SOIL, VEGETATION AND AIR QUALITY SAMPLING IN THE VICINITY OF THE CAMECO URANIUM REFINERY BLIND RIVER, ONTARIO

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1.0 INTRODUCTION

In response to a reported spill from the Cameco uranium refinery on May 16-17, 1990, the Ministry of the Environment carried out a soil and vegetation sampling program to determine levels of uranium in surrounding vegetation and soil. The Company estimated that approximately 182 kilograms (kg) of uranium were released between 1030 hours on May 16 and 1200 hours on May 17, 1990. (Table 1)

The sampling program took place on May 29, 1990. The Ministry's suspended particulate monitor results for May 17, 1990 are also summarized in this report.

2.0 Soil and Vegetation Sampling

2.1 Methods

The seven permanent sample plot locations previously established by the Ministry of the Environment were used as sample locations. One other site was added (Site 8) to better represent the area to the northeast of the refinery, due to the fact that the prevailing winds during the spill were from the southwest, and these winds would take emissions to the northeast. Wind speed and direction data are shown in Figure 1 and Table 1. At each location shown in Figure 2, triplicate samples of surface soil (0-5 centimetres) and foliage from trembling aspen were collected.

Vegetation samples were placed in plastic bags, sealed using a twist tie, and placed in coolers with cold packs. These samples were processed at the Ministry of the Environment laboratory in Sudbury as follows: vegetation samples were oven-dried, ground in a Wiley mill, and placed in glass jars; the soil samples were air-dried, ground with a mortar and pestle to pass through a 45-mesh sieve, and bottled. The samples were then delivered to the Ministry laboratory in Toronto for uranium analysis.

2.2 Results and Discussion

The concentrations of uranium in vegetation and soils are presented in Table 2. In comparison to the historical data, minor increases in uranium concentration were noted in aspen foliage at Sites 3, 5, and 6. However, these concentrations were lower than values obtained at other locations in previous years. Increases were also noted in soil samples collected at Sites 1 and 2 although these increased uranium values were consistent with a gradual increase noted since the refinery began operations and the concentrations were below the value obtained at Site 4 prior to this spill. It is not possible, therefore, to determine the influence of the spill on increasing soil uranium levels from these data.

It is highly unlikely that phytotoxic effects will result in plants via uranium uptake from soil in the vicinity of the Blind River refinery at the present uranium soil levels. Natural background uranium concentrations in uncontaminated soils range from 0.7 to 9 μg/g (Bowen, 1979). Plant uptake of uranium is usually very

low because of strong adsorption by soils (Brown et al., 1983). The minimum reported phytotoxic soil uranium concentration is 50 $\mu g/g$ (inhibition of wheat growth, cited in Nishita et al., 1978). The phytotoxic soil uranium concentration for Scots pine seedlings is >100 $\mu g/g$ (Sheppard et al., 1985). As shown in Table 2, the uranium soil concentrations obtained from the 1990 survey ranged from 0.26 to 3.43 $\mu g/g$. These values are well below reported phytotoxic concentrations.

Similarly, direct deposition of uranium to the plants is not expected to cause phytotoxicity since foliage concentrations of uranium are low and plants have been shown to accumulate high concentrations of uranium relative to background, and yet not show symptoms of phytotoxicity (Brown et al., 1983). Foliage concentrations would be influenced by both soil uptake and direct deposition.

3.0 Suspended Particulate Monitoring

The Ministry's suspended particulate monitor located on the roof of the St. Joseph Hospital in the Town of Blind River (see Figure 3) collected a 24-hour air sample from midnight to midnight on May 17, 1990. A total suspended particulate concentration of 17 $\mu g/m^3$ was obtained, which is much lower than the Provincial 24-hour objective of 120 $\mu g/m^3$.

The exposed filter was also analyzed for gross ∝ and gross ß radiation, and also for the radionuclides radium-226, lead-210, thorium (total), and uranium (total).

The results are shown in the table below:

Parameter	Concentration (Bq/m^3)	Maximum Acceptable Concentration MAC (Bq/m^3)	Target Concentration TC (Bq/m^3)
Gross ∝	$<1.4 \times 10^{-3}$	-	-
Gross ß	$<1.4 \times 10^{-3}$	-	-
Ra-226	0.16×10^{-3}	0.37×10^{-1}	0.37×10^{-2}
Pb-210	0.20×10^{-3}	0.16×10^{-1}	0.16×10^{-2}
Th (total)	$<1.1 \times 10^{-4}$	3.70×10^{-4}*	3.70×10^{-5}*
U (total)	1.6×10^{-4}	2.40×10^{-3}	2.40×10^{-4}

*For thorium-230

Health and Welfare Canada has developed draft guidelines for radionuclides in air, based on annual limits of intake through inhalation taken from the International Commission of Radiological Protection (Table 3). These draft guidelines are in the form of daily maximum acceptable concentrations (MAC) and target concentrations (TC) expressed in becquerels/cubic metre of air (see table above). Guidelines for gross ∝ and gross ß radiation do not exist. These measurements are used by monitoring agencies as a screening method to determine the relative amount of ∝ and ß emitters. The results for the May 17, 1990 filter show very low (below the detection limit) concentrations of ∝ and ß emitting radionuclides.

The May 17, 1990 results for Ra-226 and Pb-210 show concentrations well below the MAC and TC guidelines. The thorium (total) levels were below the analytical detection limit of 1.1×10^{-4} Bq/m^3.

The May 17, 1990 filter had a uranium (total) concentration of 0.013 μg/m^3 which, when converted to an activity value, translates to 1.6×10^{-4} Bq/m^3. This is far below the MAC of 2.4×10^{-3} Bq/m^3, and also below the TC of 2.4×10^{-4} Bq/m^3.

It should be noted that the Ministry's suspended particulate monitor was operating only during a fraction of the time that the abnormal release of uranium occurred. The data in Table 1 show that the largest proportion of the emission of uranium (161 Kg out of a total of 182 Kg, or 88%) occurred on May 16, 1990, when the Ministry monitor was not sampling. In addition, a westerly wind (~270°) is required to send refinery emissions towards the Town of Blind River and the Ministry monitor. The meteorological data in Table 1 show that the wind was in a westerly direction during only 2 to 3 hours on May 17, 1990.

4.0 Conclusion

Soil and vegetation sample results, from samples collected shortly after a spill of uranium dust from the Cameco refinery near Blind River, showed a slight increase in the deposition of uranium particulate at some nearby sites. However, it is not expected that phytotoxic effects will result from the low soil and vegetation uranium concentrations observed.

Suspended particulate monitoring results available during part of the spill incident yielded a very low total suspended particulate level and airborne radionuclide concentrations much below draft guidelines developed by Health and Welfare Canada.

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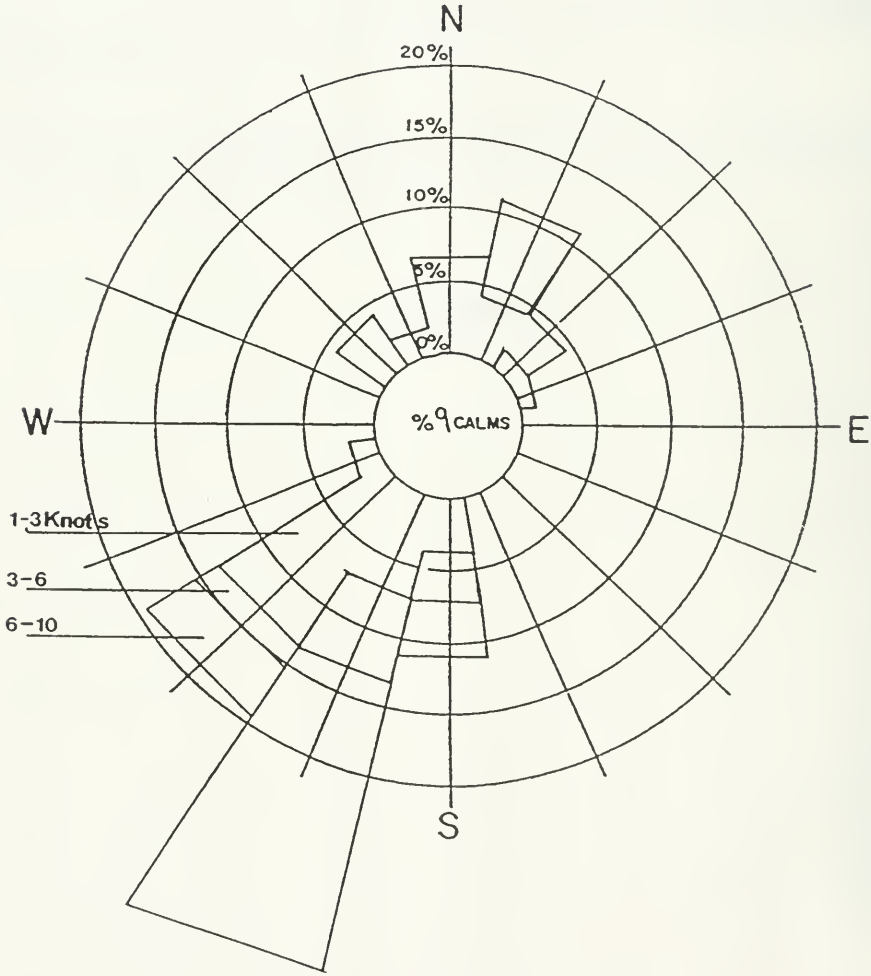
APPENDIX

Figure 1 Wind Rose Produced By Cameco From Their Met Station On Property., Blind River May 16 – 17, 1990



WIND SPEEDS IN KNOTS (1 KNOT = 0.514 m/s)

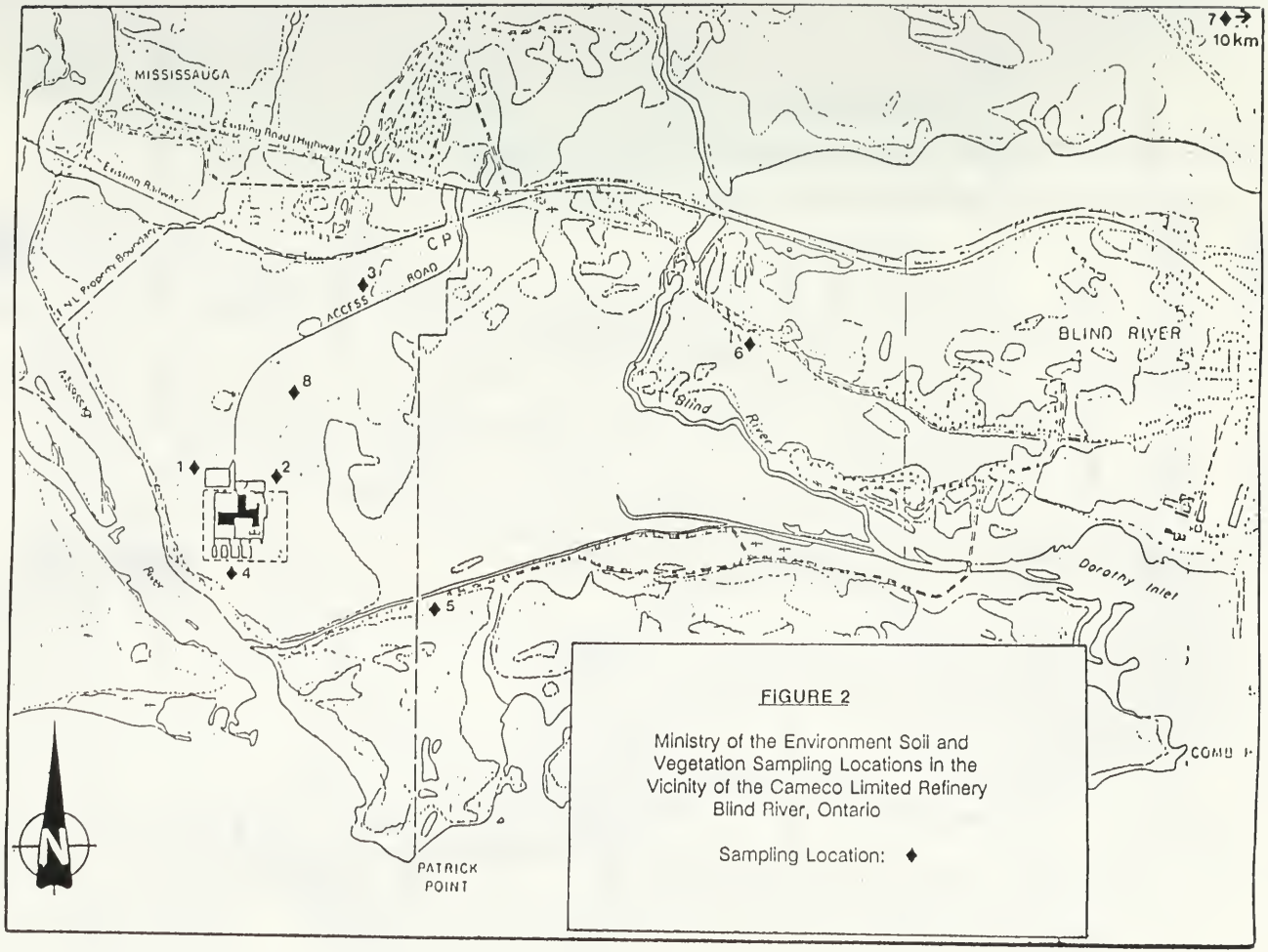


FIGURE 2

Ministry of the Environment Soil and Vegetation Sampling Locations in the Vicinity of the Cameco Limited Refinery Blind River, Ontario

Sampling Location: ♦

FIGURE 3

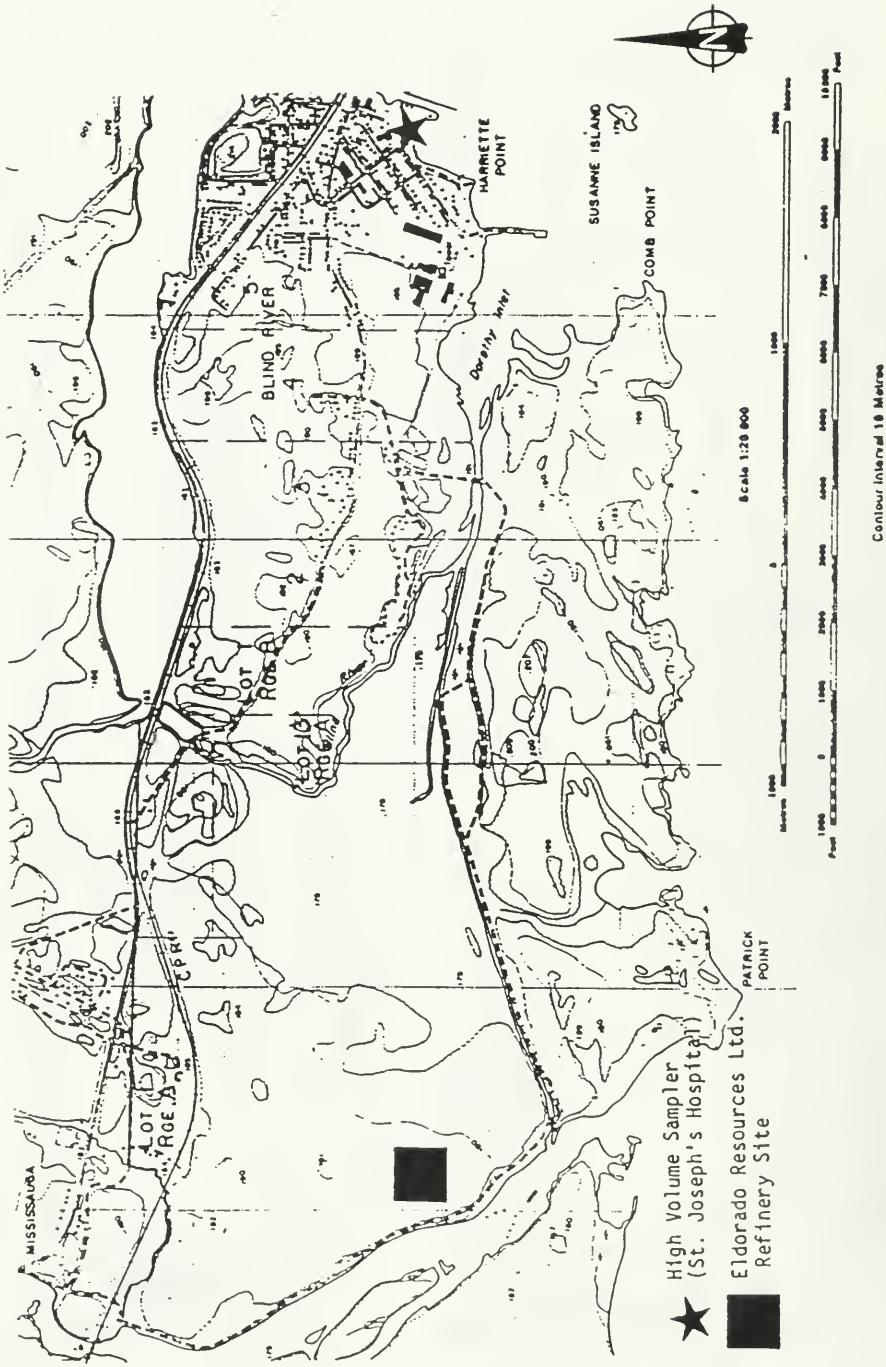

MISSISSAUGA
LOT
ROE
BLIND RIVER
LOT
ROE
LOT
ROE
HARRIETTE POINT
SUSANNE ISLAND
COMB POINT
PATRICK POINT
Scale 1:20 000
Contour Interval 10 Metres
High Volume Sampler (St. Joseph's Hospital)
Eldorado Resources Ltd. Refinery Site

TABLE 1

WIND SPEED AND DIRECTION MEASURED AT THE CAMECO METEOROLOGICAL STATION, BLIND RIVER - MAY 16-17, 1990

	TIME	WIND DIRECTION	SPEED	
		Degrees	Metres/Second	Kilometres/Hour
May 16, 1990	1000	204*	16.9	60.8
	1100	203*	17.6	63.4
	1200	204*	17.8	64.1
	1300	205*	16.4	59.0
	1400	215*	16.6	59.8
	1500	314*	16.9	60.8
	1600	215*	16.3	58.7
	1700	213*	14.8	53.3
	1800	218*	9.4	33.8
May 17, 1990	0800	245*	3.8	13.7
	0900	309*	1.8	6.5
	1000	55*	5.0	18.0
	1100	74*	3.0	10.8
	1200	313*	3.5	12.6
	1300	5*	6.4	23.0

*Southwest = 225, West = 270, Northwest = 315, Northeast = 45

The uranium emission rates are estimated at approximately: 14 kg/hr during the periods 1030-1800, 16 May and 0800-1200, 17 May; and 1.5 kg/hr over the interval 1800, 16 May - 0800, 17 May, for a total of 182 kg.

TABLE 2

CONCENTRATION OF URANIUM (μg/g)* IN VEGETATION AND SOIL SAMPLES COLLECTED IN THE VICINITY OF THE ELDORADO RESOURCES URANIUM REFINERY AT BLIND RIVER, ONTARIO - 1981 TO 1990**

SAMPLE TYPE	SITE	LOCATION	1981	1982	1983	1984	1985	1986	1987	1989	1990 (MAY 29)
Trembling Aspen	1	100 m NW	0.009	0.04	0.25	1.33	1.73	2.09	8.10	0.52	2.93
	2	200 m NE	0.018	0.03	1.50	5.69	4.20	14.57	4.23	0.68	2.06
	3	1200 m NE	0.011	0.05	0.06	0.28	0.20	0.32	0.18	<.05	0.96
	4	300 m S	0.009	0.02	0.09	2.67	<.05	0.93	2.73	0.92	1.39
	5	900 m ESE	0.009	0.01	0.05	0.20	0.24	0.11	0.22	0.09	0.56
	6	2400 m ENE	0.009	<.01	0.03	0.06	<.05	0.03	<.05	<.05	0.11
	7	10 km E	-	-	<.02	<.05	<.05	0.01	<.05	<.05	0.02
	8	640 m NNE	-	-	-	-	-	-	-	-	1.8
Soil	1	100 m NW	0.45	0.85	0.32	0.69	1.04	0.93	1.43	2.53	3.43
	2	200 m NE	0.57	0.45	0.35	1.16	1.35	1.00	2.57	2.63	3.03
	3	1200 m NE	0.01	0.31	0.25	0.55	0.90	0.41	0.90	0.73	0.96
	4	300 m S	0.02	0.55	0.54	0.80	0.85	0.65	2.37	3.57	1.70
	5	900 m ESE	1.60	1.58	0.93	0.57	1.97	2.42	0.76	1.83	1.53
	6	2400 m ENE	0.39	0.29	<.25	0.34	0.24	0.28	0.24	0.97	0.26
	7	10 km E	-	-	0.30	0.77	0.21	1.56	0.42	0.06	0.33
	8	640 m NNE	-	-	-	-	-	-	-	-	1.6

*Results are reported as the mean of triplicate samples.
**For the years 1981-1989, samples were collected in August

TABLE 3

DRAFT GUIDELINES FOR RADIONUCLIDES IN AIR

RADIONUCLIDE	ALI(inh) [Bq/Y]	MAC [Bq/m^3]	TC [Bq/m^3]
TRITIUM	$3x10^9$	5500	550
COBALT -60	$1x10^6$	1.8	0.18
STRONTIUM -89	$5x10^6$	9.1	0.9
STRONTIUM -90	$1x10^5$	0.18	0.018
IODINE -131	$2x10^6$	3.7	0.37
CAESIUM -134	$4x10^6$	7.3	0.73
CAESIUM -137	$6x10^6$	11.0	1.1
LEAD -210	$9x10^3$	0.016	0.0016
RADIUM -224	$6x10^4$	0.11	0.011
RADIUM -226	$2x10^4$	0.037	0.0037
RADIUM -228	$4x10^4$	0.073	0.0073
THORIUM -228	$4x10^2$	$7.3x10^{-4}$	$7.3x10^{-5}$
THORIUM -230	$2x10^2$	$3.7x10^{-4}$	$3.7x10^{-5}$
URANIUM-Natural	$1.3x10^3$	$2.4x10^{-3}$	$2.4x10^{-4}$

Notes: 1. The annual limits of intake through inhalation {ALI(inh)} are taken from publication #30 of the International Commission of Radiological Protection.

2. The most conservative ALI is chosen, even if this is the limit for non-stochastic effects. It is assumed that the radionuclide is in the chemical form, which results in the greatest dose-equivalent to the individual, or the greatest dose to a critical organ of the individual.

3. The MAC for a radionuclide is derived from its ALI(inh) by the following formula:

$$MAC = \frac{ALI(inh)}{365x15x100} [Bq/m^3]$$

where,
ALI(inh) (measured in Bq/year) is the annual limit of intake, through inhalation, of a radionuclide. Inhalation of this quantity would give rise to either (1) a radiation dose-equivalent equal to the maximum permissable dose-equivalent to workers classified as radiation workers, or (2) a radiation dose to an organ of an individual equal the maximum permissable dose to the organ of a radiation worker.

365 = number days/annum.

15 = number of cubic metres of air inhaled per day by an average individual.

100 = safety factor to convert dose or dose-equivalent permissable for a radiation worker to that considered acceptable for members of the public.

4. The target concentration of a radionuclide in air TC is one-tenth of the MAC.