Information Series 98

MARKETABLE MINERAL WATERS OF ALBERTA

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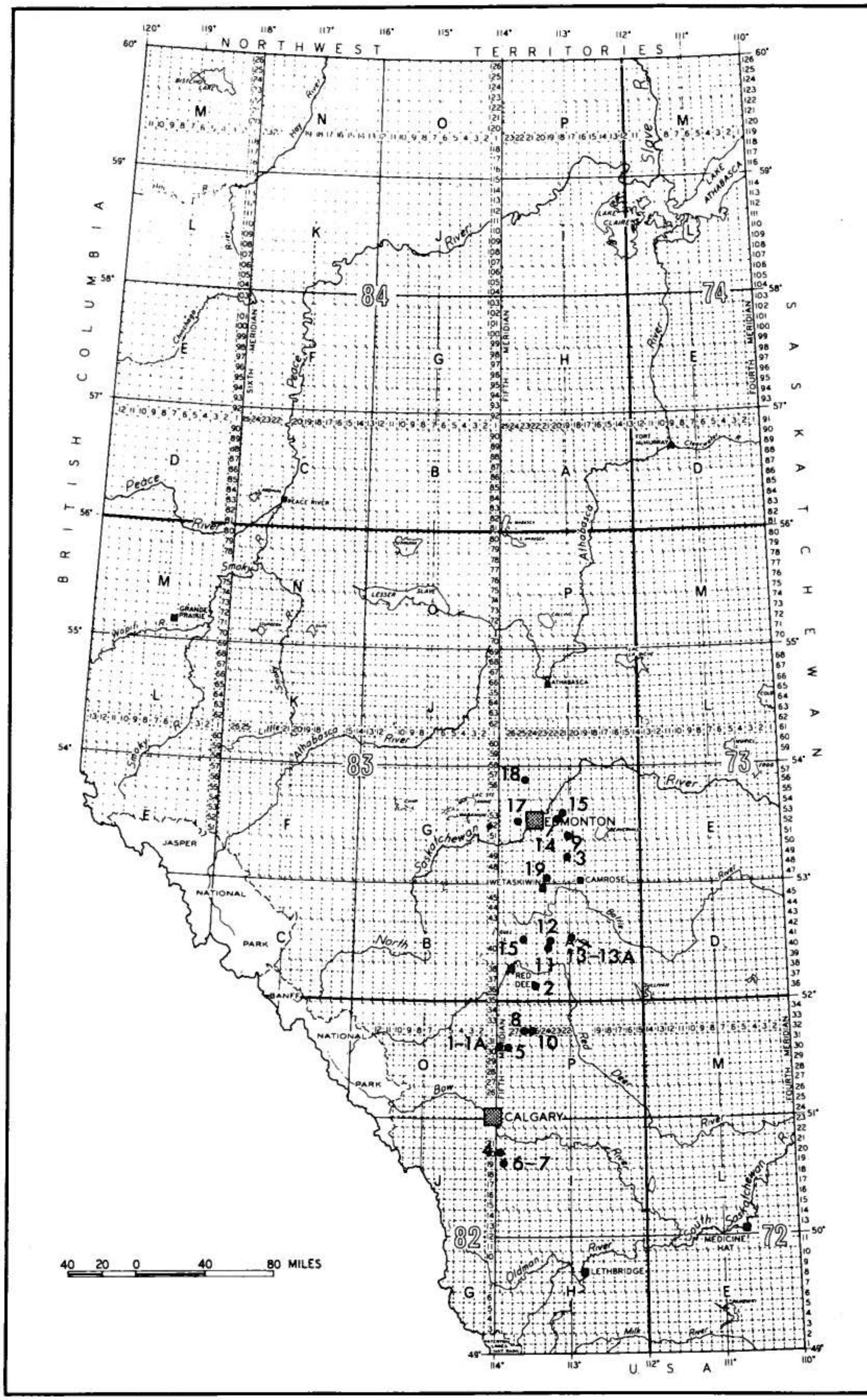

FIGURE 1. Sample locations.

ABSTRACT

Due to the growing demand for bottled waters in North America, a study was undertaken to assess the feasibility of bottling domestic well water in Alberta. Chemical quality of these groundwaters was compared with that of Canadian and imported bottled waters. This study showed that the chemical quality of Alberta groundwaters was comparable to that of certain popular brands of bottled waters. These groundwaters contained concentrations of trace elements such as phosphorus and strontium that were in excess of the acceptable limit for drinking water. These sampled waters also contained fluoride and iron concentrations that were above the limit for drinking water. It was concluded that the sampled well waters could be marketed, providing that objectionable iron and fluoride concentrations were reduced.

INTRODUCTION AND BACKGROUND

The objective of this study was to locate suitable domestic well waters near the cities of Edmonton, Red Deer, and Calgary that are of sufficiently high chemical quality and quantity for bottling and marketing.

Mineral waters in general include all waters containing more than one thousand parts per million of total dissolved solids (TDS). Natural mineral water is usually from a spring and contains only the dissolved constituents present in the water as it flows from the ground. It may be effervescent or still. Mineral water with the word "natural" in its brand name may have had minerals removed or added (Consumer Reports, 1980). It should be noted that all imported waters from Europe are from natural sources and bottled under strict standards established by their respective governments. In North America, water purity is regulated by individual states and provinces.

Bottled waters are sold mainly for drinking. In Europe, bottled waters are used extensively as a substitute for drinking water. In North America, there is an increasing demand for bottled waters. Recent surveys have shown that one third of Americans do not like the taste of their tap water and many worry about the quality of their drinking water supply.

In North America, more than 700 brands of bottled waters are now available. About 80 percent of these are not natural, but are treated or processed, usually filtered or distilled well water. Table 1 shows the chemical composition of a few popular brands of bottled waters sold in North America.

Over the past decade, the use of bottled waters has increased considerably in Canada. A survey was conducted to assess the use of bottled waters in Edmonton, Alberta. According to this survey, Woodwards Department Stores sold more than 190 000 bottles in Alberta during 1980. Table 2 shows the popular brands of bottled waters sold in Edmonton.

SAMPLING AND ANALYTICAL PROCEDURE

Well waters were sampled during March and April of 1981. Background data for these water wells were obtained from the Alberta Research Council Groundwater Department provincial pump test files. In order to be close to major markets, sampling of domestic wells was restricted to areas around Edmonton, Red Deer and Calgary. The well locations were plotted on a 1:250 000 NTS map. Figure 1 shows the locations of the sampled water wells. In all, 21 domestic wells were sampled between Edmonton and Calgary. Safe yield (Q_{20}) of these wells ranges from 2 to 547 igpm (9 to 2462 L/m). Table 3 shows the well parameters.

Water samples were collected in thoroughly rinsed one-litre plastic bottles and measurements of temperature, pH, and conductivity were made immediately. Temperature was measured using a Y.S.I. (Yellow Spring Instruments) tele-

TABLE 1.
Chemical Composition of Mineral Waters for sale in North America

Brand	Country of Origin	mg/L						
		Ca^{++}	Mg^{++}	Na^{++}	K^{+}	$SO_4^{=}$	Cl^{-}	TDS
DEER PARK[1]	United States	<7.0	2.0	<2.0	1.7	15.0	2.5	60.0
BORDEN POLAR[1]	United States	46.0	12.0	14.0	3.0	91.0	23.0	180.0
ABSOPURE[1]	United States	59.0	20.0	11.0	2.3	39.0	24.0	180.0
DISTILLATA[1]	United States	63.0	15.0	38.0	2.5	77.0	74.0	340.0
MAGNETIC SPRINGS[1]	United States	<7.0	<0.7	<2.0	1.0	6.2	9.9	80.0
VICHY SAINT-YORRE[1]	France	170.0	23.0	640.0	-	9.0	350.0	4300.0
MOUNTAIN VALLEY[1]	United States	35.0	13.0	<2.0	2.0	8.5	6.4	120.0
POLAND[1]	United States	35.0	7.0	6.0	1.9	16.0	8.2	160.0
CRODO[1]	United States	660.0	53.0	21.0	-	1800.0	11.0	-
CALISTOGA[1]	United States	32.0	2.0	80.0	12.0	28.0	140.0	-
APPOLLINARIS[1]	West Germany	39.0	85.0	7.0	-	180.0	230.0	2200.0
RAMLUSA[1]	West Germany	<7.0	2.0	260.0	4.3	13.0	35.0	600.0
SARATOGA VICHY[1]	United States	56.0	28.0	<2.0	9.9	12.0	760.0	2100.0

All Concentrations in mg/L

Brand [2]	Country of Origin	Ca^{++}	Mg^{++}	Na^{++}	K^{+}	HCO_3^{-}	$SO_4^{=}$	Cl^{-}	$NO_3^{\equiv}$
PERRIER[2]	France	140.2	3.5	14.0	0.6	347.7	51.4	30.9	-
MONTCLAIR[2]	Canada	3.8	14.6	850.0	16.6	1231.0	2.0	600.0	0.1
LABRADOR[2]	Canada	12.0	13.3	77.4	7.24	126.0	39.0	39.0	.01

[1]After Studlik and Bain, 1980
[2]Others stated on label

Fe	Conductivity μMhos)	Serving Cost ($)	pH Standard Unit
0.05	70	0.95	6.8
0.20	330	0.79	7.3
0.10	470	0.59	8.0
0.10	600	0.59	7.8
0.10	55	0.89	6.2
0.30	5400	1.49	6.9
0.10	300	0.99	7.8
0.20	205	0.99	7.6
-	1800	0.59	5.7
0.20	700	0.47	6.0
0.30	2800	1.49	6.5
0.10	800	0.99	6.3
0.30	3000	0.59	6.3

F^-	TDS	Cu^{+++}	Pb^{++}	Zn^{++}	Serving Cost ($)
-	411.3	-	-	-	0.60
.81	2091.0	.05	.07	.03	0.59 (750 ml)
.32	233.0	-	-	-	1.30 (4 litre)

thermometer. Conductivity was measured using a multirange Hach model 2510 conductivity meter. The pH measurements were made using Fisher Orion Model 407-A specific ion meter with a combination electrode. Total iron content of the water sample was measured with a Hach spectrophotometer, using Ferrover iron reagent (Hach Chemical Company, 1976). The water sample was titrated against 0.0164 N HCl to determine field alkalinity.

Two 1-litre samples were collected from each well. One sample was acidified with nitric acid to a pH of ≤ 2. This sample was used for trace element determinations and the second sample was used for chemical analysis.

Major chemical parameters were measured in the Research Council Geology Laboratory. Trace elements of the water samples were determined by Chemical and Geological Laboratories of Edmonton, using the argon plasma emission technique.

CHEMICAL COMPOSITION OF SAMPLED GROUNDWATERS

The total dissolved solids of the sampled waters range from 270 mg/L to 2818 mg/L. About 15 percent of the waters contain more than 2000 mg/L of TDS and 19 percent of the waters contain more than 1000 mg/L of TDS. Total dissolved solids of the remainder of the waters are all within the Canadian drinking water standards (see Health and Welfare Canada, 1968). Figure 2 is a Piper diagram showing the TDS of domestic waters from the study area.

Sodium is the predominant cation and bicarbonate is the dominant anion. Sulfate is higher than bicarbonate in those waters having higher TDS concentrations. Chemically, the waters from the sampled area can be classified mainly as sodium bicarbonate and sodium sulfate types. Sample No. 11 (Table 4) is the only calcium and magnesium bicarbonate type of water with a TDS of 380 mg/L.

TABLE 2.
Sale of Bottled Mineral Waters in Alberta during 1980
(Courtesy of Woodwards Department Store)

Brand Name	Supplier	Cost Per Litre (Retail)	No. of Bottles Sold in 1980
Alpine distilled (1 L) water	Robinson Webber	$ 2.23	1396
Eau Claire (300 mL)	Koskey Food Brokers Ltd.	$ 1.37	2952
Eau Claire (750 mL)	Koskey Food	$ 1.00	12360
Montclair (750 mL)	Shirra Sales	$ 1.21	15532
Appollinaris (1 L)	Shirra Sales	$ 1.59	34944
Ferrarelle Sparkling (890 mL)	Shirra Sales	$ 1.63	8736
Studemac (1170 mL)	Shirra Sales	$ 0.78	43680
Vittel (1560 mL)	Shirra Sales	$ 0.98	43680
Perrier (1 L)	Troy Beverages (Proctor & Gamble)	$ 2.39	6744
Perrier (695 mL)		$ 1.19	21540
Mont Blanc (750 mL)	Canada Dry Limited	$ 1.85	
Canada Dry (1 L)	Canada Dry Limited	$ 1.29	
Nanton Water (750 mL)	Nanton Pure Spring Water Co. Ltd.	$ 0.87	

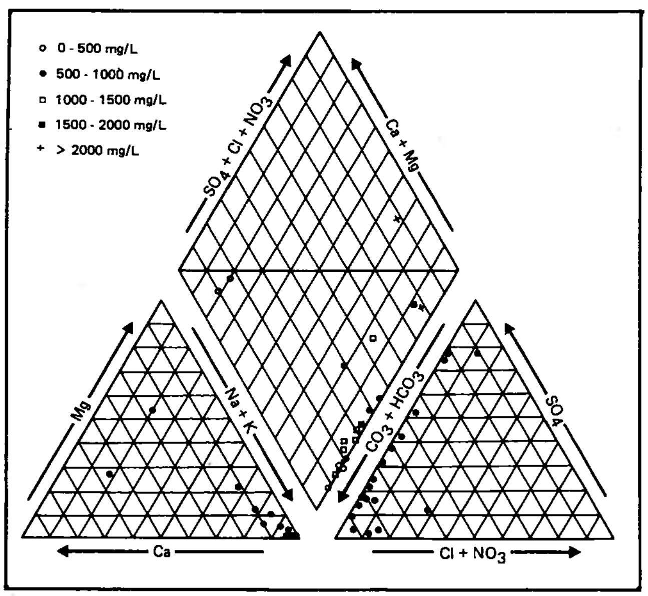

FIGURE 2. Piper diagram showing the range of dissolved solids of sampled domestic wells.

MINOR AND TRACE ELEMENTS

Among minor elements, fluoride is quite high in most samples, ranging from 0.1 to 4.5 mg/L. Maximum fluoride concentrations recommended for drinking waters range from 1.4 to 2.4 mg/L, depending on how much water is ingested.

Many trace elements are present in groundwater, often at concentrations well below 0.1 mg/L but sometimes much higher. These elements, which are present in traces, are of great concern in drinking water because of their toxic effects. Table 5 shows the trace element concentrations in the sampled waters; Table 6 shows the recommended maximum limits for trace elements in drinking water.

ALUMINUM

Aluminum rarely occurs in natural waters in concentrations greater than a few tenths of a

TABLE 3.
Parameters of Sampled Domestic Wells

Location M T R S LSD	Index No.	Owner's Name	Well Depth (ft)	Depth to Water (ft)	Q 20 (igpm)	Open Interval (ft)	Date Sampled
						75-85	
4 19 29 12 13	6	B. Swenson	172	25	2	150-172	22-4-81
4 19 29 12 13	7	B. Swenson	56	10	-	-	22-4-81
4 20 29 9 16	4	C. Ewans	65	-	3	-	23-4-81
4 32 26 16 4	8	Valleyview Colony	720	55	547	283-720	14-4-81
4 32 26 27 13	10	D. Leach	120	22	38	88-120	14-4-81
4 30 28 34 13	5	G. Brown	202	49	7	103-200	16-4-81
4 41 21 18 4	13	A. Hauser	120	44	11	-	3-4-81
4 41 21 18 4	13A	A. Hauser	"	"	-	-	3-4-81
4 30 28 32 13	1	Pheasant Farm	121	17	25	60-121	16-4-81
4 30 28 32 13	1A	Pheasant Farm	100	80	-	-	16-4-81
4 36 25 23 13	2	Pine Lake Resort	80	13	-	60-80	9-4-81
4 52 26 34 16	17	Red Wheel Ranch	99	44	250	94-99	7-4-81
4 40 23 27 16	11	T. Gillard	160	113	2	80-160	3-4-81
4 41 26 15 13	15	Smokey	202	31.5	12	127-202	2-4-81
4 56 25 16 1	18	H. Jelsvold	110	12	48	100-110	24-3-81
4 53 22 15 4	16	McConnell	185	58	8	145-185	26-3-81
4 47 23 18 1	19	Morgan	120	13	101	60-120	24-3-81
4 52 22 22 16	14	J. Warke	180	67	20	110-180	26-3-81
4 51 21 6 13	9	Gautier	100	42	8	-	1-4-81
4 49 21 6 1	3	Marcotte	50	25	21	40-50	25-3-81
4 40 23 29 1	12	Turney	220	23	2	200-220	8-4-81

TABLE 4.
Chemical Composition of Sampled Groundwater

SAMPLE NO.	mg/L							
	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{-}	HCO_3^{-}	$SO_4^{=}$	Cl^{-}
1	71	82	504	6.3	-	205	1325	4
1A	20.6	16.2	559	4.2	2.4	445	1060	4
2	3.5	.4	370	1.3	1.0	573	340	4
3	16.4	15.4	915	6.7	-	609	1650	6
4	3.2	.6	281	1.3	19.4	573	78	4
5	2.5	.6	325	1.3	29	599	110	8
6	3.2	.6	281	1.3	19.4	573	78	4
7	4.1	.4	245	1.3	9.6	385	59	96
8	1.1	.1	214	1.3	25.9	416	13	44
9	16.1	1.1	514	-	67	973	190	38
10	24.6	25.3	384	5	-	526	460	12
11	38.3	45.5	32.5	2.7	-	395	57	2
12	4.0	.3	361	1.3	14.2	867	24	28
13	6.8	.7	533	1.3	1.6	983	333	4
13A	2.9	.7	519	1.3	37.9	928	268	4
14	3	.7	785	-	76	1188	480	15.6
15	27.7	18.3	245	3.8	-	539	262	4
16	3.6	.5	544	.8	109	965	9.0	98
17	54	15.7	18.8	2.5	-	285	22.5	2
18	14.7	2.3	515	1.9	2.3	1059	225	12
19	4.9	.5	325	-	21.1	689	125	-

$NO_3^{\equiv}$	SiO_2	F^-	Fe^{++} (Field)	TDS	pH Lab	pH Field	Conductivity μMhos/cm
-	6.3	-	5.2	2176	8.1	7.1	2950
.3	6.8	.5	2.4	1731	8.4	-	2630
.3	7.1	1.4	.65	970	8.7	8.05	1550
4.4	13.2	.2	1.6	2818	8.1	6.75	3730
.8	7.4	3.1	.01	668	8.6	7.2	1120
1.6	7	4	1.2	786	8.7	8.05	1290
.8	7.4	3.1	.01	668	8.6	8.45	1120
.7	7.1	4.5	.5	607	8.5	7.95	1055
.5	7.3	3.3	.05	491	8.8	7.3	850
1.5	17.3	.3	.7	1384	8.7	6.85	2010
.1	8.5	.3	2.0	1222	8.3	7.35	1840
-	15	.1	.05	380	7.9	6.1	680
1.4	12.5	1.4	1.3	240	8.4	7.65	1380
1.8	8.9	.4	.58	1372	8.7	7.5	2150
1.7	8.4	.4	-	1298	8.7	7.65	2070
.4	13.2	.4	2.5	1942	8.7	7.15	2770
1.9	11.1	.3	1.45	786	8.0	6.7	1230
.4	7.4	.8	.45	1288	9.0	7.35	2160
.6	18.3	.5	3.0	270	8.0	6.9	464
.3	11.4	.5	.09	1332	8.8	7.15	2030
1.7	6.2	1.2	6	882	8.5	6.8	1280

TABLE 5.
Trace Element Concentration in Sampled Waters

SAMPLE NO.	ppb													
	Al	B	Ba	Cr	Cu	Fe	Li	Mn	Mo	P	Sn	Sr	V	Zn
1	141	195	4	24	7	11 000	376	191	<50	116	95	3571	14	49
2	<100	297	8	<20	12	115	106	7	<50	<100	99	63	<10	648
3	43	411	5	26	14	1794	609	215	1426	181	179	1312	13	244
4	<100	129	34	<20	7	71	77	5	41	<100	99	63	<10	24
5	<100	272	103	<20	14	499	83	9	1422	<100	185	58	<10	19
6	<100	144	56	<20	<5	125	55	6	35	<100	128	36	<10	28
7	<100	142	67	<20	13	21	48	<5	1464	<100	226	44	<10	<10
8	<100	378	42	<20	<5	18	43	<5	1417	<100	134	34	<10	<10
9	235	261	129	<20	<5	361	321	68	<50	114	361	130	<10	65
10	63	217	8	14	5	1940	213	320	<50	65	135	811	<10	76
11	69	99	36	<20	39	112	176	658	<50	<100	72	441	<10	26
12	<100	162	51	<20	20	640	108	10	<50	<147	134	48	<10	<10
13	<100	452	9	<20	33	85	314	6	<50	<100	122	84	<10	120
14	<100	146	47	<20	67	3237	310	34	<50	176	269	167	<10	103
15	96	281	24	17	33	2233	192	245	<50	73	97	714	<10	678
16	<100	257	178	<20	7	384	199	8	1432	193	225	130	<10	58
17	<100	66	137	<20	<5	3967	169	841	<50	<100	88	379	<10	34
18	<100	200	147	<20	<5	71	199	8	<50	<100	98	200	<10	369
19	<100	309	53	<20	14	136	136	24	1432	<100	99	81	<10	55

TABLE 6.
Recommended Limits for Trace Elements in Drinking Water

Trace Element	Acceptable Limit (ppm)[1]	Minimum Reporting Limit (ppm)[2]	Detectable Limit (ppm)[2]	Maximum Permissible Limit (ppm)
Aluminum	NA.[3]	0.1	>0.1	-
Arsenic	0.01	<0.1	-	0.05
Barium	1.0	<0.005	-	-
Beryllium	NA.	<0.005	-	-
Boron	5	0.005	-	-
Cadmium	0.01	0.01	-	-
Copper	1.0	0.005	-	-
Chromium	0.05	0.02	-	-
Cobalt	NA.	<0.01	-	-
Iron	0.3	0.02	-	-
Lead	0.05	0.03	-	-
Lithium	5	<0.1	-	-
Manganese	0.1	0.005	-	-
Molybdenum	NA.	<0.05	>0.05	-
Nickel	2.7	<0.03	-	-
Phosphorus	0.2	0.1	>0.1	-
Selenium	0.01	<0.1	-	-
Strontium	0.11	0.005	-	-
Silver	0.05	0.02	-	0.05
Titanium	NA.	0.01	>0.01	-
Tin	NA.	0.02	-	-
Tellurium	NA.	0.05	>0.05	-
Zinc	5	0.01	-	-
Vanadium	NA.	<0.01	>0.01	-

[1](Canadian drinking water standards)
[2](Chemical and Geological Lab)
[3]NA (Not available)

milligram per litre, except in waters of very low pH. The reporting limit for aluminum is 100 ppb. There is no limit set for aluminum in drinking water. Aluminum rarely exceeds the reporting limit in the sampled waters.

BARIUM

Barium concentration in the sampled waters range from 4 ppb to a maximum of 178 ppb, which is lower than the acceptable limit of 1000 ppb for drinking water. Barium salts, when ingested, are highly toxic to man.

BORON

All the waters sampled are within the reporting limit of 5 ppb. An acceptable limit of 5 mg/L (5000 ppb) of boron has been stipulated for drinking water. Boron is rapidly absorbed by the human intestine and excreted in the urine.

CHROMIUM

Chromium is another toxic element. Drinking water supply should not exceed 0.05 mg/L (50 ppb) chromium. The reporting limit for chromium is well below the stipulated limit for drinking waters. All the waters are within the reporting limit, except samples 1 and 3 (Table 5).

COPPER

Copper is essential to plants, animals and human beings. An adult's daily ingestion requirement is 2.0 mg/L. The acceptable limit for drinking water is 1000 ppb and the reporting limit is 5 ppb. A deficiency of copper may cause nutritional anemia in infants, but excessive copper is naturally excreted by the body. All the sampled waters are within the limit for drinking water.

IRON

This survey showed that iron contamination of domestic water supplies is common. About 50 percent of the sampled waters contain iron in excess of the drinking water acceptable limit. Iron ranges in concentrations from 18 ppb to 11 000 ppb. Excessive amounts of iron are objectionable in drinking water because it often causes bad taste and odors. The recommended maximum iron concentration for drinking waters is 0.3 mg/L.

LITHIUM

Lithium is not known to be toxic, and is known to be metabolically necessary for life (Bowen, 1966). It is related to low rates of arteriosclerosis and low rates of mental disorders (Saines, 1972). An acceptable limit of 5000 ppb has been set for lithium in drinking water. The lithium content of the sampled waters range from 43 ppb to 376 ppb.

MANGANESE

The United States Public Health Service recommends an upper limit of 0.05 mg/L (50 ppb) of manganese in drinking water and Health and Welfare Canada stipulates that manganese content should not exceed 1 mg/L or 1000 ppb.

Manganese in drinking water even in large amounts, is not only harmless, but is essential to all life. Manganese takes part in a number of reactions involving enzymes. The samples contain less than the acceptable limit for drinking water.

MOLYBDENUM

Present drinking water standards contain no limit for molybdenum, but the reporting limit is 50 ppb. About 31 percent of the sampled waters contain molybdenum in excess of the reporting limit.

PHOSPHORUS

Phosphorus is not known to be common in groundwater. In the waters sampled, the concentration of phosphorus is less than the stipulated standard of 200 ppb for drinking water. About 30 percent of the samples contain more than the reporting limit of 100 ppb phosphorus.

TIN

No limit is available for tin in drinking water, although concentrations of tin range between 72 ppb and 361 ppb. The hazards of tin in drinking waters are not known. All the sampled waters contain more than the detectable limit of 20 ppb.

Index No.	Brand	Country of Origin	Ca^{++}
MMW - 1	Alpine Distilled Water	Canada	0.1
MMW - 2	Appollinaris	West Germany	79.0
MMW - 3	Perrier	France	170.0
MMW - 4	Montclair	Canada	25.0
MMW - 5	Ferrarelle	France	454.0
MMW - 6	Eau Claire	Canada	82.0
MMW - 7	Canada Dry	United States	18.7
MMW - 8	Mont Blanc	Canada	76.0
MMW - 9	Nanton Water	Canada	56.0

STRONTIUM

Strontium is a fairly common element in minor amounts, replacing calcium or potassium. Some groundwaters contain large amounts of strontium. The acceptable limit in drinking water is 1100 ppb and the reporting limit is 5 ppb. Table 5 shows that the water samples contain strontium in the range of 36 to 3571 ppb.

ZINC

The upper limit for zinc in drinking water is 5 mg/L (5000 ppb). Zinc content of the waters sampled range from <10 to 648 ppb (<0.01 to .648 mg/L).

Silver, arsenic, cadmium, cobalt, nickel, lead, selenium, tellurium and titanium were also measured using argon plasma emission technique. These elements are not reported in the paper because concentrations in the sampled waters are lower than the detectable limit.

CHEMICAL QUALITY OF BOTTLED WATERS

All imported waters are from natural sources and bottled under strict standards established by their respective governments. These waters also meet the local standards stipulated for drinking waters.

There are many standards established by United States Public Health Services, World Health Organization and other organizations. In this study chemical quality of bottled waters are compared with the Canadian drinking water standards stipulated by Health and Welfare Canada.

Chemical compositions of 13 selected bottled waters that were analyzed by the American Public Health Association are shown in Table 1. Water quality of popular brands of bottled waters sold in Quebec is listed in Table 2, and Table 3 gives the chemical quality of bottled waters given by the suppliers.

TABLE 7.
Chemical Composition of Popular Brands of Bottled Waters Sold in Alberta

mg/L										pH
Mg^{++}	Na^{+}	K^{+}	HCO_3	$SO_4^{=}$	Cl^{-}	$NO_3^{\equiv}$	SiO_2	F^{-}	TDS	
-	6.5	3.3	3.7	19.0	2.0	0.2	-	35	5.9	
100.0	631.0	37.5	1742.0	18.00	204.0	1.8	3.3	0.4	1962	6.4
3.9	25.0	2.1	346.0	120.0	40.0	40.0	2.7	-	406	5.6
9.3	16.0	3.8	93.0	40.0	10.0	0.1	2.1	0.4	94	5.2
19.5	59.0	44.2	1642.0	20.0	18.0	3.1	8.9	-	1464	6.1
19.3	5.0	2.5	356.0	29.5	4.0	1.7	2.1	0.1	256	5.9
7.4	264.0	2.9	581.0	80.0	32.0	0.6	0.8	1.0	862	5.7
15.4	8.8	2.1	254.0	40.0	16.0	8.3	1.6	-	252	5.5
24.8	98.0	5.0	453.0	51.0	4.0	7.6	2.1	0.4	432	5.7

Nine popular brands of bottled waters were collected from a local retailer and analyzed for major constituents. Table 7 shows the chemical quality of these bottled waters.

Calcium and magnesium are the major cations of all the bottled waters analyzed. Bicarbonate is the dominant anion with chloride. Piper diagrams (Figs. 3, 4) show the total dissolved solids content of bottled waters. These Piper diagrams indicate that bottled waters can be grouped under calcium-magnesium-bicarbonate and sodium bicarbonate types. Crodo mineral water is the only calcium-magnesium-sulfate water.

SUMMARY AND CONCLUSIONS

The following conclusions may be drawn on the basis of this work:

(1) Most sampled Alberta waters can be grouped can be grouped as sodium-bicarbonate waters, with a few calcium-magnesium-sulfate waters.

(2) Trace element analyses show that, except for strontium and phosphorus, all other trace elements are well below the acceptable limit for drinking water.

(3) Fluorides and iron are quite high in most of the domestic water samples.

The chemical quality of waters in Alberta is comparable to that of commercial waters. These waters could be profitably marketed after treatment to remove iron and fluoride.

SUGGESTIONS FOR FUTURE WORK

There are waters with different chemical compositions suitable for other uses such as food processing, brewing, laundry, boilers, and other agricultural and industrial uses. Care should be taken to study the chemical quality of these waters in order to assess their utility. Further research should be conducted on a larger scale by sampling high capacity domestic wells and evaluating the hydrochemical characteristics of aquifers in Alberta.

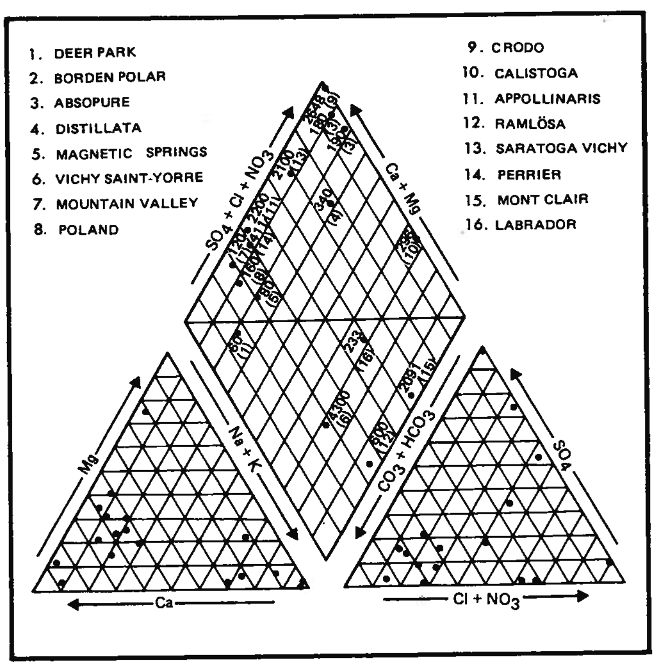

FIGURE 3. Piper diagram showing total dissolved solids of the bottled waters from tables 1 and 2.

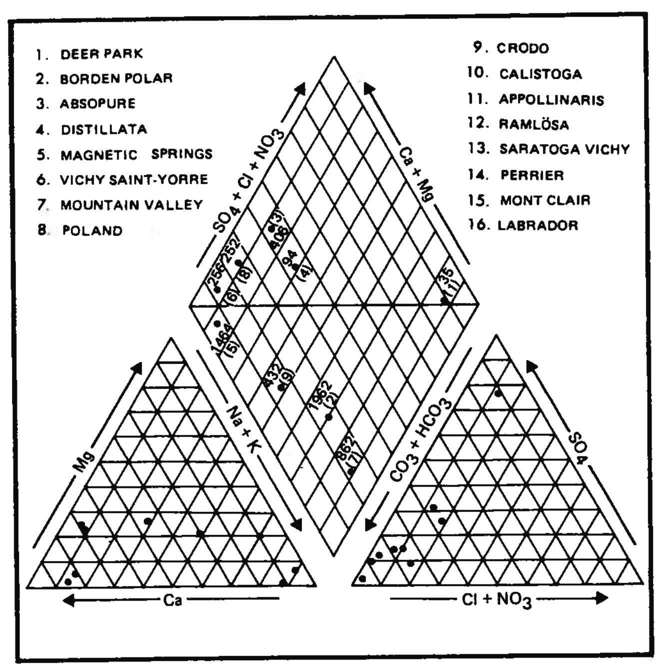

FIGURE 4. Piper diagram showing the total dissolved solids of the popular brands of bottled waters sold in Alberta.

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