL of $CHCl_3$ and 10 mL of 1 M hydroxylamine hydrochloride (freshly prepared). Extract iodine into organic phase (about 2 minutes equilibration). Draw off the organic phase (lower phase) into another separatory funnel.

3. Add 25 mL of $CHCl_3$ and 5 mL of 1 M hydroxylamine hydrochloride to the first separatory funnel and again equilibrate for 2 minutes. Combine the organic phases. Discard the aqueous phase (Upper phase).

4. Add 20 mL H_2O-HNO_3-NH_2OH HCl wash solution to the separatory funnel containing the $CHCl_4$. Equilibrate 2 minutes. Allow phases to separate and transfer $CHCl_3$ (lower phase) to a clean separatory funnel. Discard the wash solution.

5. Add 25 mL H_2O and 10 drops of 1 M sodium bisulfite (freshly prepared) to the separatory funnel containing the $CHCl_3$. Equilibrate for 2 minutes. Discard the organic phase (lower phase). Drain aqueous phase (upper phase) into a 100 mL beaker. Proceed to the Precipitation of PdI_2.

Part C

Precipitation of Palladium Iodide

CAUTION: AMMONIUM HYDROXIDE INTERFERES WITH THIS PROCEDURE

1. Add 10 mL of 3 N HCl to the aqueous phase from the iodine extraction procedure in Step 5.
2. Place the beaker on a stirrer-hot plate. Using the magnetic stirrer, boil and stir the sample until it evaporates to 30 mL or begins to turn yellow.
3. Turn the heat off. Remove the magnetic stirrer, rinse with deionized water.
4. Add, dropwise, to the solution, 2.0 mL of palladium chloride.
5. Cool the sample to room temperature. Place the beaker with sample on the stainless steel tray and put in the refrigerator overnight.
6. Weigh a clean 21 mm Whatman #42 filter which has been dried under a heat lamp.
7. Place the weighed filter in the filter holder. Filter the sample and wash the residue with water and then with absolute alcohol.
8. Remove filter from filter holder and place it in the labeled petri dish.
9. Dry under the lamp for 5-10 minutes.
10. Weigh the filter with the precipitate and calculate carrier recovery. | 4
11. Cut a 1-1/2" strip of polyester tape and lay it on a clean surface, gummed side up. Place the filter, precipitate side up, in the center of the tape.
12. Cut a 1-1/2" wide piece of mylar. Using a spatula to press it in place, put it directly over the precipitate and seal the edges to the polyester tape. Trim to about 5 mm from the edge of the filter with scissors.
13. Mount the sample on the plastic disc and write the sample number on the back side of the disc.
14. Count the sample on a proportional beta counter.

Calculations

Calculate the sample activity using computer program I131.

Part C

Precipitation of Palladium Iodide (continued)

I-131 concentration:

$$(pCi/l) = \frac{A}{2.22 \times B \times C \times D \times R} \pm \frac{2\sqrt{E_{sb}^2 + E_b^2}}{2.22 \times B \times C \times D \times R}$$ 4

where:

A = Net cpm, sample

B = Efficiency for counting beta I-131 (cpm/dpm)

C = Volume of sample (liters)

D = Correction for decay to the time of collection = $e^{-\lambda t}$ =

$$Exp\left(- \frac{0.693 \times t}{8.04}\right) = e^{-0.0862t}$$

where t = elapsed time from the time of collection to the counting time (in days)

E_{sb} = Counting error of sample plus background

E_b = Counting error of background

R = Carrier recovery 4

2.22 = dpm/pCi

Reference: "Determination of 1-131 by Beta-Gamma coincidence Counting of PdI_2". Radiological Science Laboratory. Division of Laboratories and Research, New York State Department of Health, March 1975, Revised February 1977.

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DETERMINATION OF AIRBORNE I-131 IN CHARCOAL CARTRIDGES BY GAMMA SPECTROSCOPY (BATCH METHOD)

PROCEDURE NO. TIML-I-131-02

Prepared by

Teledyne Isotopes Midwest Laboratory

Copy No. __________

Revised Pages	Revision #	Date	Pages	Prepared by	Approved by
	0	07-04-86	3	B. Grob	L.G. Huebner
1,2,3,4	1	08-01-92	4	B. Grob	L.G. Huebner

DETERMINATION OF AIRBORNE I-131 IN CHARCOAL CARTRIDGES BY GAMMA SPECTROSCOPY (BATCH METHOD)

Principle of Method

Five or six cartridges are mounted in a specially designed holder and counted. A peak of 0.36 MeV is used to calculate the concentration at counting time. The concentration at the end of collection is then calculated.

NOTE: This procedure is used for screening only. If I-131 is detected, each cartridge from the batch is analyzed individually.

Materials

Charcoal Cartridges

Apparatus

Counting Container
Germanium Detector
Rubber Band

Procedure

NOTE: Because of the short half-life of I-131, count the samples as soon as possible after receipt, but no later than 8 days after collection.

1. Load the charcoal cartridges in a specially designed holder with the rim facing the detector and the arrow (if there is one - not all cartridges have arrows) pointing away from the detector (see Figure 1). Use rubber band to hold side mounted cartridges in place.
2. Place the holder on the detector and count for a period of time that will meet the required Lower Limit of Detection (LLD).
3. Calculate concentration of I-131 at counting time by inputting sample ID, volume (use $1m^3$) and date and time (midpoint) of counting. Submit printout to data clerk for final calculations without delay.

NOTE: If I-131 is detected, (positive result) count each cartridge from the batch individually in accordance with Procedure TIML-I-131-04 and notify supervisor immediately.

Calculations:

A_1 = I-131 concentration (pCi/sample) = $\frac{A}{2.22 \times B}$ (at counting time)

Where:

A = Net count rate of I-131 in the 0.36 MeV peak (cpm)

B = Efficiency for the I-131 in 0.36 MeV peak (cpm/dpm)

2.22 = dpm/pCi

I-131 concentration at the time of collection:

$$(pCi/m^3) = \frac{A_1}{C \times D} \pm \frac{2\sqrt{E_{sb}^2 + E_b^2}}{C \times D}$$

where:

C = Volume of sample (m^3)
D = Correction for decay to the time of collection = $e^{-\lambda t}$ =

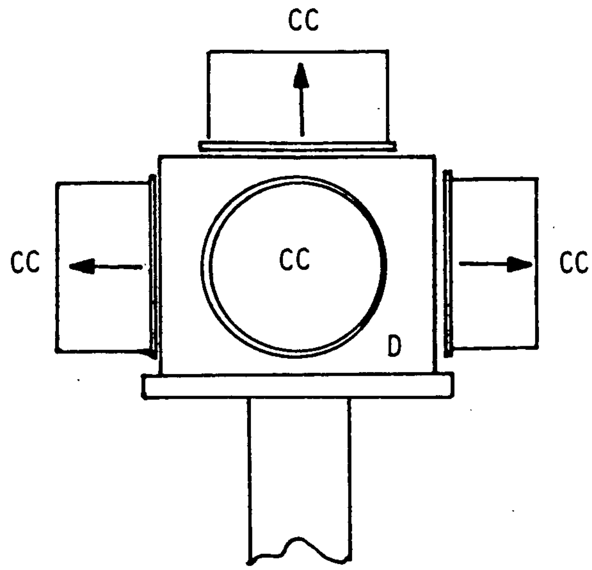
$$\mathrm{Exp}\left(-\frac{0.693 \times t}{8.04}\right) = e^{-0.0862t}$$

where t = elapsed time from the time of collection to the counting time (in days)

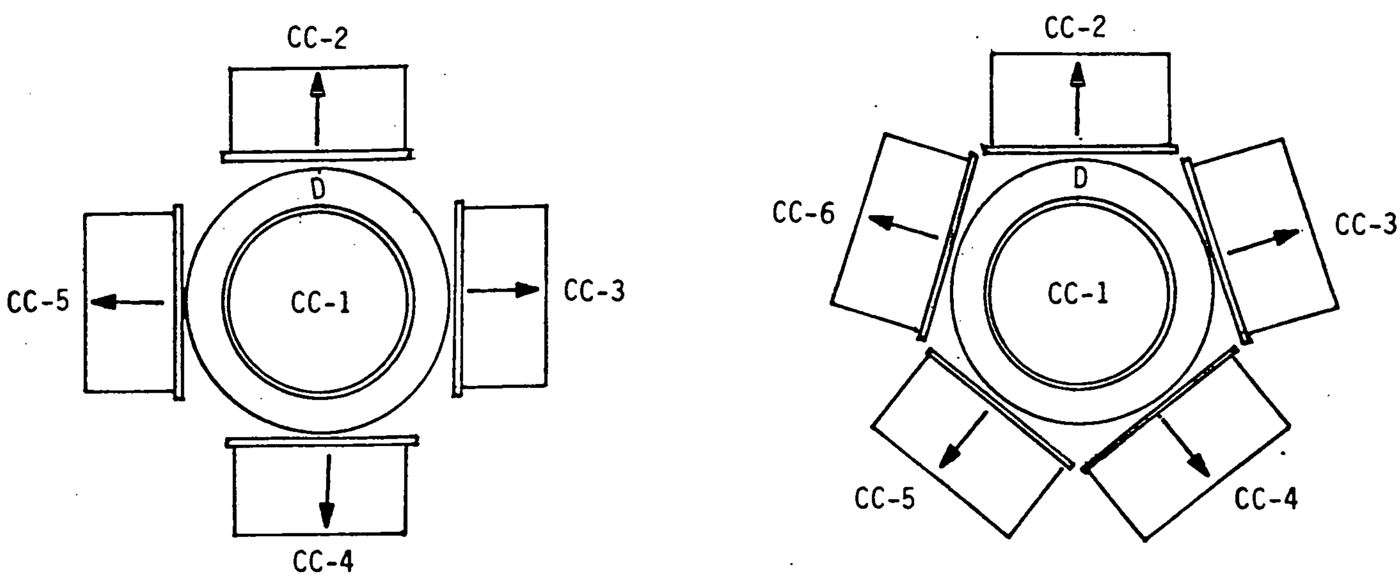
E_{sb} = Counting error of sample plus background

E_b = Counting error of background

Figure 1.



Side View (5 CC's)



5 CC's 6 CC's

Top View

Charcoal Cartridge: CC
Germanium Detector: D

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DETERMINATION OF SR-89 AND SR-90 IN WATER

(CLEAR OR DRINKING WATER)

PROCEDURE NO. TIML-SR-02

Prepared by

Teledyne Isotopes Midwest Laboratory

Copy No. ________

Revision No.	Date	Pages	Prepared by	Approved by
0	03-21-86	7	J. Kattner	[signature]

Determination of Sr-89 and Sr-90 in Water

Principle of Method

The acidified sample of clear water with stable strontium, barium, and calcium carriers is treated with oxalic acid at a pH of 3.0 to precipitate insoluble oxalates. The oxalates are dissolved in nitric acid, and strontium nitrate is separated from calcium as a precipitate in 70% nitric acid. The residue is purified by adding iron and rare earth carriers and precipitating them as hydroxides. After a second strontium nitrate precipitation from 70% nitric acid, the nitrates are dissolved in acid with added yttrium carrier and are stored for ingrowth of yttrium-90. The ittrium is again precipitated as hydroxide and separated from strontium with the strontium being in the supernate. Each fraction is precipitated separately as an oxalate (yttrium) and carbonate (strontium) and collected on No. 42 (2.4 cm) Whatman filter for counting.

Reagents

Ammonium acetate buffer: pH 5.0
Ammonium hydroxide, NH_4OH: concentrated (15N), 6 N
Ammonium oxalate, $(NH_4)_2C_2O_4 \cdot H_2O$: 0.5% w/v
Carrier solutions:
- Ba^{+2} as barium nitrate, $Ba(NO_3)2$: 20 mgBa^{+2} per ml
- Ca^{+2} as calcium nitrate, $Ca(NO_3)_2 4H_2O$: 40 mg Ca^{+2} per ml
- Sr^{+2} as strontium nitrate, $Sr(NO_3)_2$: 20 mg Sr^{+2} per ml
- Y^{+3} as yttrium nitrate, $Y(NO_3)$: 10 mg $^{+3}$ per ml

Hydrochloric acid, HCl: concentrated (3 N)
Nitric acid, HNO_3: Fuming (90%), concentrated (16 N), 6 N
Oxalic acid, $H_2C_2O_2$. $2H_2O$: Saturated at room temperature
Scavenger solutions: 20 mg Fe^{+3} per ml, 10 mg each Ce^{+3} and Zr^{+4} per ml
- Fe^+ as ferric chloride, $FeCl_3 \cdot hH_2O$
- Ce^{+3} as cerous nitrate, $Ce(NO_3)_3 \cdot 6H_2O$
- Zr^4 as zirconyl chloride, $ZrOCl_2 \cdot 8H_2O$

Sodium carbonate, Na_2CO_3: 3N, 0.1N
Sodium chromate, Na_2CrO_4: 3N

Apparatus

Analytical balance
Low background beta counter
pH meter

Procedure

1. Measure 1 liter of acidified water into a 2 liter beaker.

   NOTE: If the sample contains foreign mater, such as sand, dirt, etc., filter through a 47 mm glass fiber filter using suction flask.

2. To acidified clear water in a 2 liter beaker, add 1 ml of strontium carrier solution, 1 ml barium carrier solution, and if necessary, 1 ml of calcium carrier solution. (Improved precipitation may be obtained by additng calcium to soft waters.) Stir thoroughly, and while stirring add 125 ml of saturated oxalic acid solution.

3. Using a pH meter, adjust the pH to 3.0 with 15N NH_4OH and allow the precipitate to settle for 5 - 6 hours or overnight.

4. Decant to waste most of the supernate (liquid) and transfer the precipitate to a 250 ml centrifuge bottle using D.I. water. Discard the supernate to waste.

5. Dissolve the precipitate with 10 ml of 6N HNO^3 and transfer to a 250 ml beaker. Then use 20 ml of 16N HNO^3 to rinse the centrifuge tube and combine it to the solution in the 250 ml beaker.

6. Evaporate the solution to dryness. Cool; then add 50 ml 16N HNO_3 and repeat the acid addition and evaporation until the residue is colorless.

7. Transfer the residue to a 40 ml centrifuge tube, rinsing with a minimum volume of 16N HNO_3. Cover with parafilm and cool in an ice bath. Centrifuge at 1500 - 1800 rpm for 10 minutes, and discard the supernate to waste.

8. Dissolve the precipitate in 5 ml of 6N HNO_3 and then add 30 ml of fuming nitric acid. Cover with parafilm, cool in the ice bath, centrifuge, and discard the supernate to waste.

9. Dissolve the nitrate precipitate in about 10 ml of D.I. water (perform under the hood). Add 1 ml of scavenger solution. Adjust the pH of the mixture to 7 with 6N HN_4OH. Heat in hot water bath for 10 minutes, stir, and filter through a Whatman No. 541 filter into another 40 ml centrifuge tube. Discard the mixed hydroxide precipitate (filter paper).

10. To the filtrate, add 5 ml of ammonium acetate buffer. Adjust the pH with 3N HNO_3 or NH_4OH to pH 5.5.

    NOTE: The pH of the solution at this point is critical.

    Add dropwise with stirring 1 ml of 3N Na_2CrO_4 solution, stir, and heat in a water bath.

11. Cool and centrifuge. Decant the supernate into another 40 ml centrifuge tube. (Save the precipitate for Ba analysis if needed.)

Procedure

12. Heat the supernate in a water bath. Adjust the pH to 8 - 8.5 with NH_4OH. With continuous stirring, cautiously add 5 ml of 3N Na_2CO_3 solution. Heat gently for 10 minutes. Cool, centrifuge, and decant the supernate to waste. Wash the precipitate with 0.1N Na_2CO_3. Centrifuge again and decant the supernate to waste.

13. Dissolve the precipitate in no more than 4 ml of 3N HNO_3. Then add 20 - 30 ml of fuming HNO_3, cover with parafilm, cool in a water bath, and centrifuge. Decant and discard the supernate.

14. Repeat Step 13. Then RECORD THE TIME AND DATE AS THE BEGINNING OF YTTRIUM-90 INTROWTH.

15. Dissolve precipitate in 4 ml of 6N HNO_3 and add 1 ml of yttrium carrier solution.

16. Cover with parafilm and store for 7 - 14 days.

    NOTE: At this point, the sample can be transferred to a glass scintillation vial for the ingrowth storage. Use several portions of 6N HNO^3 (a total of not more than 4 ml); then add 1 ml of yttrium carrier to the vial.)

Separation

NOTE: If the sample was stored in the scintillation vial, transfer back into 40 ml centrifuge tube using a few drops of 6N HNO_3 as a rinse.

1. After storage (ingrowth period), heat the 40 ml centrifuge tube containing the samle in the hot water bath (approximately 90°C) for 10 minutes.

2. Adjust pH to 8 with NH_4OH, stirring continuously.

3. Cool in a cold water bath and centrifuge for 5 minutes.

4. Decant the supernate into a 40 ml centrifuge tube marked with the sample number and "SR-89." RECORD THE DATE AND TIME OF DECANTATION AS THE END OF Y-90 ingrowth in SR fraction and the beginning of its decay in Y-90 fraction.

5. Redissolve the precipitate by adding 3 - 4 drops of 6N HCl and add 5 - 10 ml of D.I. water with stirring.

6. Repeat Steps 1, 2, and 3.

7. Combine supernate with the one in Step 4.

Determination

A. Strontium-90 (Yttrium-90)

1. Add 3 drops of 6N HCl to dissolve the precipitate; then add 5 - 10 ml of water. Heat in a water bath at approximately 90°C. Add 1 ml of saturated oxalic acid solution dropwise with vigorous stirring. Adjust to a pH of 2 - 3 with NH_4OH. Allow the precipitate to digest for about an hour.

   NOTE: Do Part "B" while precipitate is digesting.

2. Cool to room temperature in a cold wate bath. Centrifuge for 10 minutes and decant most of the supernate. filter by suction on a weighed 2.5 cm filter paper. Wash the precipitate with water and alcohol.

3. Dry the precipitate under the lamp for 30 minutes. Cool and weigh. Mount and count without delay in a proportional counter. (See Part C for mounting.)

B. Strontium-89 (Total Strontium)

1. Heat the solution from Step 7 in water bath.

2. Adjust the pH to 8 - 8.5 using NH_4OH.

3. With continuous stirring, add 5 ml of 3N Na_2CO_3 solution. Stir until precipitate appears. Heat gently for 10 minutes.

4. Cool and filter on a weighed No. 42 (2.4 cm) Whatman filter paper.

5. Wash thoroughly with water and alcohol.

6. Mount and count without delay its beta activity as "total radio-strontium" in a proportional counter.

C. Filtering and Mounting

1. Place filters under heat lamps for 30 minutes before weighing.

2. Use Mettler balance (Serial No. 343112) for weighing.

3. Label a clean petri dish with the weight of the filter paper. (After samples are filtered, the filter paper will again be dried and weighed to determine weight of precipitate before mounting.)

C. Filtering and Mounting (continued)

4. Mount weighed filter paper and precipitate on nylon disk using 1" transparent tape to hold filter paper and 2" mylar foil placed over precipitate and held in place with slip-ring. Trim off excess mylar foil and place the mounted sample in a labeled petri dish.

5. Fill out corresponding loading sheets and place samples in counting room.

Calculations

Part A

$$\text{Strontium-90 Concentration (pCi/liter)} = \frac{A}{8 \times C \times D \times E \times F}$$

Where:

A = Net beta count rate of yttrium 90 (cpm)

B = Recovery of yttrium carrier

C = Counter efficiency for counting yttrium-90 or yttrium oxalate mounted on a 2.4 cm diameter filter paper (cpm/pCi)

D = Sample volume (liters)

E = Correction factor $e^{-\lambda t}$ for yttrium-90 decay, where t is the time from the time of cdecantation (Step 4, Separation) to the time of counting

F. Correction factor $1-e^{-\lambda t}$ for the degree of equilibrium attained during the yttrium-90 ingrowth period, where t is the time from collection of the water sample to the time of decantation (Step 4, Separation)

Part B

$$\text{Strontium-89 Concentration (pCi/liter)} = \frac{1}{B \times C} \quad \frac{A}{D \times E} - F\ (G \times H + I \times J)$$

Where:

A = Net beta count rate of "total radiostrontium" (cpm)

B = Counter efficiency for counting strontium-89 as strontium carbonate mounted on a 2.4 cm diameter filter paper (cpm/pCi)

C = Correction factor $e^{-\lambda t}$ for strontium-89 decay, where t is the time from sample collection to the time of counting

D = Recovery of strontium carrier

E = Volume of water sample (liters)

F = Strontium-90 concentration (pCi/liter) from Part A

G = Self-absorption factor for strontium-90 as strontium carbonate mounted on a 2.4 cm diameter filter, obtained from a self-absorption curve prepared by plotting the fraction of a standard activity absorbed against density thickness of the sample (mg/cm^2)

H = Counter efficiency for counting strontium-90 as strontium carbonate mounted on a 2.4 cm diameter filter paper (cpm/pCi)

I = Counter efficiency for counting yttrium-90 as yttrium oxalate mounted on a a2.4 cm diameter filter paper (cpm/pCi)

J = Correction factor $1-e^{-\lambda t}$ for yttrium-90 ingrowth, where it is the time from the last decantation of the nitric acid (Step 4, Separation)

REFERENCE: Radioassay Procedures for Environmental Samples, U. S. Department of Health, Education, and Welfare. Environmental Health Series, January 1967.

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DETERMINATION OF SR-89 AND SR-90 IN ASHED SAMPLES (VEGETATION, FISH, ETC.)

PROCEDURE NO. TIML-SR-05

Prepared by

Teledyne Isotopes Midwest Laboratory

Copy No. ________

Revision No.	Date	Pages	Prepared by	Approved by
0	07-23-86	7		

DETERMINATION OF SR-89 AND SR-90 IN ASHED SAMPLES (VEGETATION, FISH, ETC.)

Principle of Method

The sample with stable strontium and barium carriers added is leached in nitric acid and filtered. After filtration, filtrate is reduced in volume by evaporation. The residue is purified by adding iron and rare earth carriers and precipitating them as hydroxides. After a second strontium nitrate precipitation from 70% nitric acid, the nitrates are dissolved in acid again with added yttrium carrier and are stored for ingrowth of yttrium-90. The yttrium is precipitated as hydroxide and separated from strontium with the strontium being in the supernate. Each fraction is precipitated separately as an oxalate (yttrium) and carbonate (strontium) and collected on No. 42 (2.4 cm) Whatman filter for counting.

Reagents

Ammonium acetate buffer: pH 5.0
Ammonium hydroxide, NH_4OH: concentrated (15N), 6 N
Carrier solutions: Ba^{+2} as barium nitrate, $Ba(NO_3)2$: 20 $mgBa^{+2}$ per ml
    Sr^{+2} as strontium nitrate, $Sr(NO_3)_2$: 20 mg Sr^{+2} per ml
    Y^{+3} as yttrium nitrate, $Y(NO_3)$: 10 mg $^{+3}$ per ml
Hydrochloric acid, HCl: 6 N
Nitric acid, HNO_3: Fuming (90%), concentrated (16 N), 6 N
Oxalic acid, $H_2C_2O_2$. $2H_2O$: Saturated at room temperature
Scavenger solutions: 20 mg Fe^{+3} per ml, 10 mg each Ce^{+3} and Zr^{+4} per ml
    Fe^{+} as ferric chloride, $FeCl_3.6H_2O$
    Ce^{+3} as cerous nitrate, $Ce(NO_3)_3.6H_2O$
    Zr^4 as zirconyl chloride, $ZrOCl_2.8H_2O$
Sodium carbonate, Na_2CO_3:3N, 0.1N
Sodium chromate, Na_2CrO_4:3N

Apparatus

Analytical balance
Low background beta counter
pH meter

Procedure

1. Weigh 3 g of ash and transfer to the 250 ml beaker.

2. Add 50 ml concentrated nitric acid.

3. Add 1 ml strontium and 1 ml barium carrier solutions.

4. Place the sample on the moderate hot plate under the hood and cover with the watch glass.

5. Allow to leach for 2 hours or longer.

6. Remove sample beaker from the hot plate and allow to cool to room temperature.

7. Add deionized water, filling to 100 ml; mark on the beaker.

8. Filter the sample through Whatman No. 541 filter paper.

9. Place the filtrate on the moderate hot plate under the hood and gently evaporate to 5 ml.

10. Transfer the sample into 40 ml centrifuge tube. Rinse the beaker with 16N HNO_3. Add rinsing to the tube.

11. Centrifuge for 10 minutes and discard the supernate to waste.

12. Carefully add 30 ml of concentrated HNO_3 to the precipitate. Heat in a hot water bath for about 30 minutes, stirring occassionally. Cool the sample in an ice water bath for about 5 minutes. Centrifuge and discard the supernate.

13. Repeat Step 12.

14. Dissolve the nitrate precipitate in about 10 ml of D.I. water (perform under the hood). Add 1 ml of scavenger solution. Adjust the pH of the mixture to 7 with 6N NH_4OH. Heat in hot water bath for 10 minutes, stir, and filter through a Whatman No. 541 filter into another 40 ml centrifuge tube. Discard the mixed hydroxide precipitate (filter paper).

15. To the filtrate, add 5 ml of ammonium acetate buffer. Adjust the pH with 6N HNO_3 or NH_4OH to pH 5.5.

    NOTE: The pH of the solution at this point is critical.

    Add dropwise with stirring 1 ml of 3N Na_2CrO_4 solution, stir, and heat in a water bath.

16. Cool and centrifuge. Decant the supernate into another 40 ml centrifuge tube. (Save the precipitate for Ba analysis if needed.)

Procedure (continued)

17. Heat the supernate in a water bath. Adjust the pH to 8 - 8.5 with NH_4OH. With continuous stirring, add 5 ml of 3N Na_2CO_3 solution. Heat gently for 10 minutes. Cool, centrifuge, and decant the supernate to waste. Wash the precipitate with 0.1N Na_2CO_3. Centrifuge again and decant the supernate to waste.

18. Dissolve the precipitate in no more than 4 ml of 3N HNO_3. Then add 20 - 30 ml of fuming HNO_3, cover with parafilm, cool in a water bath, and centrifuge. Decant and discard the supernate.

19. Repeat Step 13. Then RECORD THE TIME AND DATE AS THE BEGINNING OF YTTRIUM-90 INTROWTH.

20. Dissolve precipitate in 4 ml of 6N HNO_3 and add 1 ml of yttrium carrier solution.

21. Cover with parafilm and store for 7 - 14 days.

    NOTE: At this point, the sample can be transferred to a glass scintillation vial for the ingrowth storage. Use several portions of 6N HNO_3 (a total of not more than 4 ml); then add 1 ml of yttrium carrier to the vial.)

Separation

NOTE: If the sample was stored in the scintillation vial, transfer back into 40 ml centrifuge tube using a few drops of 6N HNO_3 as a rinse.

1. After storage (ingrowth period), heat the 40 ml centrifuge tube containing the sample in the hot water bath (approximately 90°C) for 10 minutes.
2. Adjust pH to 8 with NH_4OH, stirring continuously.
3. Cool in a cold water bath and centrifuge for 5 minutes.
4. Decant the supernate into a 40 ml centrifuge tube marked with the sample number and "SR-89." RECORD THE DATE AND TIME OF DECANTATION AS THE END OF Y-90 INGROWTH in SR fraction and the beginning of its decay in Y-90 fraction.
5. Redissolve the precipitate by adding 3 - 4 drops of 6N HCl and add 5 - 10 ml of D.I. water with stirring.
6. Repeat Steps 1, 2, and 3.
7. Combine supernate with the one in Step 4.

Determination

A. Strontium-90 (Yttrium-90)

1. Add 3 drops of 6N HCl to dissolve the precipitate; then add 5 - 10 ml of water. Heat in a water bath at approximately 90°C. Add 1 ml of saturated oxalic acid solution dropwise with vigorous stirring. Adjust to a pH of 2 - 3 with NH_4OH. Allow the precipitate to digest for about an hour.

   NOTE: Do Part "B" while precipitate is digesting.

2. Cool to room temperature in a cold water bath. Centrifuge for 10 minutes and decant most of the supernate. Filter by suction on a weighed 2.5 cm filter paper. Wash the precipitate with water and alcohol.

3. Dry the precipitate under the lamp for 30 minutes. Cool and weigh. Mount and count without delay in a proportional counter. (See Part C for mounting.)

B. Strontium-89 (Total Strontium)

1. Heat the solution from Step 7 in water bath.

2. Adjust the pH to 8 - 8.5 using NH_4OH.

3. With continuous stirring, add 5 ml of 3N Na_2CO_3 solution. Stir until precipitate appears. Heat gently for 10 minutes.

4. Cool and filter on a weighed No. 42 (2.4 cm) Whatman filter paper.

5. Wash thoroughly with water and alcohol.

6. Mount and count without delay its beta activity as "total radio-strontium" in a proportional counter.

C. Filtering and Mounting

1. Place filters under heat lamps for 30 minutes before weighing.

2. Use Mettler balance (Serial No. 343112) for weighing.

3. Label a clean petri dish with the weight of the filter paper. (After samples are filtered, the filter paper will again be dried and weighed to determine weight of precipitate before mounting.)

C. Filtering and Mounting (continued)

4. Mount weighed filter paper and precipitate on nylon disk using 1" transparent tape to hold filter paper and 2" mylar foil placed over precipitate and held in place with slip-ring. Trim off excess mylar foil and place the mounted sample in a labeled petri dish.

5. Fill out corresponding loading sheets and place samples in counting room.

Calculations

Part A

Strontium-90 Concentration (pCi/g wet) =

$$\frac{A}{2.22 \times B \times C \times D \times E \times F \times G} \pm \frac{2\sqrt{E_{sb}^2 + E_b^2}}{2.22 \times B \times C \times D \times E \times F \times G}$$

Where:

A = Net beta count rate of yttrium 90 (cpm)

B = Recovery of yttrium carrier

C = Counter efficiency for counting yttrium-90 or yttrium oxalate mounted on a 2.4 cm diameter filter paper (cpm/dpm)

D = Sample size (grams), ash

E = Correction factor $e^{-\lambda t}$ for yttrium-90 decay, where t is the time from the time of decantation (Step 4, Separation) to the time of counting

F = Correction factor $1-e^{-\lambda t}$ for the degree of equilibrium attained during the yttrium-90 ingrowth period, where t is the time from collection of the water sample to the time of decantation (Step 4, Separation)

G = Ratio of wet weight to ashed weight

E_{sb} = Counting error of sample plus background

E_b = Counting error of background

Part B

Strontium-89 Concentration (pCi/g wet) =

$$\frac{1}{2.22 \times B \times C}\left[\frac{A}{D \times E \times K} - F\,(G \times H + I \times J)\right] \pm \frac{2\sqrt{E_{sb}^2 + E_b^2}}{2.22 \times B \times C \times D \times E \times F \times K}$$

Where:

A = Net beta count rate of "total radiostrontium" (cpm)

B = Counter efficiency for counting strontium-89 as strontium carbonate mounted on a 2.4 cm diameter filter paper (cpm/dpm)

C = Correction factor $e^{-\lambda t}$ for strontium-89 decay, where t is the time from sample collection to the time of counting

D = Recovery of strontium carrier

E = Sample size (grams), ash

F = Strontium-90 concentration (pCi/g wet) from Part A

G = Self-absorption factor for strontium-90 as strontium carbonate mounted on a 2.4 cm diameter filter, obtained from a self-absorption curve prepared by plotting the fraction of a standard activity absorbed against density thickness of the sample (mg/cm^2)

H = Counter efficiency for counting strontium-90 as strontium carbonate mounted on a 2.4 cm diameter filter paper (cpm/ dpm)

I = Counter efficiency for counting yttrium-90 as yttrium oxalate mounted on a 2.4 cm diameter filter paper (cpm/ dpm)

J = Correction factor $1-e^{-\lambda t}$ for yttrium-90 ingrowth, where it is the time from the last decantation of the nitric acid (Step 4, Separation)

K = Ratio of wet weight to ashed weight

REFERENCE: Radioassay Procedures for Environmental Samples, U. S. Department of Health, Education, and Welfare. Environmental Health Series, January 1967.

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DETERMINATION OF SR-89 AND SR-90 IN SOIL AND BOTTOM SEDIMENTS

PROCEDURE NO. TIML-SR-06

Prepared by

Teledyne Isotopes Midwest Laboratory

Copy No. ________

Revision No.	Date	Pages	Prepared by	Approved by
0	07-23-86	9	B. Grob	L. Huebner

DETERMINATION OF SR-89 AND SR-90 IN SOIL AND BOTTOM SEDIMENTS

Principle of Method

The sample with stable strontium and barium carriers added is leached in hydrochloric acid. After separation from calcium, the residue is purified by adding iron and rare earth carriers and precipitating them as hydroxides. After a second strontium nitrate precipitation from 70% nitric acid, the nitrates are dissolved in acid again with added yttrium carrier and are stored for ingrowth of yttrium-90. The yttrium is precipitated as hydroxide and separated from strontium with the strontium being in the supernate. Each fraction is precipitated separately as an oxalate (yttrium) and carbonate (strontium) and collected on No. 42 (2.4 cm) Whatman filter for counting.

Reagents

Ammonium acetate buffer: pH 5.0
Ammonium hydroxide, NH_4OH: concentrated (15N), 6N
Carrier solutions: Ba^{+2} as barium nitrate, $Ba(NO_3)2$: 20 mgBa^{+2} per ml
    Sr^{+2} as strontium nitrate, $Sr(NO_3)_2$: 20 mg Sr^{+2} per ml
    Y^{+3} as yttrium nitrate, $Y(NO_3)$: 10 mg $^{+3}$ per ml
Hydrochloric acid, HCl: 6 N
Nitric acid, HNO_3: Fuming (90%), concentrated (16N), 6N, 1:1
Oxalic acid, $H_2C_2O_2 . 2H_2O$: Saturated at room temperature
Scavenger solutions: 20 mg Fe^{+3} per ml, 10 mg each Ce^{+3} and Zr^{+4} per ml
    Fe^{+} as ferric chloride, $FeCl_3 . 6H_2O$
    Ce^{+3} as cerous nitrate, $Ce(NO_3)_3 . 6H_2O$
    Zr^4 as zirconyl chloride, $ZrOCl_2 . 8H_2O$
Sodium carbonate, Na_2CO_3:3N, 0.1N
Sodium chromate, Na_2CrO_4:3N

Apparatus

Analytical balance
Centrifuge
Hot plate
Low background beta counter
pH meter
Plastic disc and ring
Stirrer

Procedure

1. Weigh out a 100 g sample into a 1 liter beaker. Add 1 ml of strontium carrier and 1 ml of Ba carrier.

2. Stir mechanically while slowly adding 200 ml of 6N HCl. (It may be necessary to add a few drops of octyl alcohol to prevent excessive frothing.) Continue stirring for about 30 minutes. Allow a minimum of two hours for the insoluble material to settle.

3. Stir the mixture and filter with suction through a 24 cm Whatman No. 42 filter paper using a Buchner funnel. Wash the residue with hot water. Wash with 6N HCl and again with hot water until the yellow color of ferric chloride is removed. Discard the residue.

4. Transfer the filtrate to a 1 liter beaker and evaporate to approximately 200 ml. Cool and slowly add 200 ml of concentrated HNO_3. (If there is excessive frothing, add a few drops of octyl alcohol.) Evaporate to 100-200 ml.

5. Add 500 ml of water and stir.

6. Add 25 grams of oxalic acid with magnetic stirring until it is completely dissolved.

7. Adjust the pH to 5.5 - 6.0 with concentrated NH_4OH. (If the brown color of ferric hydroxide persists, add more oxalic acid and readjust the pH.) The optimum condition is an excess of oxalic acid in solution without causing crystallization of ammonium oxalate upon cooling.

8. Allow precipitate to settle for 5 - 6 hours or overnight.

9. Decant most of the supernate (liquid) and transfer the precipitate to a 250 ml centrifuge tube using deionized water for rinsing. Add rinsing to the tube. Centrifuge and decant supernate.

10. Wash the precipitate with 50 - 100 ml portion of water and centrifuge again.

11. Repeat washing as needed until all the yellow color of the solution has been removed.

12. Cool the precipitate and dissolve it with 6N HNO_3 and transfer it in a 250 ml beaker. Rinse the tube with 6N HNO_3, making the total volume to 50 - 100 ml. Add about 6 drops of H_2O_2 (30%) to facilitate dissolution.

13. Cool to room temperature. If insoluble material is present at this point, filter by suction through a glass fiber filter. Discard the filter and residue.

Procedure (continued)

14. Transfer the solution to an appropriate size beaker and evaporate to dryness. The evaporation must be done slowly to avoid spattering.

15. Dissolve the salt in water and perform successive fuming nitric acid separations (the first two separations at concentration slightly greater than 75%) until the strontium has been separated from the bulk of the calcium. Samples with a high calcium content will require five or more separations.

16. The volumes of 75% HNO_3 vary (fuming solutions may be changed as required by the mass of calcium present, keeping in mind that minimum volumes are always best).

17. If calcium content is still thick, evaporate the solution to dryness and bake.

18. Dissolve the residue with 50 ml boiling water and filter. Discard residue.

19. Evaporate the solution to dryness again.

20. Cool and dissolve the residue in a minimum amount of water and add 50 ml of fuming HNO_3.

21. Continue the fuming nitric acid separations until the strontium has been separated from the bulk of calcium.

22. Transfer the solution to a 40 ml conical, heavy-duty centrifuge tube, using a minimum of concentrated HNO_3 to effect the transfer. Cool the centrifuge tube in an ice bath for about 10 minutes. Centrifuge and discard the supernatant.

    NOTE: The precipitate consists of calcium, strontium, and barium-radium nitrate.

    The supernatant contains part of the sample's calcium and phosphate content.

23. Add 30 ml of concentrated HNO_3 to the precipitate. Heat in a hot water bath with stirring for about 10 minutes. Cool the solution in an ice bath, stirring for about 5 minutes. Centrifuge and discard the supernatant.

    NOTE: Additional calcium is removed from the sample.

    Nitrate precipitations with 70% HNO_3 will afford a partial decontamination from soluble calcium, while strontium, barium, and radium are completely precipitated.

Procedure (continued)

23. NOTE: (continued)

The separation of calcium is best at 60% HNO_3; however, at 60% the precipitation of strontium is not complete. Therefore, it is common practice to precipitate $Sr(No_3)_2$ with 70% HNO_3, which is the concentration of commercially available 16N HNO_3.

Most of the other fission products, induced acitivities, and actinides are soluble in concentrated HNO_3, affording a good "gross" decontamination step from a wide spectrum of radionuclides. The precipitation is usually repeated several times.

24. Repeat Step 23 two (2) more times.

25. Dissolve the nitrate precipitate in about 20 ml distilled water. Add 1 ml of scavenger solution. Adjust the pH of the mixture to 7 with 6N NH_4OH. Heat, stir, and filter through a Whatman No. 541 filter. Discard the mixed hydroxide precipitate.

26. To the filtrate, add 5 ml of ammonium acetate buffer. Adjust the pH with 6 N HNO_3 or NH_4OH to pH 5.5.

NOTE: The pH of the solution at this point is critical.

Add dropwise with stirring 1 ml of 3N Na_2CrO_4 solution, stir, and heat in a water bath.

27. Cool and centrifuge. Decant the supernate into another 40 ml centrifuge tube. (Save the precipitate for barium analysis if needed.)

28. Heat the supernate in a water bath. Adjust the pH to 8 - 8.5 with NH_4OH. With continuous stirring, add 5 ml of 3N Na_2CO_3 solution. Heat gently for 10 minutes. Cool, centrifuge, and decant the supernate to waste. Wash the precipitate with 0.1N Na_2CO_3. Centrifuge again and decant the supernate to waste.

29. Dissolve the precipitate in no more than 4 ml of 3N HNO_3. Then add 20 - 30 ml of fuming HNO_3, cover with parafilm, cool in a water bath, and centrifuge. Decant and discard the supernate.

30. Repeat Step 13. Then RECORD THE TIME AND DATE AS THE BEGINNING OF YTTRIUM-90 INTROWTH.

31. Dissolve precipitate in 4 ml of 6N HNO_3 and add 1 ml of yttrium carrier solution.

Procedure (continued)

32. Cover with parafilm and store for 7 - 14 days.

NOTE: At this point, the sample can be transferred to a glass scintillation vial for the ingrowth storage. Use several portions of 6N HNO_3 (a total of not more than 4 ml); then add 1 ml of yttrium carrier to the vial.)

Separation

NOTE: If the sample was stored in the scintillation vial, transfer back into 40 ml centrifuge tube using a few drops of 6N HNO_3 as a rinse.

1. After storage (ingrowth period), heat the 40 ml centrifuge tube containing the sample in the hot water bath (approximately 90°C) for 10 minutes.

2. Adjust pH to 8 with concentrated NH_4OH, stirring continuously.

3. Cool in a cold water bath and centrifuge for 5 minutes.

4. Decant the supernate into a 40 ml centrifuge tube marked with the sample number and "SR-89." RECORD THE DATE AND TIME OF DECANTATION AS THE END OF Y-90 INGROWTH in SR fraction and the beginning of its decay in Y-90 fraction.

5. Redissolve the precipitate by adding 3 - 4 drops of 6N HCl and add 5 - 10 ml of D.I. water with stirring.

6. Repeat Steps 1, 2, and 3.

7. Combine supernate with the one in Step 4.

Oetermination

A. Strontium-90 (Yttrium-90)

1. Add 3 drops of 6N HCl to dissolve the precipitate; then add 5 - 10 ml of water. Heat in a water bath at approximately 90°C. Add 1 ml of saturated oxalic acid solution dropwise with vigorous stirring. Adjust to a pH of 2 - 3 with concentrated NH_4OH. Allow the precipitate to digest for about an hour.

NOTE: Do Part "B" while precipitate is digesting.

Determination (continued)

A. Strontium-90 (Yttrium-90) (continued)

2. Cool to room temperature in a cold water bath. Centrifuge for 10 minutes and decant most of the supernate. Filter by suction on a weighed 2.5 cm filter paper. Wash the precipitate with water and alcohol.

3. Dry the precipitate under the lamp for 30 minutes. Cool and weigh. Mount and count without delay in a proportional counter. (See Part C for mounting.)

B. Strontium-89 (Total Strontium)

1. Heat the solution from Step 7 in water bath.

2. Adjust the pH to 8 - 8.5 using concentrated NH_4OH.

3. With continuous stirring, add 5 ml of 3N Na_2CO_3 solution. Stir until precipitate appears. Heat gently for 10 minutes.

4. Cool and filter on a weighed No. 42 (2.4 cm) Whatman filter paper.

5. Wash thoroughly with water and alcohol.

6. Mount and count without delay its beta activity as "total radio-strontium" in a proportional counter.

C. Filtering and Mounting

1. Place filters under heat lamps for 30 minutes before weighing.

2. Use Mettler balance (Serial No. 343112) for weighing.

3. Label a clean petri dish with the weight of the filter paper. (After samples are filtered, the filter paper will again be dried and weighed to determine weight of precipitate before mounting.)

4. Mount weighed filter paper and precipitate on nylon disk using 1" transparent tape to hold filter paper and 2" mylar foil placed over precipitate and held in place with slip-ring. Trim off excess mylar foil and place the mounted sample in a labeled petri dish.

5. Fill out corresponding loading sheets and place samples in counting room.

Calculations

Part A

Strontium-90 Concentration (pCi/g dry) =

$$\frac{A}{2.22 \times B \times C \times D \times E \times F} \pm \frac{2\sqrt{E_{sb}^2 + E_b^2}}{2.22 \times B \times C \times D \times E \times F}$$

Where:

A = Net beta count rate of yttrium 90 (cpm)

B = Recovery of yttrium carrier

C = Counter efficiency for counting yttrium-90 or yttrium oxalate mounted on a 2.4 cm diameter filter paper (cpm/dpm)

D = Sample weight (grams), dry

E = Correction factor $e^{-\lambda t}$ for yttrium-90 decay, where t is the time from the time of decantation (Step 4, Separation) to the time of counting

F = Correction factor $1-e^{-\lambda t}$ for the degree of equilibrium attained during the yttrium-90 ingrowth period, where t is the time from collection of the water sample to the time of decantation (Step 4, Separation)

E_{sb} = Counting error of sample plus background

E_b = Counting error of background

Part B

Strontium-89 Concentration (pCi/g dry) =

$$\frac{1}{2.22 \times B \times C}\left[\frac{A}{D \times E} - F\,(G \times H + I \times J)\right] \pm \frac{2\sqrt{E_{sb}^2 + E_b^2}}{2.22 \times B \times C \times D \times E \times F}$$

Where:

A = Net beta count rate of "total radiostrontium" (cpm)

B = Counter efficiency for counting strontium-89 as strontium carbonate mounted on a 2.4 cm diameter filter paper (cpm/dpm)

C = Correction factor $e^{-\lambda t}$ for strontium-89 decay, where t is the time from sample collection to the time of counting

D = Recovery of strontium carrier

E = Sample weight (grams), dry

F = Strontium-90 concentration (pCi/g dry) from Part A

G = Self-absorption factor for strontium-90 as strontium carbonate mounted on a 2.4 cm diameter filter, obtained from a self-absorption curve prepared by plotting the fraction of a standard activity absorbed against density thickness of the sample (mg/cm^2)

H = Counter efficiency for counting strontium-90 as strontium carbonate mounted on a 2.4 cm diameter filter paper (cpm/dpm)

I = Counter efficiency for counting yttrium-90 as yttrium oxalate mounted on a 2.4 cm diameter filter paper (cpm/dpm)

J = Correction factor $1-e^{-\lambda t}$ for yttrium-90 ingrowth, where it is the time from the last decantation of the nitric acid (Step 4, Separation)

REFERENCE: Radioassay Procedures for Environmental Samples, U. S. Department of Health, Education, and Welfare. Environmental Health Series, January 1967.

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DETERMINATION OF SR-89 AND SR-90 IN MILK

(ION EXCHANGE BATCH METHOD)

PROCEDURE NO. TIML-SR-07

Prepared by
Teledyne Isotopes Midwest Laboratory

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Revision #	Date	Pages	Prepared by	Approved by
0	06-15-88	9	[signature]	[signature]
1	11-20-90	10	[signature]	[signature]
2	06-12-92	10	[signature]	[signature]
3	12-07-93	10	[signature]	[signature]
4	08-18-94	10	[signature]	[signature]

DETERMINATION OF SR-89 AND SR-90 IN MILK (ION EXCHANGE BATCH METHOD)

Principle of Method

A citrate complex of strontium carrier at the pH of milk is added to the milk sample. Strontium, barium, and calcium are absorbed on the cation-exchange resin.

Strontium, barium, and calcium are eluted from the cation-exchange resin with sodium chloride solution. Following dilution of the eluate, the alkaline earths are precipitated as carbonates. The carbonates are then converted to nitrates. Strontium is purified by Argonne method (modified at Teledyne Isotopes Laboratory in Westwood, NJ, and TIML) using three grams of extraction material in a chromatographic column. Yttrium carrier is added and a sample is stored for ingrowth of yttrium-90. The yttrium is again precipitated as hydroxide and separated 3
from strontium with the strontium being in the supernate. Each fraction is precipitated separately as an oxalate (yttrium) and carbonate (strontium) and collected on No. 42 (2.4 cm) Whatman filter for counting.

The concentration of Sr-89 is calculated as the difference between the activity for "total radiostrontium" and the activity due to Sr-90.

Reagents

Ammonium hydroxide, NH_4OH: concentrated (15N)
Carrier solutions:
- Sr^{+2} as strontium nitrate, $Sr(NO_3)_2$: 20mg Sr^{+2} per mL
- Y^{+3} as yttrium nitrate, $Y(NO_3)_3$: 10 mg Y^{+3} per mL

Cation-exchange resin: Dowex 50W-X8 (Na^+ form, 50-100 mesh)
Citrate solution: pH 6.5
DI water
Ethyl alcohol, C_2H_5OH: 95%
Hydrochloric acid, HCl: 6N
Nitric acid, HNO_3: 3N
Oxalic acid, $H_2C_2O_2 \cdot 2H_2O$: 2N
Sodium carbonate, Na_2CO_3: 3N
Sodium chloride, NaCl: 4N
Silver nitrate, $AgNO_3$: 1N
Strontium Spec Resin

Apparatus

Ion-exchange system: The apparatus for this system is illustrated in Figure Sr-07-1. At the top is a 1-liter glass separatory funnel which serves as the reservoir. Below it is connected a 250 mL glass column, 5 cm in diameter and 25 cm long, which services as the cation column. Column has extra coarse, fritted glass disc at the bottom.

Millipore filtering apparatus (Pyrex Hydrosol Microanalysis Filter Holder)

Chromatographic Column | 3

Preparation and regeneration of cation resin:

1. Wash 170 mL of Dowex 50W resin to fill the cation column.

2. Pass 500 mL of 1N NaOH through the column at a flow rate of 10 mL/minute.

3. Rinse with 500-1000 mL of H_2O.

4. Test effluent with $AgNO_3$. If effluent is clear, the resin is ready for milk.

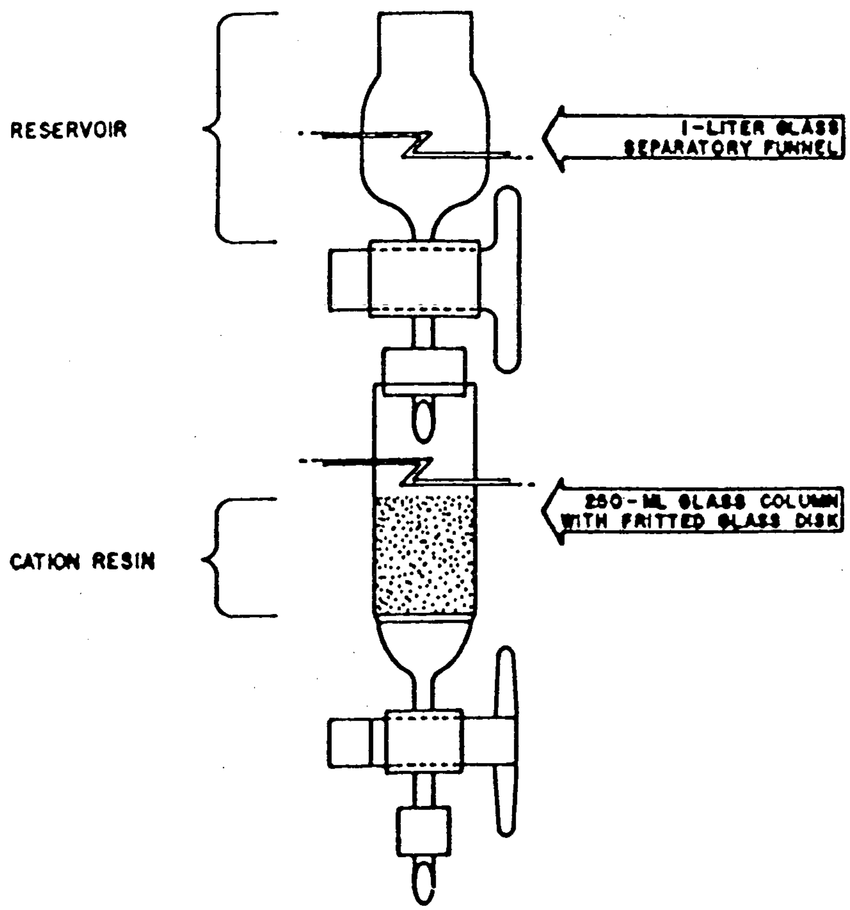

Figure SR-07-01

Part A

Total Radiostrontium (Sr-89, -90 Separation)

Procedure

1. Place 1 liter of milk in 4 liter beaker.
2. Pipette 1.0 mL of strontium carrier solution into 10 mL of citrate solution. Swirl to mix . 3
3. Transfer the mixture quantitatively to the milk with 5 mL of DI water.
4. Add a clean magnetic stirring bar to each sample beaker. Stir each sample for 5 minutes or longer on a magnetic stirrer. Allow sample to equilibrate at least 1/2 hour. If a milk sample is curdled or lumpy, vacuum filter the sample through a Buchner funnel using a cheesecloth filter. Wash the curd thoroughly with deionized water, collecting the washings with the filtrate. Pour the filtrate back into the original washed and labeled 4-liter beaker and discard the curd.
5. Add approximately 170 mL of Dowex 50Wx8 (50-100 mesh) cation resin to each sample beaker and stir on a magnetic stirrer for 2 hours. Turn off the stirrer and allow the resin to settle for 10 minutes. 3
6. Gently decant and discard the milk sample, taking care to retain as much resin as possible in the beaker. Add approximately 1 liter of deionized water to rinse the resin, allow to settle 2 minutes, and pour off the rinse. Repeat rinsing until all traces of milk are removed from the resin.
7. Using a DI water wash bottle, transfer the resin to the column marked with the sample number. Allow resin to settle 2 minutes and drain the standing water.
8. Connect 1-liter separatory funnel containing 1 liter of 4N NaCl to the cation column. Allow the solution to flow at 10 mL/minute to elute the alkali metal and alkaline earth ions and to recharge the column. Collect 1 liter of eluate into a 2-liter beaker, but leave the resin covered with 2-3 mL of solution.
9. Wash the column with 500 mL of H_2O or more to remove excess NaCl. Discard the wash.
10. Remove 20 mL of the NaCl eluate into a small bottle for the determination of stable calcium, if required (see procedure on calcium determination).
11. Dilute the eluate to 1500 mL with DI water. 3
12. Heat the solution to 85-90°C (near boiling on a hot plate) and add, with constant stirring, 100 mL of 3N Na_2CO_3. Cover with watch glass. Let stand overnight.
13. Decant most of the supernate to waste. Transfer the precipitate to a 250 mL centrifuge bottle with DI water.
14. Centrifuge. Pour off the supernate to waste. Dry the precipitate in an oven at 100°C for 1-2 hours. 3
    Cool.
15. Dissolve the precipitate in 30 mL 3M HNO_3.

16. Place each sample centrifuge tube in front of a SR extraction column. Write sample numbers on gummed labels and attach to the corresponding columns.

17. Condition columns by passing 30 mL 3M HNO_3 through them with the stopcocks fully open. Catch effluent in a waste beaker.

18. Add sample from the beaker into the correspondingly numbered column.

    NOTE: Use no water to make this transfer. Use only 3M HNO_3 to rinse out the beaker.

    Allow the sample to pass through the column. Catch effluent in a waste beaker.

19. When the column reservoir is drained, measure 70 mL 3M HNO_3 in a graduated cylinder and pass through the column to rinse. Catch effluent in a waste beaker. When the column is drained, RECORD THE DATE AND TIME ON THE WORK SHEET AS THE BEGINNING OF Y-90 INGROWTH.

20. Write the sample number on a clean 150 mL beaker. Place it under the column after the rinse solution has drained. Discard the contents of the waste beaker.

21. Elute strontium by adding 70 mL DI water to the column. Catch effluent in the 150 mL beaker. 3

22. When the elution is complete, add 1.00 mL standardized yttrium carrier to the numbered sample beaker using an Eppendorf pipet.

23. Place sample beaker on a moderate hotplate and evaporate gently to approximately 10 mL volume. Remove beaker from hotplate and allow to cool.

    NOTE: If the sample accidentally evaporates to dryness, allow it to cool, then add a few drops HNO_3 and approximately 10 mL DI water. Warm gently and swirl to dissolve residue.

24. Mark the sample number on a 40 mL centrifuge tube. Transfer the sample using the minimum amount of DI water.

25. Seal the sample tube with parafilm and place in a rack to stand for a minimum 5-day period for Y-90 ingrowth.

26. Rinse the SR extraction columns with an additional 70 mL DI water. Catch effluent in a waste beaker. Leave the columns wet with DI water, with the stopcocks closed.

27. Enter column number, date, and sample number in the SR Column Log.

Separation

1. After storage (ingrowth period), heat the 40mL centrifuge tube containing the sample in the hot water bath (approximately 90°C) for 10 minutes.

2. Adjust pH to 8.0-8.5 with NH_4OH, stirring continuously.

3. Cool in a cold water bath and centrifuge for 5 minutes.

4. Decant the supernate into a 40mL centrifuge tube marked with the sample number and "SR-89." RECORD THE DATE AND TIME OF DECANTATION AS THE END OF Y-90 INGROWTH IN SR FRACTION AND THE BEGINNING OF ITS DECAY IN Y-90 FRACTION.

5. Redissolve the precipitate by adding 3-4 drops of 6N HCl and add 5-10 mL of DI water with stirring.

6. Repeat Steps 1, 2, and 3.

7. Combine supernate with the one in Step 4.

8. Wash the precipitate twice with 20mL portions of DI Water. Centrifuge each time and discard supernate. 4

9. Proceed with determination.

Determination

A. Strontium-90 (Yttrium-90)

1. Add 3 drops of 6N HCl to dissolve the precipitate from Step 4, Separation; then add 5-10 mL of DI water. Heat in a water bath at approximately 90°C for about 10 minutes. Add 1 ml of saturated oxalic acid solution dropwise with vigorous stirring. Adjust to a pH of 2-3 with NH_4OH. Allow the precipitate to digest for approximately one hour. 3

   NOTE: Do Part "B" while precipitate is digesting.

2. Cool to room temperature in a cold water bath. Centrifuge for 10 minutes and decant most of the supernate to waste. Filter by suction on a weighed 2.5 cm filter paper. Wash the precipitate with water and alcohol. 3
3. Dry the precipitate under the lamp for 30 minutes. Cool and weigh. Mount and count in a proportional counter. (See Part C for mounting.)

B. Strontium-89 (Total Strontium)

1. Heat the solution from Step 7, Separation, in water bath.
2. Adjust the pH to 8-8.5 using NH_4OH.
3. With continuous stirring, add 5 mL of 3N Na_2CO_3 solution. Stir until precipitate appears. Heat gently for 10 minutes.
4. Cool and filter on a weighed No. 42 (2.4 cm) Whatman filter paper.
5. Wash precipitate with water and alcohol. 3
6. Dry the precipitate under the lamp for 30 minutes. Cool and weigh. Mount and count in a proportional counter. (See Part C for mounting.)

C. Filtering and Mounting

1. Place filters under heat lamps for 30 minutes before weighing.
2. Use Mettler balance (Serial No. 343112) for weighing.
3. Label a clean petri dish with the weight of the filter paper. (After samples are filtered, the filter paper will again be dried and weighed to determine weight of precipitate before mounting.)
4. Mount weighed filter paper and precipitate on nylon disc using 1" transparent tape to hold filter paper and 2" mylar foil placed over precipitate and held in place with slip-ring. Trim off excess mylar foil and place the mounted sample in a labeled petri dish.
5. Fill out corresponding loading sheets and place samples in counting room.

Calculations

Part A

$$\text{Strontium-90 Concentration (pCi/L)} = \frac{A}{2.22 \times B \times C \times D \times E \times F \times G}$$

Where:

2.22 = dpm/pCi

A = Net beta count rate of yttrium-90 (cpm)

B = Recovery of yttrium carrier

C = Recovery of strontium carrier

D = Counter efficiency for counting yttrium-90 as yttrium oxalate mounted on a 2.4 cm diameter filter paper (cpm/dpm) | 4

E = Sample volume (liters)

F = Correction factor $e^{-\lambda t}$ for yttrium-90 decay, where t is the time from the time of decantation (Step 4, Separation) to the time of counting

G = Correction factor $1-e^{-\lambda t}$ for the degree of equilibrium attained during the yttrium-90 ingrowth period, where t is the time from the beginning of ingrowth (Step 19, Total Radiostrontium Separation) to the time of decantation (Step 4, Separation) | 4

Lower Limit of Detection (LLD), at 4.66 sigma

LLD for Sr-90: 1 pCi/L. LLD is based on the following typical parameters:
Sample Size: 1 L
Recovery (Sr and Y): 0.6
Decay Factor (Y-90): 0.8
Ingrowth Factor (Y-90): 0.6
Counter Efficiency: 0.4
Counter Background: 0.3cpm | 4
Counting Time: 100 minutes

(Changes in any of the above parameters will change LLD correspondingly.)

Part B

$$\text{Strontium-89 Concentration (pCi/L)} = \frac{1}{2.22 \times B \times C}\left[\frac{A}{D \times E} - 2.22 \times F(G + H \times I)\right]$$

Where:

2.22 = dpm/pCi

A = Net beta count rate of "total radiostrontium" (cpm)

B = Counter efficiency for counting strontium-89 as strontium carbonate mounted on a 2.4 cm diameter filter paper (cpm/dpm) 4

C = Correction factor $e^{-\lambda t}$ for strontium-89 decay, where t is the time from sample collection to the time of counting

D = Recovery of strontium carrier

E = Sample volume (liters)

F = Strontium-90 concentration (pCi/liter) from Part A

G = Counter efficiency for counting strontium-90 as strontium carbonate mounted on a 2.4 cm diameter filter paper (cpm/dpm) 4

H = Counter efficiency for counting yttrium-90 as yttrium oxalate mounted on a 2.4 cm diameter filter paper (cpm/dpm) 4

I = Correction factor $1-e^{-\lambda t}$ for yttrium-90 ingrowth, where t is the time from the last decantation of the nitric acid (Step 4, Separation) to the time of counting

Lower Limit of Detection (LLD), at 4.66 sigma

LLD for Sr-89: 2. 0 pCi/L. LLD is based on the following typical parameters:

Sample Size: 1 L
Recovery: 0.7
Decay Factor: 0.5
Counter Efficiency: 0.3
Counter Background: 0.3 cpm 4
Counting Time: 100 minutes
LLD for Sr-90: 1 pCi/L

(Changes in any of the above parameters will change LLD correspondingly.)

REFERENCES: Radioassay Procedures for Environmental Samples, U. S. Department of Health, Education, and Welfare. Environmental Health Series, January 1967.

Horwitz, Dietz, Fisher, Analytical Chemistry, 63 (5), March 1991.

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PROCEDURE FOR COMPOSITING WATER AND MILK SAMPLES

PROCEDURE NO. TIML-COMP-01

Prepared by

Teledyne Isotopes Midwest Laboratory

Copy No. ________

Revised Pages	Revision No.	Date	Pages	Prepared by	Approved by
	0	11-07-88	2	B. Grob	L. G. Huebner

Procedure for Compositing Water and Milk Samples

1. At the beginning of each composite period, (month, quarter, semi-annual), prepare a one-gallon cubitainer for a specific location and time-period.

2. Remove an equal aliquoit of original sample (for example, one liter) and transfer to prepared cubitainer. Do this for each week, month, etc. Mark date of original sample on prepared cubitainer.

3. When prepared container is complete, give the sample to the recording clerk for assigning a number.

4. Analyze according to the client requirement.

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DETERMINATION OF STABLE CALCIUM IN MILK

PROCEDURE NO. TIML-CA-01

Prepared by

Teledyne Isotopes Midwest Laboratory

Copy No. ________

Revision No.	Date	Pages	Prepared by	Approved by
0	07-08-88	4	[signature]	[signature]

Determination of Stable Calcium in Milk

Principle of Method

Strontium, barium, and calcium are absorbed on the cation-exchange resin, then eluted with sodium chloride solution. An aliquot of the eluate is diluted to reduce the high sodium ion concentration. From this diluted aliquot, calcium oxalate is precipitated, dissolved in dilute hydrochloric acid, and the oxalate is titrated with standardized potassium permaganate.

Reagents

Ammonium hydroxide, NH_4OH: 6N
Ammonium oxalate, $(NH_4)_2C_2O_4.H_2O$: 0.03N
Carrier solutions:
  Ba^{+2} as barium nitrate, $Ba(NO_3)2$: 20 mgBa^{+2} per ml
  Sr^{+2} as strontium nitrate, $Sr(NO_3)_2$: 20 mg Sr^{+2} per ml
Cation-exchange resin: Dowex 50W-X8 (Na^+ form, 50-100 mesh)
Citrate solution: 3N (pH 6.5)
Hydrochloric acid, HCl: 6N
Oxalic acid, $H_2C_2O_4.2H_2$: 1N
Potassium permanganate, $KMnO_4$: 0.05N standardized
Sodium chloride, NaCl: 4N
Sodium oxalate, $Na_2C_2O_4$:

Apparatus

Burette

Procedure

1. Follow the TIML-SR-01 or SR-07 procedures, Steps 1-10.

2. Into a 40 ml glass centrifuge tube, pipette 10 ml aliquot of the initial eluate collected in Step 10.

3. Dilute the 10 ml aliquot to approximately 20 ml with D.I. water.

4. Heat in a hot water bath. Add 5 ml of 1N oxalic acid, and stir. While hot, adjust to pH 3 with 6N NH_4OH (use a pH meter) to precipitate calcium oxalate. Cool slowly to room temperature, centrifuge, and discard the supernate.

Procedure (continued)

5. Thoroughly wash the precipitate and the wall of the centrifuge tube, using not more than 5 ml of 0.03N ammonium oxalate. Centrifuge, and discard the supernatant.

6. Wash the precipitate with 10 ml of hot D.I. water. Cool to room temperature, centrifuge, and discard the supernate. (A stirring rod may be used to agitate the precipitate while it is being washed. It is important to remove all excess oxalic acid from the precipitate.)

7. Dissolve the precipitate in approximately 2.5 ml of 6N HCl. Heat in hot water bath for 5 minutes.

8. Dilute the acid solution to approximately 10 ml with D.I. water. Quantitatively transfer it to a 125 ml Erlenmeyer flask, rinsing the centrifuge tube with D.I. water.

9. Add an additional 1 ml of 6N HCl, and adjust the volume of solution to approximately 25 ml with D.I. water. Heat to near boiling.

10. While hot, titrate with standardized 0.05N $KMnO_4$ to the first faint pink endpoint which persists for at least 30 seconds.

Calculations

$$\text{Calcium (g/liter)} = \frac{A \times B \times C}{D}$$

Where:

A = Volume of $KMnO_4$ solution used for titration (ml)
B = Normality of standardized KMn_4 solution (mg/ml)
C = Milli-equivalent weight of calcium (mg/meg)
D = Sample volume (ml)

Since the sample size is 10 ml and the milli-equivalent weight of calcium is 20 mg, the equation reduces to:

Calcium (g/liter) - A x B x 2

Evaluation of Data

The standard deviation of replicate analyses has been determined to be ±0.02 g/liter.

Reference: Radioassay Procedures for Environmental Samples, U.S. Department of Health, Education and Welfare. Environmental Health Series, January 1967.

ANNUAL REPORT PART III

PROGRAM SELF-ASSESSMENT AND PROGRAM CHANGES

Kewaunee's School Forest Project and wetlands restoration project south of the plant

Kewaunee Nuclear Power Plant
Annual Radiological Environmental Monitoring Report

ANNUAL REPORT – PART III
INCIDENT REPORTS

January – December 1998

Section 2.4.1.c of the Kewaunee Radiological Environmental Monitoring Manual (REMM) states in part:

> *"The annual Radiological Environmental Monitoring Report shall include...discussion of all deviations from the sampling schedule of Table 2.2.1-A..."*

The following is a description of four events that occurred during 1998, which deviated from the requirements of the sampling schedule of Table 2.2.1-A:

1. On 3/10/98, environmental air sampler K-7 was discovered not operating. There was power to the sampling station but the sample pump motor was not operating. The motor had failed and was subsequently repaired. Total out-of-service time was 191.75 hours. (KAP-1574)

2. On 3/24/98, environmental air sampler K-1f was found not running. An investigation found that Plant Electricians had shut off electric power to the meteorological tower for routine breaker maintenance. That action caused a loss of power to the air sampler located at the tower. Total out-of-service time was 6.0 hours. (KAP-1604)

3. On 5/19/98, environmental air sampler K-2 was found not operating properly; the hour meter was not advancing even though the air sampler pump was running. Work Request No. 214197 was issued, the hour meter was replaced and returned to service on 6/25/98. Since this affected only the hour meter and not the pump, continuous sampling was maintained and K-2 was never actually out of service. (KAP-1745)

4. On 10/13/98, discovered that the run-time hour total for environmental air sampler K-15 was 24 hours less than what it should have been for the week. Inspected the air sampler, but all equipment appeared to be operating properly. Since he shortage of hours could not be explained it is assumed there had been a spurious power interruption. Total out-of-service time was conservatively calculated to be 24.0 hours. (KAP-2114)