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SEMI-ANNUAL REPORT

ENVIRONMENTAL RADIOACTIVITY IN CANADA
JANUARY - JUNE, 1978

Environmental Health Directorate
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Brooke Claxton Building,
OTTAWA K1A 0K9

ABSTRACT

The radiological surveillance program of the Department of National Health and Welfare is conducted for the purpose of determining levels of environmental radioactivity in Canada and assessing the resulting population exposures. In this report the results for the first half of 1978 from the analyses of air, precipitation, water vapour, drinking water, milk, biota and bone for critical radionuclides are presented. Radioactivity measurements are now given in the SI unit, the becquerel (Bq). One becquerel is equivalent to about 27 picocuries. The graphical format used in previous reports has been retained with extensions of the trend-lines to enable identification of changes in the levels and assessment of their potential health significance. All the levels measured during this period are below the permissible limits recommended by the International Commission for Radiological Protection.

RÉSUMÉ

Le programme de surveillance radiologique du ministère de la Santé et du Bien-être social permet de mesurer les niveaux de radioactvité ambiante au Canada et d'évaluer l'éxposition que reçoit la population. Nous présentons dans ce rapport les résultats du premier semestre de 1978, tirés des analyses entreprises afin de déterminer les concentrations des radionucléides importants dans l'air, la précipitation, la vapeur d'eau, l'eau potable, le lait, les biota et les os. Les données de radioactivité sont maintenant présentées en becquerels (Bq), employant le système international (SI). Le becquerel est égal à environ 27 picocuries. Vous trouverez ci-inclus la forme graphique qui fut utilisée dans le dernier rapport pour permettre l'identification des variations dans les niveaux et l'évaluation de leur importance au point de vue de la santé. Les niveaux mesurés durant cette periode sont au-dessous des limites maximales admissibles recommandées par la Commission Internationale de la Protection Radiologique.

ACKNOWLEDGEMENTS

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The Report was prepared by D.P. Meyerhof, B. Tracy and J.M. Quinn under the Direction of F.A. Prantl, Head, Environmental Radioactivity Section. The radiochemical analyses were carried out by: W.G. Awrey, G.P. Dumouchel, J.M. Fenning, J.F. Green, P. Lanoix, M.E. Lescot and A.Y. Lin. The graphs and tables were prepared with the assistance of J. Burns.

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INTRODUCTION

The Environmental Radioactivity Section of the Radiation Protection Bureau investigates the potential health effects to the Canadian population from natural and anthropogenic sources of environmental radioactivity. This includes the evaluation of population doses from terrestrial and cosmic radiation and potential health risks from inhaling radioactivity in air or ingesting it in drinking water and food. The data are collected by operating a nationwide network of sampling stations for air, precipitation, water vapour in air, drinking water, milk and biota, and through special surveys.

In summary, the following studies were made during the first half of 1978.

- Water supplies in areas of enhanced natural radioactivity in British Columbia, Saskatchewan, Ontario and Quebec were examined.
- The nationwide program to study radium-226, lead-210 and uranium in drinking water supplies has continued.
- A survey of technologically enhanced natural radioactivity levels was conducted in and around the community of Long Harbour, Newfoundland.
- The national study of levels of radon-222 and its daughter products in private dwellings continued.
- A special investigation of the potential health implications of the re-entry of COSMOS-954 over northern Canada has been undertaken.
- The nationwide study of nuclear weapons fallout and the potential health impact of radioactive emissions from nuclear power reactors in Canada continued.
- The pre-operational radioactivity study in the environs of the Point Lepreau Nuclear Generating Station, New Brunswick, continued.
- The study of external radiation exposure across Canada continued.

NATURAL RADIOACTIVITY

The dose received by the population from natural uranium-thorium deposits and environmental contamination from uranium mining, milling and processing operations is important in Canada. Detailed studies are made to assess its health significance. The large number of radioactive daughter products in the uranium and thorium decay series makes this a complex and difficult problem. Each radionuclide in the natural decay series has different radiological and metabolic characteristics, some still poorly understood.

Radium-226, radon-222 and its daughter products and lead-210 have been selected for study because of their high radiotoxicity. In addition, total uranium is measured because of its high chemical toxicity. Internal population exposures are evaluated from radioactivity measurements of air inside public and private buildings, radiochemical analyses of drinking water supplies and studies of the transfer of the radionuclides from soil to produce to man. In general, the levels during the first half of 1978 were with the limits for public health recommended by the International Commission on Radiological Protection (ICRP).

Drinking Water

The program to determine natural radioactivity levels in drinking water and their impact on human health continued. Analyses for radium-226 and uranium were carried out on monthly composite samples of drinking water from the 17 Canadian municipalities shown in Figure 1. In addition, selected samples were analyzed for lead-210 to determine whether equilibrium between it and radium-226 existed in the decay series. In May and June the following eight stations, which all showed consistently low levels of radioactivity, were discontinued: Edmonton, Montreal, Sault Ste. Marie, St. John's, Toronto, Vancouver, Victoria, and Winnipeg. The following four stations were added in July: Bancroft, Kelowna, Port Hope and Thunder Bay.

The results of these analyses for the first half of 1978 are shown in Figures 2 to 4. It is apparent that the radium-226 values from most of the stations were at or near the detection limit of 0.007 Bq/L. The only notable exception was Elliot Lake which showed concentrations as high as 0.03 Bq/L. This is still a factor of 10 below the Canadian drinking water objectives of 0.37 Bq/L (1). Continuous consumption of water at a concentration of 0.03 Bq/L would lead to a dose to an individual member of the public of about 10 mrem/yr to bone. This calculation is based on retention models and dosimetric data from the ICRP (2, 3). The potential health effect associated with that dose has been estimated to be 0.005 incidences of bone cancer per million persons per year (4).

According to Figure 3, the lead-210 concentrations were also at or near the detection limit of 0.01 Bq/L. Since this nuclide is about 10 times less radiotoxic than radium-226, the potential health effects would be proportionately smaller.

The uranium levels in Figure 4 show considerable variations with time and geographical area. The highest concentrations noted were 5 µg/L for Regina and 4 µg/L for Elliot Lake. These values are still a factor of 10^3 lower than the federally prescribed maximum acceptable concentration of 5 mg/L for uranium in drinking water.

National Radon Study

A program was begun in 1977 to measure background concentrations of radon-222 and daughters in air inside private dwellings. This information is needed in establishing criteria for acceptable radon gas concentrations in Canadian homes above which remedial action is required. It is also required for the design of preventive measures for future building developments in areas of enhanced natural radioactivity.

Preparations were made to extend the radion survey to a further 3900 homes in Sherbrooke, Saint John, Charlottetown, Halifax, and St. Lawrence during the summer of 1978. The results of this survey will be given in the next semi-annual report.

Enhanced Natural Radioactivity

A study of the radioactivity in lakes, rivers, and wells of communities in regions of natural uranium deposits was continued. Analyses for radium-226, lead-210 and uranium were carried out on water samples from Birch Island, the Foghorn Creek, Thompson River and the Trail-Castlegar region in British Columbia; from Wollaston Lake and the Douglas River in Saskatchewan; from the Serpent River and March Township in Ontario; and from the Oka and Laval West regions of Quebec. All measurements revealed concentrations at or near the detection limits. The respective provincial authorities were notified of the results.

RADIOACTIVITY FROM FALLOUT

Two atmospheric nuclear events occurred during the first half of 1978; a nuclear-powered satellite, COSMOS-954, disintegrated over northern Canada on January 24, and a nuclear weapons test was conducted by the People's Republic of China on March 14. Following these events, intensive monitoring and special studies were carried out. The results of the COSMOS-954 investigations are discussed later in the Section, "Special Programs". For the remainder of the time regular environmental radioactivity programs were maintained.

Surface Air and Precipitation

Regional and national averages of the results of weekly analyses of surface air particulates and monthly analyses of precipitation for gross beta radioactivity are shown in Figures 6 and 7 for the first half of 1978. Sampling locations are shown in Figure 5. Activity in air peaked in March. The main source of this fission product activity was the nuclear weapons test on the 14th, although increases normally occur in the spring due to large scale air exchanges between the stratosphere and troposphere. Levels of gross beta radioactivity in surface air and precipitation during these six months were, on average, twice those observed during the same period in 1977. Figure 8 shows the long-term trend since 1975.

March 14 Nuclear Weapons Test

This was the 20th atmospheric test conducted by the People's Republic of China since 1964. The usual precautionary procedures of nationwide daily monitoring of surface air for gross beta activity and weekly analyses of milk were carried out from March 15 to April 10. The locations are the same as in Figures 5 and 9. Air filters and the monthly precipitation samples collected during March and April were analyzed by high resolution gamma spectoscopy.

Although the test was equivalent to less than 20 kt of TNT, substantial increases in beta activity in surface air occurred 6-9 days after the test. These levels were the highest recorded since the period of intense atmospheric weapons testing which ended in 1962. The highest value following the March 14 test of 0.81 Bq/m^3 recorded at Calgary is, however, less than 1 percent of the maximum permissible level for fresh fallout (5).

In 3 to 5 days surface air activity returned to near normal levels. Fresh fission products, such as ruthenium-103, cerium-141, iodine-131, barium-lanthanum-140 and traces of cesium-137, ruthenium-106, and zirconium-niobium-95 were identified in the gamma spectroscopic analyses of the air filter and precipitation samples. The results are summarized in Tables 1 and 2.

Since the increase in air activity was of short duration, and precipitation was infrequent during this period, the beta radioactivity in precipitation samples from most stations does not show a significant increase. Windsor was the exception with levels 5 times normal. Dairy herds were on stored feed at the time and consequently, iodine-131 was not detected in any of the milk samples analyzed.

Milk

Weekly composite samples of milk collected at the locations shown in Figure 9 were analyzed monthly for cesium-137 and potassium and quarterly for strontium-90 and calcium. Regional and national averages of cesium-137 and strontium-90 levels for the first 6 months of 1978 are shown in Figure 10. Radionuclide levels remained quite constant with the exception of the Maritime region and Newfoundland where slight increases were observed. The long-term trend since 1975 is shown in Figure 11. In general, very little change occurred from the levels recorded during the same period in 1977.

Bone

Analyses of human vertebrae samples collected during 1977 from hospitals in Winnipeg and Regina were completed. The results are shown in Table 3. Levels are similar for all age groups and have remained very low.

RADIOACTIVITY FROM NUCLEAR REACTORS

Samples of air water vapour, surface water, milk and biota are collected on a regular basis from the vicinity of 6 nuclear reactor sites in Canada:

- the Whiteshell Nuclear Research Establishment (AECL-WNRE), Pinawa, Manitoba;
- the Bruce Nuclear Power Development (BNPD), Tiverton, Ontario, with a 220 MW(e) prototype generating station, three 750 (MW(e) units in service and one 750 MW(e) unit under construction;
- the Pickering Nuclear Generating Station (PNGS), Pickering, Ontario, with four 500 MW(e) units in service;
- the Chalk River Nuclear Laboratories (AECL-CRNL), Chalk River, Ontario;
- the Nuclear Power Demonstration Reactor at Rolphton, Ontario;
- the Gentilly Nuclear Site (GNS), Gentilly, Quebec, with a 250 MW(e) prototype reactor.

Sampling locations are shown in Figures 12-14 and 19-23.

The preoperational study of fission product radioactivity in the environs of the new 600 MW(e) Point Lepreau Nuclear Generating Station, New Brunswick, continued with the analyses of air water vapour and milk samples. The sampling locations are shown in Figure 24. Airborne radioactivity was monitored in the vicinity of the McMaster University research reactor, Hamilton, Ontario. Also, the potential radiological impact from visists by nuclear vessels to both coasts were studied.

A reactor incident occurred during the first half of 1978. A heavy water leak from a heat exchanger into cooling water was discovered in January at BNPD. To investigate the health impact of leaking of radioactive contaminants into drinking water supplies, water samples from Lake Huron, collected at the Kincardine and Port Elgin intakes, were analyzed for gamma emitting nuclides in addition to the regular analyses for strontium-90 and cesium-137. No radioactivity that could be attributed to the leak was detected. In general, results for the first half of 1978 showed no health significant releases from any of the installations.

Air Water Vapour

Atmospheric water vapour is collected in metallic cells containing molecular sieve. They are placed around BNPD, PNGS and GNS. Air is drawn through the samplers over a period of a month, depositing atmospheric moisture on the sieve. Subsequently, the cells are heated to desorb the water which is then analyzed for tritium. Figures 15-17 contain the results for the first half of 1978. The highest levels were observed at Station 4, 1.5 km northeast, and Station 5, 1 km east of PNGS. Relative to the same period in 1977, mean levels near BNPD doubled, those near PNGS and GNS remained the same. As shown in Figure 18, the highest levels around the 3 sites were similar to those measured during the first half of 1977. All levels were far below those considered health significant.

Water

Untreated water is collected daily at drinking water intakes on the 'innipeg River, Lakes Huron and Ontario, the Ottawa River and the St. Lawrence River; see Figures 19-23. The results of quarterly analyses for cesium-137 and strontium-90 are given in Figures 25-27 for the first half of 1978. Levels of both radionuclides remained within normal seasonal fluctuations, with the exception of strontium-90 in the Winnipeg River which decreased 20 percent over the same period last year. The impact of these radionuclides from all nuclear installations on environment and health did not exceed that of residual fallout from nuclear weapons testing.

Milk

Weekly samples of raw milk from the vicinity of the Whiteshell Nuclear Research Establishment and the Bruce Nuclear Power Development are analyzed for iodine-131, cesium-137 and potassium. Results for the two radionuclides for the first half of 1978 are shown in Figure 28. Iodine-131 was not detected at either location. The cesium-137 levels in raw milk from these sites were similar to those in pasteurized milk from the national network. This suggests, as has been observed in the past, that fallout was the major contributor to the radionuclide levels around the reactor locations. This is also confirmed by comparing the long-term trends of the Whiteshell and the national network results since 1975, shown in Figure 11.

Biota

Biota is sampled semiannually. Fish from several sites on the Ottawa River were received during the first half of 1978 for analyses for cesium-137, strontium-90, calcium and potassium. The purpose is to assess the health significance of these radionuclides in this particular link of the food chain as fish are an important dietary item for Canadians.

Point Lepreau Study

This is the first Canadian reactor to have potential impact on the population through a marine environment. On-line reactor operations are scheduled for 1980. The setting raises new questions in relation to the demographic situation and differences in the pathways of fission products. A study of the population dose continued with the determination of pre-operational levels of tritium in air water vapour, cesium-137 and strontium-90 in milk.

Levels of tritium in atmospheric water vapour from Dipper Harbour and Welsh Cove were non-detectable during the first half of 1978. Mean cesium-137 and strontium-90 levels in raw milk samples collected during 1977 and 1978 are 1.4 Bq/L and 1.0 Bq/L, respectively. These levels are four times higher than those measured in pasteurized milk from Moncton, N.B. Investigations into the reasons for the difference are being made.

McMaster University

Gross beta radioactivity levels on daily air filters were normal.

Nuclear Vessels

One nuclear submarine visited Shearwater, Nova Scotia, during the first half of 1978. Gross beta radioactivity was measured on air filters and gross gamma activity on seawater samples collected before, during and after the visit. No activity was found that could be attributed to a release from the vessel.

Seawater and sediment samples received from Esquimalt and Nanoose Bay, British Columbia, in connection with nuclear vessel visits to the west coast were analyzed by gamma spectroscopy. Again, no activity was detected that could be associated with a release.

EXTERNAL RADIATION EXPOSURE

Quarterly evaluations of terrestrial and cosmic gamma radiation in 12 cities and around 3 reactor sites were done with CaF_2: Mn bulb type thermoluminescent dosimeters (TLD's). At the 12 locations in Figure 5, the TLD's are attached to the weather housing of the air sampling equipment. The results for the first half of 1978 are reported in Table 4. All stations showed normal background dose rates. In the vicinity of BNPD, PNGS, and GNS, the TLD's are attached to the housing of air water vapour collection units at the locations in Figures 12-14. The results for the first half of 1978, in Table 5, remained within the range of those in Table 4. This shows that all reactor monitoring stations had normal background dose rates.

INTERCOMPARISON PROGRAM

Laboratory quality control programs continued through participation in interlaboratory comparisons sponsored by the United States Environmental Protection Agency, the World Health Organization and the International Atomic Energy Agency.

SPECIAL PROGRAMS

Public Health Impact of the Re-entry of COSMOS-954

On January 24, 1978, the Russian nuclear powered satellite, COSMOS-954, which had reentered the earth's atmosphere, disintegrated over northern Canada. As a result, radioactive fragments and particles of minute size were scattered over large parts of the Northwest Territories, particularly along its trajectory over the Great Slave Lake Region.

Public concern centres around the potential impact of the event on the environment and health of residents in this region. The questions of greatest concern are the extent and severity of radioactive contamination of the environment, the likelihood of not being able to remove all of it, the pathways to man and the potential health hazards upon its encounter.

To answer these questions, the Environmental Radioactivity Section has undertaken an investigation of the main health issues. It consists of two parts:

1. Radioactivity in air, drinking water and snow has been monitored since the disintegration of the satellite. In addition, radioactivity in caribou meat will be monitored later in the season. The purpose is to safeguard against possible traces of radioactive contamination along the most important pathways to man.
2. Physical, chemical and biological properties of the small, widely dispersed radioactive particles are being studied to predict their environmental and physiological behaviour: their likelihood of becoming re-suspended in air, entering water systems or food products and the degree of potential health hazard upon inhalation or ingestion.

Analyses of air and drinking water samples from the region indicated no increase in radioactivity beyond normal seasonal variations. Snow samples were also normal, except for two from the immediate vicinity of satellite fragments. The total activity of gamma emitting nuclides in these two samples was of the order of 5 Bq/L. Radioactive decay and dilution during snowmelt was expected to reduce this concentration to a negligible level by the spring. However, as a precautionary measure, studies of drinking water in several Northwest Territories communities are continuing.

The most important study concerns a number of highly radioactive particles in the size range of 0.2 to 0.3 mm which were discovered on the snow along the trajectory of the satellite. High resolution gamma spectroscopy revealed a variety of fission and activation products on the particles. The dose rates of the most active particles at contact were between 10 to 15 mR/hr at the time of discovery. Due to radioactive decay, the particle dose rates quickly decreased.

The particle densities are very high. For this reason, it can be expected that in natural water systems these particles will not remain in suspension, but rather will be trapped in the sediments. This greatly reduces the risk of their entering drinking water systems. Their solubilities in natural water were found to be extremely low. Over a period of 8 days, not more than 0.005 percent of the most soluble radionuclide, niobium-95, was found to enter into solution. To simulate conditions of ingestion, solubilities in dilute hydrochloric acid were also tested. These solubilities reached at the most, only a few percent in the case of zirconium-95.

The low solubilities and consequently relatively short residence times of the particles in the body reduce greatly the potential health risk upon their inhalation or ingestion. The dose to the different segments of the gastrointestinal tract during transit of such a particle was estimated to be 5 rem for the most active particle if it were ingested immediately following the event. This is about equivalent to the total dose received from medical X-rays during a gastrointestinal series. Because of radioactive decay, this dose level would be reduced by half, were the particle ingested two or three months later. Due to the aerial distribution and vegetation cover of the ground later in the season, the probability of encountering and ingesting or inhaling such a particle is considered extremely small.

The investigations have shown to date that the contamination from re-entry of COSMOS-954 over the Northwest Territories may have a potential environmental and health impact. However, the efficient removal of hazardous debris during extensive search and recovery operations and monitoring programs to protect the public, which are continuing, have reduced potential serious health effects from the event. Scientifically, any contamination could have a health impact and the door must be left open for evidence of damage to persons which may only materialize in the future.

Radiation Survey of Long Harbour, Newfoundland

At the request of the Newfoundland Department of Health and the Canadian Public Health Association, a study was undertaken of the health significance of radioactivity associated with the production of phosphorus fertilizer material. A major industrial plant has been operated since 1968 by ERCO Industries Limited at Long Harbour. One of the principal raw materials in the phosphorous production process is phosphate ore which contains traces of natural uranium and its radioactive decay products. Through the production process, these are transferred to the furnace slag, a waste product of the plant. The slag material has been used as landfill in roadbeds and around private homes. The natural radioactivity in it gives rise to external gamma radiation. Furthermore, the radium-226 in the slag material generates radon gas which can diffuse through the building structure into the homes.

To assess the radiological significance of these emissions to the health of the plant workers and members of the surrounding communities, field and laboratory measurements were undertaken. Measurements of external gamma radiation were carried out at various sites at the plant and the slag dump. Also, a total of 80 homes in Long Harbour and 64 homes in neighbouring communities were surveyed for external gamma radiation and their levels of radon and its radioactive daughter products. Samples of phosphate ore, silica and coke feed materials, and furnace slag were brought back to our laboratories and analyzed for radium-226.

At some sites in the slag dump, external gamma radiation levels were as high as 110 µR/hr. In the community of Long Harbour, gamma levels varied from 7 to 18 µR/hr in homes without slag, and from 9 to 25 µR/hr in homes surrounded by slag. Compared with background, the difference is relatively small. The levels of radon and its daughter products were all normal in both the homes of Long Harbour and the surrounding communities.

Laboratory analyses of both the phosphate ore and the slag showed radium-226 concentrations of about 2 Bq/g. This indicates that most of the activity is passed from the ore to the slag. Concentrations in the coke and silica feed materials were comparable to normal background from soil.

Results and recommendations from this study were published in the report of the Canadian Public Health Association and formed part of a paper at the NEA Specialists Meeting in Paris, France.

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TABLE 1

GROSS BETA RADIOACTIVITY IN SURFACE AIR
FOLLOWING ATMOSPHERIC NUCLEAR EVENTS
JANUARY-JUNE, 1978
(Becquerelsper cubic metre)

Station	COSMOS-954 Incident January, 24, 1978		Weapons Test March 14 (<20 kt)		Normal Maximum
	Maximum	Mean	Maximum	Mean	
Calgary	0.005	.003	0.810	0.063	0.004
Churchill	0.004	.003	0.008	0.005	0.004
Coral Harbour	0.004	.003	0.008	0.004	0.005
Edmonton	0.004	.003	0.340	0.026	0.005
Fredericton	0.005	.003	0.016	0.006	0.005
Goose Bay	0.002	.001	0.030	0.003	0.004
Halifax	0.003	.001	0.010	0.003	0.005
Inuvik	0.004	.002	0.006	0.004	0.005
Montreal	0.005	.003	0.013	0.007	0.005
Moosonee	0.003	.002	0.006	0.004	0.004
Ottawa	0.001	.001	0.007	0.002	0.003
Quebec	0.004	.002	0.007	0.004	0.004
Regina	0.004	.003	0.530	0.031	0.005
Resolute	0.004	.002	0.011	0.003	0.004
St. John's	0.006	.001	0.010	0.004	0.003
Saskatoon	0.004	.002	0.630	0.034	0.006
Sault Ste. Marie	0.003	.002	0.052	0.009	0.004
Thunder Bay	0.004	.002	0.022	0.007	0.005
Toronto	0.002	.001	0.027	0.006	0.003
Vancouver	0.001	.001	0.031	0.003	0.004
Whitehorse	0.003	.002	0.035	0.004	0.004
Windsor	0.004	.003	0.100	0.012	0.005
Winnipeg	0.004	.003	0.280	0.028	0.006
Yellowknife	0.005	.003	0.015	0.006	0.004

TABLE 2

GROSS BETA RADIOACTIVITY IN PRECIPITATION
FOLLOWING ATMOSPHERIC NUCLEAR EVENTS
JANUARY-JUNE, 1978
(Gigabecquerels per square kilometre)

Station	COSMOS-954 Incident January 24, 1978		Weapons Test March 14 (<20 kt)		Normal Maximum
	January	February	March	April	
Calgary	0.03	0.03	0.21	0.23	0.17
Churchill	0.03	0.03	0.05	0.04	0.04
Coral harbour	0.05	0.02	0.33	0.13	0.01
Edmonton	0.02	0.03	NS	NS	0.05
Fredericton	0.06	NS	0.20	0.10	0.13
Goose Bay	0.03	0.03	0.03	0.09	0.08
Halifax	NS	NS	0.20	0.14	0.17
Inuvik	0.02	0.02	0.03	0.03	0.07
Montreal	NS	0.04	0.14	0.07	0.18
Moosonee	0.02	0.04	0.05	0.16	0.05
Ottawa	0.04	0.04	0.16	0.25	0.33
Quebec	0.06	0.02	0.11	0.14	0.19
Regina	0.02	0.02	0.08	0.11	0.16
Resolute	0.02	0.09	0.02	0.02	0.06
St. John's	0.10	NS	0.18	0.19	0.16
Saskatoon	0.03	0.04	0.07	0.18	0.14
Sault Ste. Marie	0.05	0.05	0.08	0.19	0.24
Thunder Bay	0.03	0.02	0.06	0.16	0.13
Toronto	NS	0.05	0.20	0.18	0.14
Vancouver	0.16	0.15	0.21	0.28	0.17
Whitehorse	NS	0.02	NS	NS	0.04
Windsor	0.06	0.02	0.68	0.30	0.14
Winnipeg	0.02	0.02	0.17	0.10	0.14
Yellowknife	0.02	0.02	0.04	NS	0.07

TABLE 3

STRONTIUM-90 IN HUMAN BONE

Age Group	0-5 Months	6-11 Months	12-23 Months	2-4 Years	5-9 Years	10-19 Years	Over 20 Years
Number of Samples	17	1	3	6	NS	6	6
Bq/gCa	0.06	0.08	0.08	0.06	NS	0.06	0.04

NS - no sample

TABLE 4

EXTERNAL RADIATION DOSE RATES
AT ENVIRONMENTAL STATIONS

Station	Dose Rate (μR/hr)	
	Jan-Mar	Apr-June
Calgary, Alta.	5.7	9.6
Churchill, Man.	3.4	4.1
Fredericton, N.B.	4.5	8.3
Halifax, N.S.	5.6	7.1
Inuvik, N.W.T.	4.3	4.7
Ottawa, Ont.	3.1	5.0
Saskatoon, Sask.	8.6	10.9
St. John's, Nfld.	11.1	9.8
Thunder Bay, Ont.	7.6	10.3
Vancouver, B.C.	5.2	8.4
Windosr, Ont.	5.6	-
Yellowknife, N.W.T.	8.2	10.0

TABLE 5

EXTERNAL RADIATION DOSE RATES IN THE VICINITY OF NUCLEAR REACTORS

Station	Dose Rate (μR/hr)					
	BNPD		PNGS		GNS	
	Jan-Mar	Apr-June	Jan-Mar	Apr-June	Jan-Mar	Apr-June
1	3.7	3.6	-	-	3.9	4.9
2	5.1	6.4	5.8	4.3	-	-
3	3.3	5.8	6.8	6.5	-	-
4	6.1	7.5	6.1	7.1	4.0	5.0
5	3.0	3.9	8.8	8.7	-	-
6	9.1	8.8	4.2	-	-	-
7	-	-	5.7	5.4	-	-

- Sites not applicable

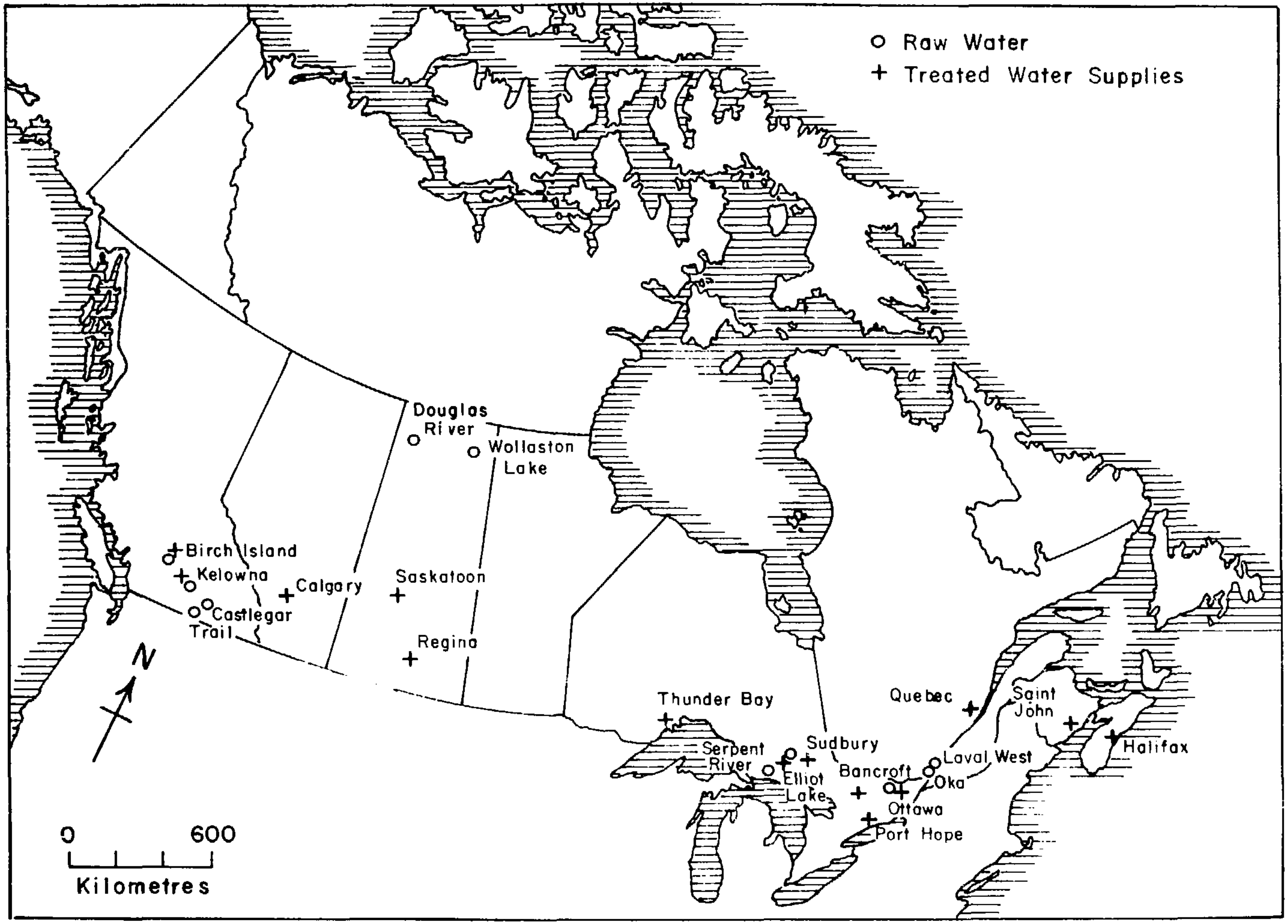

Figure 1. Canadian Sampling Station Network - Drinking Water

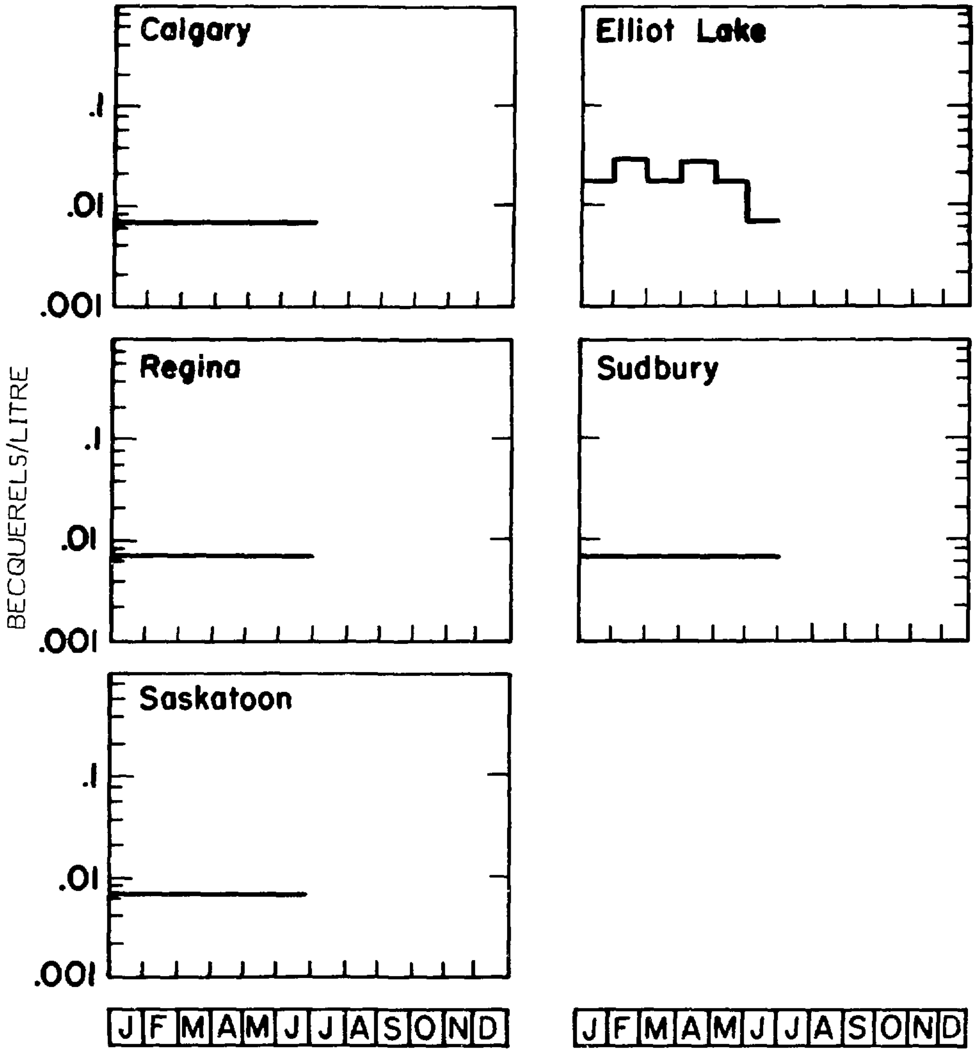

Figure 2a. Radium-226 Levels in Drinking Water, 1978
(Detection Limit is 0.007 Bq/L)

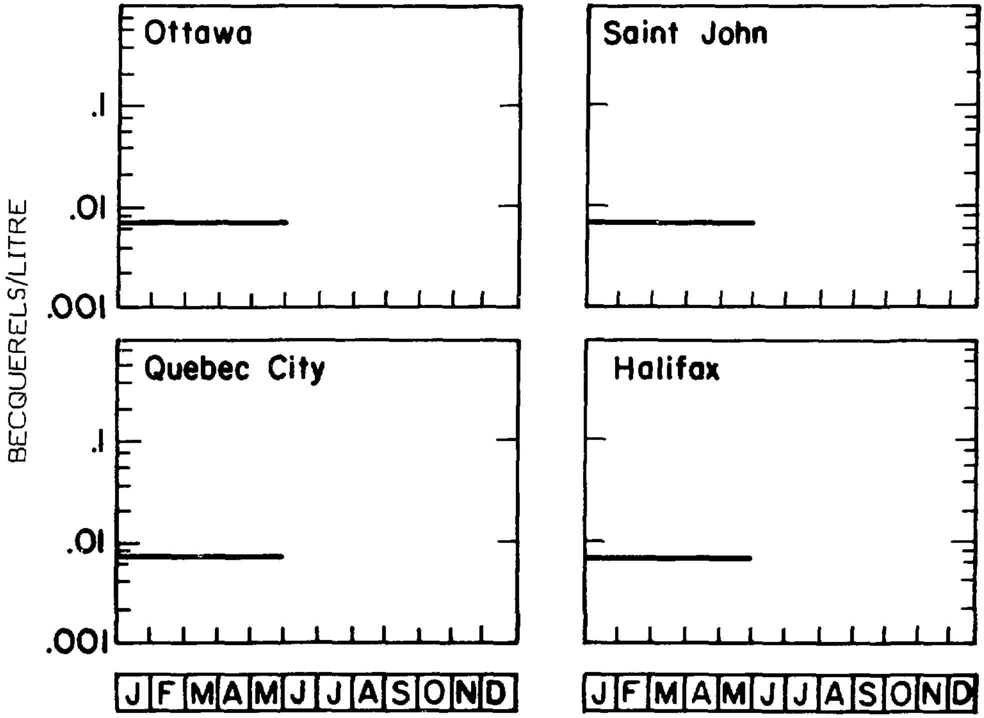

Figure 2b. Radium-226 Levels in Drinking Water, 1978
(Detection Limit is 0.007 Bq/L)

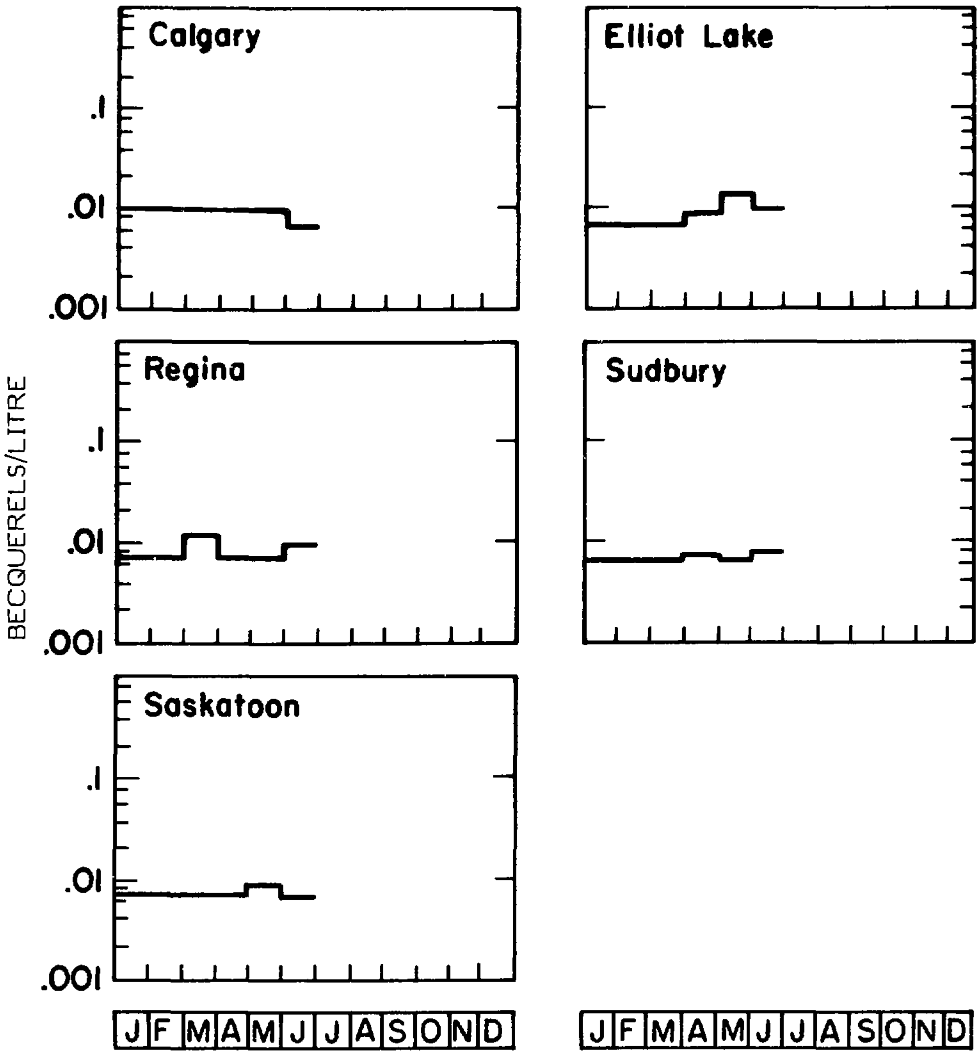

Figure 3a. Lead-210 Levels in Drinking Water, 1978
(Detection Limit is 0.007 Bq/L)

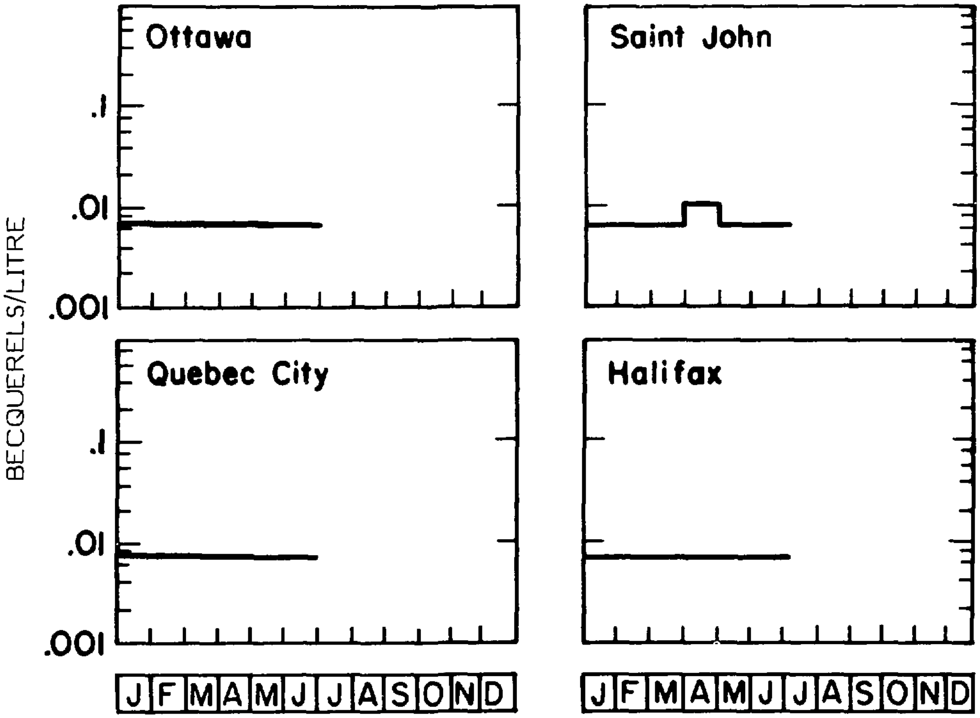

Figure 3b. Lead-210 Levels in Drinking Water, 1978
(Detection Limit is 0.007 Bq/L)

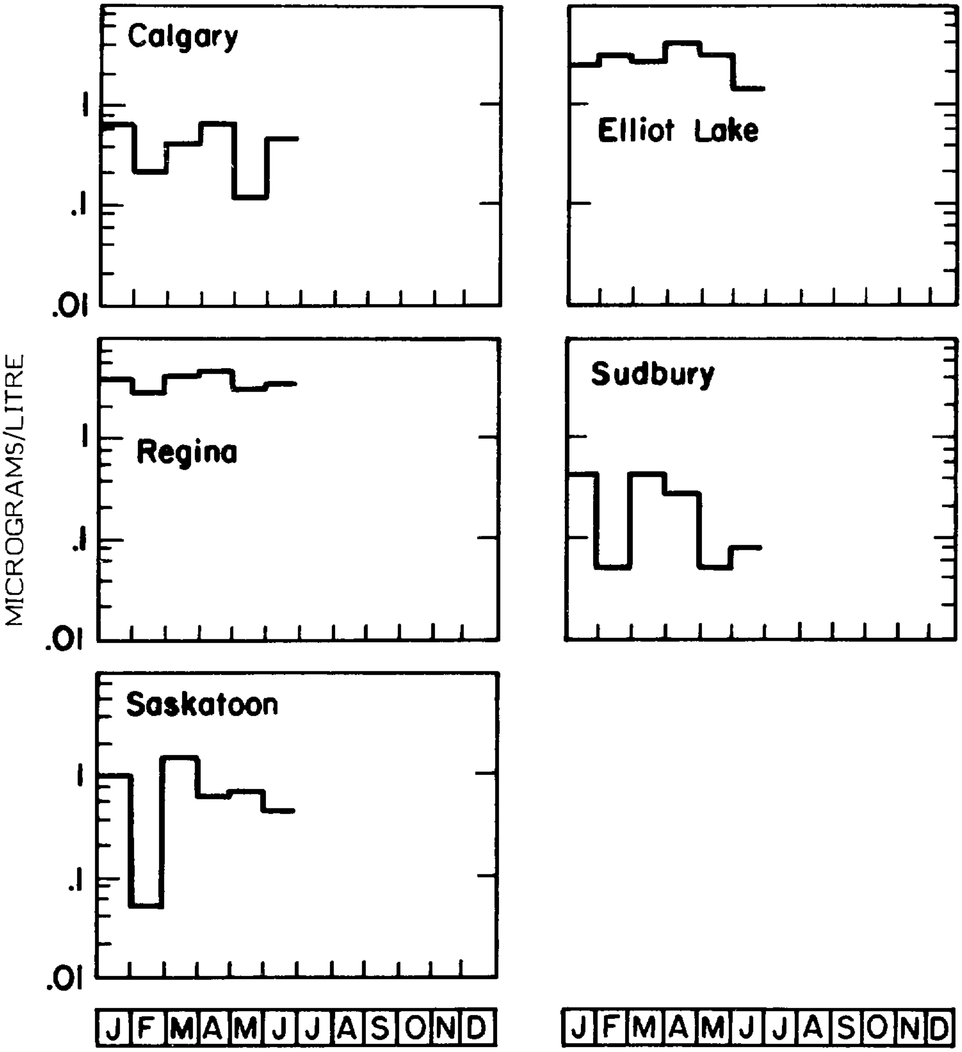

Figure 4a. Uranium Levels in Drinking Water, 1978
(Detection Limit is 0.05 µg/L)

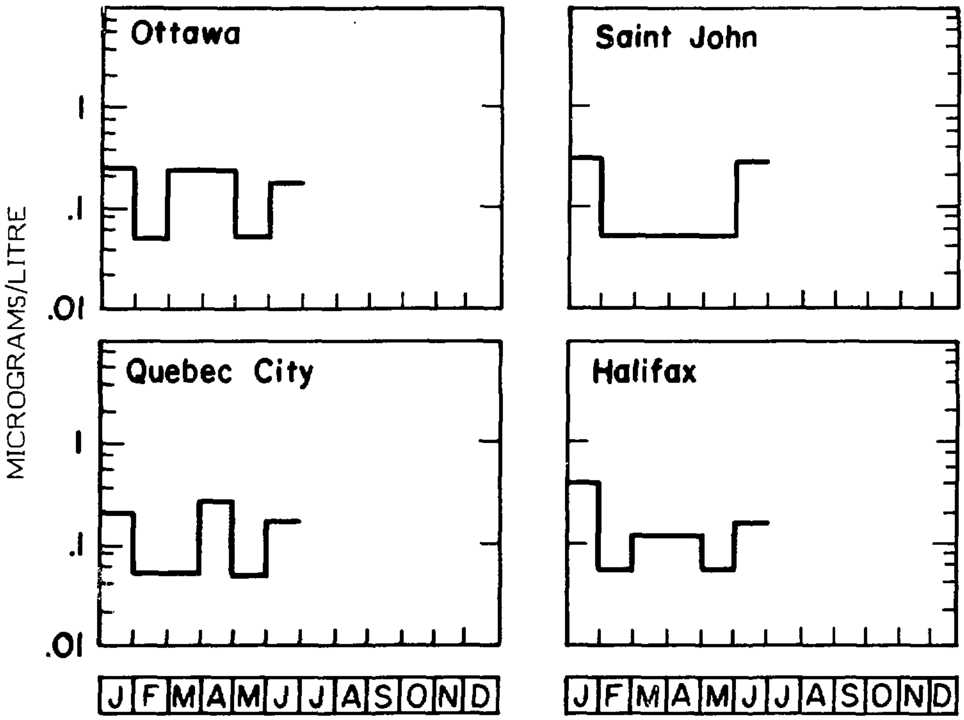

Figure 4b. Uranium Levels in Drinking Water, 1978
(Detection Limit is 0.05 µg/L)

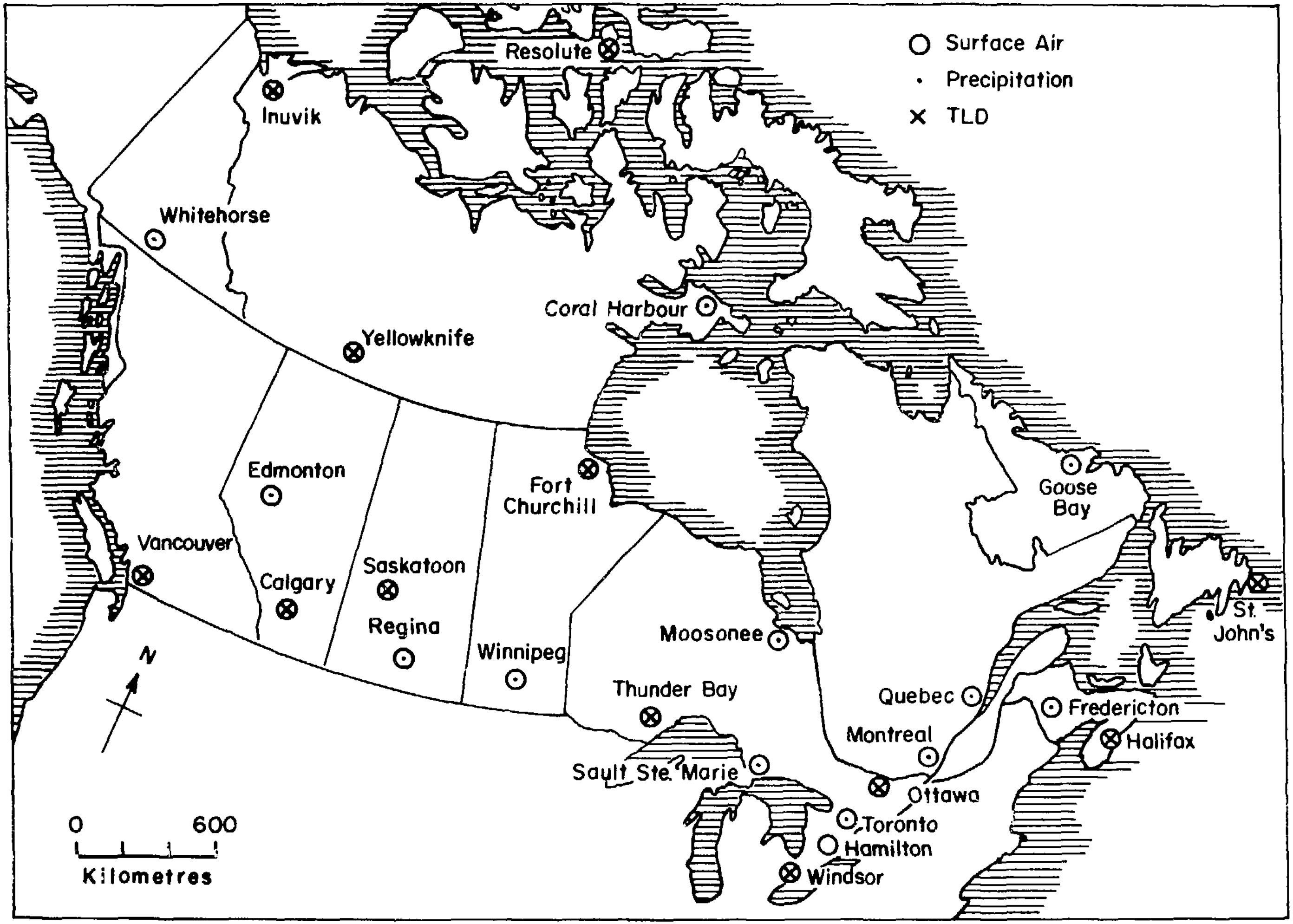

Figure 5. Canadian Sampling Station Network - Air, Precipitation and TLD

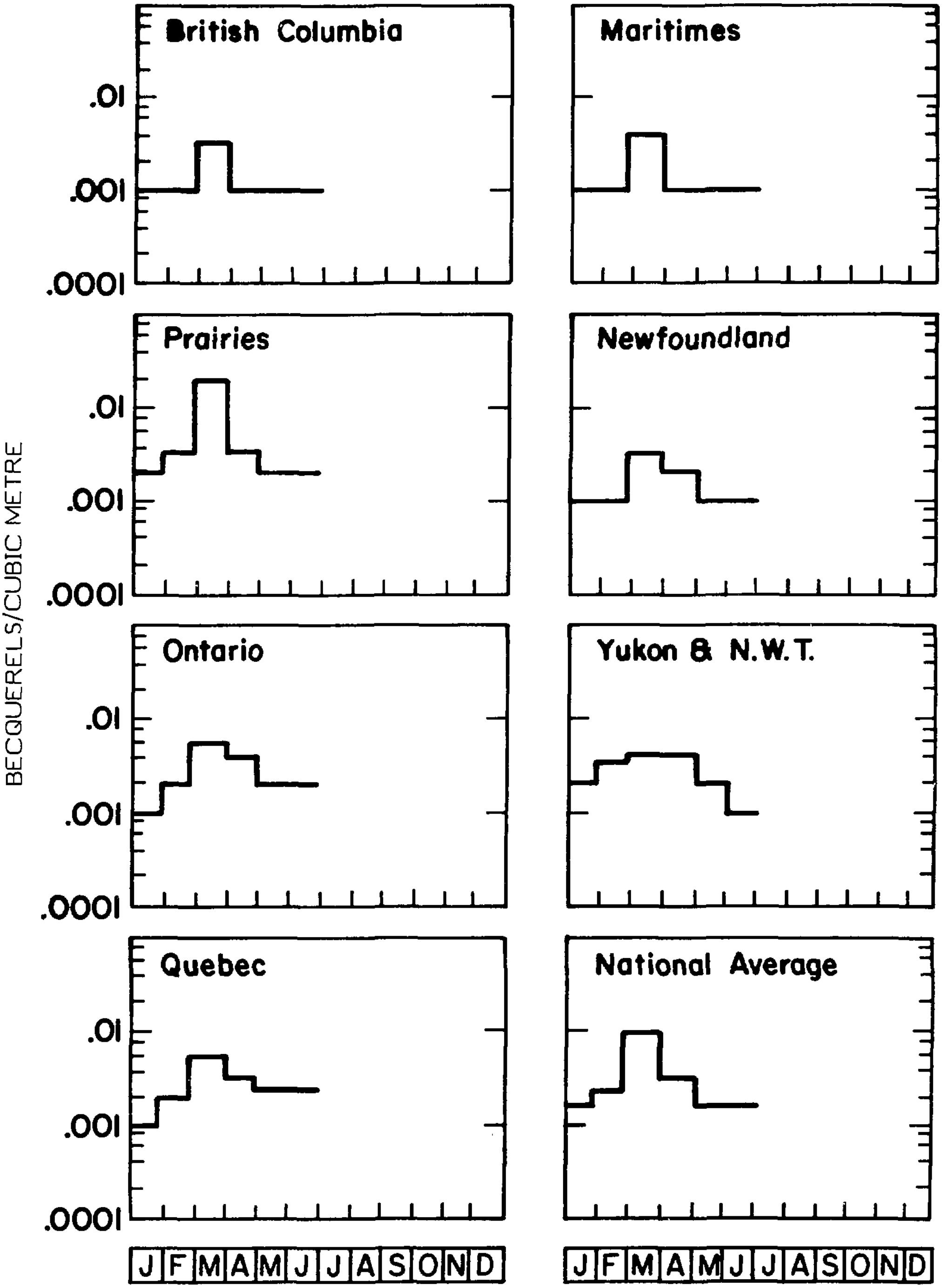

Figure 6. Gross Beta Radioactivity in Surface Air, 1978
(Detection Limit is 0.001 Bq/m^3)

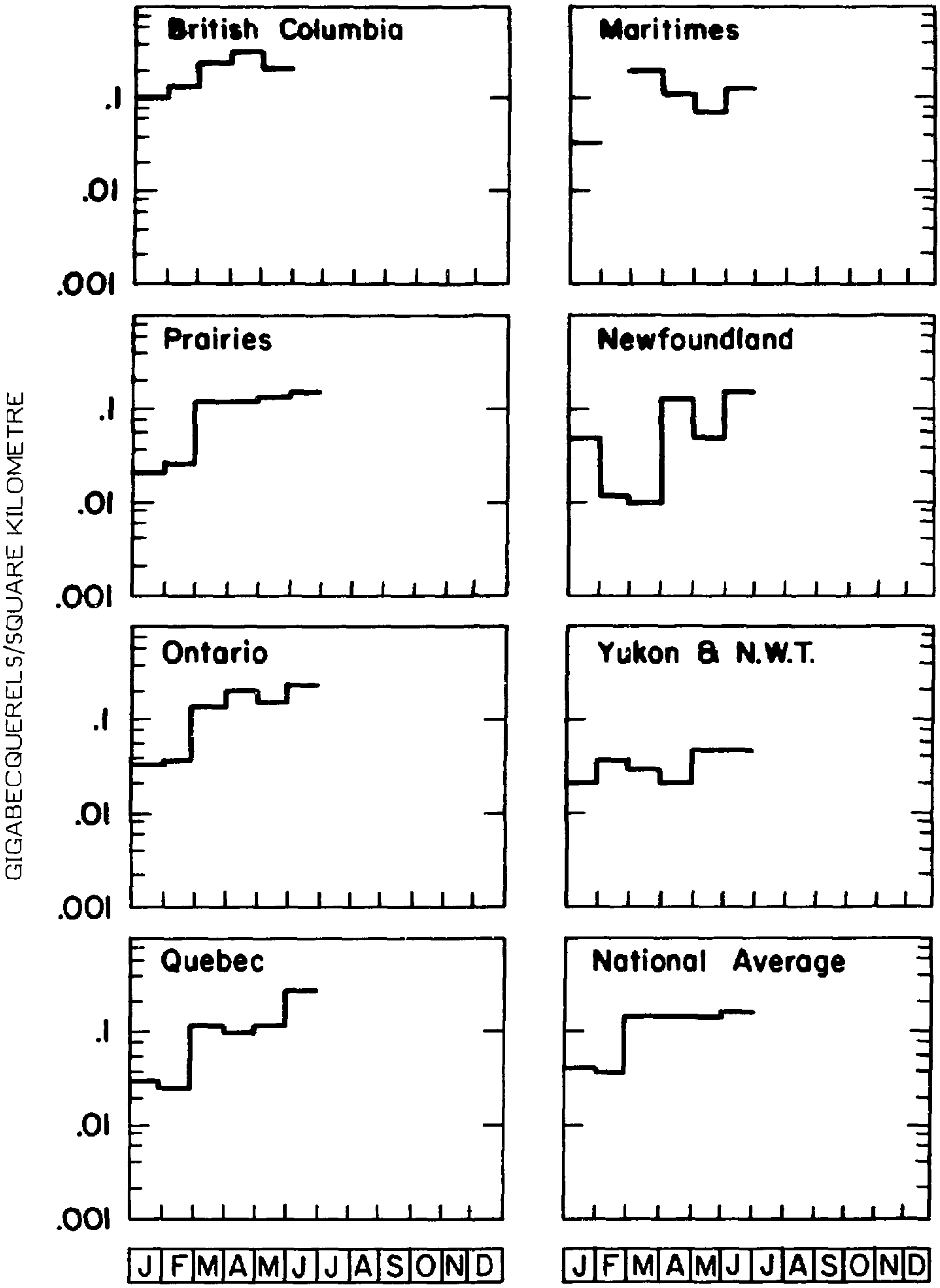

Figure 7. Gross Beta Radioactivity in Precipitation, 1978
(Detection Limit is 0.004 GBq/m^2)

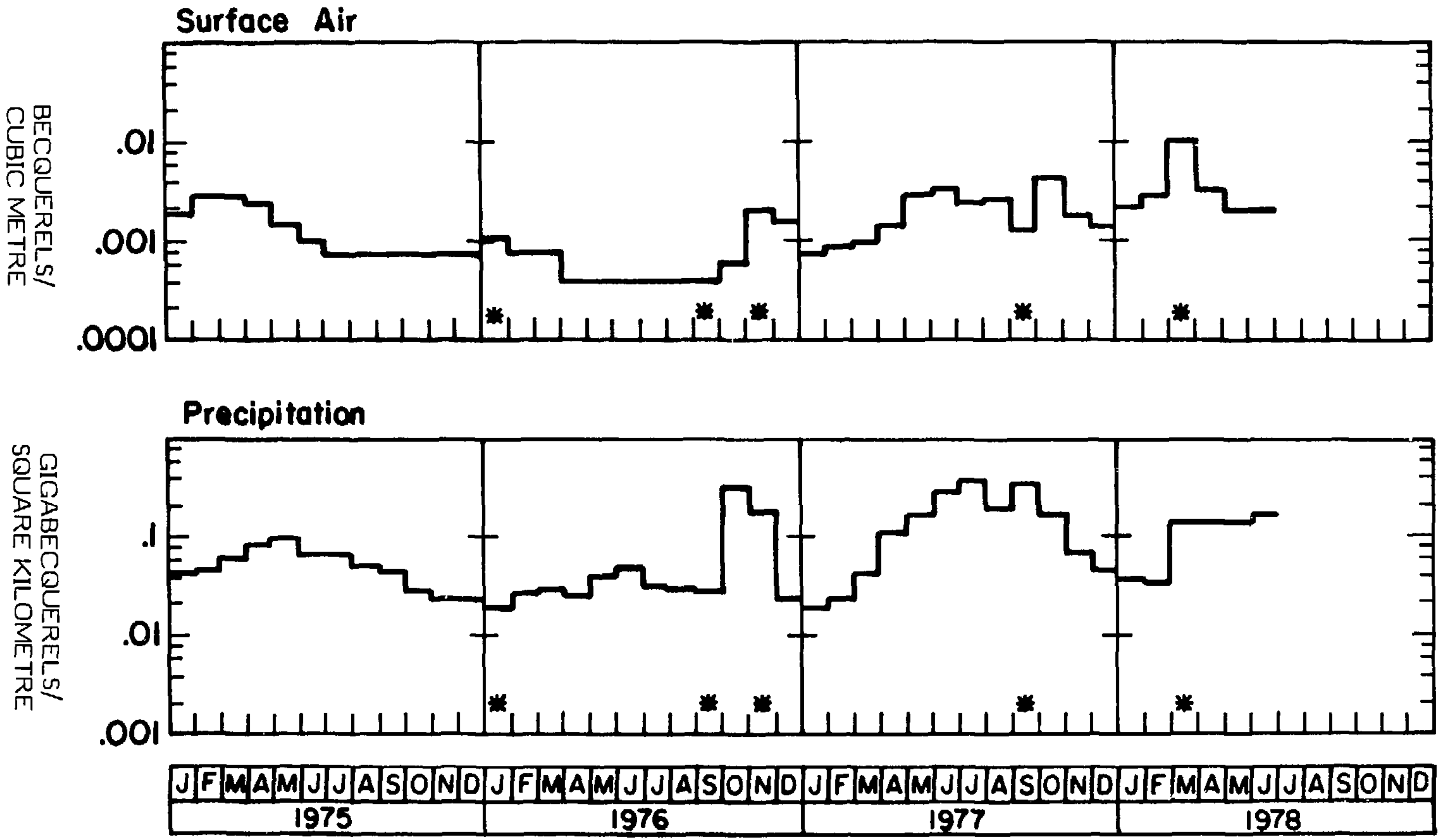

Figure 8. Gross Beta Radioactivity, National Averages, 1975-1978

*Atmospheric Nuclear Weapons Tests Conducted by the People's Republic of China at Lop Nor

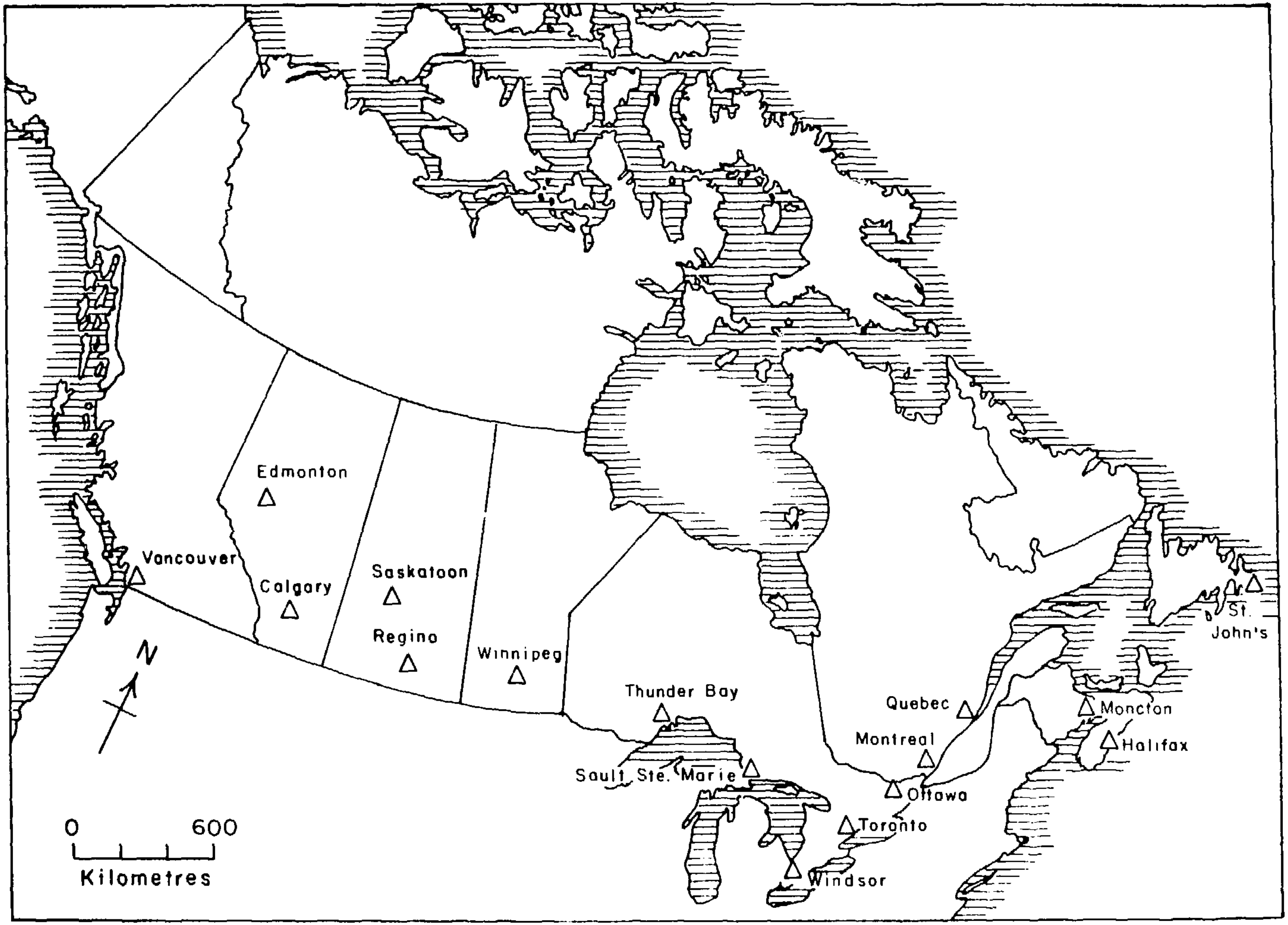

Figure 9. Canadian Sampling Station Network - Milk

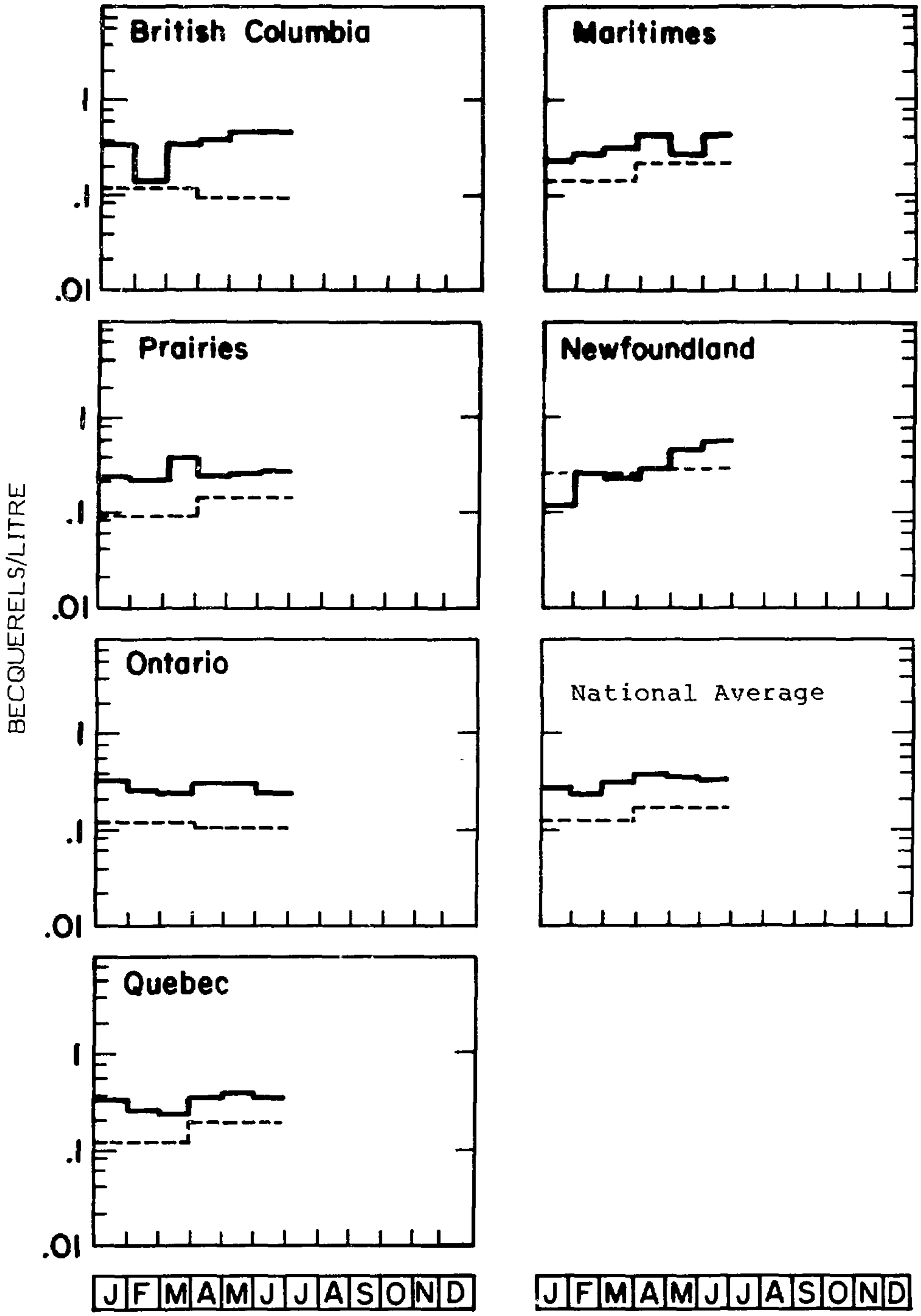

Figure 10. Fallout Radioactivity Levels in Whole Milk, 1978

——— Cesium-137 -------- Strontium-90

(Detection Limits are 0.04 Bq/L, Cesium-137 and 0.001 Bq/L, Strontium-90)

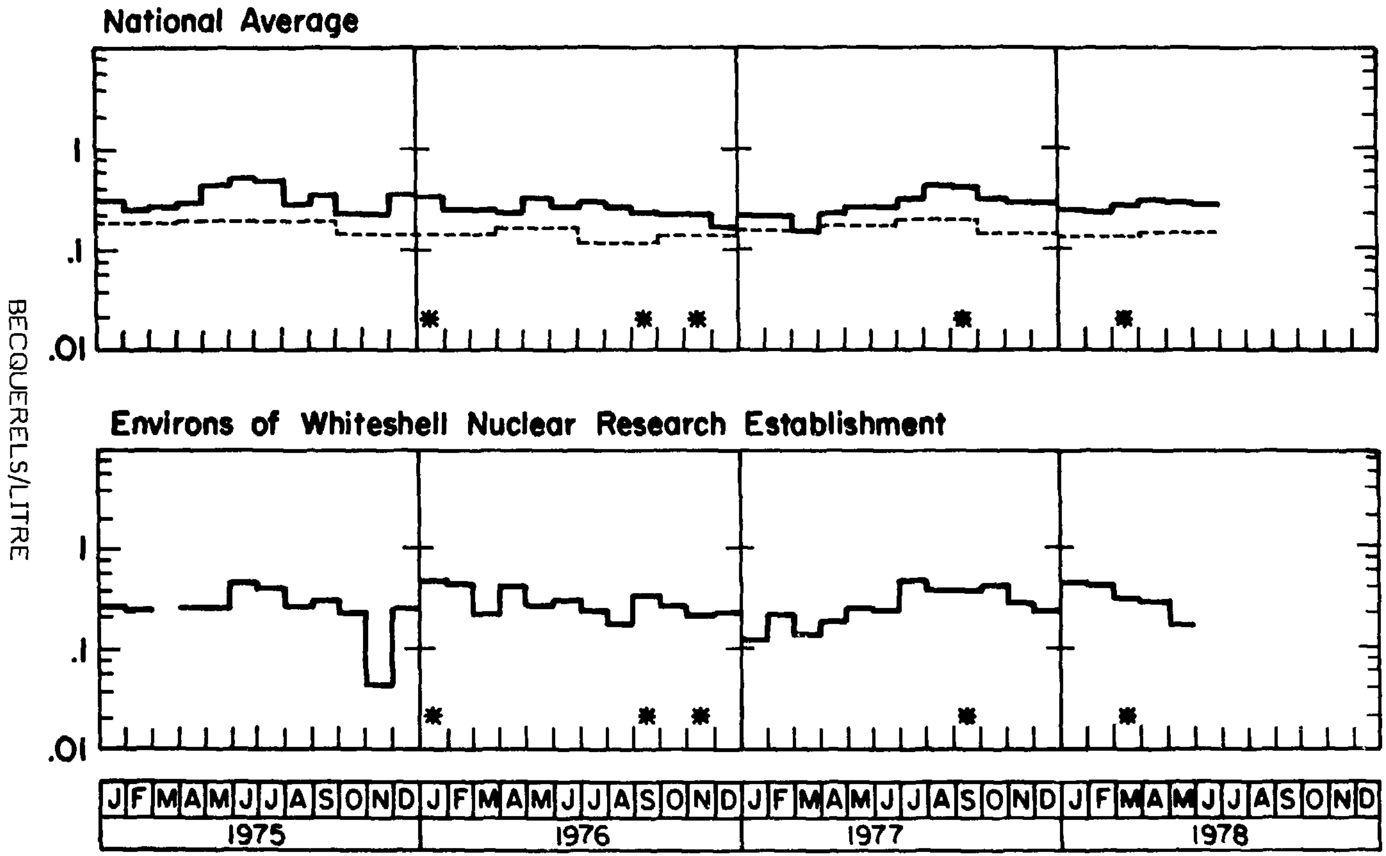

Figure 11. Radionuclide Levels in Milk, 1975-1978

——— Cesium-137 -------- Strontium-90

*Atmospheric Nuclear Weapons Tests Conducted by the People's Republic of China at Lop Nor

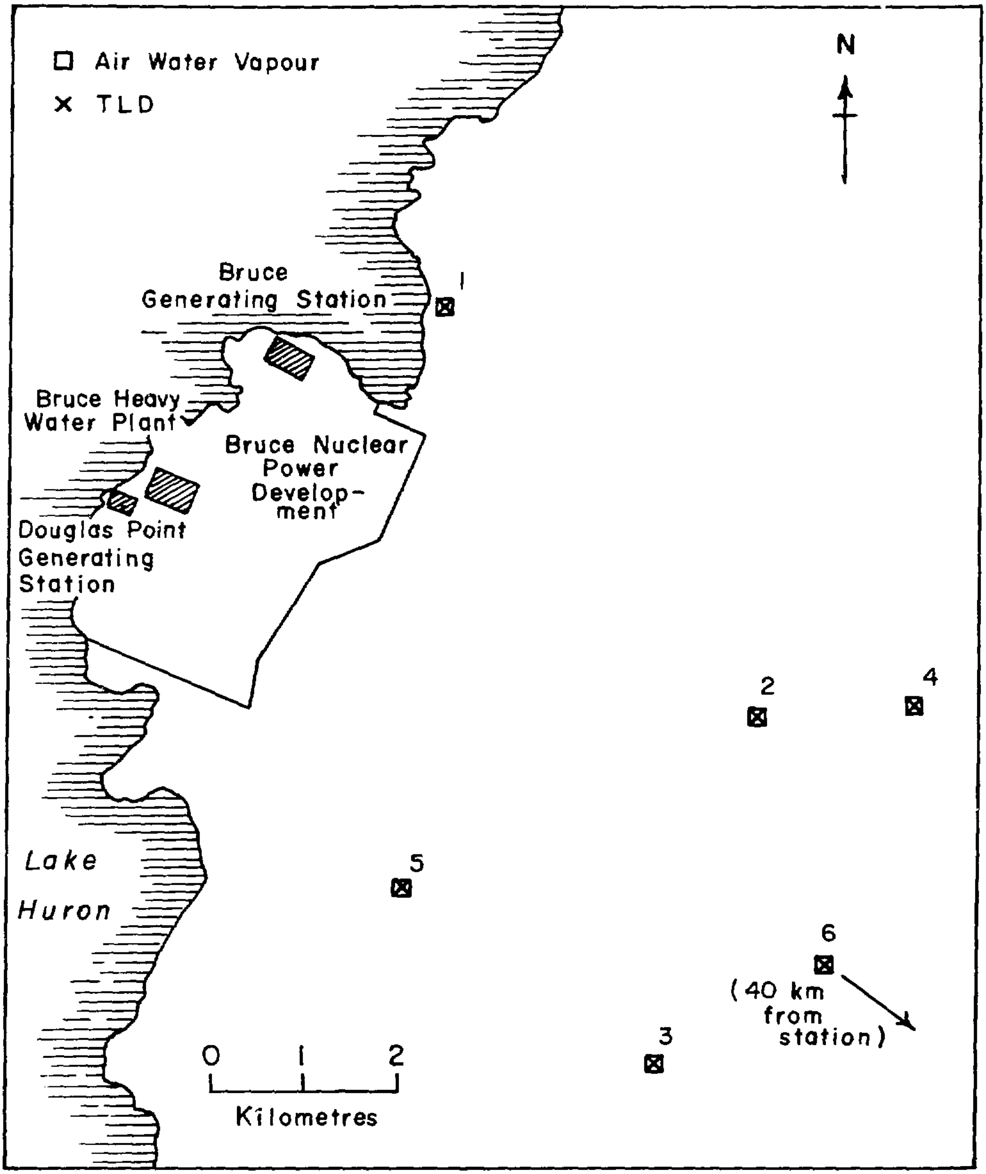

Figure 12. Sampling Stations in the Vicinity of the
Bruce Nuclear Power Development

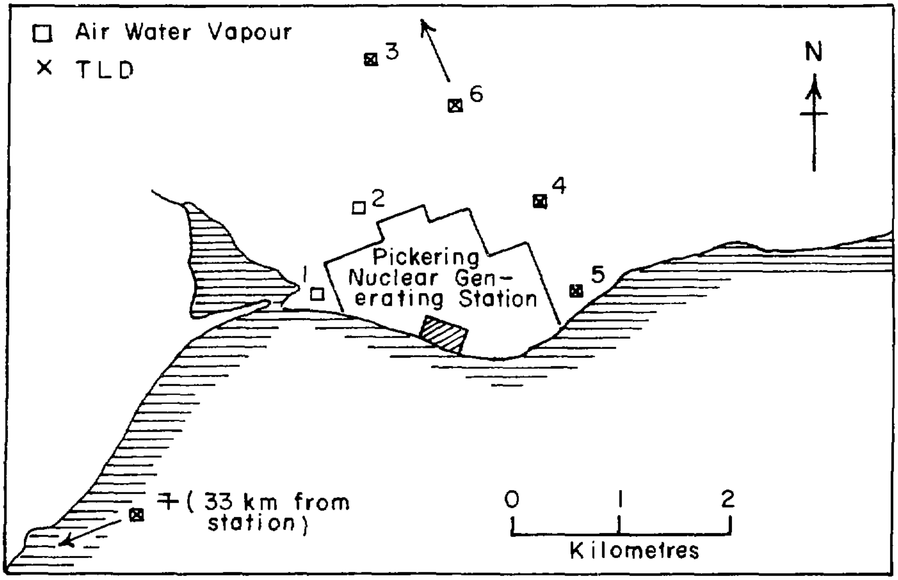

Figure 13. Sampling Stations in the Vicinity of the Pickering Nuclear Generating Station

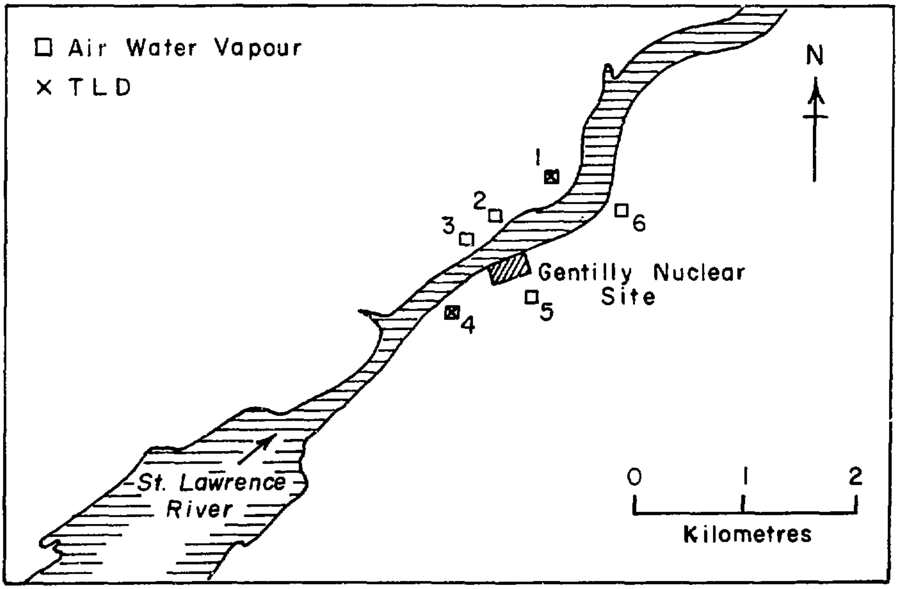

Figure 14. Sampling Stations in the Vicinity of the Gentilly Nuclear Site

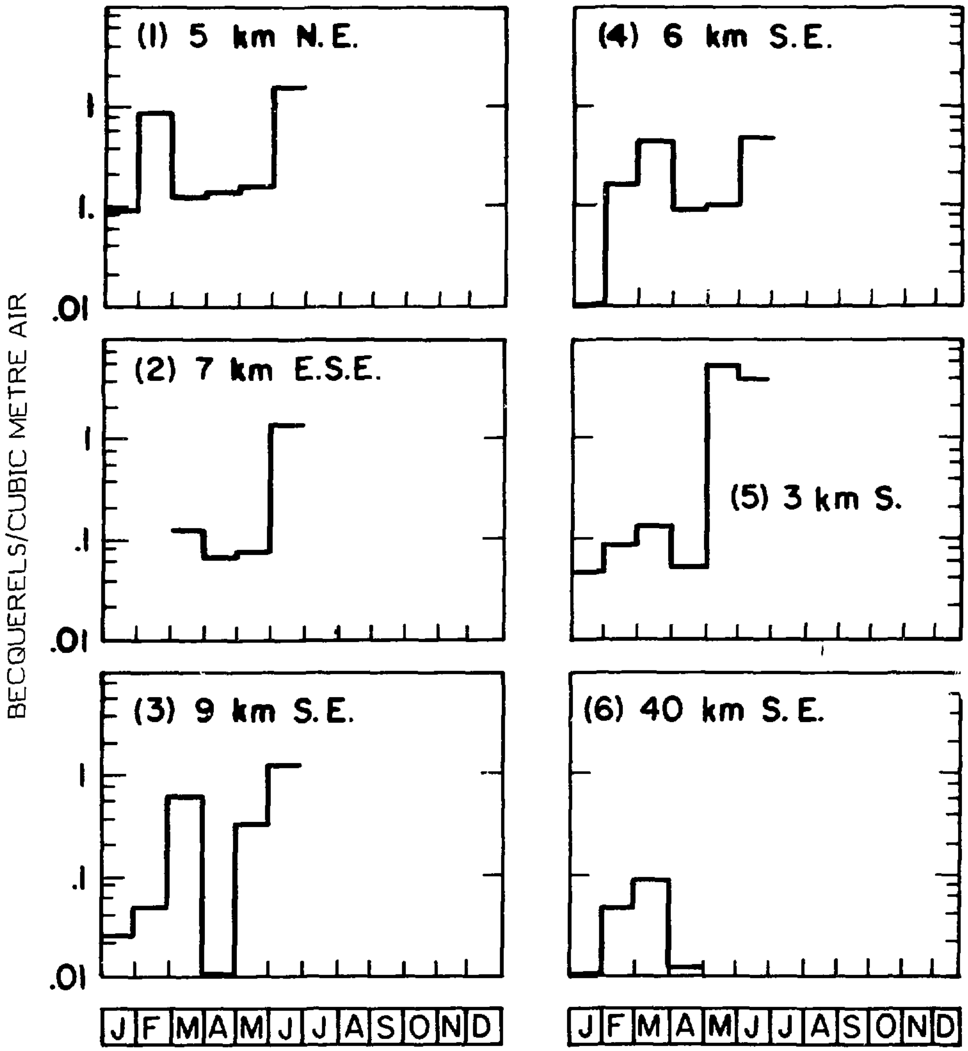

Figure 15. Tritium Levels near the Bruce Nuclear Power Development, 1978 (Detection Limit is 0.01 Bq/m^3)

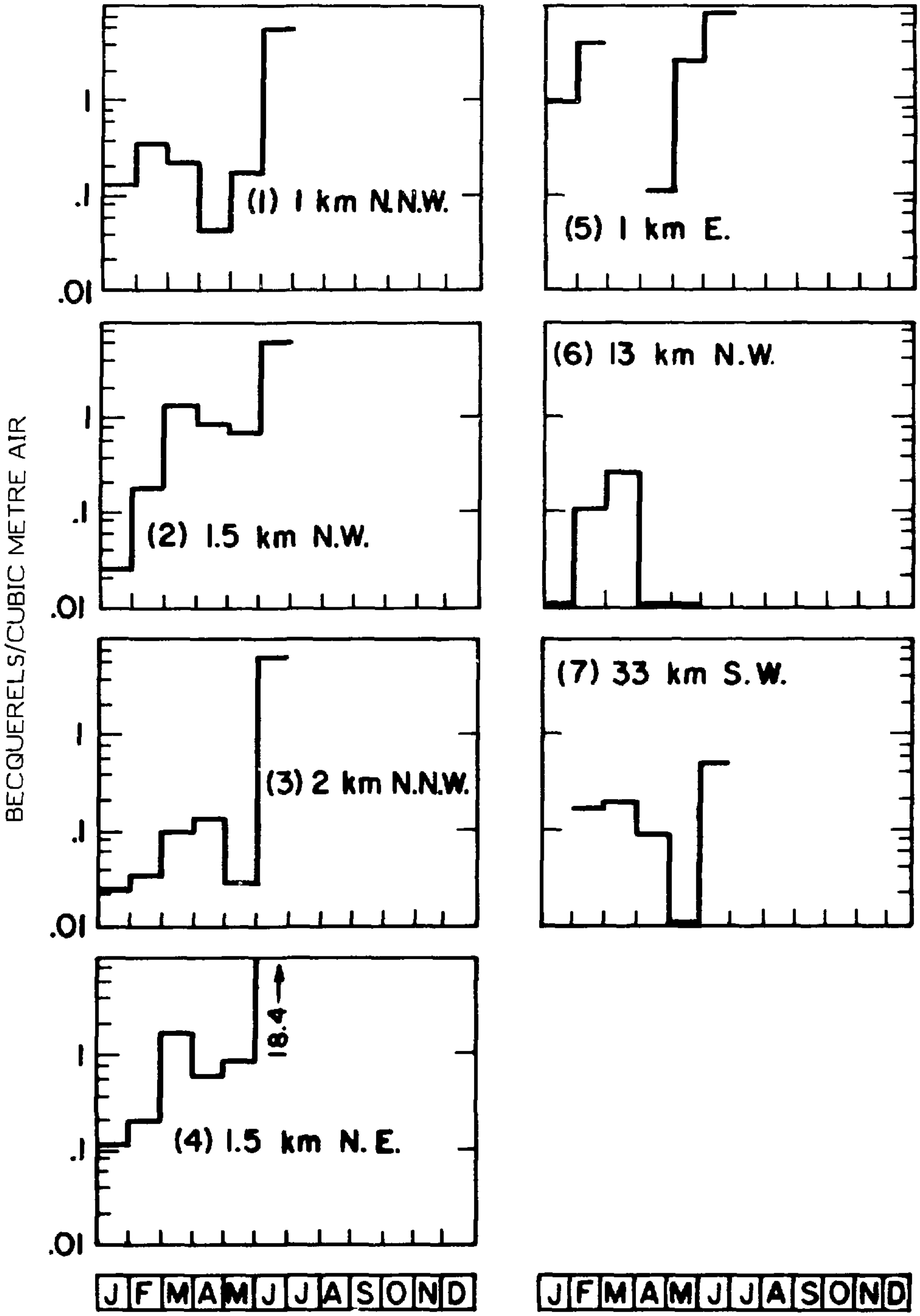

Figure 16. Tritium Levels near the Pickering Nuclear Generating Station, 1978 (Detection Limit is 0.01 Bq/m^3)

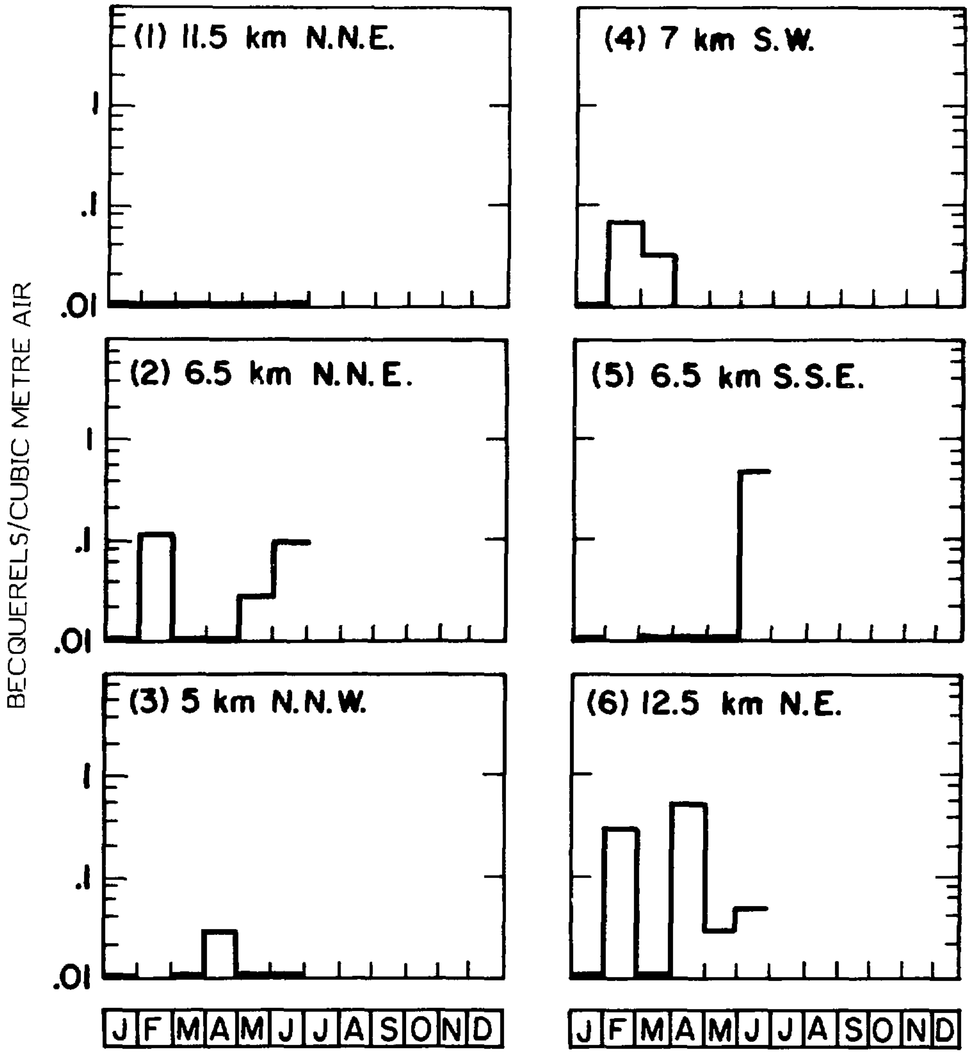

Figure 17. Tritium Levels near the Gentilly Nuclear Site, 1978
(Detection Limits is 0.01 Bq/m^3)

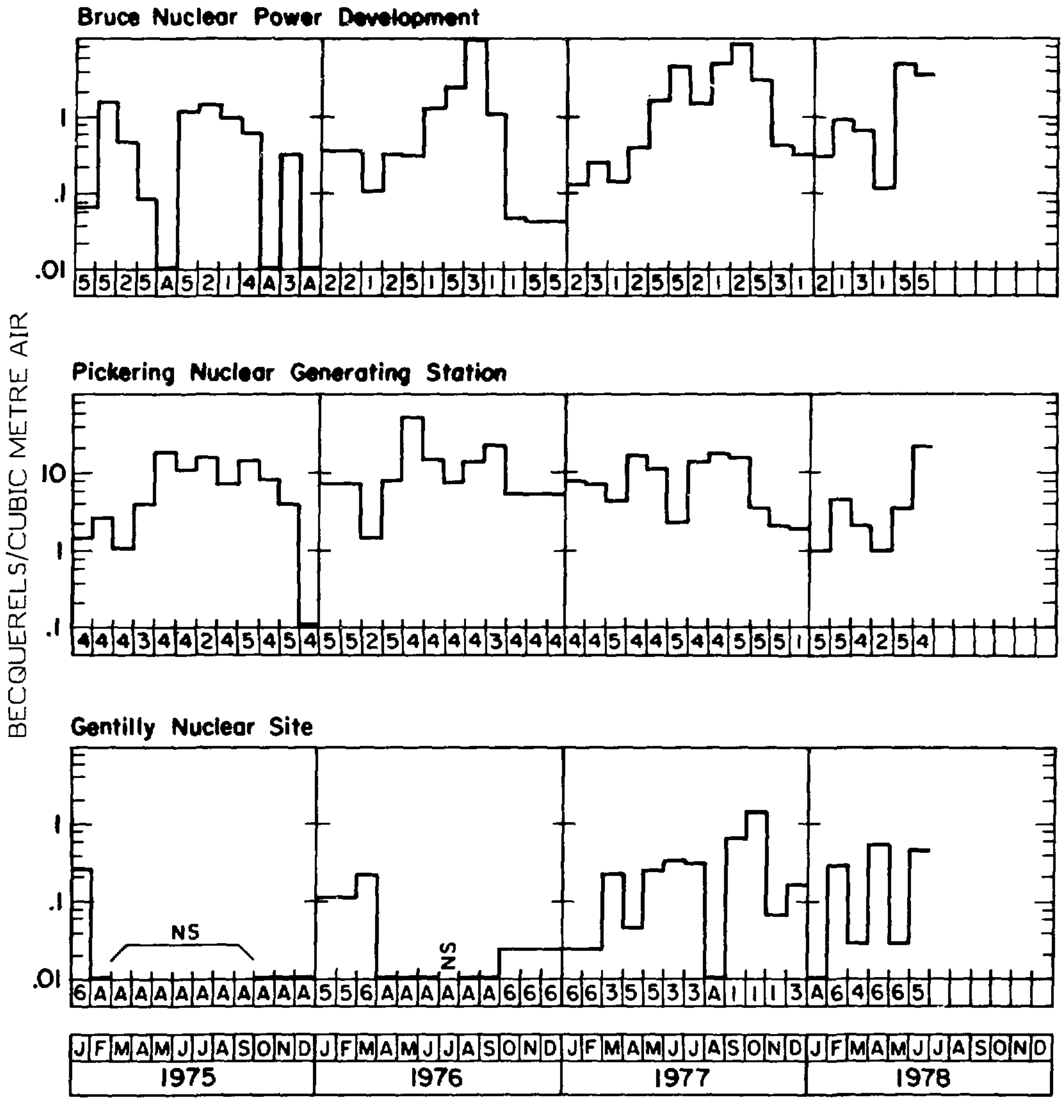

Figure 18. Maximum Tritium Levels around Nuclear Power Stations in Canada, 1975-1978

(Detection Limit is 0.01 Bq/m^3) NS-No Sample

(Numbers Beneath the Graphs Indicate the Station at which the Measurement was Made. A = All Stations)

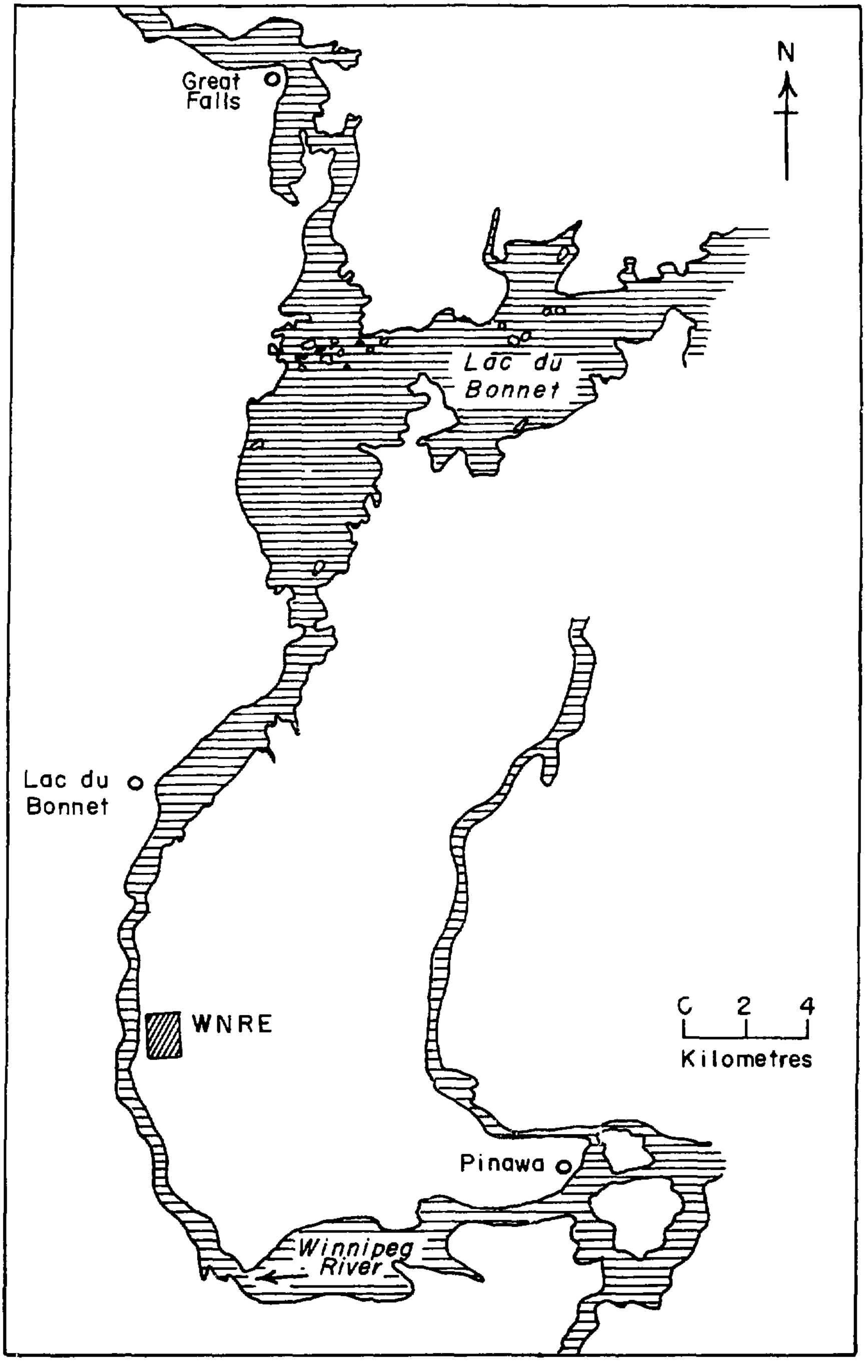

Figure 19. Drinking Water Sampling Locations on the Winnipeg River

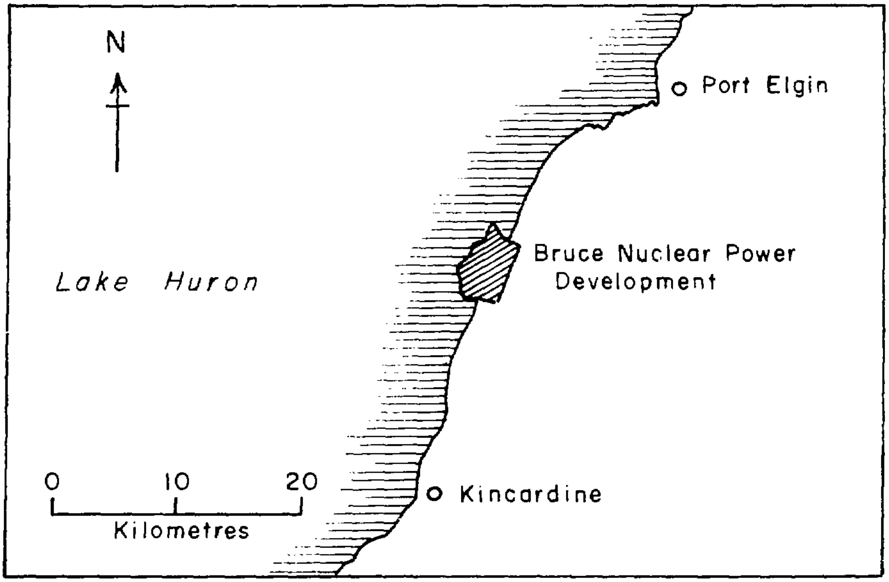

Figure 20. Drinking Water Sampling Locations on Lake Huron

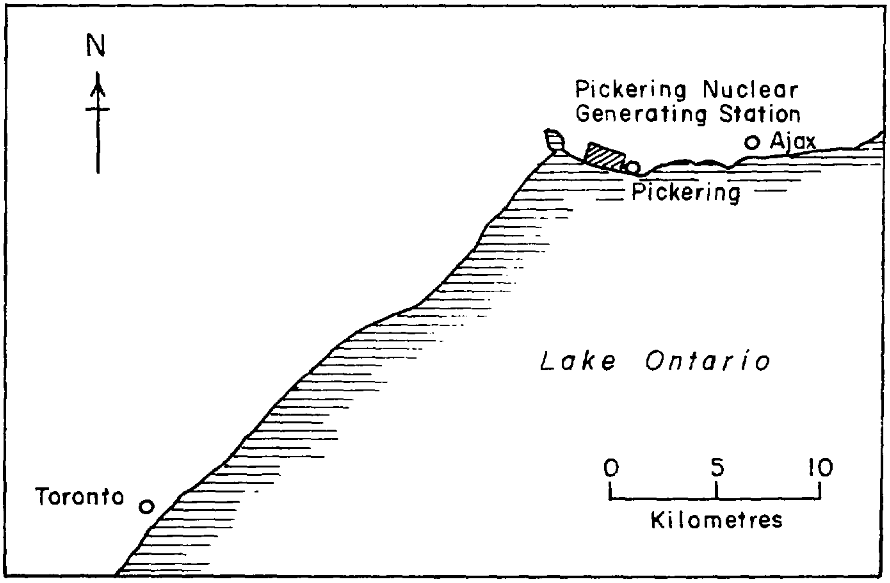

Figure 21. Drinking Water Sampling Locations on Lake Ontario

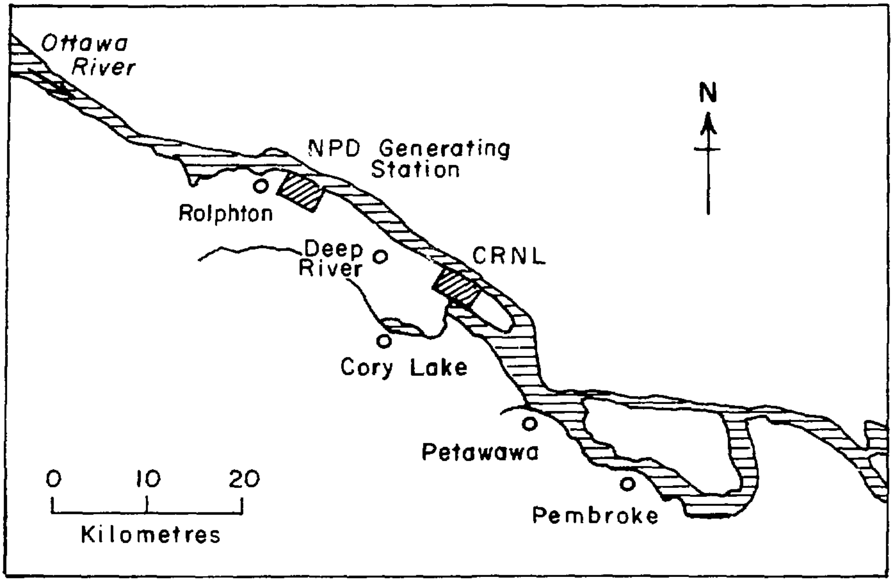

Figure 22. Drinking Water Sampling Locations on the Ottawa River

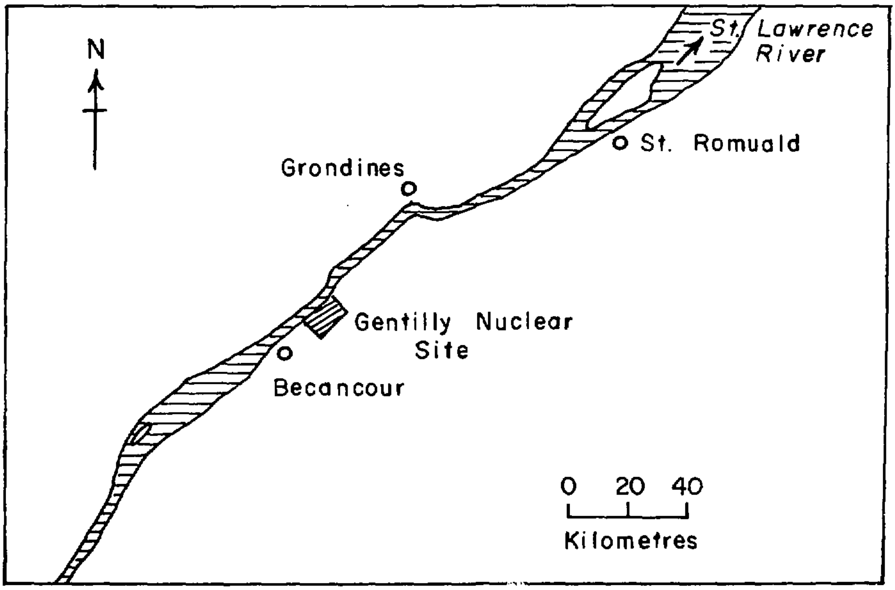

Figure 23. Drinking Water Sampling Locations on the St. Lawrence River

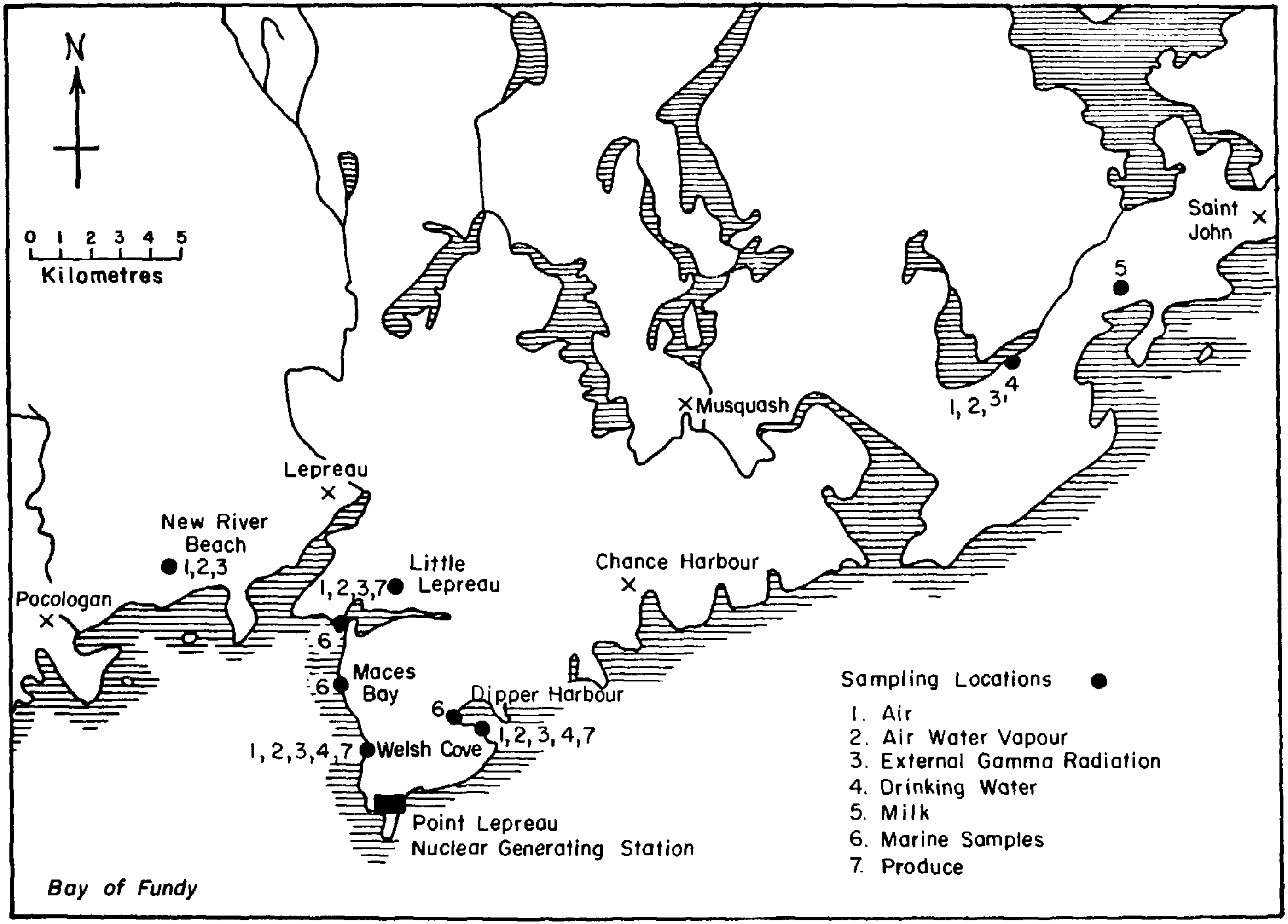

Figure 24. Sampling Locations in the Vicinity of the Point Lepreau Nuclear Generating Station

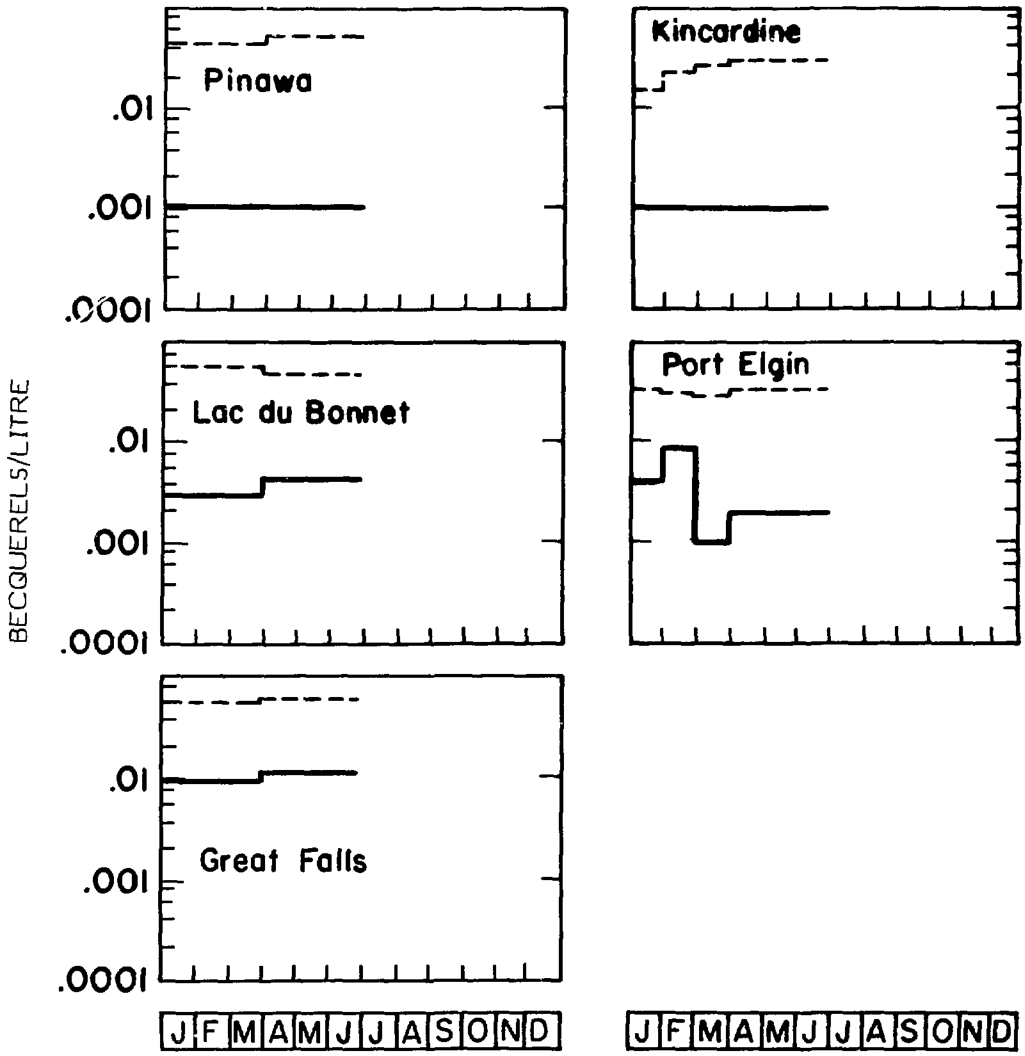

Figure 25. Radionuclides in the Winnipeg River and Lake Huron, 1978

——— Cesium-137 -------- Strontium-90

(Detection Limit is 0.001 Bq/L, Cesium-137 and Strontium-90)

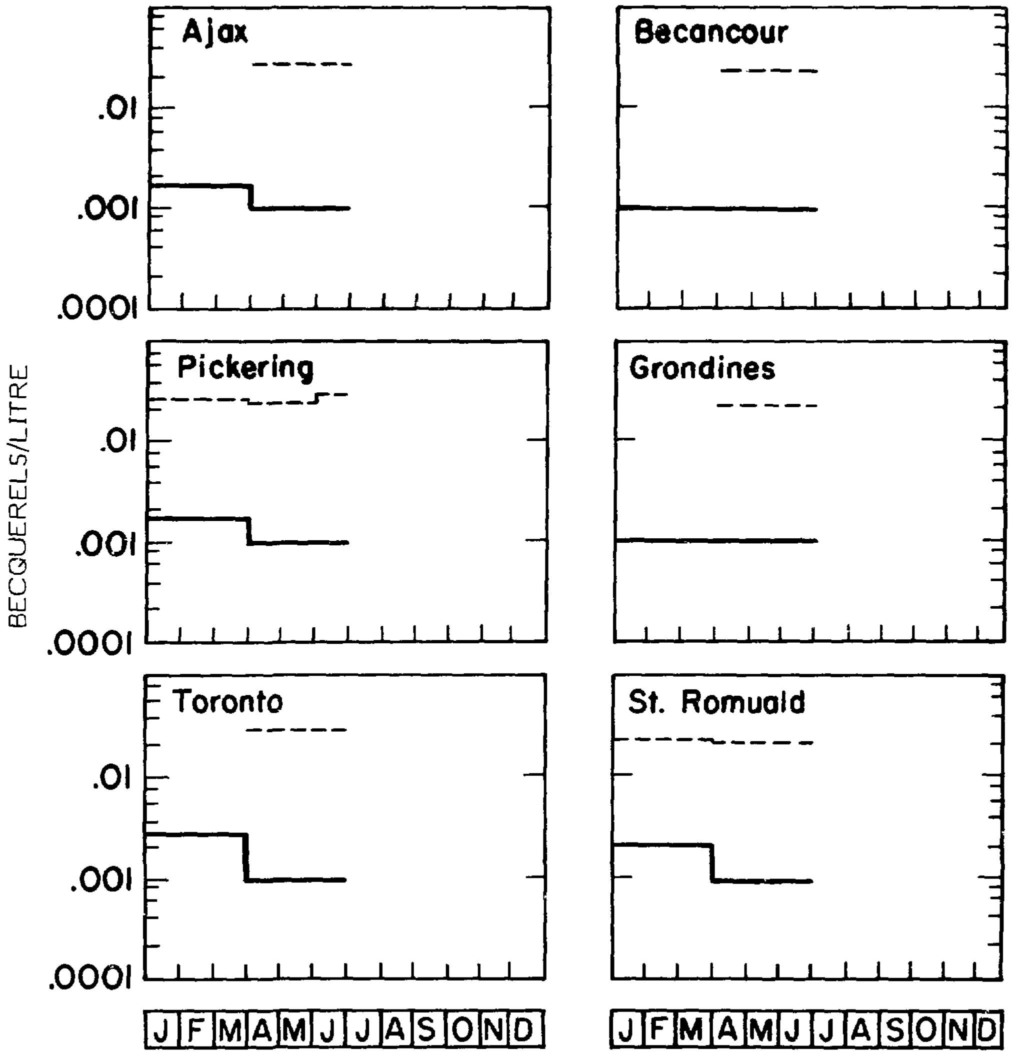

Figure 26. Radionuclides in Lake Ontario and the St. Lawrence River, 1978

———— Cesium-137 -------- Strontium-90

(Detection Limit is 0.001 Bq/L, Cesium-137 and Strontium-90)

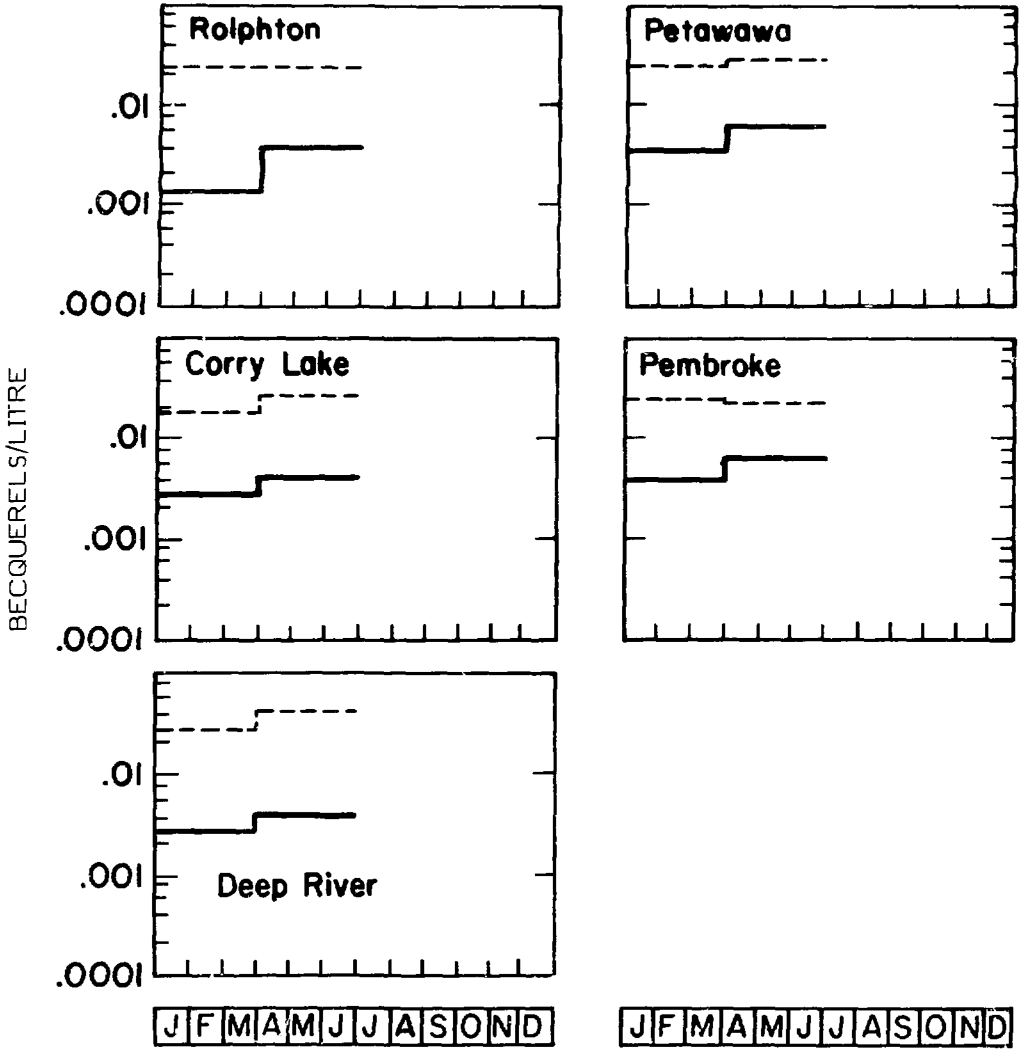

Figure 27. Radionuclides in the Ottawa River, 1978

——— Cesium-137 -------- Strontium-90

(Detection Limit is 0.001 Bq/L, Cesium-137 and Strontium-90)

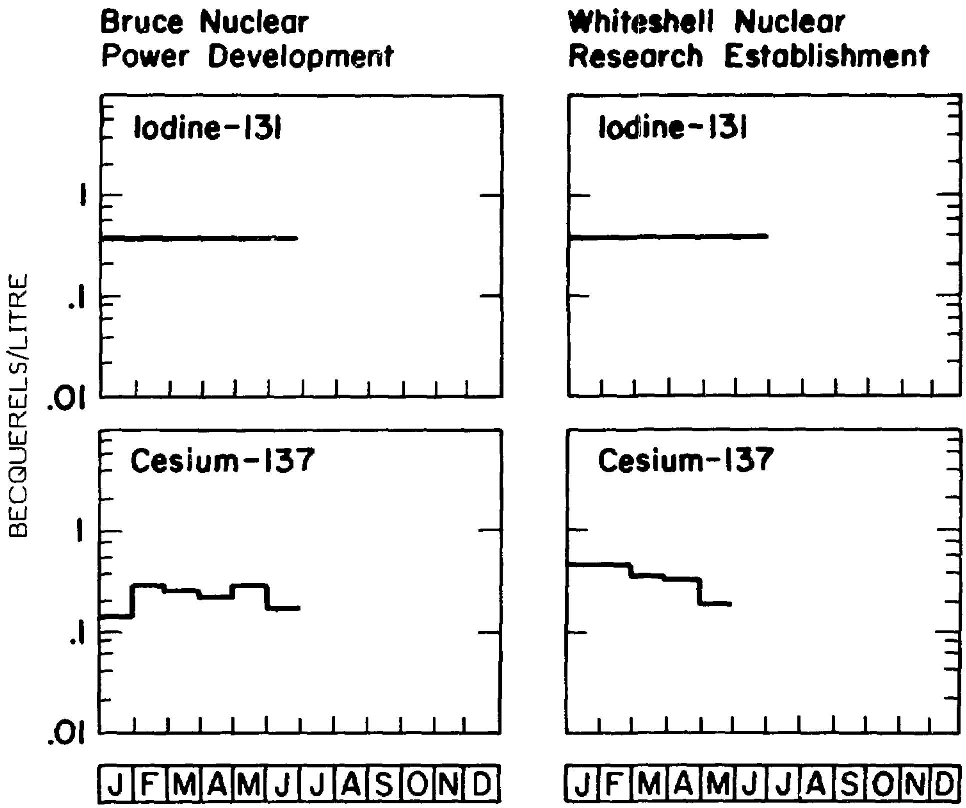

Figure 28. Radionuclides in Milk from Nuclear Reactor Environs, Monthly Averages for 1978

(Detection Limits are 0.4 Bq/L, Iodine-131 and 0.04 Bq/L, Cesium-137)