Earth Sciences Report 82-3

SPRINGS OF ALBERTA

By D. Borneuf

Alberta Research Council
1983

Copies of this report are available from:

Alberta Research Council
Editing and Publications Department
5th Floor, Terrace Plaza
4445 Calgary Trail South
Edmonton, Alberta
T6H 5R7
phone: 438-1666

Alberta Research Council
Industrial and Engineering Services
Petroleum Recovery Institute
2nd Floor, 3512 - 33 St. NW
Calgary, Alberta
T2L 2A6
phone: 282-9136

ABSTRACT

Many springs in Alberta have been studied and observed — some observations date back as far as 1898. In the recent past, various authors and organizations have made observations and published a few studies. This report looks at about 600 springs on a provincial scale.

The province of Alberta has a variety of springs, a variety which is directly related to geology and lithology, to the topography and, thus, to groundwater flow, and to the position of a spring relative to a particular physiographic region. The first part of this report looks at the spatial distribution of the springs by region, flow rate, water temperature, and water chemistry. In the second part, the report describes in detail several springs that were chosen because of the magnitude of their discharge (Maligne Canyon karst springs), or because of their geologic and lithologic setting (Storm Creek Springs, Butte Springs, and Bow Island Spring), or because of associated mineral depositions and their chemical characteristics (La Saline Spring, Obed Spring).

Springs having the largest discharge and the least mineralization are generally found in the Rocky Mountains where fracture, fissure, and cavity-type permeabilities are encountered, together with steep groundwater gradients, relatively short flow systems, large amounts of precipitation, and proximity to recharge areas. Away from the Rocky Mountains and towards the northeast and the southeast of the province, the character of the permeability changes to an intergranular type, although there is some fracturing of the sediments in the plains. Groundwater gradients are moderate and flow systems are possibly longer than in the mountains. Water quality deteriorates towards the northeast and the southeast. In general, spring waters change from a calcium-magnesium bicarbonate type in the Rocky Mountains to a calcium-magnesium sulfate or sodium-sulfate type in the Interior Plains to a sodium-chloride type in the Devonian subcrop area in northeastern Alberta.

TABLE OF CONTENTS

PLATES

TABLE

ILLUSTRATIONS

INTRODUCTION

Spring, in this report, is defined by Meinzer (1923): "A spring is a place where, without the agency of man, water flows from a rock or soil upon the land or into a body of surface water."

Springs have been used by man since time immemorial. Some springs were considered sacred in ancient times, and the curing qualities of some springs were acknowledged then as now in many parts of the world. Villages, towns, and cities all over the world use or have used springs for their water supplies. Spring waters, for many people, are a symbol of purity and are used in manufacturing food products and beverages. Advertising adroitly emphasizes the use of these waters — Cool Spring beer in Alberta, for example. Several fish-rearing stations in Alberta (Waterton, Jasper, and Raven hatcheries) have used or still use spring water.

In Alberta, although springs have been observed for a long time, this natural phenomenon has not been studied on a provincial basis. The location of springs, particularly well-known springs such as the Crowsnest Spring, have been indicated on topographical and geological maps of Alberta from as early as 1941 (Beach and Hume, 1941). The Middle and Upper Hot Springs at Banff and Miette Hot Springs in Jasper National Park have been advertised widely as tourist attractions.

Springs are mentioned in geological (Allan and Sanderson, 1945; Allan and Carr, 1947) and other reports of the Alberta Research Council where springs and other discharge features are discussed to some extent. Many springs found, observed, and sampled during the course of field work are indicated on the Alberta Research Council's hydrogeological maps and are mentioned in various reports (Tóth, 1966, 1971; Tokarsky, 1971a, 1971b, 1974; Ozoray, 1972, 1974, 1976; Ozoray *et al.*, 1980; Vanden Berg and Geiger, 1973; Borneuf, 1974; Hackbarth, 1975; Currie, 1976a, 1976b and Stein, 1976). This study describes the physical and chemical characteristics of many springs in Alberta in order to evaluate aspects such as discharge, water quality, and pollution, and to relate these to potential use.

Springs selected for study are characterized by one or both of the following features: (1) a flow rate equal to or greater than 3.8 L/s (50 igpm); (2) a total dissolved solids content equal to or greater than 1000 mg/L. In addition, to provide a better understanding of the variety of springs found throughout the province, several springs presenting strongly developed characteristics were selected — major salt, calcareous tufa, iron or sulfur depositing springs; hot and warm springs; examples of soap hole areas; springs due to man's activities; and a few saline streams and springs related to the presence of Devonian carbonate rocks located in the northeastern part of the province.

This report is in two parts. Part one contains general aspects of springs in Alberta including the distribution of springs by regions, lithologies, flow rates, water temperature, and water chemistry. Part two describes in detail a selection of springs typical of those issuing from the main rock types in the province. Characteristics such as geology, mineral deposits, temperature, and chemistry are described. Each spring area is presented showing topography, drainage, and geology. The relation of each spring to the geology is illustrated on a cross-section, and photographs of many spring sites are presented.

Springs issue mainly from limestones and dolomites, sandstones, shales, coals, evaporites, colluvium, and alluvium. Appendix A contains a list of the springs used in this report.

PREVIOUS WORK AND PRESENT INVESTIGATION

Thermal and mineral springs found in the province were observed and described by Dowling (1911, 1912); Elworthy (1917, 1918, 1926); Satterly and Elworthy (1917); Warren (1927); Pickering (1954); and Waring (1965). Tilden (1898) mentioned algae in the Banff Upper Hot Springs. Boyle and McIntosh (1914) talked about the presence of radium in some western Canada springs. Some thermal and mineral springs in the southern Rocky Mountains of Alberta and British Columbia were observed and described by van Everdingen (1972). Souther and Halstead (1973) reviewed the mineral and thermal waters of Canada. Karst spring studies have been conducted parallel to karst studies by Brown (1970) and Ford (1971a and b). These studies cover such mountain springs as the Crowsnest, Ptolemy, Castleguard, and Maligne Canyon karst springs, the latter being the largest in the province and among the largest in the world. The Butte Springs, a few miles southeast of Rocky Mountain House, have been studied and portions of the observations were reported by Geoscience Consulting Ltd. (1975). Numerous springs of varying importance have been observed and sampled by various investigators of the Alberta Research Council in all parts of the province. Hydrogeological maps published by the Alberta Research Council show many of these springs. This information has been gathered throughout the years and is stored in the files of the Groundwater Department of the Alberta Research Council. Data for this report are from those files and from various other reports, supplemented by additional information gathered in the field during the summer and fall of 1976, during which time observations and samplings were conducted in every physiographic region of the province. Field work also included an airborne survey in the northeastern region of the province.

PART ONE

THE PHENOMENON OF SPRINGS

Figure 1 outlines the groundwater regions of the province (Ozoray, pers. comm.). These regions are general subdivisions based on geology, orography, climate, vegetation, and soils. The main subdivisions are based on the orography and geologic setting of which the province is divided into the Rocky Mountains, the foothills, the crystalline shield, and the Interior Plains region, which is further divided into sub-regions such as the oil sands area of the Fort McMurray region and the Devonian subcrop area. The Interior Plains are mostly composed of soft Cretaceous sediments.

The climate, vegetation, and soils allow a further subdivision of the Interior Plains into four sub-regions. One such region extends from northwest of High Level in the northwestern part of the province to southeast of the town of St. Paul in east-central Alberta. This sub-region is forested and has short cool summers. The second sub-region, which extends south of the first sub-region, is forested and has a foothills ecosystem. Examples of the third type of sub-region, which has parkland and grassland vegetation and long cool summers, are the Peace River-Grande Prairie area, the areas around Edmonton, Red Deer, and Calgary, and the area west of Lethbridge. Finally, the steppe sub-region, with both moist and dry grassland, is found in southeastern Alberta.

OCCURRENCE AND DISTRIBUTION

Springs are found in a wide range of geographic and hydrogeologic settings, and are frequently found at break points in slopes. Some springs issue from pools like the Ink Pots. "The name Ink Pots was given by the Warden Service of Banff National Park to a group of springs located in that Park. It is based on the one feature that makes these springs of more than passing interest, namely the greenish milky appearance of the water in ponds 5 and 6 as compared with that of the other ponds" (modified from van Everdingen, 1972). A similar example is found in Bow Valley Provincial Park. Other springs issue from the bottom of lakes like the blue holes (Barnes, pers. comm.); the blue-hole springs are a variation of the Ink-Pot types in that these springs issue from the bottom of lakes and that the water is a similar color. They have been observed in the Brazeau area (Plate 1), in Maligne Lake, and in other parts of the Rocky Mountains and foothills. Others start at high elevations from perched aquifers (Storm Creek Spring, see page 42). The various types of springs are related to the permeability characteristics of the aquifer from which they issue. These permeabilities can be of intergranular, fissure, fracture, dissolution channel, or fault type, or a combination of all of these. Springs can also be the result of sharp permeability contrasts, as in contact springs.

The most common and widespread type of spring is the contact spring, which is found mainly in the Interior Plains. Contact springs are found at the contact between two layers of materials with sharply contrasting permeabilities, such as surficial sediments resting on shales or sandstones of lesser permeability, or sandstones resting on top of shales. Very often seepages are contact springs. At Trapper's Cabin Spring (Appendix A, No. 355) near

PLATE 1. Blue holes in the Brazeau River valley

Rocky Mountain House, groundwater discharges from surficial sediments (sands, gravels, and clays) overlying shales; spring waters here deposit calcareous tufa over a fairly large area (Plate 2). In the Edson area similar springs have been observed at several locations (Appendix A, Nos. 439, 441, 445). Springs of this type have also been found along the eastern shore of Long Lake (Appendix A, No. 187) and in the Cypress Hills Park. Within the Edmonton city limits, on the north bank of the North Saskatchewan River to the west of the Groat Bridge, a series of springs issue at the contact between the till and the underlying shales of the Wapiti Formation (Appendix A, Nos. 168-169).

Although springs issuing from fissures and fractures are sometimes found in the plains region of Alberta, the majority of such springs, due to the presence of faults and dissolution channels, are found in the Rocky Mountains and the foothills regions of Alberta. Turtle Springs, located to the west of the Frank Slide in southwestern Alberta, are probably related to the presence of the Turtle Mountain thrust fault. Banff Upper Hot Springs may be related to the Sulphur Mountain thrust fault; the Fortune Spring west of the Spray Lakes reservoir to the presence of the Bourgeau thrust; Miette Hot Springs to the presence of the Hot Spring fault; and Canyon Creek Spring, southwest of the town of Bragg Creek, is located near the axis of an anticline in the Banff and underlying formations.

In the Rocky Mountains regions, many karst springs have been located and observed. A karst spring can be defined as the natual occurrence of a stream from a karst, which, in turn, can be defined as "the aggregate of the characteristic landforms produced primarily as a result of solutional removal of mineral in rock" (Ford and Quinlan, 1973). Karst springs are numerous and some are quite spectacular. The most important ones are the

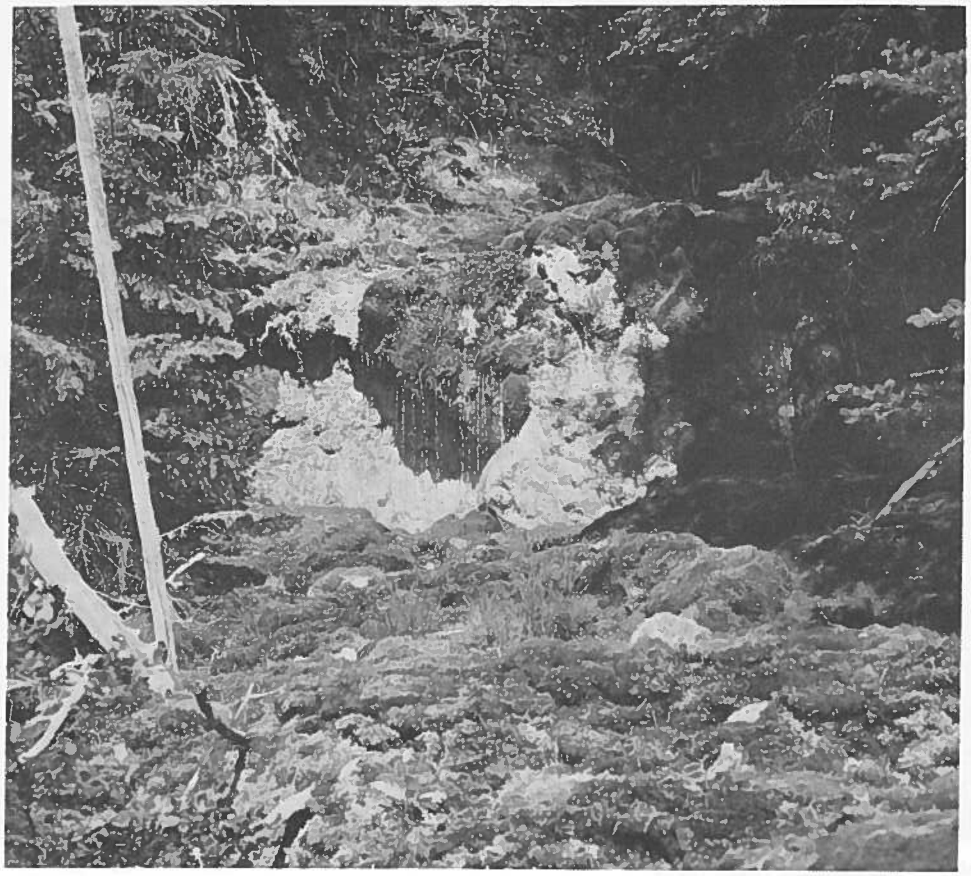


PLATE 2. Calcareous tufa deposition at Trapper's Cabin Spring, west of Rocky Mountain House

Maligne Canyon karst springs, the Castleguard Big Springs, the Canyon Creek Springs, and the Crowsnest and Ptolemy karst springs.

The Butte Springs (see page 34), southeast of Rocky Mountain House, belong to a different type of spring; they appear to be a resurgence of the waters of the Clearwater River through underflow in sand and gravel deposits. A similar situation appears to exist close to the town of Okotoks in south-central Alberta. As indicated by the temperature data, the Bow Island group of springs (see page 40), which issues from gravels, is probably from a resurgence of water from a lake above and upstream from them.

Figure 1 shows that, of the 568 springs included in this study, most are in the Rocky Mountain and foothills regions. These two physiographic areas also have the largest and most spectacular springs found in the province issuing from karstic rocks (Maligne Canyon, page 19; Mount Castleguard, page 21; and Crowsnest, page 21). The Alberta Interior Plains contain an uneven scatter of springs with the greatest concentration in a belt more or less parallel to the foothills and extending from Grimshaw in the northwest to the Cypress Hills in the southeast. In the remainder of the Interior Plains, springs are distributed sparsely.

DISCHARGE

The magnitude of discharge from springs largely depends on the permeability of the water-bearing material, the hydraulic gradient, and the amount of water available for recharge.

The presence of predominantly fracture and cavity-type permeabilities partly explains the larger discharge values in the foothills and mountain regions compared with the Interior Plains where intergranular permeability is most common. Also, annual precipitation, which is directly related to the amount of water available for recharge to aquifers, differs significantly from about 230 mm (9 in) in the southeastern part of the province to 1020 mm (40 in) and possibly higher in the mountain regions (Environment Canada, 1973).

The discharge of springs in various environments in Alberta ranges from innumerable trickles to very large outflows such as Maligne Canyon karst springs in Jasper National Park. These karst springs have a maximum discharge rate greater than 37 m^3/s (about 800 cfs) (Plate 3), making them "probably the world's largest karst springs" (Ford, 1969). Between these two extremes are numerous springs with discharge rates of less than 3.8 L/s (50 igpm) in all regions of the province. Figure 1 contains the location and the order of magnitude for Alberta springs included in this report. Most springs in the Interior Plains have discharge rates of 3.8 L/s (50 igpm) or less, with a very few exceptions, such as Bow Island Springs (see page 40) and the one located below Waterton reservoir (Appendix A, No. 27). These springs are exceptions because of local conditions; they issue from alluvial sediments (sands and gravels).

Table 1 shows the distribution of discharge rates for springs included in this report.

About 77 percent of the springs have discharge rates ranging from 0.1 to 100 L/s (1.32 to 1320 igpm) (Table 1) and belong to the fourth, fifth, and sixth orders of magnitude. Within these three categories, 42 percent belong to the fifth order of magnitude (1 to 10 L/s or 13.2 to 132 igpm). In general, the discharge rates decrease from the mountains towards the plains (Fig. 1). The combined effects of steep gradients, extensive fracture permeability, the nature of the sediments, and higher precipitation values result in higher discharge rates in the mountains and foothills regions. The combined effects of gentle gradients, intergranular permeability, generally lower precipitation values, and the nature of the sediments are responsible for much lower discharge rates in the plains, particularly in northeastern Alberta.

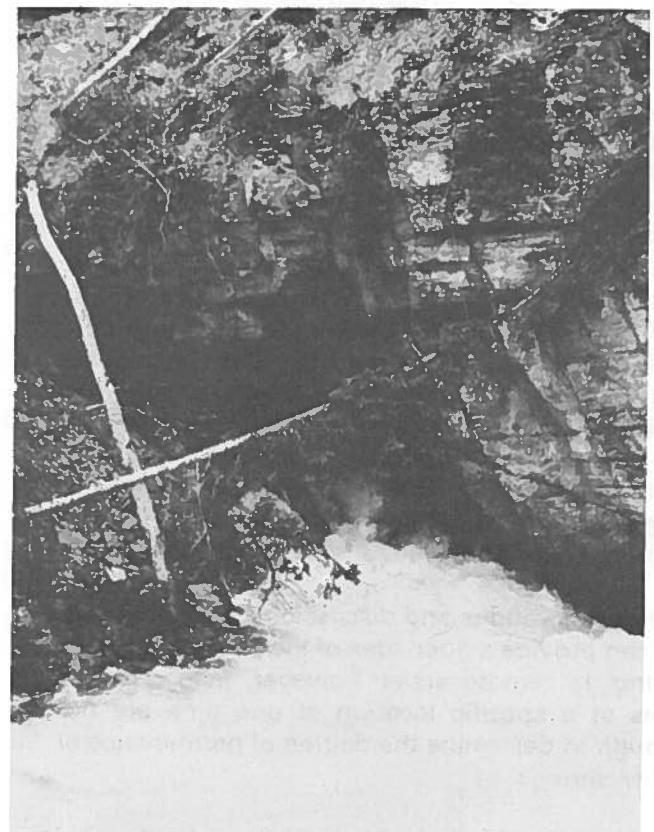


PLATE 3. One of the Maligne Canyon springs, in the lower Maligne Canyon

The exceptions to this trend are due to local conditions; for example, the occurrence of more permeable alluvium or bedrock channel sediments results in higher discharge rates.

VARIABILITY OF DISCHARGE RATES AND PERMANENCE

The discharge rates of individual springs vary greatly, more so for those located in the foothills and mountain regions than for those in the plains. An example of the variability in spring discharge is Butte Springs (see page 34) in the foothills region about 26 km (16 mi) southeast of Rocky Mountain House. "The springs are located 1½ miles or less from the Clearwater River and are due to underflow of river water through alluvial gravels at low points on the alluvial flats" (Geoscience Consulting Ltd., 1975). The discharge of these springs was measured periodically for eighteen months (1971-72) and was found to range from 230 L/s to 4242 L/s (3000 to 56 000 igpm). A karst spring (Appendix A, No. 352), found along the northern shore of Abraham Lake (Fig. 2) west of the town of Nordegg, that issues from limestone, had an estimated discharge of about 760 L/s (10 000 igpm) at the end of July 1976; a week later the flow had decreased to about 4 L/s (50 igpm). Discharge from the Castleguard Big Springs (see page 21) (karst) was found to range from 9.1 to >11.3 m^3/s (320 to >400 cfs) in a ten day period in August 1961; in April 1961, these springs were entirely dry (Ford, 1969). The Banff Upper Hot Springs (Appendix A, No. 288) dried up completely in March 1923 (van Everdingen, 1972).

Field observations and discussions with local people can provide a good idea of the permanence of a spring. In remote areas, however, field observations at a specific location at one time are not enough to determine the degree of permanence of many springs.

Calcareous tufa deposits indicate once flowing springs that are now dry; for example, in the Brazeau River valley and south of the Bistcho Lake area in northwestern Alberta. Many springs in all three physiographic regions are probably non-permanent.

In probably 99 percent of the cases, the flow regime of Alberta springs is unknown. Eighteen months of discharge measurements were taken at Butte Springs (see page 34) and at the Maligne karst springs (see page 19). In general, spring discharges have seldom been monitored. The study of hydrographs of various types of springs in various environments throughout the province would provide valuable information concerning the question

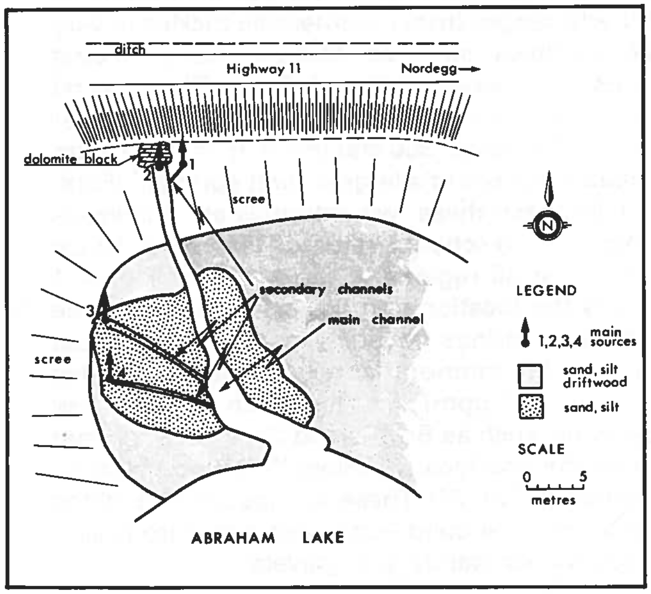


FIGURE 2. Abraham Lake Springs

TABLE 1. Distribution of spring discharge rates

	Discharge rate* Metric	English	No. of springs**	Percent
I	>10 m^3/s	>132 000 (igpm)	1	0.2
II	1-10 m^3/s	13 200-132 000 (igpm)	2	0.5
III	0.1-1 m^3/s	1320-13 200 (igpm)	23	5.6
IV	10-100 L/s	132-1320 (igpm)	76	18.7
V	1-10 L/s	13.2-132 (igpm)	172	42.3
VI	0.1-1 L/s	1.32-13.2 (igpm)	64	15.7
VII	0.01-0.1 L/s	0.13-1.32 (igpm)	33	8.1
VIII	<0.01 L/s	<0.13 (igpm)	35	8.6

*After Meinzer (1923) I, II etc: Meinzer's order of magnitude
**Springs with known discharge rates that are included in this report

of the rates of recharge and the permeabilities of various aquifers. These rates of recharge and, to some degree, the permeability values, are not very well known and are often guessed at when trying to establish a groundwater balance. These aspects deserve study.

TEMPERATURES

Various geographic, climatologic, and hydrologic factors acting individually or together influence spring temperatures. Geographic factors include latitude, altitude, and the nature of the vegetative cover. Climatologic factors are mean annual air temperature and influence of precipitation. Hydrologic factors are the length of flowpath from the recharge to the discharge point at the spring, permeability of the sediments along that same flow path, and depth to which the water travels before reaching the spring.

The temperatures of the springs included in this report were measured at different times of the year. The range of temperatures (see Fig. 3) varied from less than 1°C in the mountains and the northern parts of the province, to 51.2°C at Miette Hot Springs (Appendix A, No. 432).

The coldest and hottest springs in Alberta are located in mountain and foothill areas. The mountains-foothills area can be divided into a northern half and a southern half with respect to temperature values. According to the data available to date, the northern half of the area has cooler spring temperatures on the average. An area of warmer springs surrounds Miette Hot Springs (see Appendix A, No. 432). Only one spring found in this general area, however, would be considered warm (according to the definition of Schoeller, 1962): "A warm spring is one whose temperature is at least 5°C above the mean annual air temperature." This spring has a temperature of 12°C, compared to a mean annual air temperature of 2.6°C at Jasper town. Two springs near the Alberta-British Columbia boundary (Appendix A, Nos. 541 and 548) can also be considered warm springs with temperatures of 9°C and 14°C. The northern half of that same area has two other warm springs. One should be careful, however, when examining these temperature values, because continuous temperature records are unavailable for the province, excepting those of Miette Hot Springs (see Appendix A, No. 432). Several of these springs may possibly be warmed by the sun.

The springs of the southern half of the mountains-foothills region have, on the average, higher temperatures, particularly south and east of the area of Banff Upper Hot Springs (Appendix A, No. 288) and Vermilion Lakes Hot Spring (Appendix A, No. 290), whose average water temperatures are 45.4°C and 20°C, respectively.

The high temperatures of Miette and Banff Springs may indicate deep groundwater circulation, possibly related to faults in the area. If one uses a geothermal gradient of 1°C/33 m (100 ft) of depth increase (AAPG, 1976) and a mean annual air temperature of 2.8°C and 2.6°C (Environment Canada, 1973) for the towns of Jasper and Banff, respectively, the depth of groundwater circulation would be equal to 1620 m (5320 ft) for Miette Hot Springs (Appendix A, No. 432) and 1480 m (4860 ft) for Banff Upper Hot Springs (Appendix A, No. 288). This, however, is only an approximation. A cooling effect may occur if ascending hot water is being mixed with colder water at shallower depths and the geothermal gradient may be different from the value used here.

Warm and hot springs are the exception rather than the rule in the mountains-foothills region of the province. Spring waters are usually cold in these areas, ranging from less than 1°C to about 5°C.

Cold and warm springs are found in the Interior Plains. In southern Alberta, temperatures above 5°C are found along a band parallel to the foothills. The reasons for this trend, which are not known, could be due to many factors. Heat from the sun could be an important reason, at least in southern Alberta. One spring with a temperature of 14°C, at the northern end of this trend, has been reported to be truly a warm spring (Barnes, pers. comm., 1975). In northern Alberta south of Bistcho Lake, most water temperatures measured in 1977 were above 10 to 12°C, except one spring associated with tufa deposition which had a temperature of 1.3°C. This low temperature is probably due to the fact that the spring is located in the discontinuous permafrost zone.

In the rest of the province, temperatures range up to 21°C but, due to a poor distribution and scarcity of temperature measurements, a particular trend cannot be discerned.

CHEMICAL TYPES

Generally, mineralization and chemical types of spring water vary greatly over the province of Alberta. In contrast to this provincial diversity, regional unity is obvious in the mountains, the foothills, and the northeastern portions of the province (see Fig. 5, the Piper diagram). The map of chemical types (Fig. 4) also indicates the types of spring waters in the main physiographic regions of the province.

Mineralization of Spring Waters

Total dissolved solids (TDS) values of water from springs throughout the province range from a minimum of 22 mg/L in the mountains to over 300 000 mg/L in the Devonian subcrop area in the northeastern part of Alberta. This wide range of values is somewhat misleading because high TDS values are few and are limited to a small area. TDS contents of spring waters are generally low and quite often below 1000 mg/L. Good quality spring waters exist most everywhere in the province, although exceptions are found in various regions.

As mentioned earlier, in the mountains-foothills region, the combined effects of steep gradients, short flow systems, extensive fracture permeability, the nature of the sediments encountered, and higher precipitation are responsible for the lower TDS. The least mineralized (lowest TDS content) spring waters are found in these areas. The great majority of these springs have TDS contents ranging from 24 to about 500 mg/L (Fig. 4) and among these a few have TDS lower than 100 mg/L. Some springs have TDS up to 2450 mg/L. These highest values are found at the boundary between the foothills and the plains regions and also "... in the deeper valleys at the faulted basal contact of thick carbonate rock units" (Barnes, 1977) in the northern half of the mountains-foothills region.

In the plains region of Alberta, the combined effects of gentle gradients, longer flow systems, intergranular as well as local fissure and small fracture permeability in some instances, generally lower precipitation, and the shaley nature of the sediments are responsible for higher TDS contents. In the plains region closest to the northern part of the foothills, the TDS content of spring waters is within the same range as that found in the foothills region. The southern Alberta plains display spring waters with TDS values up to 14 000 mg/L in areas of saline soils. The average TDS in this area is 1850 mg/L. The central portion of the Interior Plains contains spring waters with TDS content ranging from about 500 to 2500 mg/L. In northeastern Alberta, many springs to the west of the Slave River and in the Fort McMurray area have TDS values ranging from about 700 to over 300 000 mg/L. The higher mineralization is related to the presence of Devonian rocks, evaporites in particular.

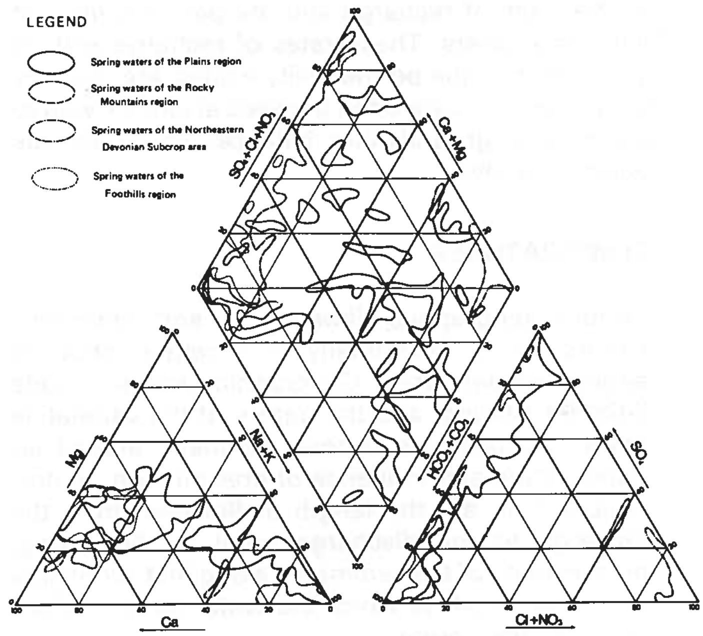


FIGURE 5. Piper diagram showing distribution of chemical types by physiographic regions

CHEMICAL TYPES OF SPRING WATER

Five main chemical types of spring waters are found in Alberta. The dominant chemical type (42 percent of the springs included in this report) is calcium-magnesium bicarbonate. Springs discharging this type of water are found in a variety of rock formations and in most regions of the province with the exception of south-central and northern Alberta. Most spring waters of the mountains and foothills regions are of this type. In addition, the Interior Plains region, directly adjacent to the foothills, has a band about 10 to 110 km (6 to 70 mi) wide of spring waters with the same calcium-magnesium bicarbonate type. TDS content for these springs ranges from a minimum of 23 mg/L in the mountains to 682 mg/L in the plains area closest to the foothills.

The next most common chemical type of spring water (14 percent) is the calcium-magnesium sulfate type, also found in most regions of the province; in the northwestern portion of the Rocky Mountains and foothills, in the central foothills, and in the south and south-central part of the province. The TDS content of spring waters of this type ranges from a low of 388 mg/L in the southern Rocky Mountains to a high of 6759 mg/L in the southern part of the province where many spring waters of this type are found. About 90 percent of these springs contain TDS of about 1000 mg/L.

Nine percent of the spring waters sampled are the sodium sulfate type. This chemical type of water is found exclusively in the Interior Plains and is commonly found in association with spring waters of calcium-magnesium-sulfate type. The largest concentration of springs with this type of water is found in the southern and south-central portions of the province. In these regions, deposition of Glauber's salt can be observed at some spring sites. TDS content in this group ranges from 1000 mg/L in south-central Alberta to 19 660 mg/L in the northeastern part of the province. In the extreme southern region of the province, a cluster of spring waters of this type have a TDS content ranging from about 2000 mg/L to over 14 000 mg/L.

Seven percent of spring waters sampled are of a sodium bicarbonate type and are scattered all over the Interior Plains. TDS content ranges from 432 mg/L to 2970 mg/L.

Spring water of a sodium chloride type (4 percent of the springs) is found almost exclusively in the northeastern region of the province in the Devonian subcrop area. These spring waters also have the highest TDS contents of all the springs in Alberta. In this area, TDS content of spring waters ranges from 1751 mg/L to over 300 000 mg/L. Various types of salt deposition are associated with these springs (see La Saline Springs, page 28).

The waters of the remaining 24 percent of springs belong to other mixed-chemical types and are scattered in the Interior Plains.

The Piper diagram (Fig. 5) shows the distribution of the chemical types of spring waters by physiographic regions. Figure 5 also shows on a provincial scale the evolution of the composition of the spring water from a mainly calcium-magnesium bicarbonate type in the Rocky Mountain regions, characterized by fast moving groundwater resulting from steep gradients and high permeabilities in fissures and fractures; to a calcium-magnesium sulfate or sodium-bicarbonate sulfate type moving more sluggishly through relatively lower permeability (intergranular) sediments throughout the Interior Plains; to a sodium chloride type of water in the evaporite area of the Devonian subcrop area.

MINERAL DEPOSITS ASSOCIATED WITH SPRINGS

Calcareous Tufa

Among mineral deposits associated with springs, calcareous tufa, composed mainly of calcium carbonate, is probably the most common and is found in various regions of the province, including the mountains, the foothills, and parts of the plains region closest to the foothills. The precipitation of calcium carbonate is related to the concentration of carbon dioxide in natural waters. If the concentration of carbon dioxide dissolved in the water is less than the concentration of free CO_2, the solution will not be in equilibrium and $CaCO_3$ will precipitate. This is a widespread phenomenon in various environments throughout the province. Calcareous tufa and marl deposits have been investigated for possible use as soil conditioners in the province by the Alberta Research Council, Geological Survey Department. Some of the springs depositing calcareous tufa included in this report warrant further investigation as possible sources of calcium carbonate to be used as a soil conditioner, with adequate consideration given to preserving the spring site.

Some deposits, such as the ones found at the Jacknife Springs (Appendix A, No. 426) (Ozoray, 1972), are rather unusual. At Jacknife Springs, a travertine mound about 30 m (100 ft) in diameter and 3 m (10 ft) high is topped by a twin-bathtub-like structure composed of calcareous tufa (Fig. 6). During the summer, water very slowly overflows the rims of the bathtubs as well as through the permeable mass of underlying calcareous tufa and around the base of the mound. The total discharge from the springs is quite small and more or less ceases during the winter.

Calcareous tufa deposits have been observed and recorded in the Edson area (Plate 4) (Vogwill, pers. comm.) and in the Mount Robson-Wapiti area (Barnes, 1976). Springs found in association with some of these deposits have been called "boulder type springs" (Vogwill, pers. comm.) because boulders found downstream from the spring are encrusted with calcareous tufa deposits (Plates 5 and 6).

Large calcium carbonate deposits resulting from spring deposits can be seen in Big Hill Springs Provincial Park (Appendix A, No. 292 and Plates 7 and 8) northwest of Calgary. A spring located on private land upstream from the park has deposited tufa along most of the length of the park along the stream issuing from the spring. Close to the western boundary of the park is a natural dam formed by tufa that is at some places 3 to 4 m (10 to 12 ft) high. This dam is perpendicular to the stream bed and could have been formed by the encrustation or petrification of a beaver dam by calcium carbonate. The stream flows through an eroded part of the dam.

In calcareous tufa, petrified vegetal matter is common. In some instances, mosses, leaves, pieces of small branches, molds of twigs and leaf stems are seen; in some cases, minute details can still be observed. A good example of this is found at a spring site in Whitemud Park in Edmonton (Appendix A, No. 167).

Abandoned spring sites can be recognized by the presence of calcareous tufa. Such occurrences have been found in the Rocky Mountains in the Brazeau River valley (Barnes, pers. comm.) (Plate 9). Another abandoned spring site was found north of Zama Lake in northwestern Alberta. Nearby a spring issues from a depression atop a mound of iron oxide. Miette Hot Springs (Appendix A, No. 432) and Banff Upper Hot Springs (Appendix A, No. 288) also have calcareous tufa deposits at sites abandoned by these springs.

Hydrogen Sulfide and Associated Phenomena

Hydrogen sulfide gas (H_2S) commonly occurs in spring waters in the mountains, foothills, and plains. Hydrogen sulfide is related to the presence of bacteria, which are observed in numerous springs. The bacteria can be white, pale yellow, and pale brown and sometimes form filamentous colonies that float gently in the spring waters. The Canyon Creek Spring site (Plate 10), in certain spring waters along the forestry trunk road (Appendix A, No. 362 and Plate 11) and in spring waters near Mountain Park (Appendix A, No. 413), have spectacular colonies of these bacteria. Associated with

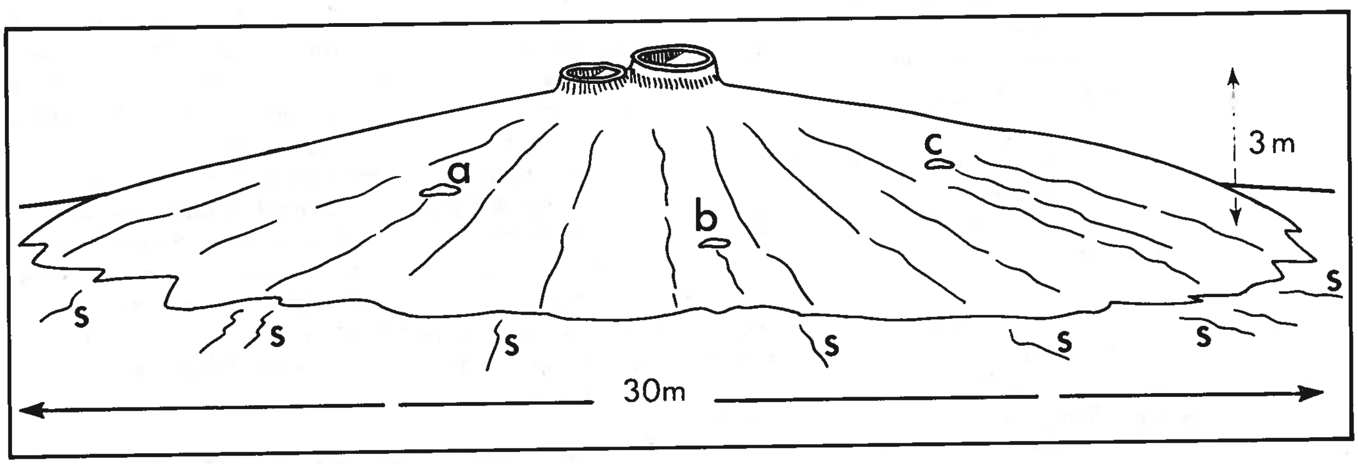


FIGURE 6. Jacknife Spring

PLATE 4. Calcareous tufa deposition in the Edson area

PLATE 5. "Boulder type" spring in the Edson area

PLATE 6. "Boulder type" spring in the Edson area (detail)

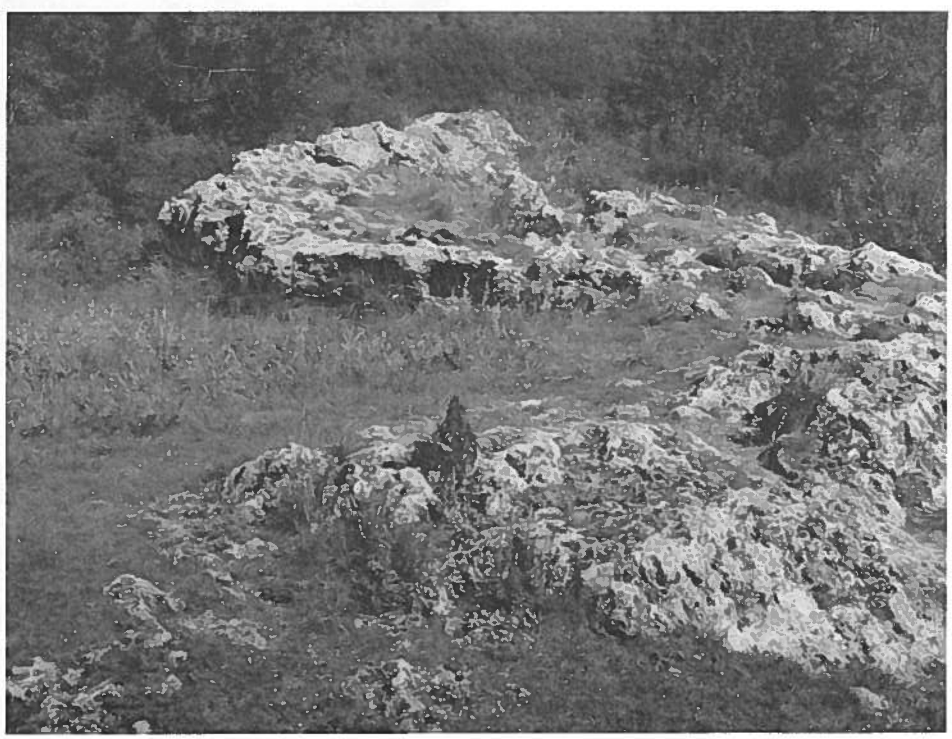


PLATE 7. Big Hill Springs Provincial Park; calcareous tufa deposition

PLATE 8. Big Hill Springs Provincial Park; calcareous tufa deposition (detail)

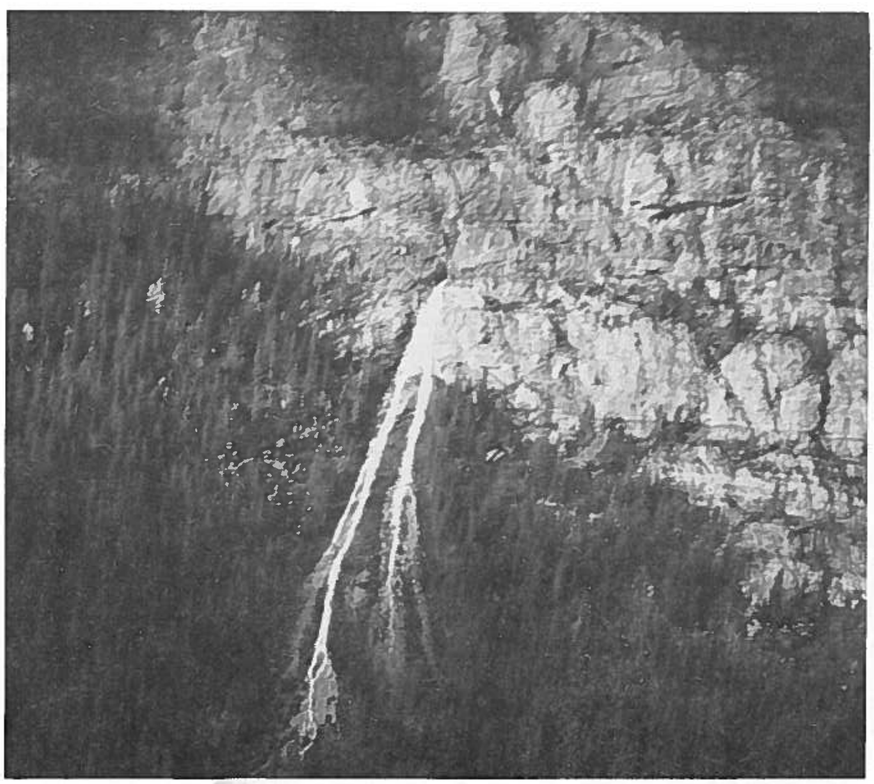


PLATE 9. Abandoned spring orifice in the Brazeau River valley

PLATE 10. Colonies of sulfur bacteria at Canyon Creek Spring site

PLATE 11. Filamentous colonies of bacteria in the foothills region

hydrogen sulfide gas is sulfur, which can be observed either in suspension in spring water, giving it a milky appearance, or as sulfur deposits around the spring orifice. Sulfur deposits and hydrogen sulfide are also present at Banff and Miette Hot Springs (Plate 12).

Hydrogen sulfide is also found at springs depositing iron. Some examples of these springs have been observed in the plains (Appendix A, No. 199). The presence of hydrogen sulfide can be related to the activity of sulfur and iron bacteria. Dirty spring waters often display a strong hydrogen sulfide smell from bacterial activity.

Iron Deposits

Springs that deposit iron are a common occurrence in the province. Only those that show substantial amounts of deposit have been indicated on Figure 1. These iron-depositing springs frequently originate in surficial deposits; however, iron staining is quite common in other types of springs. Iron staining is common in spring outlets from fractures in sandstones, shales, and coals, as well as in colluvial and alluvial sediments. The delta of the McIvor River at the southern end of Lake Claire in northeastern Alberta displays spectacular iron precipitation.

Salts

Salt deposits have been seen at many localities in the province. Glauber's salt, in the southern, south-central, and northeastern Alberta regions, is often associated with discharge areas. Sodium chloride is found around several springs in northeastern Alberta. A few examples of salt deposition are found in the Lake Claire-Fort Chipewyan area in northeastern Alberta, and at La Saline Springs (Plate 13 and page 28) north of Fort McMurray and south of Fort Smith, Northwest Territories (Appendix A, No. 231). All these latter springs issue from Devonian rocks. Also, in the same area, several streams discharge brines; some of their names reflect their chemical composition, for instance, Brine Creek, Salt River.

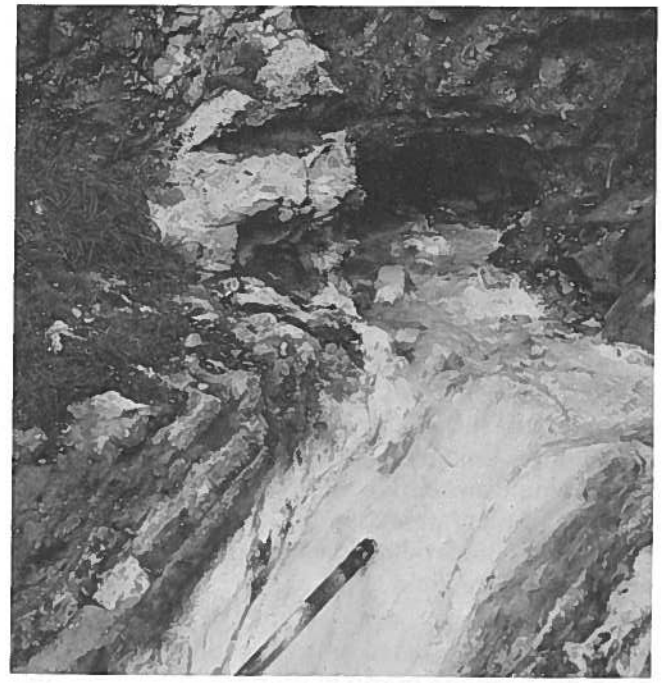


PLATE 12. Sulfur deposition at one of the outlets of Miette Hot Springs

PLATE 13. Salt deposition at La Saline Springs, north of Fort McMurray

Salicornia, a red plant that thrives on salt is common in salt-laden discharge areas. A striking example of this is found in the McIvor Delta at the southern end of Lake Claire.

POLLUTION OF SPRINGS

Evidence of spring pollution is minimal. One example was encountered in southern Alberta where garbage and refuse are dumped at a spring site (Lsd 16, Sec 28, Tp 21, R 13, W 4th Mer). The extent to which the water chemistry of the spring is modified is unknown. Nitrates are not present in detrimental amounts; the water is a calcium-magnesium-sulfate type; but the TDS content is 3068 mg/L. Bacteriological analyses of the spring water are unavailable.

A water sample collection from a spring issuing out of an old garbage dump in Edmonton (Lsd 14, Sec 33, Tp 52, R 24, W 4th Mer) had TDS content of 2330 mg/L. The spring water is a sodium sulfate type. Again, bacteriological analyses of the spring water are unavailable.

Mining operations create various pollution problems. Ammonium nitrate used for blasting in coal mining operations finds its way into spring and stream waters in the Grande Cache area.

Waters coming out of coal mines are diverted into streams. These waters are often loaded with iron, such as in the Coleman area (Plate 14). Water flowing out of a mine tunnel at about 75 L/s (1000 igpm) is directed to a wooden canal in which weirs are placed at about 1.5 m (5 ft) intervals to allow the iron to precipitate before the water is diverted into a nearby stream.

Although examples of spring pollution are few, the probability of pollution is higher for springs issuing from highly fractured rocks and in karst areas of the province. As the pressure of industrial and recreational development increases towards more remote areas of the province, the probability of pollution of spring waters will be higher and steps will have to be taken to protect spring catchment areas. Pollution of springs will more likely occur in developed areas of the province where pressure from industrial and recreational activities is more intense.

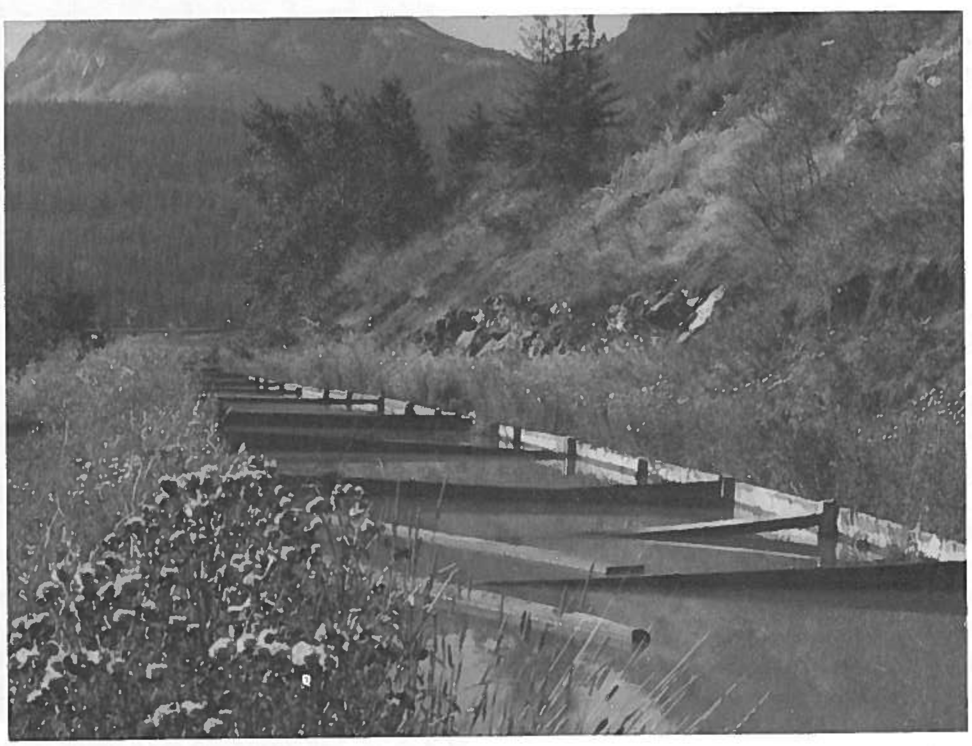


PLATE 14. Discharge of mine tunnel water in the town of Coleman

USE OF SPRING WATERS IN ALBERTA

Other than small springs used by farmers for their own water supply or for watering their cattle, springs are not used widely for medium and large water supplies in Alberta. The main reasons for this are that water wells are more convenient, they can be located closer than springs, and they are easier to keep unpolluted. Although spring waters have not been tapped extensively, as population centers grow, this resource may need to be developed. The chemical analyses included in this study could serve as a reference for further studies, and especially for any change occurring in the water quality of these springs, since most of the springs included here are still in a virgin or near-virgin state.

The medium- and large-sized springs that are or were used to some extent either commercially or industrially are as follows:

— Raven Spring near Caroline, west of Innisfail (Appendix A, No. 327), and a spring at the lower portion of the Maligne River close to the town of Jasper (Appendix A, No. 503) are, or were, used for fish rearing (Plate 15). In the past, another fish-rearing station in the Waterton National Park also used spring water.

— At Whitelaw in northwestern Alberta and Nanton in south-central Alberta, springs are used for water supplies.

— Miette Hot Springs and Banff Sulfur Hot Springs in Jasper and Banff National Parks are used for tourist bathing facilities.

— Several campsites in the province probably use springs for occasional water supplies during the summer months. A few provincial parks such as Beauvais Lake and Bragg Creek Provincial Parks have considered using springs for their water supplies. In the Cypress Hills Provincial Park, Nichol Spring (Appendix A, No. 36) provides water for one picnic site, and Big Hill Springs Provincial Park (Appendix A, No. 292 and Plates 7 and 8) 22 k (15 mi) north of Cochrane has been created to preserve a

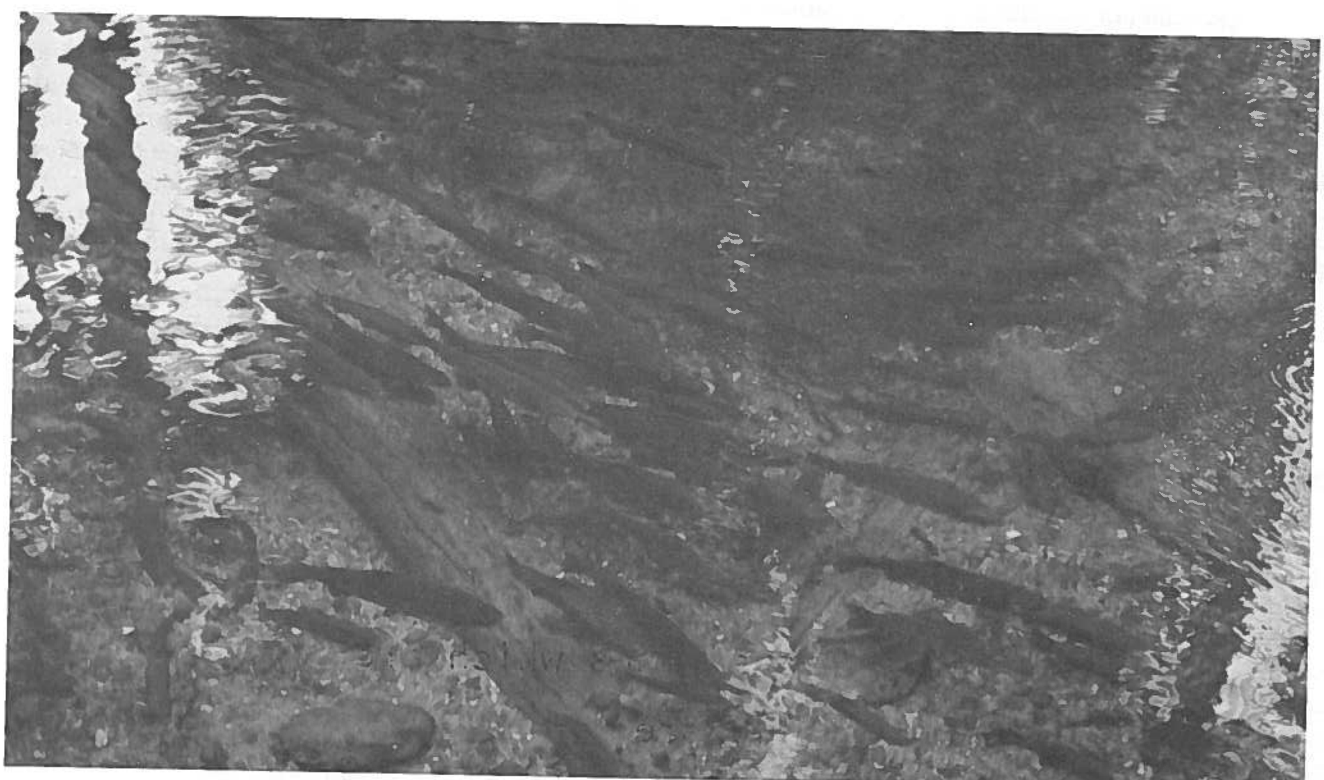


PLATE 15. Trout rearing at the Raven trout rearing station

magnificent display of spring water cascading over large and extensive calcareous tufa deposits. Numerous examples of magnificent tufa deposits, which can be found in many regions of the province, deserve to be kept intact by preservation within small provincial parks in a manner similar to the one used when Big Hill Springs Provincial Park was created.

Spring Catchments

Most spring catchments derive their water from natural discharge without touching the water in storage in the aquifer. Different types of catchments have been built to capture spring waters in various parts of the world and many cities and towns depend on springs for their water supplies.

In Alberta, spring catchments are usually built by farmers. Designs are simple and common construction materials are used. Usually, construction of the spring catchment consists of excavating at the spring site and installing either a length of steel culvert or a wooden cribbing, or sometimes a masonry structure with an overflow. At other times, a pipe (steel or plastic) is driven horizontally into the sediments and water is directed to a cistern or other reservoir. Figure 7 (after Todd, 1960) is an example of a good spring catchment.

The main concern in the construction of spring catchments is to protect the site against pollution, be it from man's activities or from animals. The spring site is protected by fencing it off, by keeping

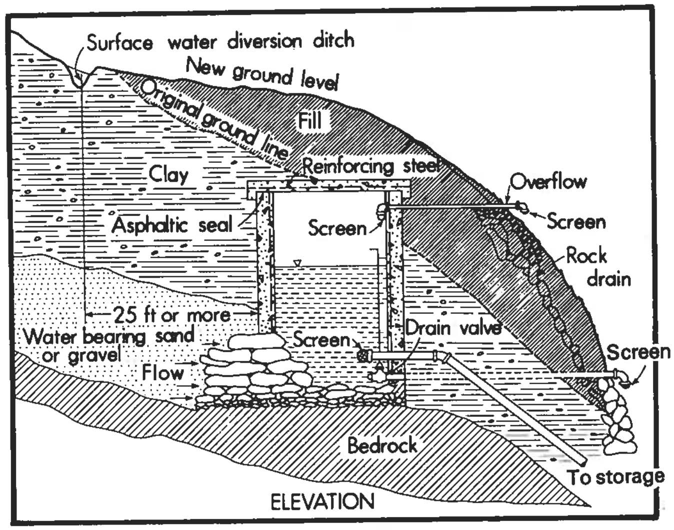


FIGURE 7. Typical method of sanitary protection for a spring (after Todd, 1960)

the site clean, and by chlorinating the spring water if it is to be used for human consumption. Standards for construction and sanitary protection of spring catchments should be developed just as they have been for the water well industry in this province.

When dealing with karst springs, it is obvious that, due to the extensive fracture permeability systems involved, pollution is likely to reach spring outlets quickly; thus, the spring basin should be protected. This is not an easy task when one considers the complexity of outlining the basin of a spring in a karst environment.

PART TWO

DESCRIPTION OF INDIVIDUAL SPRINGS

This section describes some springs that issue from the various rock formations throughout the province, selected on the basis of their size and typicalness. Examples of springs issuing from limestones, sandstones, shales, coal beds, alluvium, and colluvium are described. Unique hydrogeologic features, soap holes, which can be considered springs, are also described. A bedrock geology map of Alberta is included (Fig. 30) for the convenience of the reader.

KARST SPRINGS

The largest and most spectacular springs in Alberta are karst springs. These springs are mainly in the Rocky Mountain regions and in northeastern Alberta. Ford and Quinlan (1973) have worked extensively on the inventory and study of the karst regions of Canada. In addition, Ford (1969, 1971) and Ford and Quinlan (1973) studied the main karst areas of the province and presented information about the main karst springs. Brown (1970) describes in detail the karst geomorphology and hydrogeology of the lower Maligne Basin in which the largest karst springs of the province are found. Other smaller karst springs have been observed in the field by various investigators of the Alberta Research Council during several field seasons: Tokarsky (1971b, 1974); Barnes (1976); Ozoray *et al.* (1980); and Borneuf (1979).

The following definitions of karst and karst springs are excerpts from International Association of Hydrogeologists (1975) Glossary of karst hydrology *in* Hydrogeology of Karst Terrains:

Karst

(a) Definition of karstic region: region underlain by compact and soluble carbonate rocks in which appear distinctive surficial and subterranean features, caused by solutional erosion.

Karst regions are characterized by limestones and other soluble rocks at or near land surface that have been modified by solution erosion.

(Note: the term can also be applied to any region made up of soluble rocks: gypsum, salt, etc.).

(b) In a broader sense, the term is utilized to designate every phase of the karstification process in karstifiable rocks.

Karstic spring (Synonym: karstic emergence or discharge)

Any natural appearance of a watercourse originating from a karst. Numerous types of karstic springs are distinguishable (according to the origin of their water, to their regime, to their morphology and to their geographic or geologic location).

Karst terrains in Alberta are found in two main areas of the province, the northeastern Interior Plains and the Rocky Mountains.

Several authors (Ford and Quinlan, 1973; Ozoray, 1974, 1976, 1977) discussed the karst features of the northeastern Interior Plains, which are in limestones, dolomites, anhydrite, gypsum, and salt of Devonian age. These features are indicated on a few Alberta Research Council maps (Bayrock, 1970a, 1970b, 1970c). Gypsum karst in Wood Buffalo National Park was observed by Ford (1973) and Lytviak (pers. comm.); salt springs are also common in this area. Sinkholes have been studied north of the town of Fort McMurray along the Athabasca River (Ozoray, 1976) and to the west of the Slave River. La Saline Spring (see page 28), north of Fort McMurray, is an example of groundwater movement through evaporites (Hitchon *et al.,* 1969).

The other karst region of Alberta is found in the Rocky Mountains where the largest karst springs in the province are found. Karst features are developed in Middle Cambrian age carbonates, from which the Mount Castleguard Big Springs (page 21) issue (Ford, 1971b). The Crowsnest Spring (page 21) issues from the Fairholme Group of Upper Devonian age; the origin of its waters is in carbonate rocks of the Rundle Group of Mississippian age. The Canyon Creek Springs (page 21) issue from limestones of the Banff Formation of lower Mississippian age as do the Turtle Mountain Sulfur Springs (Appendix A, No. 260). The largest karst springs in the province are the Maligne Canyon Springs (Appendix A, No. 504), which discharge more than 37 m^3/s (800 cfs), from limestones of the Palliser Formation of Upper Devonian age (Brown, 1970).

Maligne Canyon Karst Springs

Appendix A, No. 504
Location: Sec 36, Tp 45, R 1, W 6th Mer
Figure 8
Plates 3 and 16

This is the largest group of karst springs in Alberta and is probably among the largest in the world and has been studied in detail by Ford (1969). Brown (1970), in an unpublished Ph.D. thesis, covered in detail the karst morphology and hydrogeology of the lower Maligne basin where these springs are located. Tracer experiments carrried out by Ford and Brown demonstrate that water infiltrates through the bottom of Medicine Lake and flows through karstified limestone to discharge at a rate varying from 2.8 m^3/s (100 cfs) in the winter to over 37 m^3/s (800 cfs) during the summer from limestones of the Palliser Formation of Upper Devonian age in the lower part of the Maligne Canyon. The distance from the sink points to the main springs is 16 km (9.8 mi) in a straight line.

"Knowing the flow-through time and flow rate, the total volume of water contained by the system at one time was calculated. With a discharge of 800 cfs, a water filled cylinder 9.8

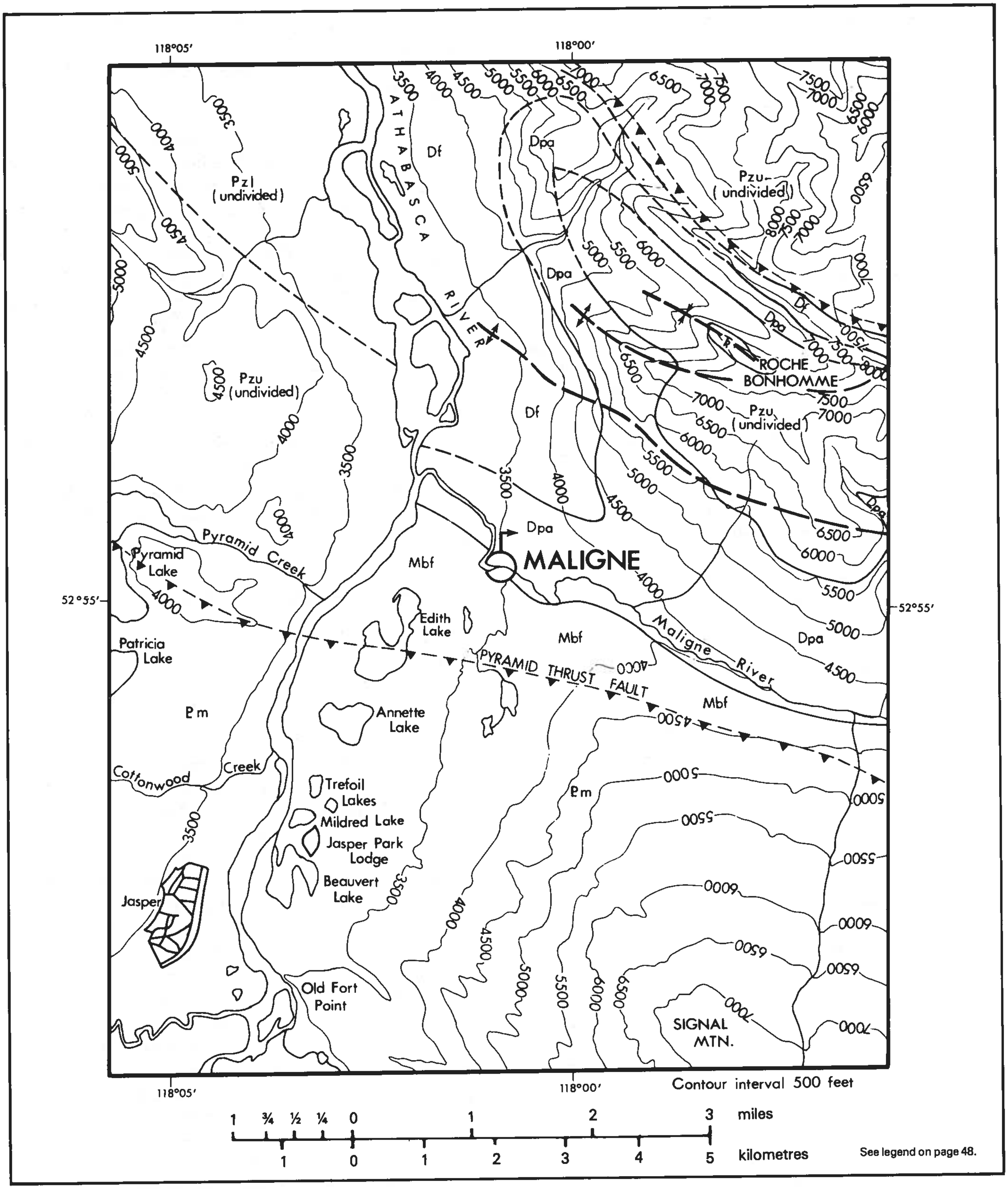


FIGURE 8. Maligne Canyon Springs: location and geology

miles in length would be 54 inches in diameter disregarding friction" (Brown, 1970).

To date the main cave of the system has not been found.

PLATE 16. Maligne Canyon Spring in the lower Maligne Canyon

Big Springs, Mount Castleguard Area

Appendix A, No. 334
Location: Lsd 9, Sec 4, Tp 36, R 23, W 5th Mer
Figure 9

Big Springs are a group of large karst springs that issue from limestones of the Cathedral Formation of Middle Cambrian age. The flow of these springs has been known to vary in a few days in 1969 from 9.1 to >11 m^3/s (320 to >400 cfs) (Ford, 1971). Earlier in the same year, these springs were entirely dry. Ford (1971) studied the karst system of the Mount Castleguard area in detail. He states that over 75 percent of the discharge of the Big Springs is derived from meltwater from the sole of the Columbia Icefield. The spring waters have a temperature of about 2°C; total dissolved solids content is near 32 mg/L; and the chemical type of the waters is calcium-magnesium bicarbonate. Numerous sinkholes are present in the general area and 10.2 km (6.4 mi) of cave passages have been explored and mapped. The main cave entrance starts about 1.6 km (1 mi) above the Big Springs; a smaller spring starts below the mouth of the cave.

Crowsnest Lake Spring

Appendix A, No. 261
Location: Lsd 13, Sec 9, Tp 8, R 5, W 5th Mer
Figure 10
Plate 17

This is also a large karst spring and is along the north side of the C.P.R. tracks. This spring flows out of a small cave developed in light grey dolomite of the Upper Devonian Fairholme Group and flows into Crowsnest Lake. Ford (1970) shows that the origin of the spring waters is approximately 4.5 km (2.8 mi) to the northwest of the Bighorn Range, which is formed of carbonate rocks of the Mississippian Rundle Group. Tracer experiments indicate that surface water enters a number of sinkholes in carbonate rocks in that area and flows beneath the Crowsnest Ridge to discharge at the spring.

Ford (1970) measured the flow rates of Crowsnest Spring and found them to be about 2120 L/s (28 000 igpm). Water temperature measured in August 1976 was 4.9°C. The total dissolved solids content was 141 mg/L. The chemical type is calcium bicarbonate. Because the water circulates rapidly, these karst springs might easily be polluted, so their catchment area should be protected.

Canyon Creek Springs

Appendix A, No. 279
Location: Lsd 7, Sec 29, Tp 22, R 6, W 5th Mer
Figure 11
Plates 18 and 19

This group of springs is interesting by virtue of its location and the number of natural phenomena associated with it. The total flow of about 76 L/s (1000 igpm) issues from the valley side of Canyon

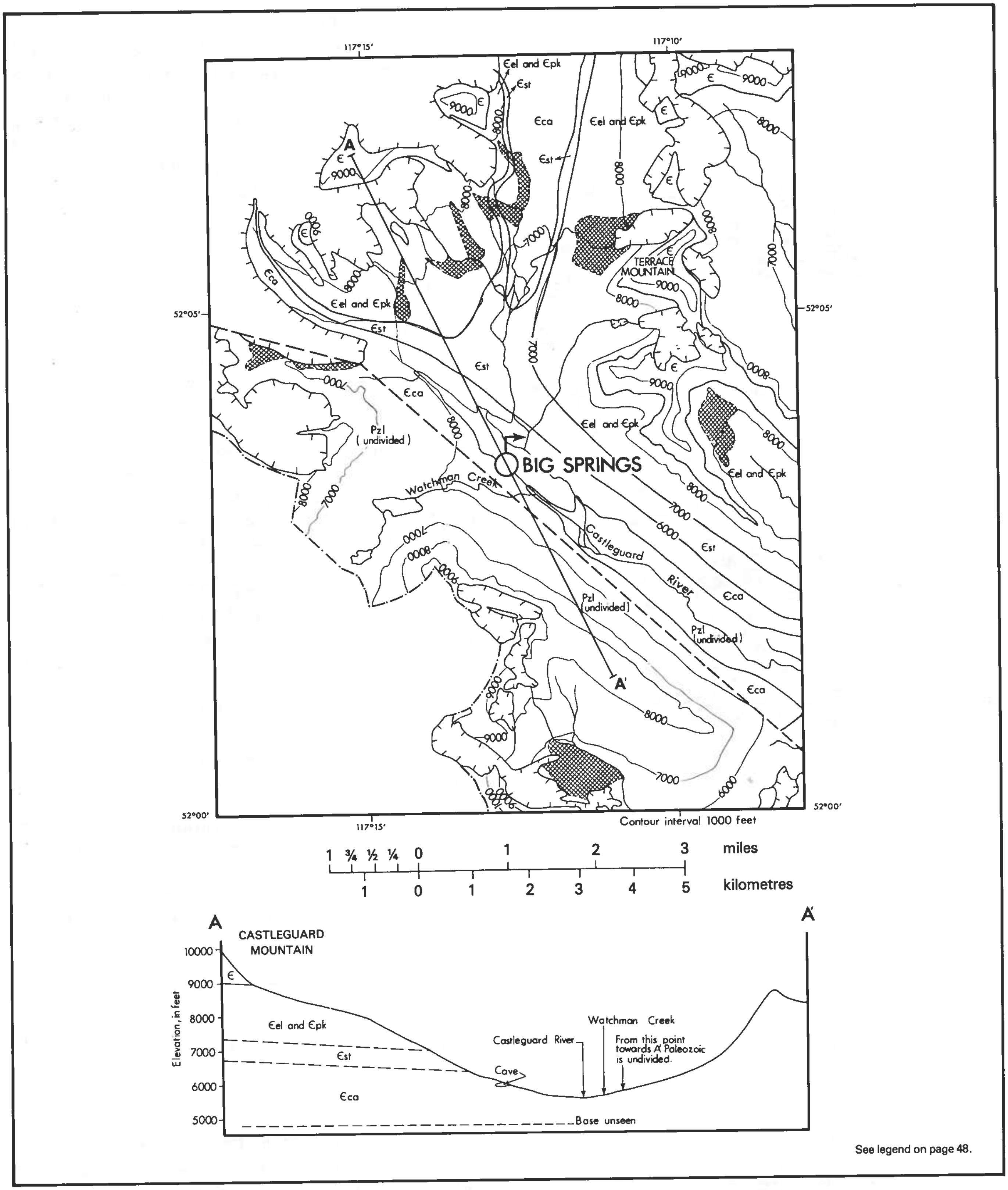


FIGURE 9. Big Springs: location and geology (after Ford, 1971)

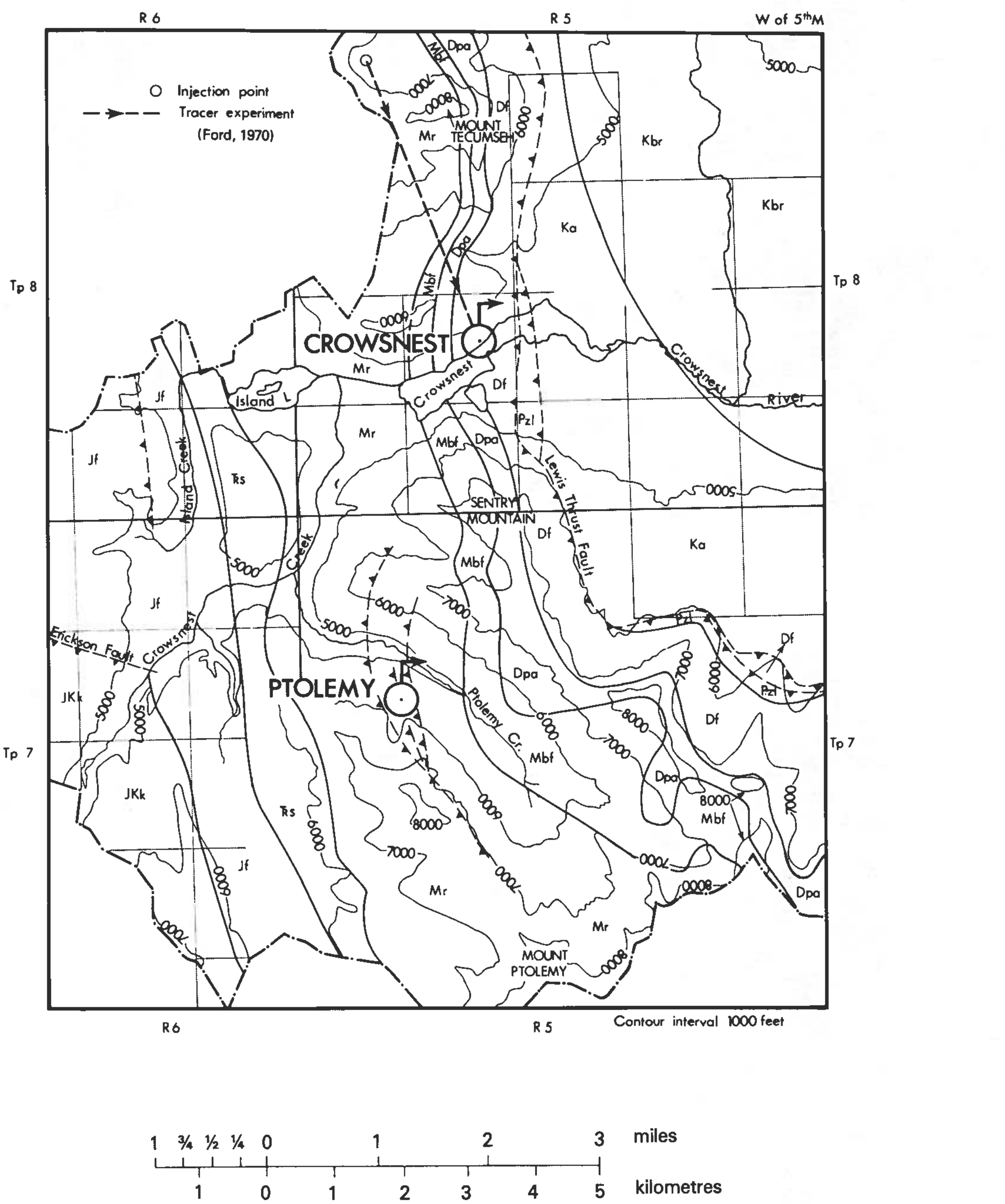


FIGURE 10. Crowsnest and Ptolemy spring locations (after Ford, 1970)

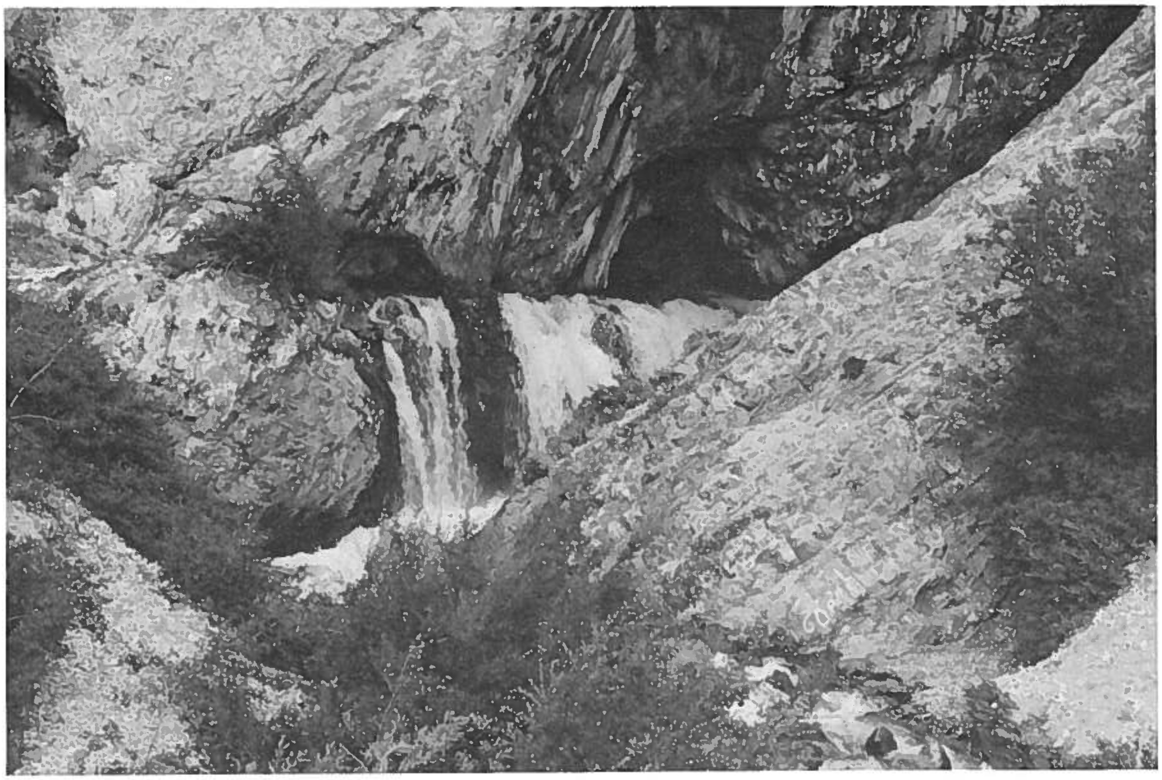


PLATE 17. Crowsnest Lake spring outlet

PLATE 18. Canyon Creek Springs - general view downstream from the springs

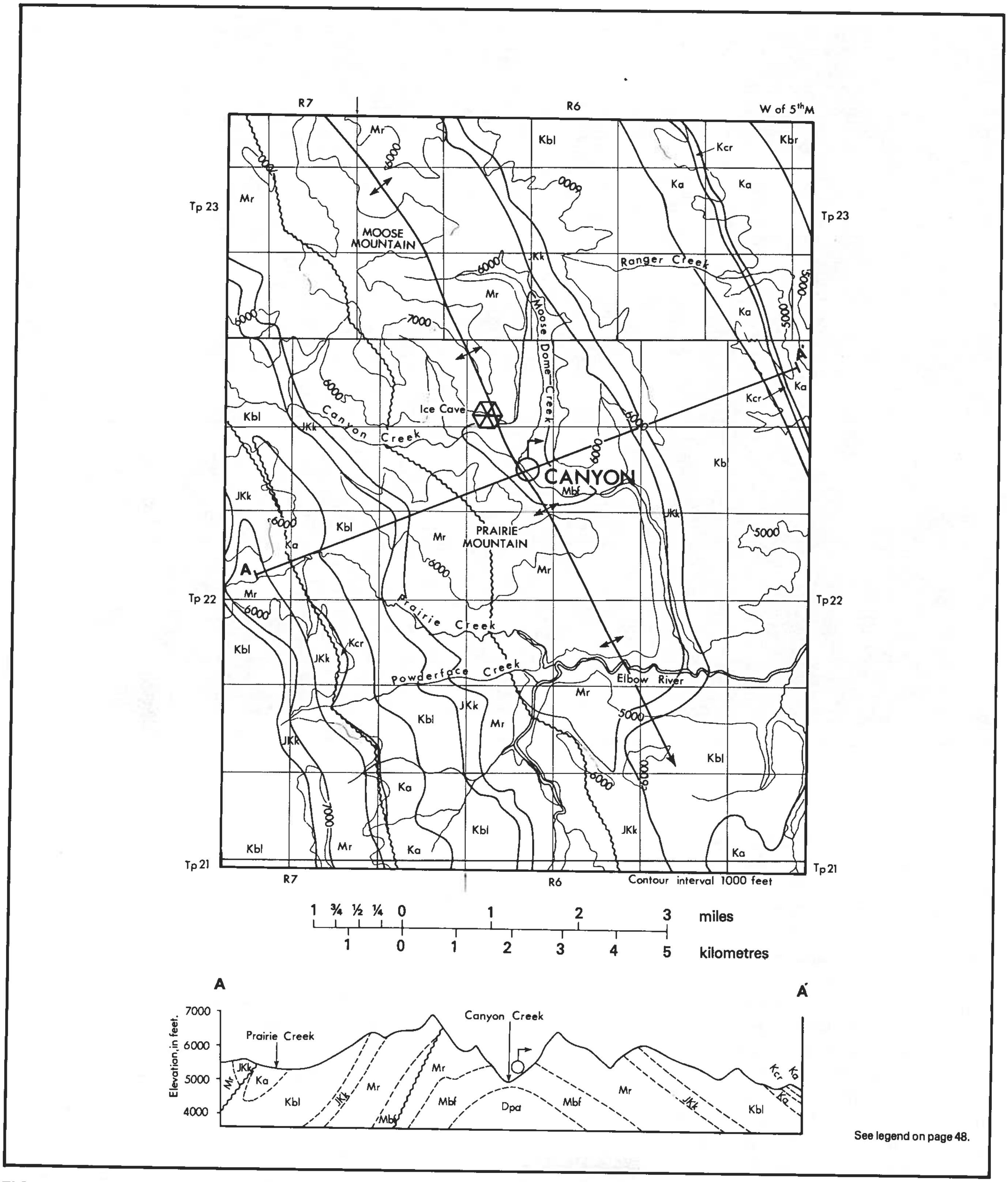


FIGURE 11. Canyon Creek Springs: location and geology

PLATE 19. Canyon Creek Springs, elemental sulfur and colonies of sulfur bacteria in suspension in the spring waters

Creek through a thick pile of deadwood. The exact discharge points are hidden but most probably the springs issue from limestones of the Banff Formation of Lower Mississippian age. The springs, which are close to the fold axis of an anticline in Devonian, Mississippian, and Pennsylvanian rocks, contain strong hydrogen sulfide gas and suspended sulfur. The Canyon Creek waters are ponded in many large pools (Plates 18 and 19) and contain trees and vegetation. A large concentration of whitish filamentous sulfur bacteria *(Desulfovibrio Desulfuricans?)* are found in the channels where the water flows. The spring waters have a TDS count of 470 mg/L and the waters are a calcium-sulfate bicarbonate type. Downstream from the pools most of the spring water reinfiltrates into the bed of Canyon Creek.

Turtle Mountain Sulfur Springs

Appendix A, No. 260
Location: Lsd 12, Sec 36, Tp 7, R 4, W 5th Mer
Figure 12
Plate 20

This sulfur spring about 1.6 km (1 mi) northwest of the spectacular Frank Slide was described in detail by van Everdingen (1972). This spring issues out of fractured limestones of the Banff Formation of Lower Mississippian age where the Turtle Mountain thrust fault brings the Banff Formation into contact with the Fernie Group sediments of Middle and Lower Jurassic age.

The main spring has a temperature of 9.1°C (August 1976). A smaller spring a short distance

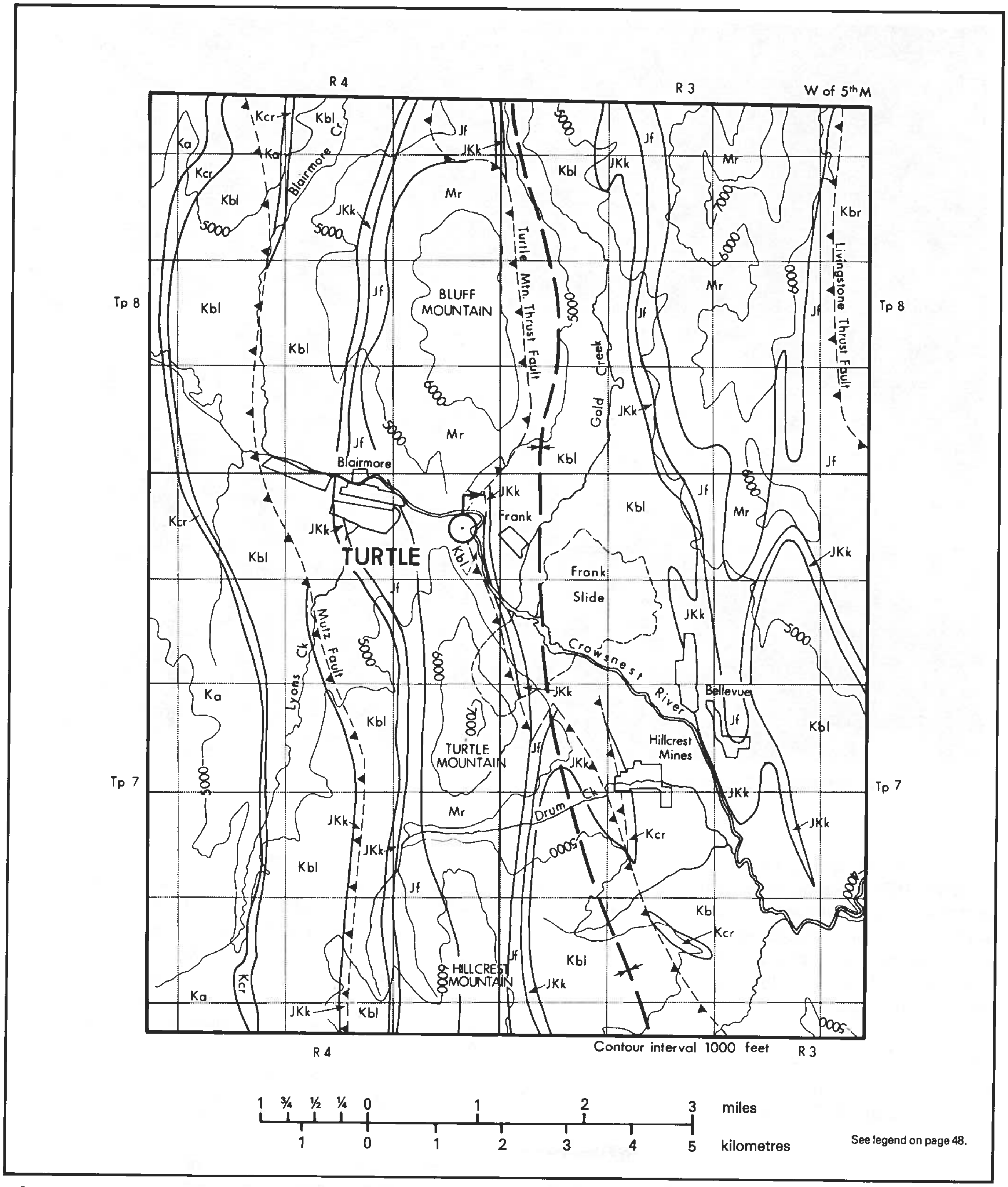


FIGURE 12. Turtle Mountain Sulfur Springs: location and geology

PLATE 20. Turtle Mountain cold sulfur spring

from the main spring has a temperature of 7.7°C (August 1976). Suspended sulfur gives the spring water a milky appearance; the rocks over which the water flows are coated with a whitish deposit, probably sulfur bacteria (Plate 20). The spring water has 333 mg/L TDS and is a calcium-sulfate bicarbonate type.

La Saline Springs

Appendix A, No. 201
Location: Lsd 16, Sec 15, Tp 93, R 10, W 4th Mer
Figure 13
Plate 13

This pair of saline springs in northeastern Alberta at the contact between the shales and argillaceous limestones of the Beaverhill Lake Formation and the overlying sandstones of the McMurray Formation are situated about 15 m (50 ft) above Saline Lake. The main spring flows at an estimated rate of 0.75 L/s (10 igpm); the secondary spring nearby flows at approximately 0.4 L/s (5 igpm). The main spring, which contains TDS of 71 400 mg/L, issues from a mound about 3 m (10 ft) in diameter with a 0.6 m (2 ft) deep pool in the center. Hydrogen sulfide gas bubbles up in the pool with the water. The spring water is a sodium chloride type. The side spring is the same type with a similar TDS content (69 764 mg/L). The X-ray analysis of the mineral deposits from the spring mound shows that it contains calcite, dolomite, quartz, gypsum, anhydrite, baryte, and elemental sulfur.

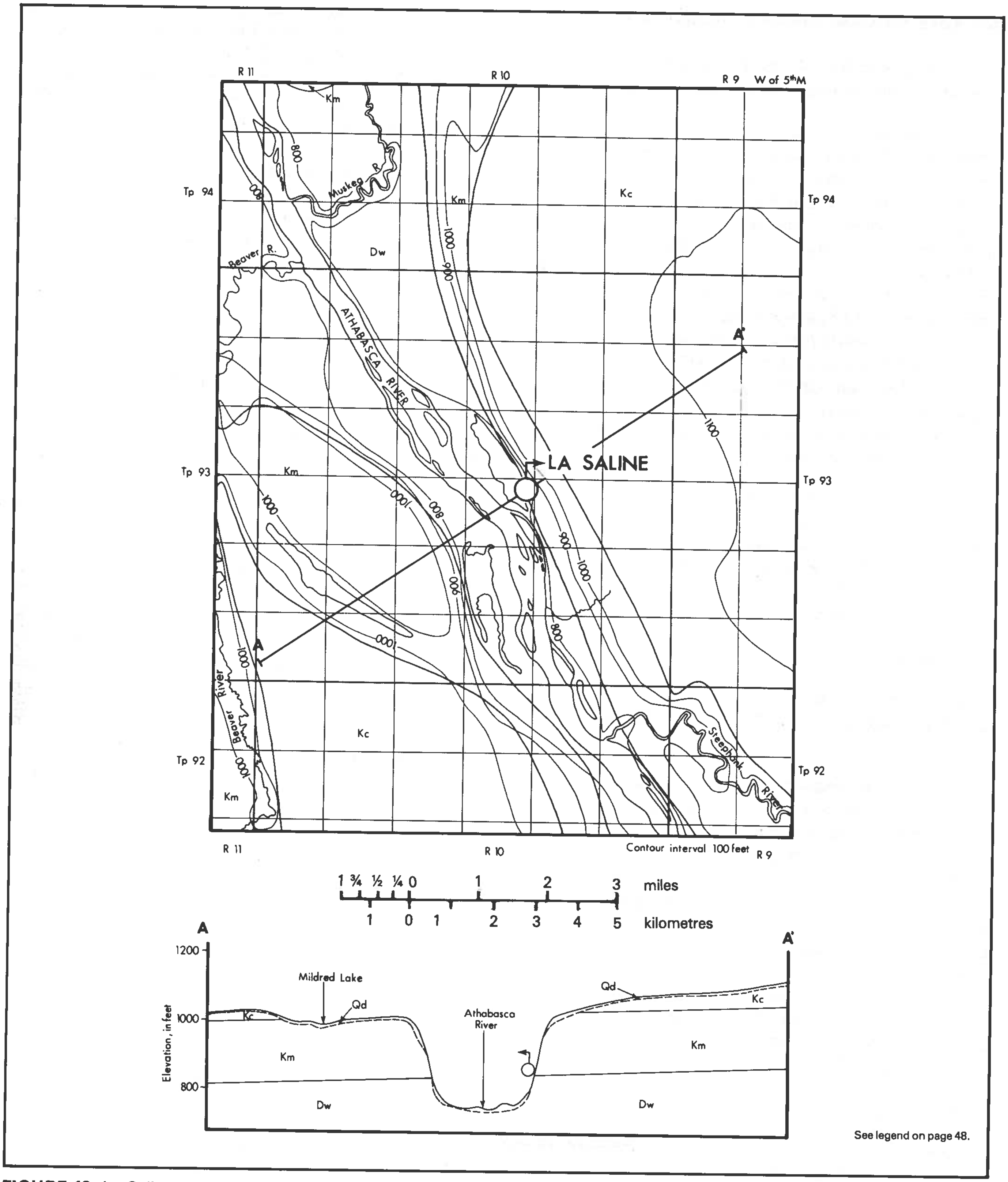


FIGURE 13. La Saline Springs: location and geology

SPRINGS ISSUING FROM SANDSTONES

In Alberta, sandstones of Proterozoic to Tertiary age are found in every physiographic region.

To a large extent, these sediments are important aquifers in Alberta, especially sandstones of Cretaceous and Tertiary age. The most important sandstone aquifers are the Upper Cretaceous Milk River sandstone in southern Alberta; the Upper Cretaceous Horseshoe Canyon, Belly River, and Wapiti Formations that extend from southern Alberta to the northwest-central part of the province; the Tertiary Paskapoo sandstones that extend from northwestern Alberta and parallel the Rocky Mountain Foothills in a wide belt that terminates south of the town of Grande Prairie in the northwest-central region of the province; and the Peace River and Dunvegan sandstones in the Peace River country to the northwest.

The following examples are springs issuing from the Paskapoo Formation of Lower Tertiary (Paleocene) and Upper Cretaceous age, respectively. One example is located in the northwestern Plains region (Obed) and the other (Rockyford) in the southern Alberta Plains area.

Obed Spring

Appendix A, No. 445
Location: Lsd 16, Sec 4, Tp 53, R 22, W 5th Mer
Figure 14

This spring, in west-central Alberta approximately midslope between a topographic high and a river valley low, is believed to flow from Paskapoo sandstones, although there might be some drift water contribution. Calcareous tufa deposits are widespread in the vicinity of the spring and farther downstream towards Highway 16. The flow of the spring is in the order of 18 L/s (240 igpm) and the TDS content is 320 mg/L. Chemically, the spring water is a calcium bicarbonate type. The low TDS content suggests that the recharge area of the spring is probably quite close and is most likely in the hills southwest of the spring.

Rockyford Spring

Appendix A, No. 105
Location: Lsd 12, Sec 35, Tp 26, R 23, W 4th Mer
Figure 15

This spring issues from fractures in the Scollard Member of the Paskapoo Formation and has a flow rate of 4.5 L/s (60 igpm). Sodium bicarbonate lines the edges of the downstream spring channel. The spring water, with a TDS content of 2617 mg/L, is sodium bicarbonate. Irrigation water possibly infiltrates down through the thin surficial deposits into the Paskapoo Formation along the ridge about 1.6 km (1 mi) north of the spring. The infiltration of irrigation waters leaches salts from the soils and would account for the high TDS found in the spring water.

SPRINGS IN COAL AND SHALES

In Alberta, shales are found in geologic deposits ranging in age from Precambrian to Upper Cretaceous. Coal beds are found in sediments ranging in age from Triassic to early Tertiary. The main coal-bearing strata, though, are of Upper Cretaceous age in the plains and of Lower Cretaceous age in the mountains and in the foothills.

Small springs and seepages are usually the rule in shales and coals and can be observed at many localities in the province; larger springs issuing from these sediments are usually the exception and are the result of fissure and fracture permeability. The Mountain Park Spring and the Whisky Gap Springs described in the following section are two of these exceptions.

Mountain Park Spring

Appendix A, No. 413
Location: Lsd 11, Sec 32, Tp 45, R 23, W 5th Mer
Figure 16

This spring issues from fractured carbonaceous shales and coals of the Luscar Formation of Lower Cretaceous age. The spring, a short distance west of the abandoned town of Mountain Park at the boundary between the foothills and the mountains, discharges at a range from 23 to more than 68 L/s (300 to >890 igpm) and has a temperature of 4.5°C. Sulfur bacteria can be seen on the rocks in the stream issuing from the spring, and hydrogen sulfide can be smelled in the vicinity. The TDS content is 536 mg/L and the spring water is a sodium bicarbonate type. The recharge area of the spring is probably a few kilometres southwest in the Cheviot Mountains area.

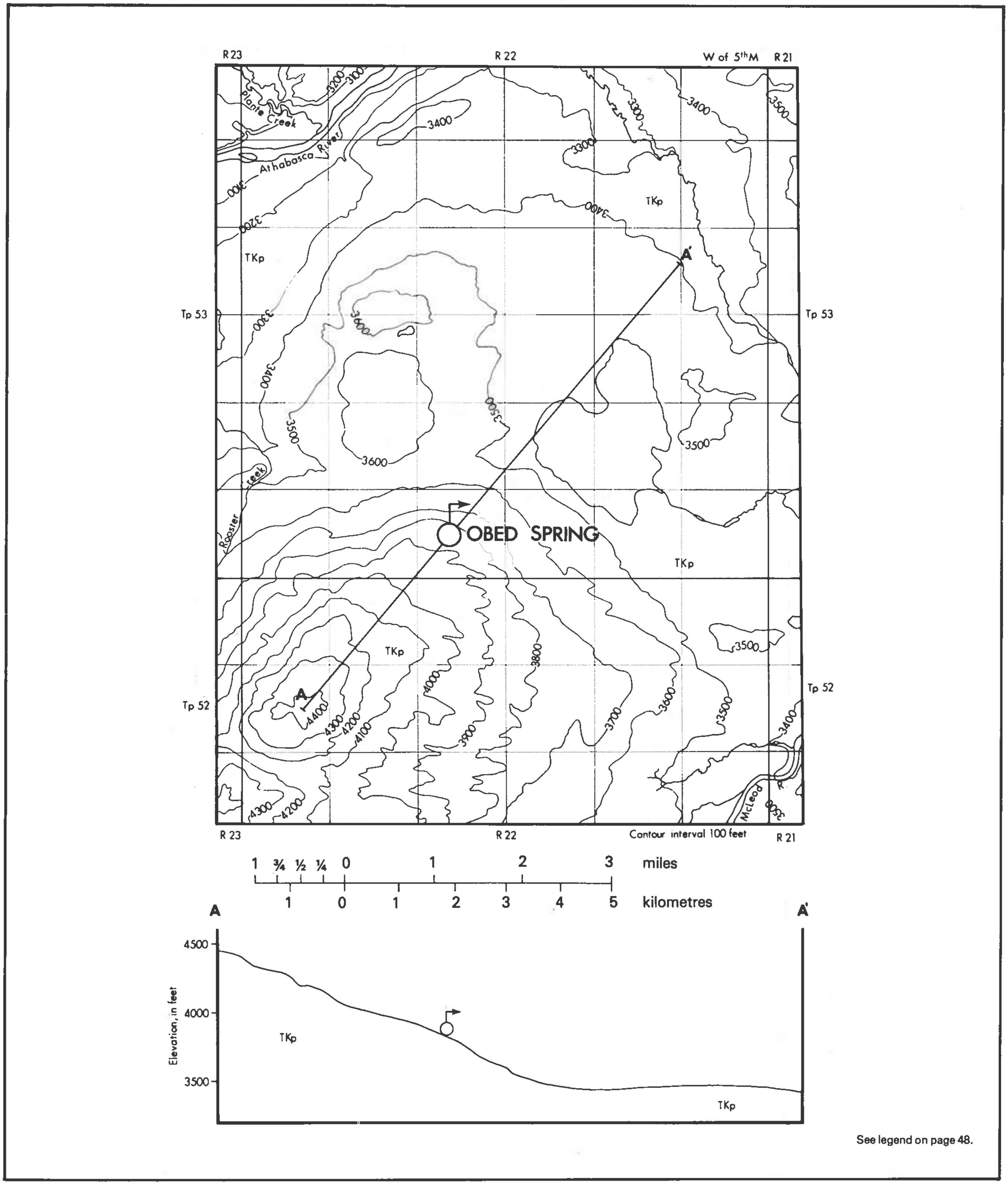


FIGURE 14. Obed Spring: location and geology

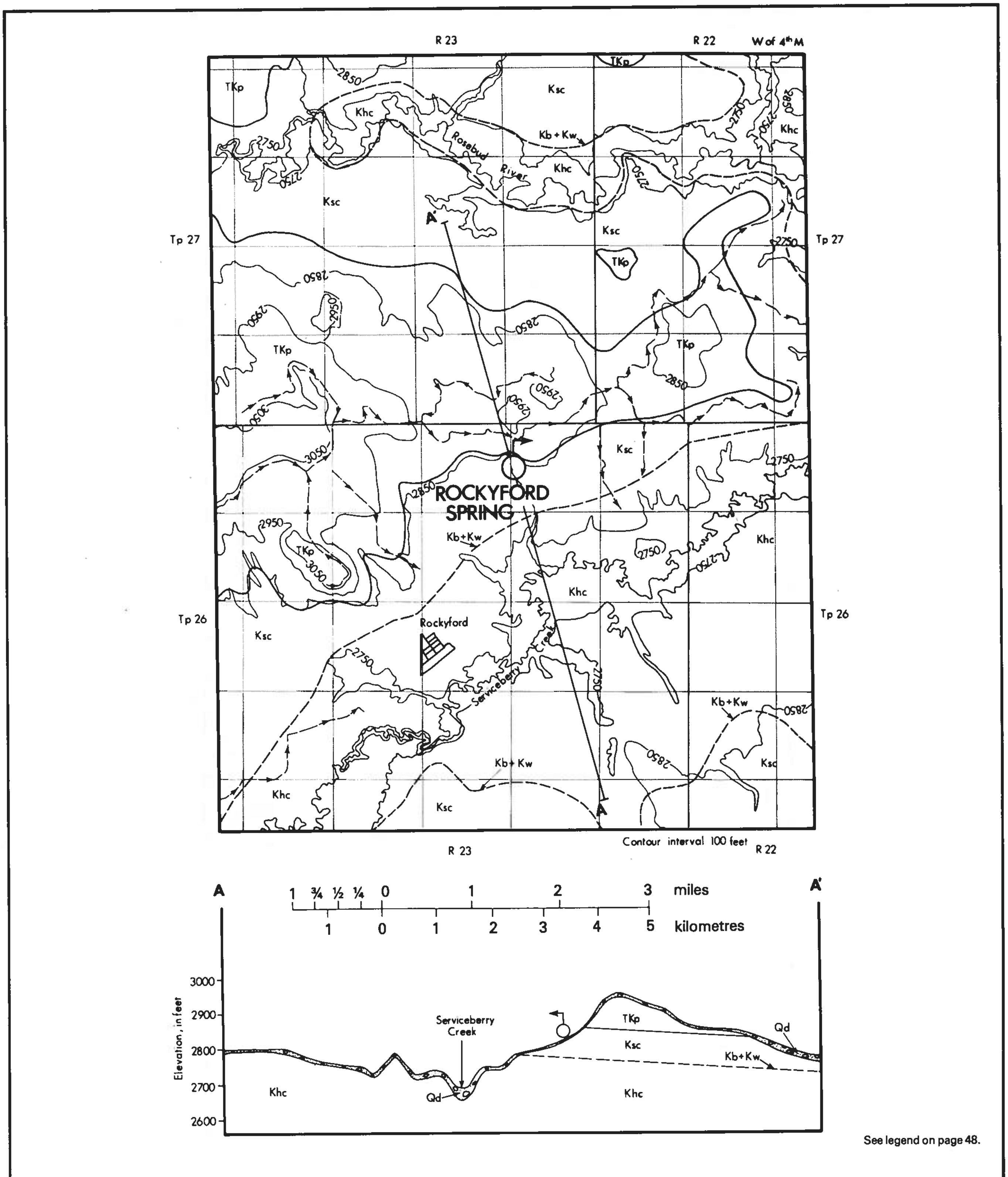


FIGURE 15. Rockyford Spring: location and geology

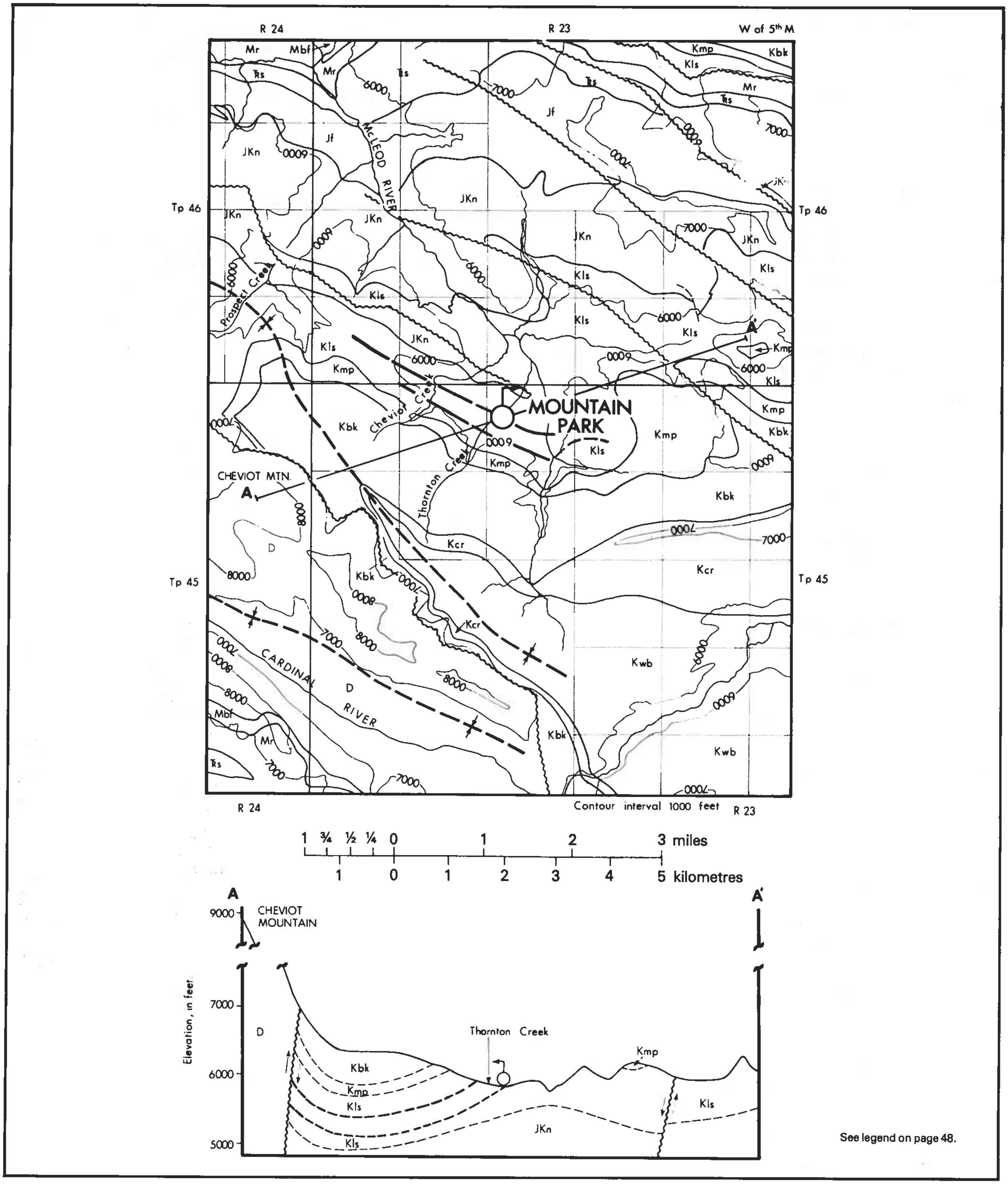


FIGURE 16. Mountain Park Spring: location and geology

Whisky Gap Springs

Appendix A, No. 5
Location: Lsd 15, Sec 10, Tp 1, R 23, W 4th Mer
Figure 17
Plate 21

This group of springs, in southwestern Alberta 3.2 km (2 mi) north of the Alberta-Montana border, is a good example of fractured grey shales with a large number of individual springs (Fig. 17). These slightly sandy shales are part of the St. Mary River Formation of Upper Cretaceous age. The combined flow of these springs is about 3.5 L/s (50 igpm). Iron staining is present in the fractures from which the water flows. The TDS content is 408 mg/L and the spring waters are a calcium-magnesium bicarbonate type. The low TDS value suggests that the waters have not travelled for a long period of time, so the recharge area for the springs probably lies a short distance away, possibly in the hills 3.2 km (2 mi) northwest of the springs. The waters likely infiltrate through the Willow Creek Formation into the St. Mary River Formation.

PLATE 21. Whisky Gap Springs. A number of small springs issue from fractured shales. Iron has precipitated in the fractures.

SPRINGS IN ALLUVIUM

Springs issuing from alluvium sediments are found at many locations in the province. Alluvium is "a general term for all detrital deposits resulting from the operations of modern rivers, and includes the sediments laid down in river-beds, flood-plains, lakes, fans at the foot of mountain slopes, and estuaries" (Rice, 1963).

Butte Springs

Appendix A, Nos. 335, 336, 337
Locations: Lsd 3, Sec 19, Tp 37, R 5, W 5th Mer
Lsd 13, Sec 24, Tp 37, R 6, W 5th Mer
Lsd 6, Sec 26, Tp 37, R 6, W 5th Mer
Figures 18 to 26

Three interesting springs, in the Rocky Mountain House area in southwestern Alberta, are unusual in that they are resurgences of the Clearwater River. As can be seen on the cross-section (after Geoscience Consulting Ltd., 1975), the Clearwater River is at a higher elevation and is hydraulically connected to the springs through alluvial sands and gravels that are present in the river valley, and to the east of the river along Stauffer Creek. These springs were monitored for eighteen months by the Alberta Research Council. The fluctuations that can be observed on the original hydrographs are due to:

(a) a daily negative fluctuation due to the influence of evapotranspiration;
(b) positive fluctuations that are the result of rainfall and snow melt; and
(c) positive fluctuations related to the high water stages of the Clearwater River.

If one compares the hydrographs of the Clearwater River and the hydrographs of the springs (Figs. 19, 20, 25, 26), their discharge rates vary at about the same time during the eighteen-month period. The

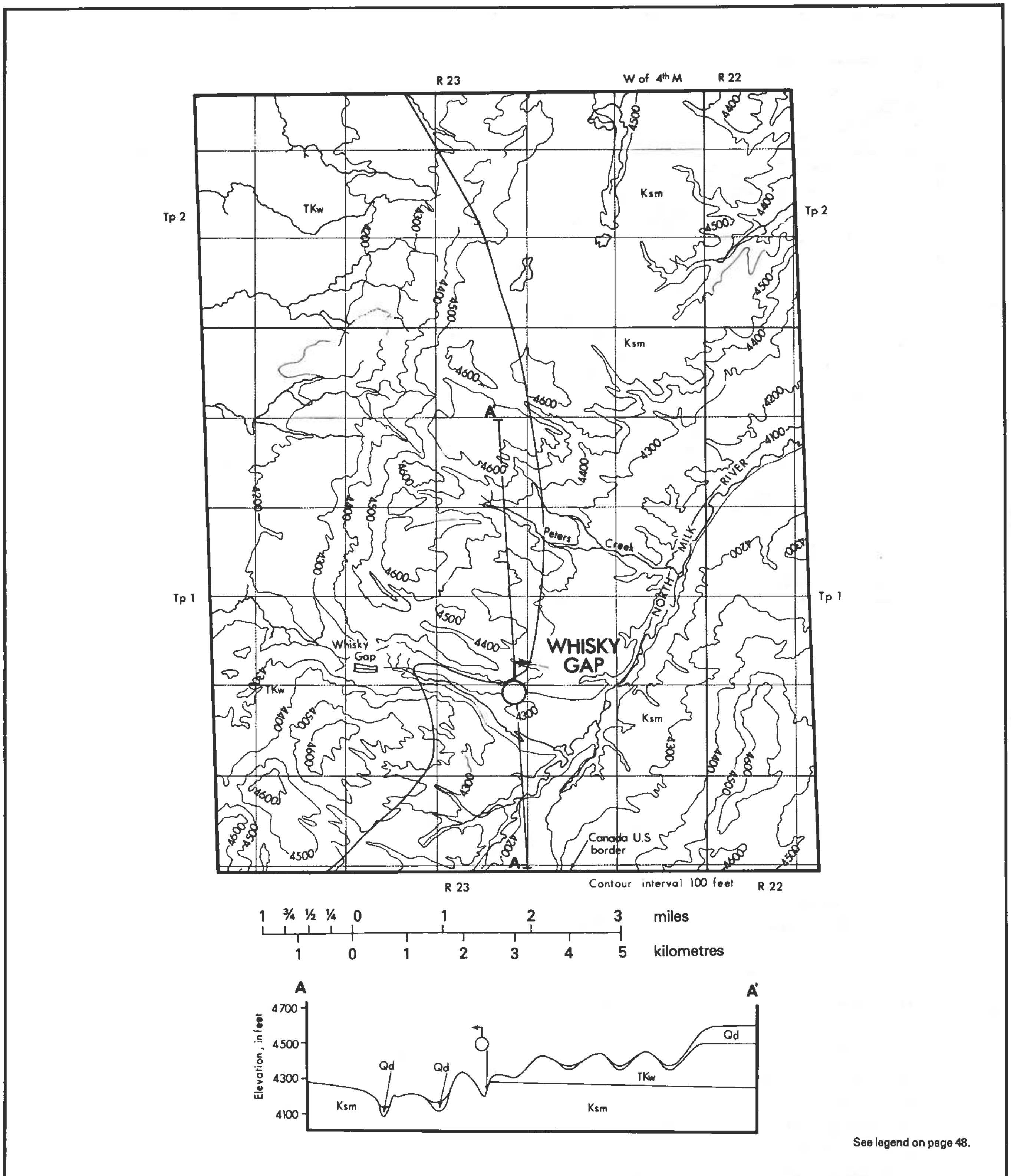


FIGURE 17. Whisky Gap Springs: location and geology

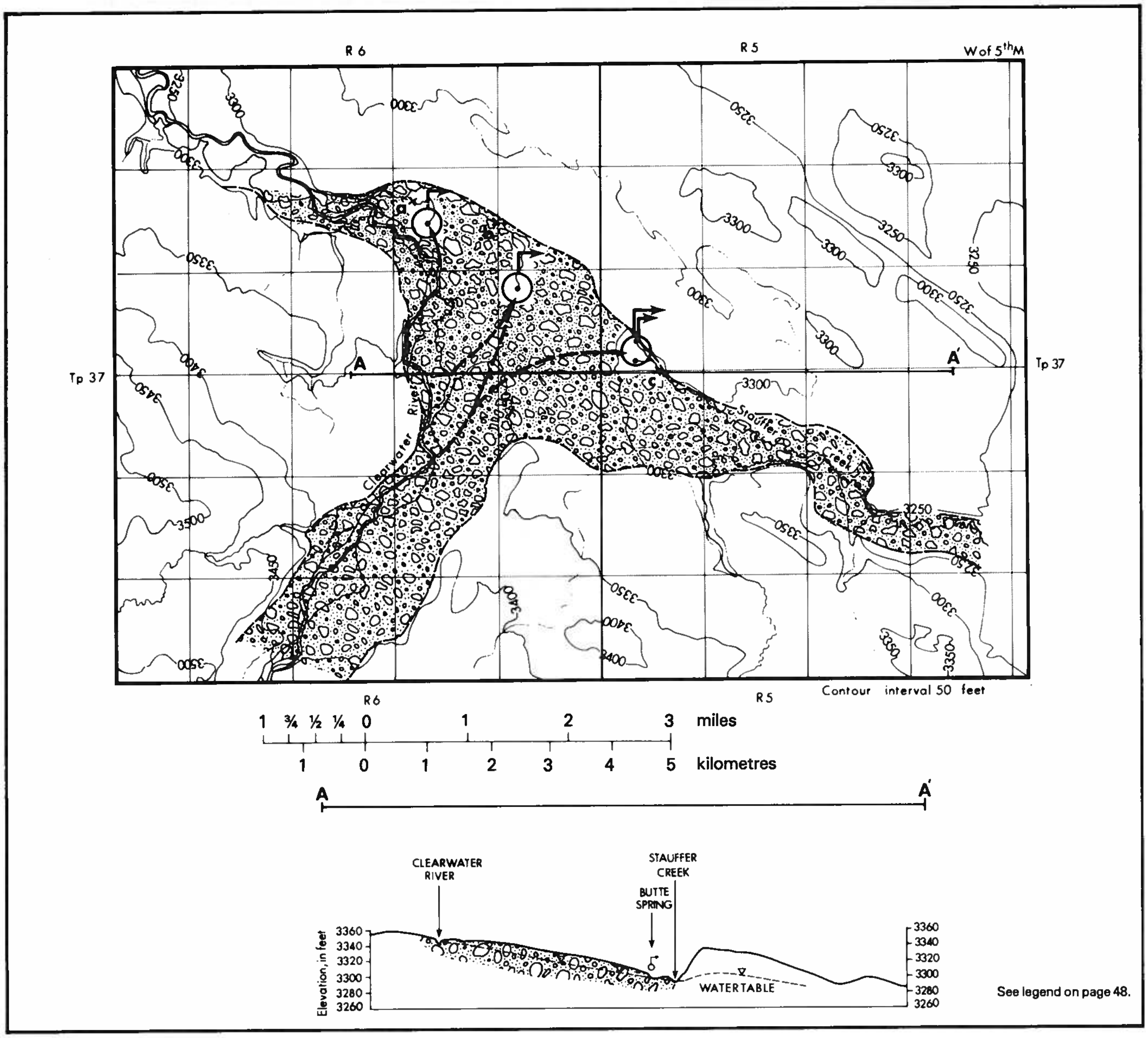


FIGURE 18. Butte Springs: location and cross section (after Geoscience Consulting Ltd., 1975)

influence of the snowmelt during the months of March, April, and May 1971 and 1972 can be observed on the discharge hydrographs of both the springs and river. The flow rates of the springs vary over a wide range. In 1972, discharge from Edmonds Spring varied from a minimum of 150 L/s (200 igpm) in April to 4200 L/s (56 000 igpm) in June. The latter value does not reflect the true discharge of the spring, because the Clearwater River overflowed into the spring channel during this flood period. During the same period, the discharge of Stauffer Spring varied from about 190 L/s (2500 igpm) in January to 380 L/s (5200 igpm) in June. Clear Spring discharge varied from about 230 L/s (3000 igpm) to 530 L/s (7000 igpm) in June.

The arrows on Figure 18 indicate the general routes of the water from the Clearwater River through the alluvial sand and gravel to the various spring

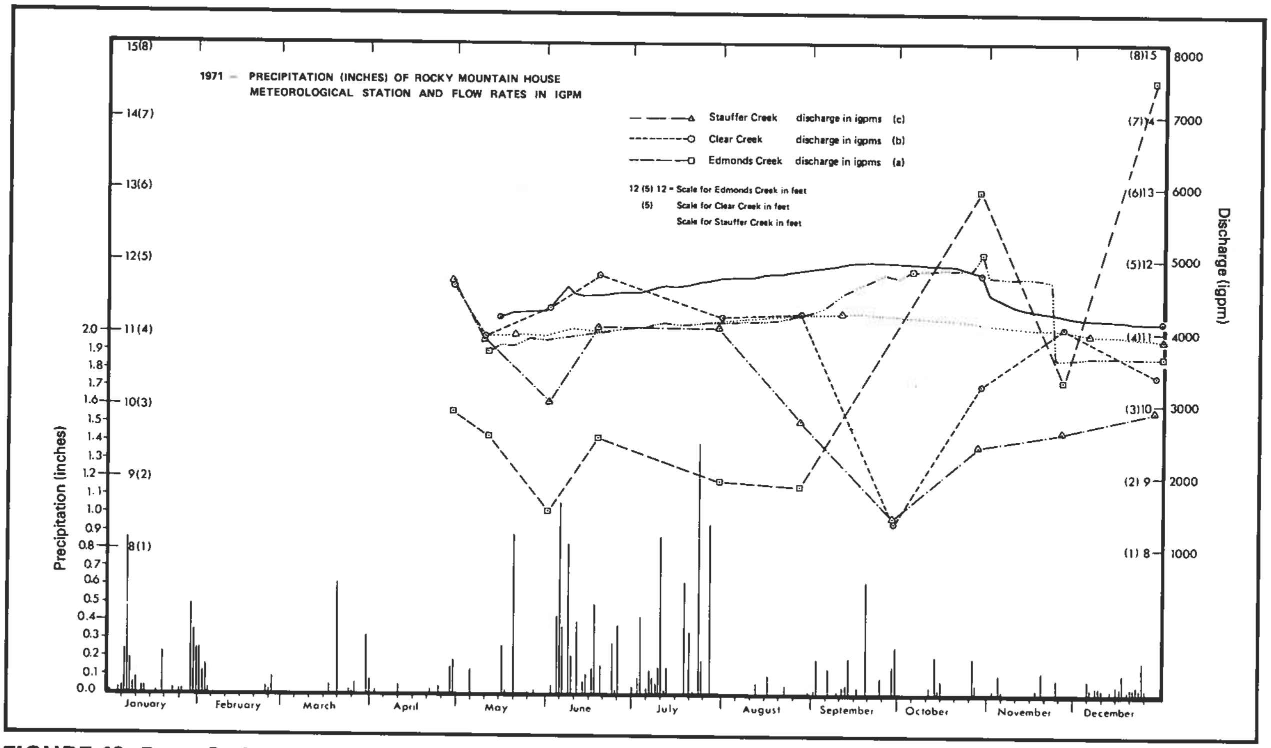


FIGURE 19. Butte Springs: discharge for part of the year 1971

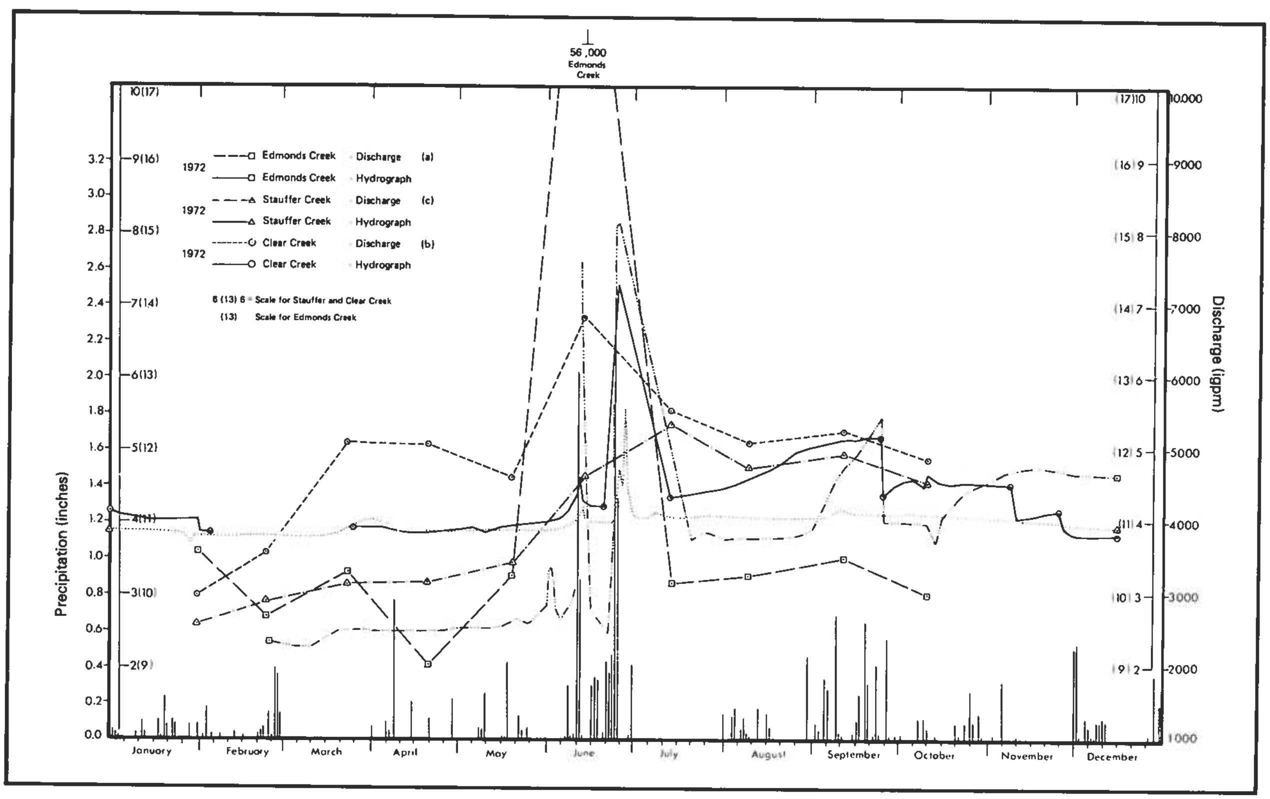


FIGURE 20. Butte Springs: discharge for the year 1972

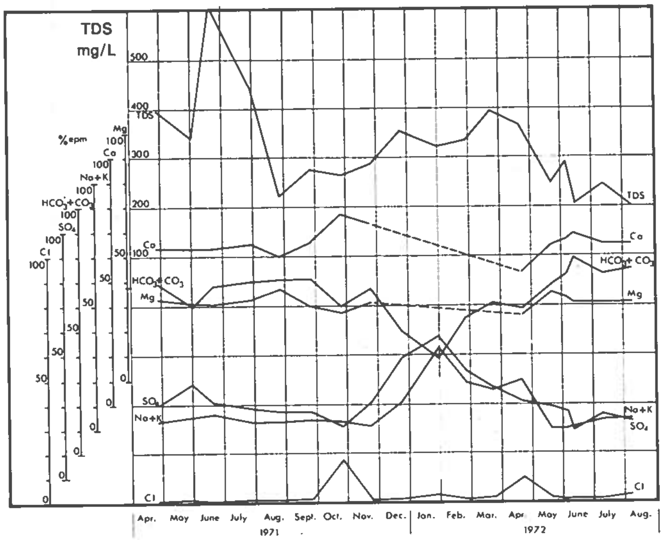


FIGURE 21. Chemistry - Edmonds Spring, 1971-1972

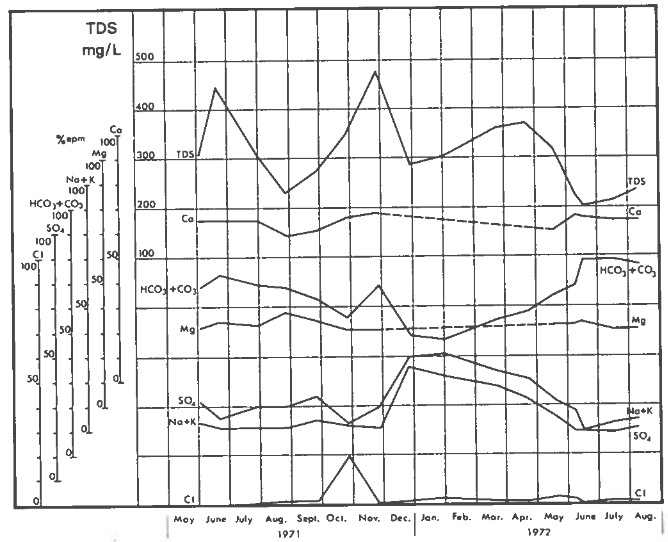


FIGURE 22. Chemistry - Rauch Spring, 1971-1972

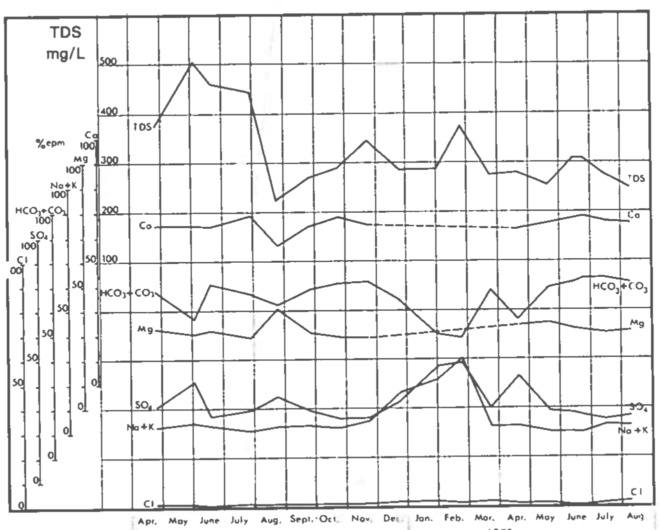


FIGURE 23. Chemistry - Ditch Spring, 1971-1972

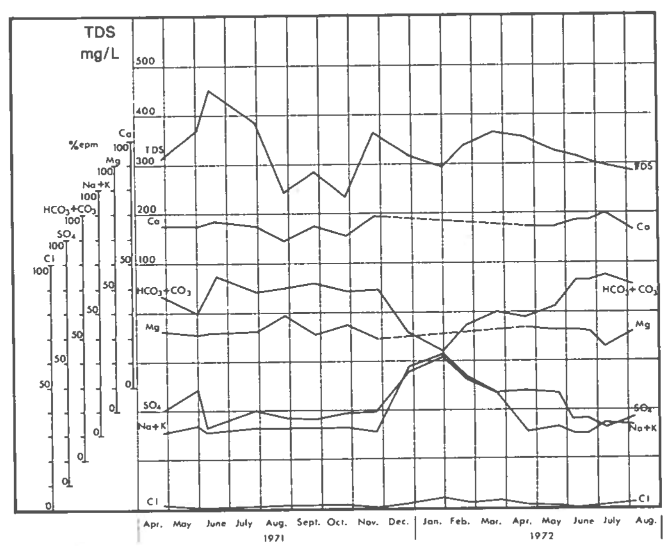


FIGURE 24. Chemistry - Clearwater River, 1971-1972

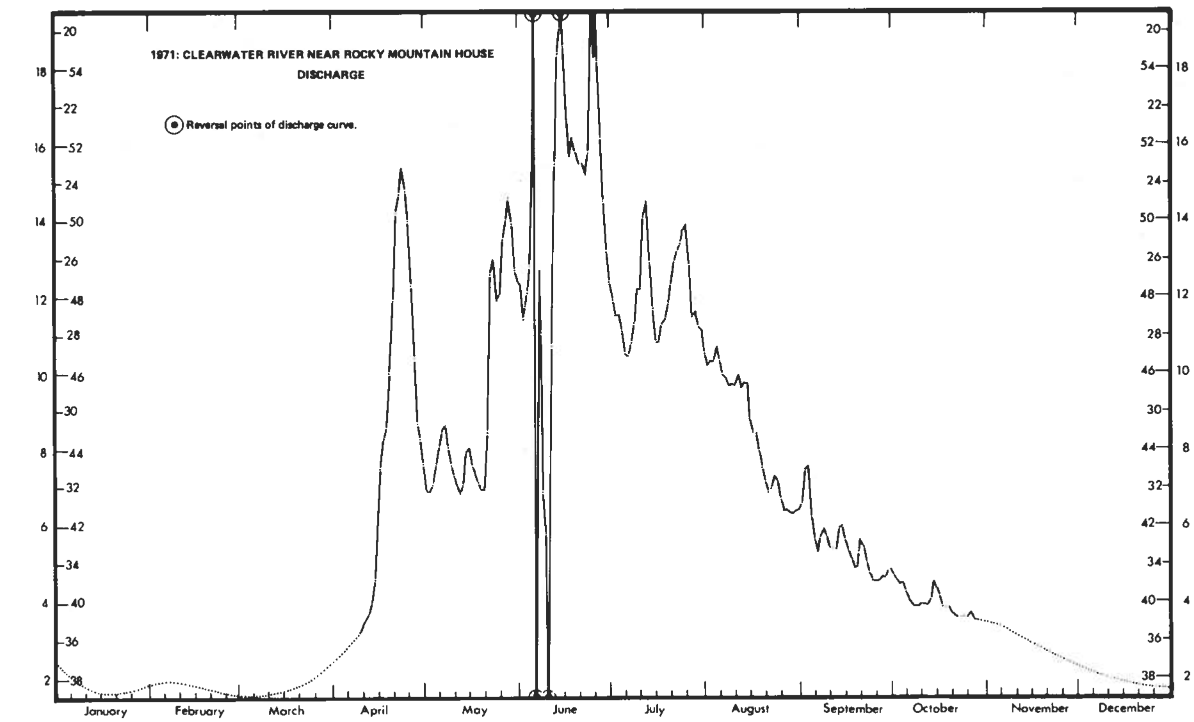


FIGURE 25. Discharge of the Clearwater River near Rocky Mountain House - 1971

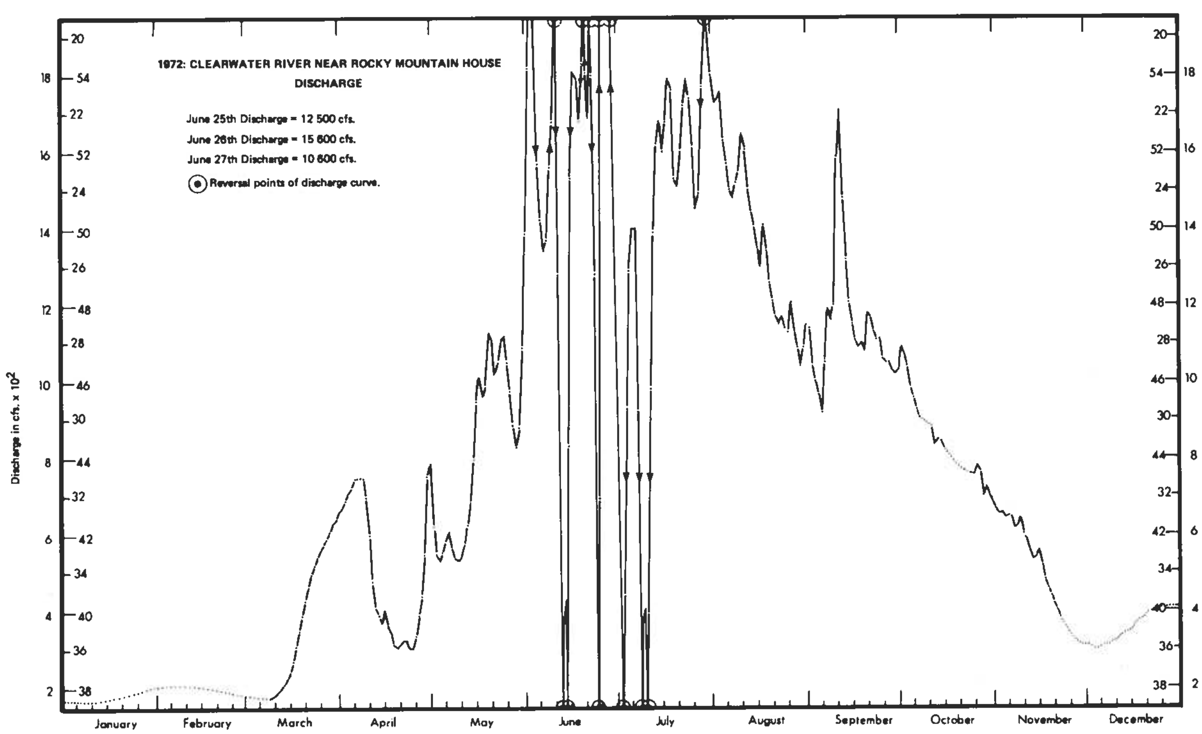


FIGURE 26. Discharge of the Clearwater River near Rocky Mountain House - 1972

points. The distance covered by the underflow of water is up to and over 3 km (2 mi) before the water resurges at the surface. By comparing water temperatures of the Clearwater River and of the spring water, Tokarsky (pers. comm.) calculated the velocity of the groundwater to be about 3 m/day (10 ft/day) at the Edmonds Spring, 5 m/day (15 ft/day) at Rauch Spring, and 8 m/day (26 ft/day) at Ditch Spring.

Using an average velocity of 5.3 m/day (17 ft/day), porosity of the sand and gravel of 35 percent, and an hydraulic gradient of 0.0043 (from wells in the area), an hydraulic conductivity of 428 m/day (8700 igpd/ft^2) was calculated. Assuming a saturated thickness of aquifer of about 6 m (20 ft), a transmissivity value of 2609 m^2/day (174 000 igpd/ft) can be calculated. These values compare well with transmissivity values and hydraulic conductivity of sands and gravels in the Calgary area and at Peace Point near Medicine Hat.

The spring waters are generally a calcium bicarbonate type. Chemical variations of the water from the springs and of the Clearwater River are indicated on figures 21, 22, 23, and 24 for the eighteen-month period during which the springs were monitored. Fluctuations of the TDS of the water from the springs and of the Clearwater River follow the same trend.

The TDS content of the water of Edmonds Spring, which is closest to the river, varied from a minimum of about 200 mg/L at the end of August 1971 to a maximum of about 560 mg/L in June 1971 (Fig. 21). TDS content of the water of Ditch Spring, which is the farthest away from the river, varied from a minimum of about 235 mg/L at the end of October 1971 to a maximum of about 450 mg/L in the middle of June 1971 (Fig. 23). Rauch Spring, which is about halfway between the two other springs, had TDS content that varied from about 225 mg/L in August 1971 to a maximum of about 505 mg/L in June 1971 (Fig. 22). Variation differences were greatest close to the Clearwater River and smallest farther away from the river. This may indicate a better permeability of the alluvial sands and gravels away from the Clearwater River, whose water may have swept silt into the sand and gravel closer to the river.

The size of these springs makes them attractive for some potential major use. The area in which they are located, however, is subject to flooding, which renders the springs rather unsuitable for on-site development for activities such as fish rearing. High turbidity during periods of flooding also makes the springs unfit for use unless the water is filtered.

Bow Island Springs

Appendix A, Nos. 57, 58, 59, 60, 61
Location: Lsd 13, Sec 20, Tp 11, R 13, W 4th Mer
Figure 27
Plate 22

The Bow Island Springs are exceptional in that their origin is at least partly due to man's activities. Four major springs are located in a coulee just below a small dam. The total discharge from the "springs" (or resurgence from the lake) is 64 L/s (850 igpm). The springs' waters possibly have a double origin, such as from the lake and from the gravel aquifer.

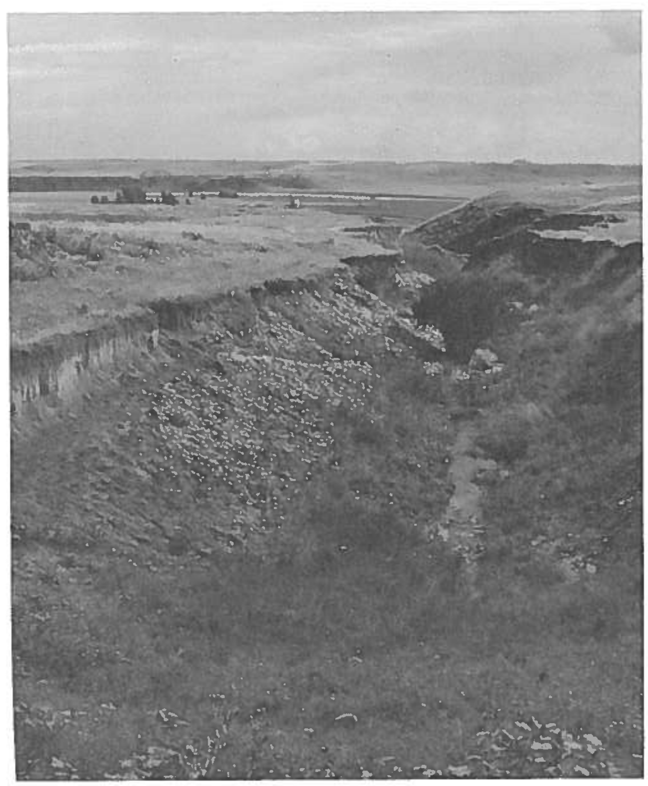
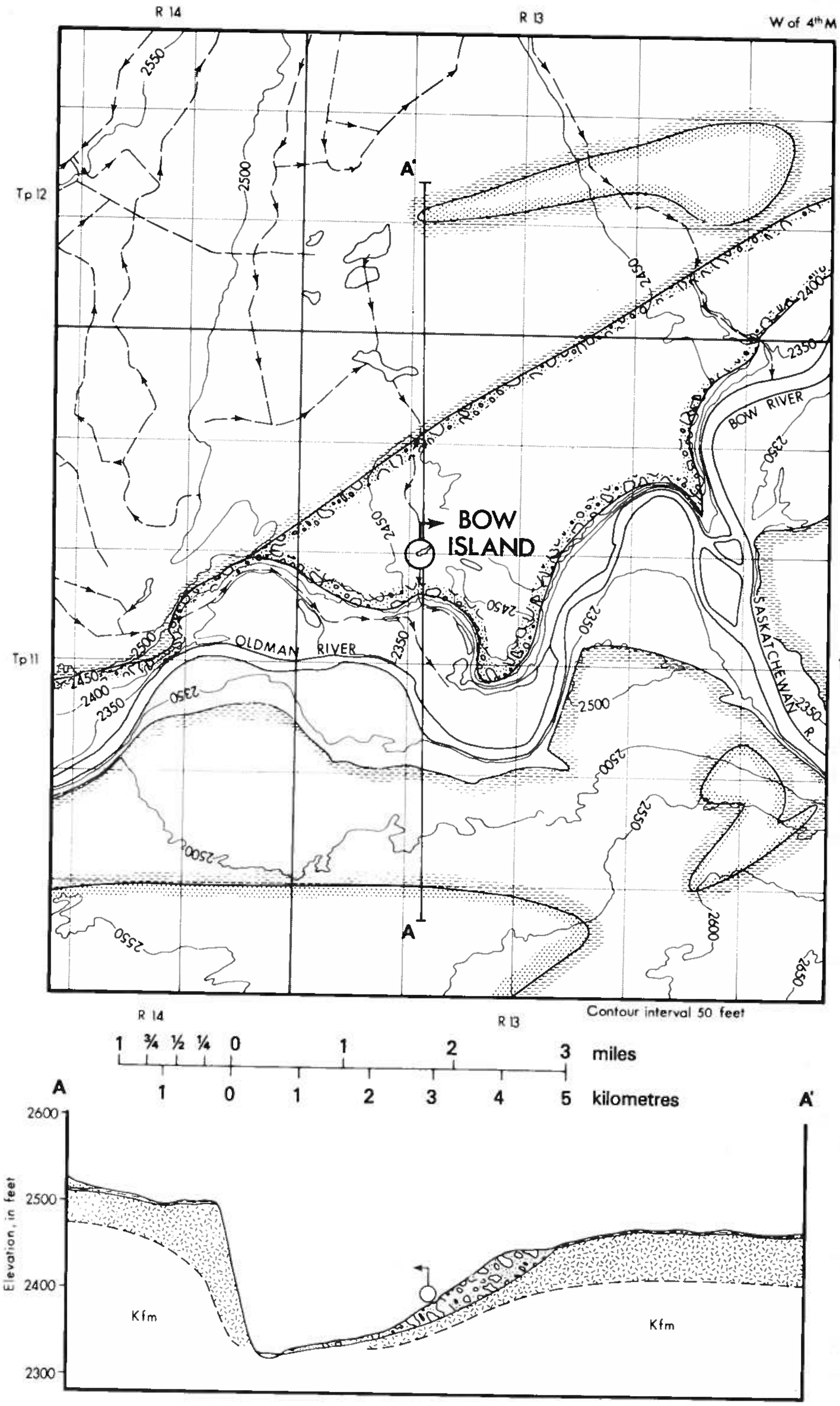


PLATE 22. Bow Island Springs



See legend on page 48.

FIGURE 27. Bow Island Springs: location, surficial geology and cross section

Discussions with farmers reveal that the springs existed at the same location in the past and were used for water supply in the early settlement years. Other smaller springs and seepages may be observed to the east of this location. The spring waters are still used for drinking water by people of the area. Waters from three of the springs are a calcium-magnesium bicarbonate type and one spring is a calcium-magnesium bicarbonate-sulfate type. This spring is also the farthest downstream from the dam. Between September and December 1976, TDS content of water at the spring outlets ranged from a low of 274 to a high of 508 mg/L.

In August 1976, lake water and spring waters had temperatures within 1°C. As time passed, however, temperatures decreased in the lake as well as in the springs, but when the lake was frozen in December 1976, the various spring temperatures were still between 8.3°C and 12.1°C.

SPRINGS ISSUING FROM COLLUVIUM

Colluvium is defined as "heterogeneous aggregates of rock detritus, such as talus and avalanches, resulting from the transporting action of gravity" (Rice, 1963). Such sediments are best developed in the Rocky Mountains and foothills regions, and many springs issuing from colluvium have been observed. Springs of this type vary in size from seepages to several tens of litres per second (several hundreds of igpm). The origin of spring waters can be from above the colluvium, from springs starting higher up, or from the bedrock situated behind the colluvium, or from both.

Storm Creek Springs

Appendix A, No. 270
Location: Tp 19, R 8, Sec 12, Lsd 1, W 5th Mer
Figure 28
Plate 23

One of many typical examples is Storm Creek Springs, located in the southern Rocky Mountain area. Here, several springs start at an elevation of about 2750 m (9000 ft) and discharging water flows down the steep mountain slopes to disappear at the point where colluvium sediments start (Plate 23). Several tens of metres down the colluvial slopes, springs again emerge. The colluvial spring waters originate from both the spring waters found at higher elevations and also partly from groundwaters in bedrock sediments under the colluvium. A small stream flowing at about 7.5 L/s (100 igpm) starts from the colluvial springs and forms a tributary to Storm Creek.

Sunwapta Pass Springs

Appendix A, No. 349
Location: Lsd 4, Sec 35, Tp 37, R 23, W 5th Mer
Plate 24

Another example of springs issuing from colluvium is a group of springs a short distance northeast of Sunwapta Pass and south of Highway 93 (Plate 24) where a small stream starts from numerous small colluvial springs on both sides of the highway. Several of these small springs deposit iron. TDS content of the spring waters is in the order of 200 mg/L and the waters are a calcium bicarbonate type.

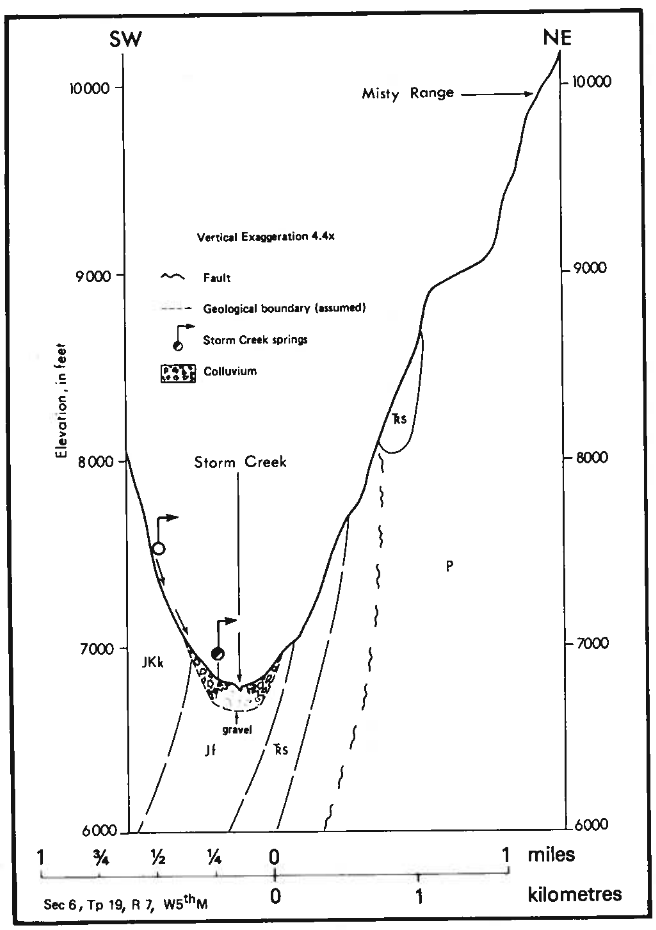


FIGURE 28. Storm Creek Springs: position in relation to the geology of the area

PLATE 23. Storm Creek Springs

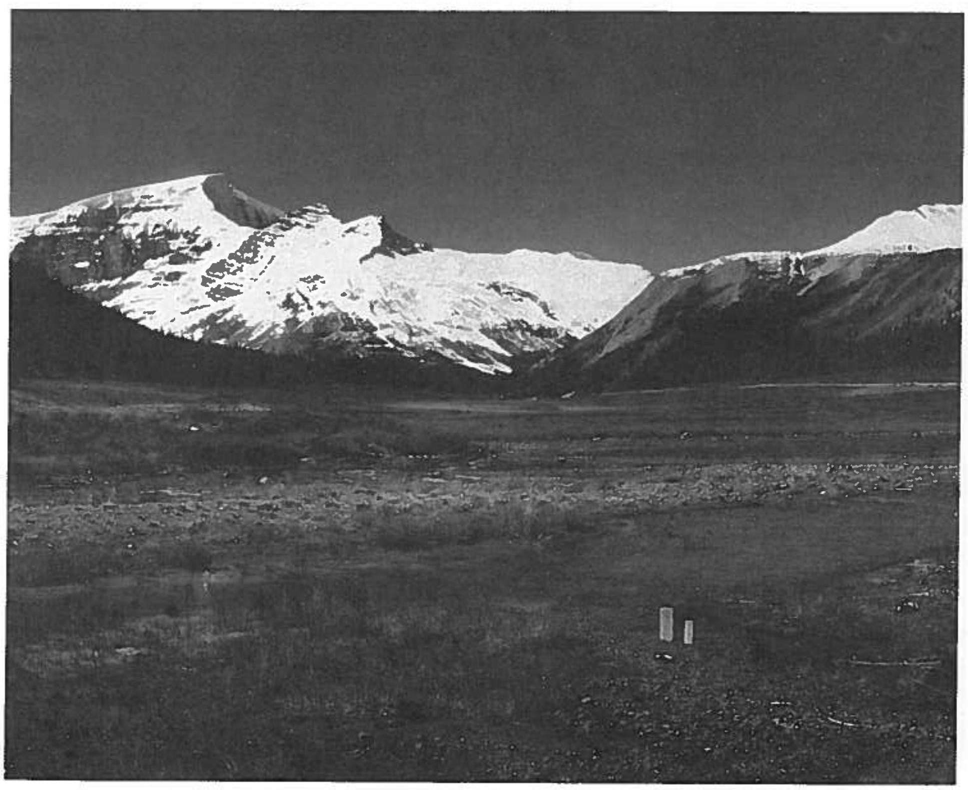


PLATE 24. Sunwapta Pass Springs

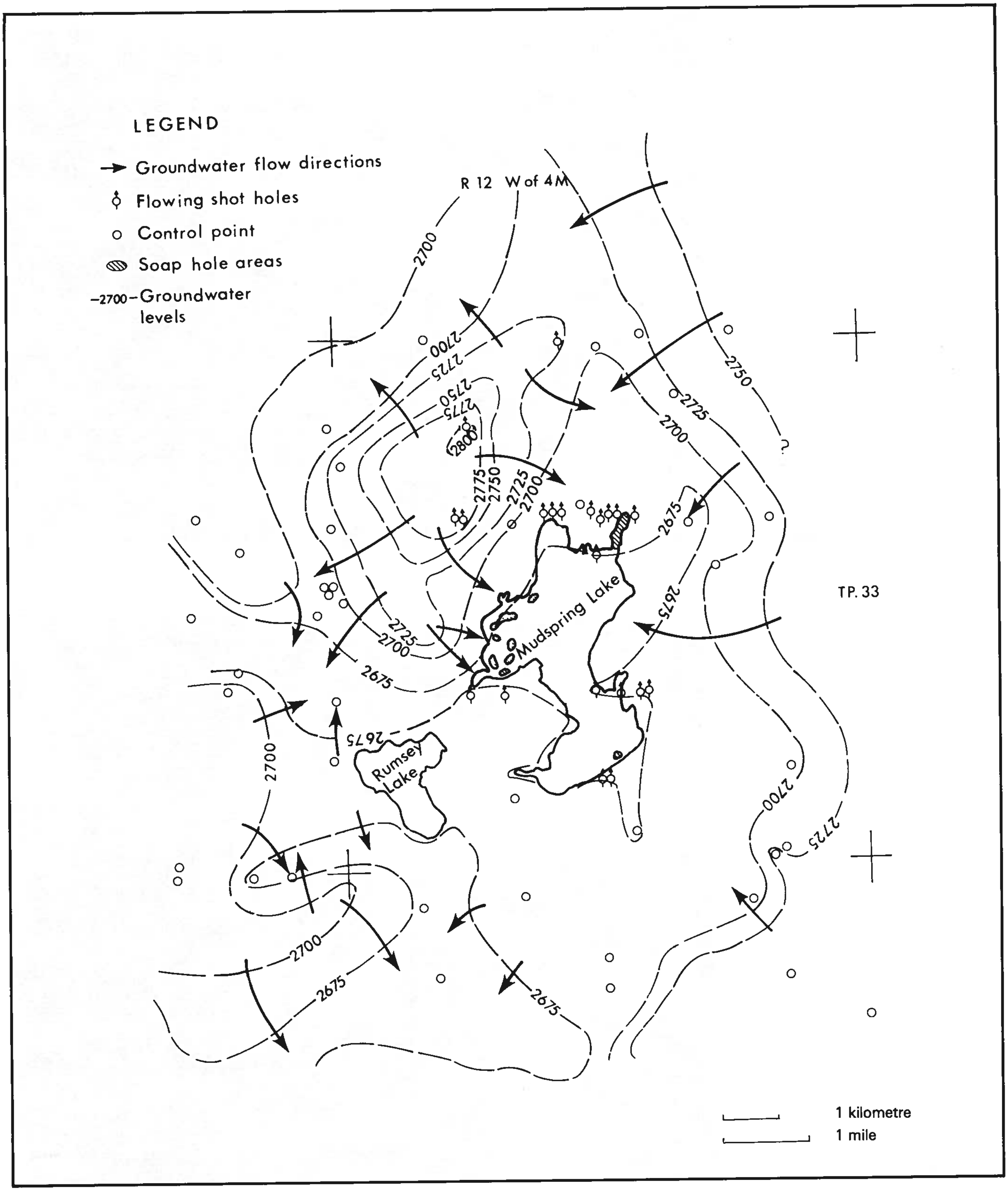


FIGURE 29. Mudspring Lake soap holes: location and water levels

SOAP HOLE TYPE OF SPRINGS

Spring discharge can take various appearances and soap holes are a unique variation. Soap holes have been defined as "a part of the land surface characterized by a local weakness of limited extent underlain by an admixture of sand, silt, clay and water" (Tóth, 1966, p. 42).

Soap holes, a relatively common feature of the central and southern Interior Plains of the province, have also been observed in the Rocky Mountains and foothills regions. The main soap hole areas, the Red Deer, Drumheller, Three Hills-Trochu, Olds and Pointe aux Pins areas, were investigated and described by various authors (Tóth, 1966; Clissold, 1967; Gabert, 1975; Currie, 1976). Soap holes are often associated with hummocky ground and salt deposits.

Mudspring Lake

Appendix A, No. 146
Location: Tp 33, R 20, W 4th Mer
Figure 29

Mudspring Lake, in southern Alberta about 53 km (33 mi) north of the town of Drumheller, is the site of a large concentration of soap holes in and around the lake area. At the northern end of the lake and to the north of the secondary highway, the presence of numerous soap holes has obliged the telephone company and a local farmer to move telephone poles and a fence to the north. Bentonitic mud and silts as well as sand can be seen oozing very slowly together with water from several of these soap holes. Tension cracks are also present and it is unsafe to come too close to them. In one instance, a 4 m (12 ft) pole was driven by hand with no difficulty into a soap hole without finding a solid bottom. Quick ground conditions make these areas unsafe and farmers usually fence the areas off to avoid losing cattle. Soap holes at a given site have also been known to dry up and to reappear at new locations. Soap holes can be seen in other parts of the Mudspring Lake area, south of the secondary highway and at the southern end of the lake. Aerial photographs suggest the presence of soap holes within the lake itself.

CONCLUSIONS

The largest number of springs included in this report are found in the mountains and the foothills regions of Alberta. The springs are also among those having the largest discharge rates. Among them are two springs of the second order of magnitude (see Meinzer spring order of magnitude in Table 1), and one group is of the first order and among the largest karst springs in the world. The main springs (by size and related to karst terrains) have been studied in some detail by a few authors.

The large majority of spring waters found in the mountains, the foothills, and in that part of the Interior Plains parallel to the foothills region are a calcium-magnesium bicarbonate type and have a TDS content that, on the average, ranges from 200 to 300 mg/L.

Calcareous tufas, iron, hydrogen sulfide gas, sulfur, and sodium sulfate are commonly associated with springs in most parts of the province. Sodium chloride deposits are found exclusively in the northeastern and northern parts of the province where Devonian rocks are near the surface.

Calcareous tufa deposits are widespread over the province and should be investigated in order to provide people, who are interested in calcium carbonate as a soil conditioner, with a set of phenomena associated with these deposits, such as plant association, groundwater temperature, pH, activity of specific types of bacteria, and types of soils.

Large fluctuations of the discharge rate of springs have been observed in the mountains and the foothills regions: however, little is known about the flow regime of most springs. These natural variations should be studied in the future.

Initially, springs with discharge rates ranging from 100 to 1000 L/s (1320 to 13 200 igpm) and the relationship of spring occurrence to rock types or to geologic formations in the province should be investigated. Some factors that could be studied include the permeability of the main rock types, the amount of precipitation that reaches aquifers, and the variations of the recharge in various rock types and environments. If, in the future, some spring waters are needed for industrial or recreational use, the variations of the discharge, temperature, and chemistry will need to be known. As well, the potential for pollutants to reach some springs should be investigated.

REFERENCES

Allan, J. A. and J. L. Carr (1947): Geological map Highwood-Elbow area; Alberta Research Council Map 20, Report 49, 75 p.

Allan, J. A. and J. O. G. Sanderson (1945): Geology of Red Deer and Rosebud sheets, Alberta; Alberta Research Council Report 13, 109 p.

American Association of Petroleum Geologists (1976): Geothermal gradient map of North America, scale 1:5 000 000.

Bayrock, L. A. (1970a): Surficial geology, Lake Claire, NTS 84, Alberta Research Council map.

________(1970b): Surficial geology, Bitumount, NTS 74E, Alberta Research Council map.

________(1970c): Surficial geology, Peace Point and Fitzgerald west of 110°20′, NTS 84P, 74M, Alberta Research Council map.

Barnes, R. (1976): Hydrogeology of the Mount Robson-Wapiti area, Alberta Research Council Report 76-5, 33 p.

Beach, H. H. and G. S. Hume (1941): Geological map Bragg Creek area, Geological Survey of Canada map 654A (scale 1 in to 1 mi).

Borneuf, D. M. (1974): Hydrogeology of the Foremost area, Alberta; Alberta Research Council Report 74-4, 26 p.

________(1979): Hydrogeology of the Kananaskis Lake area, Alberta; Alberta Research Council Report 79-4, 13 p.

Boyle, R. W. and D. McIntosh (1914): On the amount of radium and radium emanation present in the waters of several western springs; Royal Society of Canada Proceedings and Transactions, 3rd series, Vol. 7, Sec. 3, 163 p.

Brown, M. C. (1970): Karst geomorphology and hydrogeology of the lower Maligne basin, Jasper, Alberta; McMaster University, Ph.D. thesis, 178 p.

________(1972): Karst hydrology and infrared imagery: an example; Geological Society of America Bulletin, Vol. 83, p. 3151-3154.

Clissold, R. J. (1967): Mapping of naturally occurring surficial phenomena to determine groundwater conditions in two areas near Red Deer, Alberta; Unpublished University of Alberta M.Sc. thesis, 126 p.

Currie, D. V. (1976a): Hydrogeology of the Tri-Creek basin, Alberta; Alberta Research Council Bulletin 33, 67 p.

Currie, D. V. and N. Zacharko (1976b): Hydrogeology of the Vermilion area, Alberta; Alberta Research Council Report 75-5, 15 p.

Elworthy, R. T. (1917): Examination of the hot springs at Banff, Alberta; Royal Society of Canada Proceedings and Transactions, 3rd Series, Vol. 11, Sec. 3, p. 27-33.

________(1918): Mineral springs of Canada, Part II, The chemical character of some Canadian mineral springs; Canada Department of Mines Bulletin 20, (Mines Branch No. 472), 173 p.

________(1926): Hot springs in Western Canada — their radioactive and chemical properties; Canada Department of Mines, Mines Branch, Inventory Mineral Resources and Mining Industry, 1925, Bulletin 699, 33 p.

Environment Canada (1973): Canadian Normals Precipitation 1941-1970; Vol. 2, Downsview, Ontario, 330 p.

Ford, D. C. (1969): Short report to the National Parks and Historic Branch Department of Indian Affairs and Northern Development; under the terms of Contract No. 69-75, 1969.

________(1971a): Characteristics of limestone solution in the Southern Rocky Mountains and Selkirk Mountains, Alberta and British Columbia; Canadian Journal of Earth Sciences, Vol. 8, No. 6, p. 585-608.

________(1971b): Alpine karst in the Mt. Castleguard-Columbia Icefield area, Canadian Rocky Mountains; Arctic and Alpine Research, Vol. 3, No. 3, p. 239-252.

Ford, D. C. and J. F. Quinlan (1973): Theme and resource inventory study of the karst regions of Canada; Final report upon Project A, under the terms of Contract 72-32 of the National and Historic Parks Branch, Parks Canada, Ottawa, 111 p.

Gabert, G. M. (1975): Hydrogeology of Red Deer and vicinity, Alberta; Alberta Research Council Bulletin 31, 100 p.

Geoscience Consulting Ltd. (1975): Large springs in Alberta; prepared for Underwood, McLellan and Associates Ltd., Calgary, Alberta, 39 p.

Hackbarth, D. A. (1975): Hydrogeology of the Wainwright area, Alberta; Alberta Research Council Report 75-1, 16 p.

Hitchon, B., A. A. Levinson, and S. W. Reeder (1969): Regional variations of river water composition resulting from halite solution, Mackenzie River drainage basin, Canada; Water Resources Research, Vol. 5, No. 6, p. 1395-1403.

International Association of Hydrogeologists (1975): Hydrogeology of karstic terrains, Paris, 190 p.

Meinzer, O.E. (1923): Outline of ground-water hydrology; U.S. Geological Survey Water Supply Paper 494, 71 p.

Ozoray, G. F. (1972): Hydrogeology of the Wabamun Lake area, Alberta; Alberta Research Council Report 72-8, 19 p.

________(1974): Hydrogeology of the Waterways-Winnifred Lake area, Alberta; Alberta Research Council Report 74-2, 18 p.

________(1976): The scientific and economic value of karst studies in Alberta; The Albertan Geographer, No. 12, 1976, p. 43-60.

________(1977): The Athabasca carbonate and evaporite buried karst; Memoirs of the International Association of Hydrogeologists, Vol. XII, p. 85-98 *in* Proceedings of the International Association of Hydrogeologists 12th International Congress, Huntsville, Alabama, U.S.A.

Ozoray, G. F., D. A. Hackbarth, and A. T. Lytviak (1980): Hydrogeology of the Bitumount-Namur Lake area, Alberta; Alberta Research Council Report 78-6.

Pickering, B. J. (1954): Principal hot springs of the southern Rocky Mountains of Canada; Alberta Society of Petroleum Geologists, Guidebook 4th annual field conference, Banff-Golden-Radium, p. 146-148.

Rice, C. M. (1963): Dictionary of Geological Terms (exclusive of stratigraphic formations and paleontologic genera and species), 465 p.

Satterly, J. and R. T. Elworthy (1917): Mineral springs of Canada, Part I, The radioactivity of some Canadian mineral springs; Canada Department of Mines Bulletin 16 (Mines Branch No. 435), 60 p.

Schoeller, H. (1962): Les Eaux Souterraines; Masson et Cie Editeurs, Paris, 642 p.

Souther, J. G. and E. C. Halstead (1973): Mineral and thermal waters of Canada; Geological Survey of Canada Paper 73-18, Department of Energy, Mines and Resources, Ottawa, 31 p.

Stein, R. (1976): Hydrogeology of the Edmonton area (northeast segment), Alberta; Alberta Research Council Report 76-1, 21 p.

Tilden, Josephine E. (1898): Observations on some west American thermal algae; Botany Gazette, Vol. 24, p. 194-199.

Todd, D. K. (1960): Ground Water Hydrology, John Wiley and Sons, Inc., New York, 336 p.

Tokarsky, O. (1971a): Hydrogeology of the Grimshaw-Chinook valley area, Alberta; Alberta Research Council Report 71-2, 19 p.

________(1971b): Hydrogeology of the Rocky Mountain House area, Alberta; Alberta Research Council Report 71-3, 15 p.

________(1974): Hydrogeology of the Lethbridge-Fernie area, Alberta; Alberta Research Council Report 74-1, 18 p.

Tóth, J. (1966): Mapping and interpretation of field phenomena for groundwater reconnaissance in a prairie environment, Alberta, Canada; International Association of Scientific Hydrology XI Année, No. 2, p. 1-49.

________(1971): Groundwater discharge: A common generator of diverse geologic and morphologic phenomena; Bulletin of the International Association of Scientific Hydrology, XVI, 1.3, p. 7-24.

Vanden Berg, A. and K.W. Geiger (1973): Chemistry and hydrology of groundwater in the vicinity of the Waterton reservoir, Alberta; Alberta Research Council Report 73-3, 55 p.

van Everdingen, R. O. (1972): Thermal and mineral springs in the southern Rocky Mountains of Canada; Environment Canada, Water Management Service, Ottawa, Canada, 151 p.

Waring, G. A. (1965): Thermal springs of the United States and other countries of the world — a summary; Geological Survey Professional Paper 492, 383 p.

Warren, P. S. (1927): Banff area, Alberta, Canada; Geological Survey Memoir 153 (Geological Series No. 134), 94 p.

LEGEND FOR FIGURES (No 8 to 22)

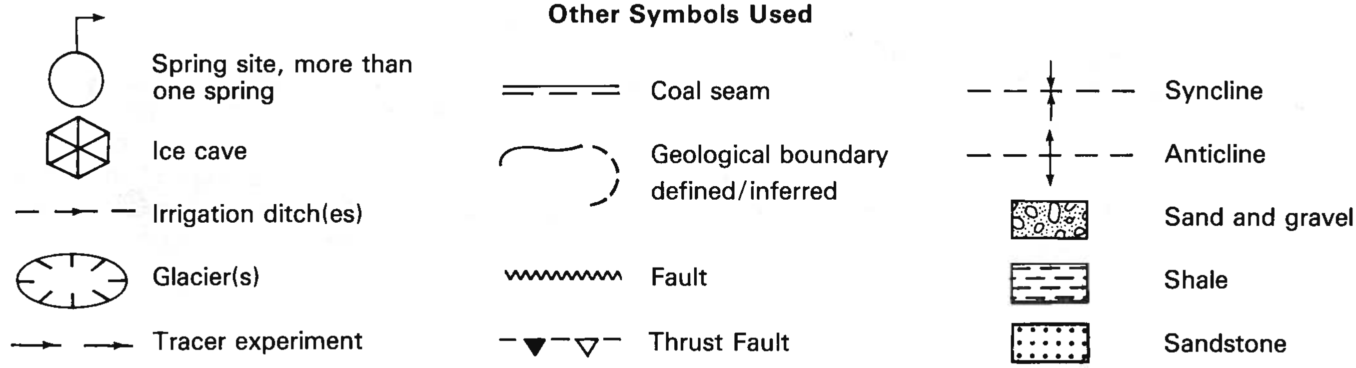
Rock Units or Time Units and Abbreviations

Qd	-	unconsolidated surficial deposits
TKp	-	Paskapoo Fm.
Tkw	-	Willow Creek Fm.
Ksc	-	Scollard Member
Ksm	-	St. Mary River Fm.
Kb + Kw	-	Battle and Whitemud Fm.
Khc	-	Horseshoe Canyon Fm.
Kbr	-	Belly River Fm.
Ka	-	Alberta Grp. (undivided)
Kwb	-	Wapiabi Fm.
Kcr	-	Cardium Fm.
Kbak	-	Blackstone Fm.
Kmp	-	Mountain Park Fm.
Kbl	-	Blairmore Fm.
Kls	-	Luscar Fm.
Kc	-	Clearwater Fm.
Km	-	McMurray Fm.
JKk	-	Kootenay Fm.
Jf	-	Fernie Grp.
TR	-	Triassic (undivided)
TRs	-	Spray River Grp.
Pzu	-	Upper Paleozoic (undivided)
Pzl	-	Lower Paleozoic (undivided)
Mr	-	Rundle Grp.
Mbf	-	Banff Fm.
Dpa	-	Palliser Fm.
Df	-	Fairholme Grp.
Dw	-	Waterways Fm.
Є	-	Upper Cambrian (undivided)
Єlx	-	Lynx Grp.
Єpk	-	Pika Fm.
Єel	-	Eldon Fm.
Єst	-	Stephen Fm.
Єca	-	Cathedral Fm.
Ᵽ	-	Miette Grp.

Note: The north is always toward the top of the figures.

Scale: 1:50 000 (unless otherwise indicated)

Other Symbols Used



APPENDIX A

Characteristic features of some Alberta springs

Abbreviations used

Mer	—	meridian
Tp	—	township
R	—	range
Sec	—	section
Lsd	—	legal subdivision
Elev	—	elevation (in ft a.m.s.l.)
Meinz.	—	Meinzer spring order of magnitude
field cond.	—	field conductivity (μmhos/cm)
field temp.	—	field temperature (in degrees Celsius)
alk.	—	alkalinity (as mg/L $CaCO_3$)
g	—	gravel
s & g	—	sand and gravel
ss	—	sandstone
cgl	—	conglomerate
ls	—	limestone
dol	—	dolomite
gyp	—	gypsum
sh	—	shale
sst	—	siltstone

Index No	Mer	Tp	R	Sec	Lsd	Elev ft	Flow Rate L/sec	Meinz.	Aquifer Lithology	Nature of Permeability	Permanence	Mineral Deposit	Field Cond. µmhos/cm²	Field Temp. °C	Field pH
1	4	1	13	12	1	3725	-	-	-	-	-	-	-	-	-
2	4	1	15	27	16	3300	-	-	-	-	-	-	-	-	-
3	4	1	18	14	-	4200	-	-	-	-	-	-	-	-	-
4	4	1	21	18	16	4190	7.9	V	s & g	intergranular	yes	no	710	8.9	7.9
5	4	1	23	10	15	4200	3.8	V	shale	fracture	yes	iron	420	6.6	7.6
6	4	1	27	33	2	4490	3.8	V	-	-	yes	-	-	4.5	-
7	4	2	15	6	9	3340	0.38	VI	till	intergranular	-	iron	-	8.0	-
8	4	2	15	29	16	3425	-	-	-	-	-	-	5,000	12.2	-
9	4	2	17	4	1	3775	-	VII	ss	-	yes	salts	-	6.0	-
10	4	2	17	6	14	3720	0.08	VII	-	intergranular	yes	salts	7,100	5.8	6.9
11	4	2	17	7	7	3665	0.08	VII	ss	-	yes	no	-	-	-
12	4	2	19	20	11	3675	0.08	VII	-	-	yes	no	-	9.0	-
13	4	2	21	24	13	3975	-	-	-	-	-	-	-	-	-
14	4	2	21	31	14	4150	7.6	V	-	-	yes	no	-	5.0	-
15	4	2	29	8	4	4200	15.1	IV	s & g	intergranular	yes	no	335	19.2	8.3
16	4	2	29	17	4	4280	56.8	IV	s & g	intergranular	yes	no	-	6.7	-
17	4	3	18	31	10	3950	0.08	VII	-	-	yes	no	-	7.0	7.6
18	4	3	23	32	13	3775	1.21	V	sand	intergranular	yes	no	-	5.0	-
19	4	3	24	23	-	3875	-	-	-	-	-	-	-	-	-
20	4	4	18	21	12	3415	0.08	VII	ss & sh	fracture	-	salts	16,900	9.1	7.6
21	4	4	18	31	6	2290	0.08	VII	-	-	yes	no	-	11.0	6.9
22	4	4	18	31	8	3330	0.08	VII	ss	fracture	yes	no	-	7.0	7.9
23	4	4	19	20	13	3660	0.28	VI	ss	fracture	-	-	-	8.0	-
24	4	4	22	10	8	3575	0.76	VI	-	-	-	-	-	-	-
25	4	4	23	15	1	3770	-	-	-	-	-	-	-	-	-

All measurements of dissolved solids and alkalinity given in mg/L.

Lab. pH	TDS	Ca	Mg	Na+K	HCO_3 $+CO_3$	SO_4	Cl	NO_3	SiO_2	Fe	Field Alk.	Lab. Alk.	Remarks
-	7,016	-	-	-	-	3963	74	30	-	0.1	-	373	
-	1,070	-	-	-	-	283	9	0	-	1.0	-	490	Red Creek spring
-	6,654	-	-	-	-	355	69	-	-	-	-	940	
8.0	418	55	39	40	386	18	4	64	7.6	0.3	384	309	Two springs at same location
7.7	403	57	34	48	386	45	4	18	7.8	0.1	408	309	Whisky Gap Springs; see text, p. 34
-	218	-	-	-	-	12	2	0	-	0	-	160	
8.4	1,348	25	20	354	416	366	6	1	-	0	-	416	
8.2	4,812	198	195	1019	417	2875	108	26	-	0.1	-	417	Forms pond
8.7	2,990	29	51	903	322	1725	43	22	-	0	-	322	Concrete catchment
7.0	6,193	380	268	1259	473	3635	148	258	12.2	1.4	521	378	Wooden cribbing around spring
7.9	1,456	185	83	158	388	515	37	1	-	0	-	388	
-	1,104	-	-	-	-	457	14	0	-	0	-	514	Plastic pipe for catchment
7.6	1,128	146	93	77	427	558	38	0	-	0	-	350	
-	662	-	-	-	-	298	20	15	-	0	-	198	Crystal spring colony 5' deep reservoir
7.5	200	33	23	8	232	5	4	3	9.5	0.3	-	186	
8.2	164	35	28	8	200	6	1	3	-	0	-	200	Used in the past for fish hatchery
-	1,066	-	-	-	-	322	6	0	-	0	-	476	
8.1	2,396	188	135	270	324	1257	10	20	-	0	-	324	Wooden cribbing around spring
-	1,768	-	-	-	-	868	22	8	-	0.1	-	408	
7.7	14,089	380	440	3881	1017	8500	120	262	6.7	2.4	1035	814	
-	14,680	-	-	-	-	8976	280	41	-	0.1	-	610	Slumping in the area
7.7	6,184	166	218	1488	276	3750	213	93	-	0	-	276	Pipe in hillside
-	2,286	-	-	-	-	1158	24	8	-	0.1	-	392	
-	1,980	-	-	-	-	1073	12	3	-	0	-	355	Reservoir at spring site
-	5,076	-	-	-	-	3000	16	142	-	0.1	-	585	

Index No	Mer	Tp	R	Sec	Lsd	Elev ft	Flow Rate L/sec	Meinz.	Aquifer Lithology	Nature of Permeability	Permanence	Mineral Deposit	Field Cond. µmhos/cm²	Field Temp. °C	Field pH
26	4	4	27	21	1	3700	-	-	-	-	-	-	-	-	-
27	4	4	27	28	16	3700	379.0	III	-	-	yes	no	610	13.0	8.1
28	4	5	20	5	10	3475	0.08	VII	-	-	-	salts	-	12.5	-
29	4	5	21	4	1	3665	0.9	VI	-	-	yes	no	-	-	6.9
30	4	5	21	11	3	3525	0.08	VII	-	-	yes	no	-	-	7.1
31	4	5	22	11	16	3350	-	-	-	-	-	-	-	-	-
32	4	5	22	35	4	3215	-	-	-	-	-	-	-	-	-
33	4	5	23	27	3	3400	0.08	VII	ss	fracture	yes	no	-	8.0	-
34	4	6	10	33	1	2675	0.23	VI	ss	fracture	-	salts	-	7.5	-
35	4	7	29	36	10	3600	2.65	V	ss	-	yes	no	-	7.0	-
36	4	8	3	11	13	4700	3.8	V	cgl	intergranular	yes	no	-	-	-
37	4	8	21	17	16	2925	0.08	VII	sand, silt clay	intergranular	-	iron	-	11.0	-
38	4	8	21	18	12	3042	0.04	VII	-	-	-	-	-	-	-
39	4	8	26	15	3	3400	-	VIII	sand, silt clay	intergranular	-	salts	-	-	-
40	4	8	29	7	4	4025	-	-	-	-	-	-	-	-	-
41	4	9	3	9	16	2525	1.51	V	-	-	-	-	-	-	-
42	4	9	22	12	12	3025	-	VIII	-	-	-	-	-	-	-
43	4	9	22	24	14	3225	-	VIII	-	-	-	-	-	-	-
44	4	9	22	25	9	3240	-	VIII	-	-	-	-	-	-	-
45	4	9	30	2	4	4750	-	-	-	-	-	-	-	-	-
46	4	10	3	22	2	3090	0.08	VII	sand	intergranular	yes	no	1,500	6.5	7.8
47	4	10	9	12	8	2575	1.51	V	sand	intergranular	yes	no	2,000	10.0	7.6
48	4	10	13	4	16	2555	0.45	-	-	-	-	salts	6,000	6.6	7.8
49	4	10	17	2	1	2605	-	VIII	ss	fracture	-	salts	-	8.9	-
50	4	10	17	18	16	2500	1.51	V	s & g	intergranular	-	-	-	-	8.4

All measurements of dissolved solids and alkalinity given in mg/L.

Lab. pH	TDS	Ca	Mg	Na+K	HCO_3 $+CO_3$	SO_4	Cl	NO_3	SiO_2	Fe	Field Alk.	Lab. Alk.	Remarks
-	1,540	-	-	-	-	680	0	5	-	0	-	150	Five small springs along bank
7.8	400	44	28	63	222	144	4	1	6.7	0.3	237	178	Three flowing wells in coulee; see text p. 5
8.6	1,968	48	31	1230	526	2279	47	35	-	0	-	526	Pipe in hillside
-	2,188	-	-	-	-	1101	20	25	-	0	-	348	
-	1,512	-	-	-	-	651	20	3	-	0.3	-	485	Piped to house
4.1	3,613	163	330	291	10	2600	360	18	-	0.1	-	8	
-	1,238	-	-	-	-	543	10	3	-	0.1	-	305	
8.3	2,336	134	171	274	194	1240	13	46	-	0	-	194	
8.4	1,646	6	3	587	924	263	50	8	-	0	-	924	Slumping in spring area
8.6	1,112	24	35	280	190	600	34	2	-	0	-	-	
-	214	-	-	-	160	14	2	0	-	0	-	160	Nichol Spring Cypress Hills Provincial Park
7.9	1,892	208	109	204	182	1096	17	2	-	0	-	182	Wooden cribbing around spring
-	6,210	-	-	-	-	3270	75	416	-	7.9	-	190	Slumping in the area
9.1	2,536	11	35	720	530	840	108	81	-	0	-	530	Slumping in the area
-	2,038	-	-	-	-	1064	34	36	-	0	-	410	
-	1,032	-	-	-	-	439	4	-	-	0	-	426	
-	3,136	-	-	-	-	1836	5	10	-	0.2	-	180	
-	3,738	-	-	-	-	2232	36	0	-	0.9	-	150	
-	3,196	-	-	-	-	1142	57	0	-	1.4	-	990	
8.1	2,101	72	42	621	772	950	29	0	-	2.5	-	633	
8.0	1,356	137	82	146	420	510	11	8	-	0.1	-	420	
8.0	1,360	10	3	518	843	185	30	7	-	0.1	-	843	
8.0	5,994	27	19	1681	1514	2000	56	24	-	0.2	-	1514	
-	7,996	-	-	-	-	4547	226	20	-	0	-	244	
-	1,790	-	-	334	466	806	15	-	-	-	-	-	Along Oldman River

Index No	Mer	Tp	R	Sec	Lsd	Elev ft	Flow Rate L/sec	Meinz.	Aquifer Lithology	Nature of Permeability	Permanence	Mineral Deposit	Field Cond. µmhos/cm²	Field Temp. °C	Field pH
51	4	10	17	21	13	2700	1.51	V	s & g	intergranular	-	-	-	-	8.4
52	4	10	24	15	1	3125	-	-	-	-	-	-	-	-	-
53	4	10	24	17	8	3015	0.08	VII	ss	fracture	yes	no	-	6.0	-
54	4	11	3	35	3	2475	0.16	VI	ss	fracture	yes	no	1,400	8.0	8.0
55	4	11	11	8	16	2350	7.5	V	s & g	intergranular	-	iron & salts	2,700	14.5	8.2
56	4	11	11	22	8	2300	5.68	V	s & g	intergranular	yes	no	-	10.1	-
57	4	11	13	20	13	2450	64.0 Total	IV	s & g	intergranular	yes	no	395	18.7	7.8
58	4	11	13	20	13	2450	-	-	s & g	intergranular	yes	no	535	17.7	7.7
59	4	11	13	20	13	2450	-	-	s & g	intergranular	yes	no	485	17.4	7.8
60	4	11	13	20	13	2450	-	-	s & g	intergranular	yes	no	455	16.9	7.7
61	4	11	13	20	13	2450	-	-	s & g	intergranular	yes	no	355	17.1	7.7
62	4	11	13	20	13	2455	-	-	-	-	yes	no	400	14.6	9.2
63	4	11	14	23	1	2475	0.02	VII	s & g	intergranular	yes	no	2,300	12.5	7.3
64	4	11	15	11	3	2540	0.02	VII	s & g	intergranular	-	salts	5,000	17.0	7.8
65	4	11	16	5	4	2500	-	-	-	-	-	-	-	-	-
66	4	11	16	30	4	2575	-	-	-	-	-	-	-	-	-
67	4	12	3	5	1	2500	-	-	gravel	intergranular	-	-	-	-	-
68	4	12	5	31	-	2250	0.76	VI	-	-	-	-	-	-	-
69	4	12	8	26	14	2300	-	-	-	-	-	-	-	-	-
70	4	12	12	16	2	2390	3.80	V	s & g	intergranular	yes	no	700	15.4	7.4
71	4	12	21	28	1	3035	-	-	-	-	-	-	-	-	-
72	4	13	6	13	16	2175	-	-	-	-	-	-	-	-	-
73	4	13	6	23	16	2325	-	-	-	-	-	-	-	-	-
74	4	13	6	25	-	2200	-	-	gravel	intergranular	-	-	-	-	-
75	4	14	22	24	14	2975	-	-	-	-	-	-	-	-	-

All measurements of dissolved solids and alkalinity given in mg/L.

Lab. pH	TDS	Ca	Mg	Na+K	HCO_3 $+CO_3$	SO_4	Cl	NO_3	SiO_2	Fe	Field Alk.	Lab. Alk. mg/l	Remarks
-	1,814	-	-	483	525	720	26	-	-	-	-	-	Along Oldman River
8.6	6,124	262	290	1250	-	3967	58	-	-	0.1	-	440	
-	1,564	-	-	-	-	863	32	14	-	0	-	164	
7.9	1,310	101	44	177	324	457	7	2	-	0.1	-	324	
8.0	1,621	34	73	485	939	504	52	2	9.5	-	1039	751	Three discharge points with wooden cribbing around
8.1	1,236	64	41	238	424	313	17	9	-	0	-	424	Extenisve slumping in general area
7.5	284	40	20	40	190	78	4	2	7.3	-	197	152	Bow Island Springs main stream See text, p. 40
7.4	394	53	30	48	234	126	12	1	9.1	0.1	250	187	Bow Island Springs Discharge point B See text, p. 40
7.5	304	43	19	38	215	79	8	2	9.4	0	229	172	Bow Island Springs Discharge point C See text, p. 40
7.5	340	42	21	37	224	48	6	1	9.4	-	236	179	Bow Island Springs Discharge point D See text, p. 40
7.3	319	43	22	40	224	86	8	0	10.8	-	237	179	Bow Island Springs Discharge point E See text, p. 40
7.4	268	24	18	34	142	71	10	9	1.1	0	103	114	Lake to the north of Discharge point B See text, p. 40
7.7	2,514	313	138	153	264	1300	16	5	-	0.1	-	264	Slumping in the area
8.0	5,678	458	222	899	249	3400	78	8	-	0.1	-	249	Seepages in the area
-	1,428	-	-	-	-	662	12	-	-	0	-	323	
8.7	1,254	12	35	374	468	469	13	3	-	0	-	468	
-	1,340	-	-	-	-	582	32	0	-	0.1	-	406	
8.1	2,444	242	185	150	128	1441	33	3	-	0	-	128	
8.0	1,672	18	15	541	818	283	49	6	-	0	-	818	
8.1	744	69	32	75	358	105	0	2	-	0.1	-	358	Quick ground
7.6	4,576	400	330	351	785	1663	323	136	-	0.2	-	785	
7.8	3,388	463	134	260	232	1925	50	93	-	0	-	232	
-	1,254	-	-	-	-	498	39	22	-	5.0	-	190	
8.3	1,341	25	67	384	988	343	35	0	-	0	-	811	
8.0	2,832	144	145	575	506	1562	28	5	-	0	-	506	

Index No	Mer	Tp.	R	Sec	Lsd	Elev ft	Flow Rate L/sec	Meinz.	Aquifer Lithology	Nature of Permeability	Permanence	Mineral Deposit	Field Cond. µmhos/cm²	Field Temp. °C	Field pH
76	4	14	23	11	4	2975	-	-	-	-	-	-	-	-	-
77	4	15	23	20	1	3120	-	-	-	-	-	-	-	-	-
78	4	15	23	20	1	3120	-	-	-	-	-	-	-	-	-
79	4	16	24	14	1	3375	-	-	-	-	-	-	-	-	-
80	4	16	30	36	14	3565	-	-	-	-	-	-	-	-	-
81	4	17	24	24	13	3250	-	-	-	-	-	-	-	-	-
82	4	17	24	26	4	3355	-	-	-	-	-	-	-	-	-
83	4	19	29	17	16	3465	-	-	-	-	-	-	-	-	-
84	4	20	1	26	13	2375	0.08	VII	-	-	-	-	-	-	-
85	4	20	28	15	14	3550	-	-	-	-	-	-	-	-	-
86	4	20	29	27	4	3425	-	-	-	-	-	-	-	-	-
87	4	21	9	33	14	2225	-	-	-	-	-	-	-	-	-
88	4	21	13	28	16	2300	3.8	V	s & g	intergranular	yes	iron	3,750	12.4	7.7
89	4	21	14	14	16	2450	0.38	VI	sand	intergranular	-	-	-	10.0	-
90	4	22	6	8	16	2050	-	-	-	-	-	-	-	10.0	-
91	4	22	9	2	1	2050	-	-	-	-	-	-	-	-	-
92	4	22	12	34	4	2175	0.38	VI	-	-	-	-	1,500	4.0	-
93	4	23	7	9	16	2025	1.51	V	-	-	-	-	2,100	22.0	-
94	4	23	7	10	16	2025	0.23	VI	-	-	-	-	1,800	16.0	-
95	4	24	2	31	1	2325	-	-	-	-	-	-	-	-	-
96	4	24	14	18	13	2230	0.15	VI	gravel	intergranular	yes	salts	2,400	20.0	7.0
97	4	25	5	5	1	2450	-	VIII	-	-	-	salts	5,000	13.0	7.5
98	4	25	7	36	6	2590	0.76	VI	sand, silt clay	intergranular	yes	no	1,500	13.0	6.8
99	4	25	14	16	16	2350	0.30	VI	gravel	intergranular	yes	no	2,100	7.5	7.0
100	4	25	20	6	-	2950	-	VIII	sand, silt clay	intergranular	yes	slight salts	-	-	-

All measurements of dissolved solids and alkalinity given in mg/L.

Lab. pH	TDS	Ca	Mg	Na+K	HCO_3 $+CO_3$	SO_4	Cl	NO_3	SiO_2	Fe	Field Alk.	Lab. Alk.	Remarks
7.3	1,524	94	76	150	463	722	19	0	-	0.1	-	381	
-	2,098	-	-	-	-	492	81	0	-	1.0	-	1145	Spring #1
-	4,904	-	-	-	-	2564	35	212	-	0	-	750	Spring #2
8.0	1,080	106	44	-	-	337	15	-	-	0.1	-	312	
7.5	1,106	88	55	182	399	382	8	10	-	0	-	399	
7.4	1,627	141	105	253	509	843	29	0	-	0.1	-	417	
-	3.156	-	-	-	-	1637	32	0	-	0	-	370	
-	1,012	-	-	-	-	410	2	8	-	0.1	-	425	
8.4	4,722	29	37	1473	512	2580	168	11	-	0	-	512	
7.6	1,322	75	45	256	424	446	7	12	-	0.1	-	424	
-	2,080	-	-	-	-	241	834	2	-	0.5	-	373	
8.3	1,892	22	27	504	580	632	11	9	-	0	-	580	
7.8	3,068	385	150	338	368	1985	14	1	14.4	0	394	294	Wooden cribbing around spring
7.7	1,448	173	73	110	84	836	8	1	-	0	-	84	
8.7	1,070	13	36	329	580	288	29	1	-	0	-	580	
8.3	2,250	4	2	779	682	770	139	9	-	0	-	682	
8.4	1,178	80	50	161	190	470	7	13	-	0	-	190	
8.3	1,624	35	93	304	323	744	19	1	-	0	-	323	Two other springs nearby in Red Deer Valley
7.9	1,206	41	95	209	362	539	13	8	-	0	-	362	In Red Deer Valley
-	1,324	-	-	-	-	417	6	5	-	0	-	441	One other spring in the vicinity
7.6	2,212	199	107	354	494	1006	22	3	-	0.1	-	494	
8.3	5,270	100	224	1234	478	3160	70	1	-	0	-	478	
7.7	1,228	202	84	89	336	548	16	0	-	0.1	-	336	Ponded
7.5	1,560	176	74	271	676	540	8	1	-	0.2	-	676	One other spring nearby
-	-	-	-	-	-	-	-	-	-	-	-	-	Soap hole,tension cracks

Index No	Mer	Tp	R	Sec	Lsd	Elev ft	Flow Rate L/sec	Meinz.	Aquifer Lithology	Nature of Permeability	Permanence	Mineral Deposit	Field Cond. µmhos/cm²	Field Temp. °C	Field pH
101	4	25	23	12	14	2900	-	VIII	sand, silt clay	intergranular	yes	slight salts	-	-	-
102	4	25	23	18	4	2975	0.15	VI	-	intergranular	yes	no	1,015	18.8	8.0
103	4	26	15	20	4	2625	-	-	-	-	-	-	-	-	-
104	4	26	22	6	13	2900	-	-	-	-	-	-	-	-	-
105	4	26	23	35	12	2900	4.5	V	ss	fracture	yes	salt	3,450	7.1	7.9
106	4	26	29	25	1	3625	-	-	-	-	-	-	-	-	-
107	4	27	1	17	14	2400	0.08	VII	sand	intergranular	yes	no	1,200	20.0	7.0
108	4	27	3	19	13	2450	-	-	-	-	-	-	-	-	-
109	4	27	3	35	4	2550	-	-	-	-	-	-	-	-	-
110	4	27	6	25	8	2490	0.08	VII	sand	intergranular	yes	no	3,500	11.0	6.8
111	4	27	15	1	16	2675	-	-	-	-	-	-	-	-	-
112	4	27	17	1	4	2550	-	-	-	-	-	-	-	-	-
113	4	27	18	17	4	2650	-	-	-	-	-	-	-	-	-
114	4	27	20	17	13	2600	1.14	V	-	-	-	-	-	8.0	-
115	4	27	23	22	16	2800	0.76	VI	ss	fracture	-	-	-	-	-
116	4	27	24	19	1	2950	-	-	-	-	-	-	-	-	-
117	4	28	2	2	4	2375	-	-	-	-	-	-	-	-	-
118	4	28	22	9	13	2800	-	-	-	-	-	-	-	-	-
119	4	28	22	17	12	2890	0.08	VII	-	-	-	salts	-	12.5	-
120	4	28	27	30	8	3180	0.91	VI	ss	fracture	yes	-	-	-	-
121	4	29	2	7	3	2350	1.51	V	sandy clay	intergranular	yes	iron	1,700	17.0	7.0
122	4	29	6	30	1	2400	0.15	VI	gravel	intergranular	yes	no	2,000	14.0	7.0
123	4	29	14	18	16	2700	-	-	-	-	-	-	-	-	-
124	4	29	27	4	1	3140	0.15	VI	-	-	-	iron	-	-	-
125	4	29	28	3	8	3200	-	-	-	-	-	iron	-	-	-

All measurements of dissolved solids and alkalinity given in mg/L.

Lab. pH	TDS	Ca	Mg	Na+K	HCO_3 $+CO_3$	SO_4	Cl	NO_3	SiO_2	Fe	Field Alk.	Lab. Alk.	Remarks
-	-	-	-	-	-	-	-	-	-	-	-	-	Soap hole tension cracks
8.0	679	43	24	186	534	147	6	1	10.3	0	570	427	Discharge increases downstream
8.3	1,040	-	-	-	-	292	11	6	-	0	-	500	
-	1,428	-	-	-	-	667	10	29	-	0	-	340	
7.9	2,618	79	31	753	422	1520	14	6	7.0	0	445	338	Rockyford Spring See text, p. 30
7.6	2,284	-	-	-	-	380	550	0	-	5.0	-	400	
7.9	2,434	81	133	490	528	1110	20	2	-	0.1	-	528	Dugout for spring discharge
-	2,336	-	-	-	-	1179	28	0	-	15.0	-	480	
-	1,690	-	-	-	-	641	24	0	-	0.5	-	582	
7.9	3,012	93	60	794	554	1575	18	12	-	0.1	-	554	Dugout for spring discharge
-	1,760	165	85	-	-	475	20	9	-	1.2	-	790	
8.4	1,644	-	-	-	-	378	26	-	-	-	-	880	Cement catchment
-	1,494	-	-	-	-	750	12	0	-	-	-	340	
8.5	1,076	11	16	338	604	263	16	2	-	0	-	604	
8.6	1,214	25	8	381	378	532	12	0	-	0	-	378	One other spring nearby
8.9	1,500	18	68	430	640	566	8	1	-	0	-	640	
-	1,028	-	-	-	-	271	14	0	-	0	-	460	
-	1,546	-	-	-	-	686	6	0	-	0.2	-	415	
8.2	1,390	12	2	506	608	477	5	0	11.2	-	-	608	
7.6	1,948	150	77	387	456	955	7	2	-	-	-	456	Flow increases rapidly with rainfall
8.2	1,242	95	90	188	434	510	16	1	-	0.1	-	434	
8.1	1,416	45	53	354	328	660	24	0	-	0	-	328	
-	1,336	102	37	-	-	201	15	0	-	0	-	490	
7.9	2,110	208	144	134	484	1025	4	1	-	-	-	484	Seepages in vicinity
7.4	3,158	450	220	119	424	1688	9	11	-	-	-	424	

Index No	Mer	Tp	R	Sec	Lsd	Elev ft	Flow Rate L/sec	Meinz.	Aquifer Lithology	Nature of Permeability	Permanence	Mineral Deposit	Field Cond. µmhos/cm²	Field Temp. °C	Field pH
126	4	29	28	18	6	3300	-	VIII	-	-	-	-	-	-	-
127	4	30	1	8	8	2325	1.90	V	s & g	intergranular	yes	iron	940	14.6	7.8
128	4	30	3	33	3	2210	-	VIII	s & g	intergranular	yes	no	-	-	7.0
129	4	30	8	19	1	2450	-	-	-	-	-	-	-	-	-
130	4	30	29	10	4	3200	-	-	-	-	-	-	-	-	-
131	4	31	1	23	13	2190	-	VIII	-	-	-	-	1,550	23.0	-
132	4	31	3	11	15	2375	-	VIII	sandy clay	intergranular	-	-	2,500	15.0	7.0
133	4	32	22	23	1	2750	0.15	-	-	-	-	-	-	6.5	7.9
134	4	32	24	1	1	2935	-	-	-	-	-	-	-	-	-
135	4	32	24	4	12	2790	0.3	VI	-	-	-	iron	-	4.1	-
136	4	33	9	23	16	2500	0.15	VI	sand	intergranular	-	salts	-	7.0	-
137	4	33	23	8	1	2850	0.23	VI	-	-	-	salts	-	-	-
138	4	33	23	8	13	2775	0.15	VI	-	-	-	-	-	-	-
139	4	33	23	17	16	2875	0.04	VII	-	-	-	salts	-	-	-
140	4	33	24	11	13	2940	0.04	VII	-	-	-	-	-	-	-
141	4	34	6	14	4	2575	0.15	VI	sandy clay	intergranular	yes	no	-	-	-
142	4	34	25	27	16	3015	-	-	-	-	-	-	-	-	-
143	4	35	21	22	4	2500	-	-	-	-	-	-	-	-	-
144	4	35	22	4	13	2850	-	-	-	-	-	-	-	-	-
145	4	38	22	3	1	2700	-	-	-	-	-	-	-	-	-
146	4	33	20	-	-	2670	-	VIII	sand, silt clay	intergranular	yes	salt	-	-	-
147	4	39	10	29	5	2350	7.6	V	-	-	yes	no	800	10.9	8.3
148	4	40	16	36	14	2350	-	-	-	-	-	iron	-	-	-
149	4	40	17	10	16	2490	-	-	-	-	-	-	-	-	-
150	4	40	23	19	13	2750	3.79	V	-	-	yes	calcareous tufa	1,100	5.9	7.8

All measurements of dissolved solids and alkalinity given in mg/L.

Lab. pH	TDS	Ca	Mg	Na+K	HCO3 +CO3 g/l	SO_4	Cl	NO_3	SiO_2	Fe	Field Alk.	Lab. Alk.	Remarks
7.6	1,870	240	113	189	532	843	4	17	8.3	-	-	532	
7.7	701	109	54	60	412	244	18	0	13.4	2.5	443	330	Flow increases rapidly with rainfall
7.6	1,216	68	38	296	388	420	26	29	-	0	-	388	Seepage area
8.3	1,371	19	2	441	549	631	8	0	-	1.7	-	450	
-	1,274	-	-	-	-	403	3	0	-	1.0	-	595	
8.0	1,108	79	56	193	410	385	24	1	-	0.1	-	410	Dugout gathered discharge
7.7	2,718	55	57	833	752	1160	42	33	-	0.1	-	752	
7.8	2,482	27	5	883	1207	799	7	0	-	0	-	1010	
-	3,086	-	-	-	-	1316	27	3	-	0	-	445	
7.9	1,394	36	40	389	482	634	5	0	-	0.4	-	425	
7.9	3,224	23	5	1033	488	1875	12	3	-	0.1	-	488	
7.5	1,380	19	45	383	689	480	3	-	-	0	-	565	Seepages in the area
7.4	1,168	22	28	347	750	301	0	-	-	1.6	-	615	Other springs nearby
8.0	2,198	16	46	667	897	906	5	-	-	0	-	735	
8.3	1,002	5	3	365	365	312	2	-	-	0.6	-	470	
7.8	1,102	108	40	237	402	495	11	1	-	0.1	-	402	Spring mound
-	1,258	-	-	-	-	457	0	1	-	0.4	-	555	Wooden catchment
-	1,276	-	-	-	-	196	4	-	-	0.1	-	875	
7.8	1,511	112	108	225	630	750	3	0	-	0	-	516	
7.3	1,748	114	29	462	946	564	6	0	-	0.7	-	775	
-	-	-	-	-	-	-	-	-	-	-	-	-	Mudspring Lake; numerous soap holes, tension cracks. See text, p.45
8.2	512	82	37	65	442	95	2	2	11.3	1.4	467	354	
-	2,620	-	-	-	-	1264	16	-	-	4.5	-	126	
8.1	1,195	45	9	409	867	293	7	0	-	0.2	-	712	
7.9	656	61	36	152	593	101	4	2	8.1	0	629	474	

Index No	Mer	Tp	R	Sec	Lsd	Elev ft	Flow Rate L/sec	Meinz.	Aquifer Lithology	Nature of Permeability	Permanence	Mineral Deposit	Field Cond. μmhos/cm^2	Field Temp. °C	Field pH
151	4	42	17	2	6	2275	-	-	-	-	-	-	-	-	-
152	4	42	17	11	3	2425	-	-	-	-	-	-	-	-	-
153	4	43	17	10	13	2320	-	-	-	-	-	-	-	-	-
154	4	44	19	6	5	2275	-	VIII	-	-	-	-	-	-	-
155	4	45	1	3	16	1800	0.08	VII	-	-	yes	iron & salt	1,070	11.8	8.2
156	4	49	19	32	16	2450	-	-	-	-	-	-	-	-	-
157	4	50	19	10	1	2400	-	-	-	-	-	-	-	-	-
158	4	50	19	11	13	2375	-	-	-	-	-	-	-	-	-
159	4	50	19	12	7	2320	-	-	-	-	-	-	-	-	-
160	4	51	19	3	4	2330	-	-	-	-	-	-	-	-	-
161	4	51	25	29	4	2150	-	-	-	-	-	-	-	-	-
162	4	51	25	33	16	2125	-	-	-	-	-	-	-	-	-
163	4	52	18	19	4	2275	-	-	-	-	-	-	-	-	-
164	4	52	19	24	16	2300	-	-	clay	-	-	-	-	-	-
165	4	52	19	25	16	2275	-	-	-	-	-	-	-	-	-
166	4	52	24	33	14	2100	0.08	VII	-	-	-	no	-	-	-
167	4	52	25	13	13	2075	2.30	V	sand	intergranular	yes	calcareous tufa	2,050	5.0	-
168	4	52	25	36	15	2050	1.5	V	gravel	intergranular	yes	calcareous tufa & iron	1,350	4.0	-
169	4	52	25	36	13	2050	0.15	VI	sand	intergranular	yes	calcareous tufa & iron	1,550	7.0	-
170	4	52	25	36	16	2050	5.4	V	sand	intergranular	-	iron	1,800	6.0	-
171	4	53	17	31	4	2200	-	-	-	-	-	-	-	-	-
172	4	53	19	25	16	2275	-	-	-	-	-	-	-	-	-
173	4	53	22	4	3	2330	-	-	-	-	-	-	-	-	-
174	4	53	22	12	1	2330	-	-	-	-	-	-	-	-	-
175	4	53	22	17	10	2250	-	-	-	-	-	-	-	-	-

All measurements of dissolved solids and alkalinity given in mg/L.

Lab. pH	TDS	Ca	Mg	Na+K	HCO3 +CO3	SO_4	Cl	NO_3	SiO_2	Fe	Field Alk.	Lab. Alk.	Remarks
-	2,970	-	-	-	-	372	288	-	-	6.4	-	1560	Other springs nearby
-	2,360	-	-	-	-	528	12	-	-	2.4	-	1230	Brown in color
-	1,702	-	-	-	-	634	6	-	-	-	-	300	Brownish in color
-	1,436	-	-	-	-	571	6	-	-	0.3	-	350	
8.0	1,366	37	22	437	856	425	12	2	10.3	0.9	907	685	Plastic pipe for catchment
8.1	1,634	19	23	548	1071	134	13	0	-	0.1	-	1071	
-	1,734	-	-	-	-	649	6	10	12	0	-	675	
-	2,056	24	8	-	-	54	23	0	-	-	-	1610	
-	1,784	10	4	-	-	408	152	11	12	-	-	825	
-	1,580	-	-	-	-	571	10	0	-	3.8	-	480	
7.8	1,572	286	78	130	150	1000	8	0	-	0.3	-	123	
7.9	2,290	303	88	272	354	540	542	2	-	0	-	354	
-	2,326	52	9	806	1366	660	5	-	-	0.4	-	1125	
-	1,214	-	-	-	-	355	2	2	-	0	-	545	
-	2,514	59	14	714	707	1213	2	0	-	1.8	-	540	
7.8	2,330	85	51	512	444	690	206	10	-	0.1	-	444	Old garbage dump site
-	1,700	-	-	-	-	845	12	-	-	1.8	-	531	Whitemud Park See text, p. 10
7.7	1,054	131	56	81	216	466	12	5	-	0.1	-	216	North of Groat Bridge and to the west
-	-	-	-	-	-	-	-	-	-	-	-	-	North of Groat Bridge and to the west
7.9	1,334	184	59	171	506	528	8	5	-	0.2	-	506	Park north west of Groat Bridge
-	1,744	12	5	631	926	547	8	-	-	0.3	-	800	
-	2,514	59	14	-	300	1218	2	0	-	1.8	-	500	
-	1,020	-	-	-	-	223	13	-	-	0	-	605	
-	1,014	-	-	-	-	198	4	4	-	0.2	-	687	
7.8	1,355	164	21	-	357	0	20	-	-	0.1	-	596	

Index No	Mer	Tp	R	Sec	Lsd	Elev ft	Flow Rate L/sec	Meinz.	Aquifer Lithology	Nature of Permeability	Permanence	Mineral Deposit	Field Cond. µmhos/cm²	Field Temp. °C	Field pH
176	4	53	22	22	9	2195	-	VIII	sand, silt & clay	intergranular	yes	salt	2,200	-	-
177	4	53	24	3	4	2050	0.09	VII	shale	fracture	-	-	-	-	-
178	4	53	24	6	16	2150	-	-	-	-	-	-	-	-	-
179	4	54	20	21	13	2335	-	-	-	-	-	-	-	-	-
180	4	55	12	33	13	1900	3.79	V	-	-	yes	iron	880	13.8	7.8
181	4	57	21	1	15	2025	0.76	VI	sand	intergranular	yes	iron	2,350	2.2	7.0
182	4	58	15	36	3	2100	3.80	IV	sand	intergranular	yes	iron	495	3.6	7.5
183	4	60	6	15	5	1850	1.90	V	sandy clay	intergranular	yes	iron	1,260	7.2	7.2
184	4	60	17	4	1	2050	-	-	-	-	-	-	-	-	-
185	4	62	5	30	12	1700	-	-	-	-	-	-	-	-	-
186	4	62	7	35	14	1760	3.4	V	sand	intergranular	yes	iron	1,005	4.8	7.6
187	4	63	19	1	1	2100	3.79	V	sand	intergranular	yes	iron	650	8.8	-
188	4	67	16	29	16	1900	-	-	-	-	-	-	-	-	-
189	4	67	19	14	8	1900	0.38	VI	-	-	-	iron	1,850	7.0	-
190	4	68	21	16	13	1675	0.38	VI	-	-	-	salts	500	12.0	-
191	4	68	21	20	3	1800	0.76	VI	sand	intergranular	yes	no	-	5.5	-
192	4	69	23	2	15	-	-	-	-	-	yes	-	-	-	-
193	4	81	3	23	9	1500	0.15	VI	-	-	-	-	-	-	-
194	4	88	6	26	8	1000	-	-	-	-	-	salts	-	-	-
195	4	88	6	26	9	1000	-	-	ss	-	-	salts	-	-	-
196	4	89	1	2	12	1000	0.23	VI	ls	-	yes	salts	-	4.0	-
197	4	89	3	11	13	1000	7.6	V	ls	-	yes	salts	-	5.0	-
198	4	89	3	16	10	1000	3.8	V	ss	-	yes	salts	-	6.5	-
199	4	89	3	19	7	1500	7.6	V	-	-	yes	salts	-	6.5	-
200	4	89	8	2	3	900	-	-	-	-	-	-	-	-	-

All measurements of dissolved solids and alkalinity given in mg/L.

Lab. pH	TDS	Ca	Mg	Na+K	HCO3 +CO3	SO_4	Cl	NO_3	SiO_2	Fe	Field Alk.	Lab. Alk.	Remarks
8.2	1,568	25	10	480	-	241	34	0	-	0.2	-	1002	Soap Holes
8.7	1,158	5	1	362	694	109	4	3	-	0.4	-	694	Approximately 102 Avenue & 87 Street, Edmonton
7.8	1,170	222	96	123	414	524	70	0	-	1.1	-	339	
-	1,420	124	107	124	354	238	209	99	-	0.4	-	290	
7.8	567	94	34	80	527	79	6	1	15	1.1	573	422	
6.5	949	127	20	327	54	34	400	0	14.2	16.8	89	43	Pipe in ground
7.2	274	66	20	9	317	4	2	2	14.9	2.2	336	254	
7.3	797	98	41	146	654	153	6	9	21.8	2.0	694	523	Concrete construction over spring; sulfur smell
-	1,142	-	-	-	-	256	8	0	-	0.1	-	600	
7.8	1,318	74	31	405	720	454	72	15	-	-	-	590	
7.3	498	94	47	27	488	66	4	1	19.9	1.0	622	390	
-	348	-	-	-	-	71	2	0	-	16.4	-	285	Three springs in the vicinity
7.9	1,212	86	44	290	638	429	43	7	-	0.1	-	523	
8.3	1,258	80	35	277	330	493	38	3	-	0.1	-	330	Near Pine Creek
-	1,428	-	-	-	-	544	108	0	-	0	-	437	Two springs in vicinity; quick ground
-	1,236	-	-	-	-	559	38	0	-	0	-	383	
-	-	-	-	-	-	-	-	-	-	-	-	-	Slumps and springs in vicinity
-	2,414	-	-	-	-	37	866	1	-	0.9	-	839	
-	19,660	-	-	-	-	11733	1075	1	-	0.1	-	314	Ponded spring
8.1	18,858	300	78	6539	456	718	9860	4	1.3	0.1	-	456	H_2S gas
8.4	3,452	71	50	1210	331	68	1760	2	5.4	0.0	-	331	H_2S gas
8.1	7,346	119	78	2592	184	394	3840	6	-	0.1	-	184	Three main springs
8.6	7,358	189	1	2390	240	445	3630	3	6.8	0.1	-	240	
7.9	20,452	480	200	6667	256	1776	10000	9	-	0.1	-	256	H_2S gas; milky water See text, p. 15
-	10,124	-	-	-	-	5266	1082	0	-	0.1	-	395	Several ponds

Index No	Mer	Tp	R	Sec	Lsd	Elev ft	Flow Rate L/sec	Meinz.	Aquifer Lithology	Nature of Permeability	Perman-ence	Mineral Deposit	Field Cond. µmhos/cm²	Field Temp. °C	Field pH
201	4	93	10	15	16	860	0.9	VI	ls	-	yes	salts	-	8.0	-
202	4	94	11	23	11	770	0.76	VI	ss	intergranular	-	iron	-	10.0	-
203	4	97	13	11	-	1500	0.76	VI	ss/sh	-	yes	-	-	-	8.3
204	4	100	9	11	5	770	-	-	-	-	-	-	-	-	-
205	4	100	9	11	11	770	-	-	-	-	-	-	-	10.0	-
206	4	105	14	9	8	-	-	-	-	-	-	iron	-	8.0	-
207	4	105	16	1	16	-	-	-	-	-	-	-	-	7.0	-
208	4	105	17	25	14	-	-	-	sst,sh	-	-	-	-	8.0	-
209	4	106	14	7	2	-	-	-	s & g	intergranular	-	-	-	16.0	-
210	4	106	14	7	7	-	-	-	s & g	intergranular	-	-	-	16.0	-
211	4	106	17	10	2	-	-	-	-	-	-	iron	-	13.0	-
212	4	107	13	22	2	-	-	-	-	-	-	-	-	-	-
213	4	107	20	19	4	-	-	-	clay	-	-	-	-	-	-
214	4	108	14	26	9	-	-	-	-	-	-	sulfur	-	4.0	-
215	4	115	13	1	10	-	-	-	sand	intergranular	-	-	-	-	-
216	4	116	18	27	7	800	-	-	sand	intergranular	yes	-	1,300	17.0	7.8
217	4	116	18	27	7	-	-	-	-	-	yes	-	2,200	18.0	7.9
218	4	118	10	26	1	-	-	-	sand	intergranular	yes	salts	>8,000	13.0	8.0
219	4	119	9	19	15	-	-	-	silt, sand	intergranular	yes	-	10,000	16.5	8.6
220	4	120	9	17	16	-	-	-	sand	intergranular	-	no	2,600	17.0	8.7
221	4	120	10	4	15	725	-	-	-	-	-	-	>8,000	4.5	7.1
222	4	120	12	30	1	-	-	-	sand	intergranular	yes	no	1,500	12.5	8.0
223	4	121	9	34	13	-	-	-	silt, sand	intergranular	-	iron	>8,000	15.5	8.6
224	4	121	10	30	11	-	-	-	silt, sand	intergranular	yes	no	>8,000	13.5	8.1
225	4	121	11	8	4	-	-	-	silt, sand	intergranular	yes	-	>8,000	12.5	8.2

All measurements of dissolved solids and alkalinity given in mg/L.

Lab. pH	TDS	Ca	Mg	Na+K	HCO_3 $+CO_3$	SO_4	Cl	NO_3	SiO_2	Fe	Field Alk.	Lab. Alk.	Remarks
7.3	71,140	1708	480	23672	525	4310	39200	0	-	-	-	430	La Saline springs H_2S gas; see text, p. 28
7.3	1,292	37	14	444	588	2	444	1	-	-	-	482	Spring flowing through slump
8.9	1,672	6	4	628	1122	254	138	9	7.2	-	-	958	H_2S gas
6.0	4,904	672	89	804	44	2070	78	0	-	-	-	-	
7.3	4,520	636	89	741	447	1775	1014	0	-	-	-	-	
7.4	1,429	330	45	31	100	955	2	6	10.9	-	-	80	Slumping and seepages in vicinity
7.4	1,196	179	38	169	246	674	2	1	12.0	-	-	197	Seepages
8.6	1,751	21	11	541	343	327	660	10	4.8	-	-	287	Seepages in vicinity
7.7	1,183	172	55	126	454	582	4	7	14.4	-	-	363	Seepages
6.8	1,124	215	46	65	449	555	6	2	14.2	-	-	359	Seepages
7.4	2,113	202	112	347	625	1126	10	4	4.2	-	-	500	Seepages
7.5	27,123	1300	139	8768	271	3470	13300	1	11.6	-	-	217	Ponded, H_2S gas
7.3	2,794	480	225	50	264	1890	16	1	1.5	-	-	211	Seepages and slumps in vicinity
6.4	2,703	585	85	54	449	1705	4	2	47.6	-	-	359	
8.0	1,062	226	49	15	122	700	2	4	6.2	-	-	98	Seepages
7.6	1,016	175	53	47	158	519	23	1	-	0.1	-	158	Kilpatrick Creek
7.6	2.026	500	52	53	184	1200	60	3	-	0.1	-	184	Stream
7.6	7,466	480	163	1824	186	1588	3060	5	-	0.1	-	186	Seepages along stream
7.6	5,264	186	82	1605	236	271	2720	1	-	0	-	236	Darough Creek
7.6	1,494	97	54	313	204	65	654	2	-	0	-	204	Stream
7.4	41,440	730	248	14028	222	1929	23300	2	-	0.2	-	220	Ponded spring
7.8	1,194	260	47	17	196	675	6	1	-	0	-	196	Stream
7.6	9,090	255	100	2926	148	483	4777	1	-	0	-	148	Stream
7.0	27,338	1275	248	7160	172	2321	13700	3	-	0.4	-	-	Pond
7.8	6,100	350	100	1657	266	960	2610	1	-	0	-	266	Stream

Index No	Mer	Tp	R	Sec	Lsd	Elev ft	Flow Rate L/sec	Meinz.	Aquifer Lithology	Nature of Permeability	Permanence	Mineral Deposit	Field Cond. µmhos/cm²	Field Temp. °C	Field pH
226	4	121	11	8	4	780	-	-	sand	intergranular	-	iron	>8,000	4.0	7.0
227	4	123	11	6	13	-	-	-	sand	intergranular	yes	salts	>8,000	17.5	8.2
228	4	123	11	6	13	-	-	-	sand	intergranular	yes	salts	>8,000	15.5	8.7
229	4	123	11	27	3	-	-	-	silt, sand	intergranular	yes	-	>8,000	21.0	7.6
230	4	123	12	27	5	-	-	-	sand	intergranular	yes	no	2,000	15.5	7.7
231	4	123	20	29	6	925	-	-	-	-	yes	salts	1,350	12.0	7.6
232	4	124	11	6	1	-	-	-	silt, sand	intergranular	no	iron	>8,000	12.0	7.4
233	4	124	11	6	1	-	-	-	silt, sand	intergranular	no	iron	>8,000	17.5	8.0
234	4	124	11	8	16	-	-	-	sand	intergranular	no	salts	5,500	14.0	7.5
235	4	124	11	25	7	-	-	-	silt, sand	intergranular	yes	-	>8,000	17.5	8.6
236	4	124	12	11	10	-	-	-	silt, sand	intergranular	yes	iron	>8,000	17.0	8.1
237	4	124	12	22	13	-	-	-	gravel	intergranular	-	salts	>8,000	6.0	7.5
238	4	124	12	35	7	-	-	-	gravel	intergranular	yes	-	>8,000	19.5	8.3
239	4	124	12	35	9	-	-	-	silt, sand	intergranular	yes	no	5,000	18.0	8.4
240	4	124	13	36	8	-	-	-	s & g	intergranular	-	no	>8,000	19.0	8.1
241	4	125	12	8	12	-	-	-	sand	intergranular	yes	no	>8,000	21.0	8.2
242	4	125	12	10	12	-	-	-	silt, sand	intergranular	-	iron	5,000	1.0	7.0
243	4	125	13	9	7	-	-	-	shale	-	-	-	>8,000	7.0	7.2
244	4	125	13	32	12	-	-	-	silt, sand	intergranular	yes	no	>8,000	15.0	8.2
245	4	125	13	32	12	-	-	-	silt, sand	intergranular	yes	no	>8,000	16.0	8.7
246	4	125	14	36	2	600	-	-	gypsum	-	yes	no	8,000	1.5	7.5
247	4	125	14	36	8	-	-	-	shale & gypsum	-	-	salts	>8,000	19.5	6.6
248	4	125	20	4	14	-	-	-	gravel	intergranular	yes	no	2,500	16.0	7.7
249	4	126	14	3	7	-	-	-	shale	-	yes	calcareous tufa	5,000	7.5	7.9
250	4	126	14	6	13	600	-	-	gypsum	-	yes	-	2,800	4.0	7.7

All measurements of dissolved solids and alkalinity given in mg/L.

Lab. pH	TDS	Ca	Mg	Na+K	HCO_3 $+CO_3$	SO_4	Cl	NO_3	SiO_2	Fe	Field Alk.	Lab. Alk.	Remarks
7.5	11,424	655	134	3194	252	1956	4850	1	-	0.2	-	252	H_2S gas
8.2	20,110	500	86	6826	208	1034	11000	0	-	0	-	208	Salt River
8.0	8,066	205	70	2590	200	419	4320	0	-	0	-	200	Stream
6.9	44,216	2113	242	10290	153	1221	22700	1	-	0.4	-	153	Ponded
7.3	1,246	165	35	155	200	305	251	3	-	0	-	200	Ponded; quick ground
7.9	1,020	230	24	13	141	526	16	0	-	0	-	141	H_2S gas; see text, p.15
7.8	7,436	565	234	1239	238	194	3525	2	-	0.1	-	238	Stream
7.8	9,448	483	196	2340	250	207	4675	2	-	0	-	250	Stream
7.7	3,586	250	87	661	147	79	1640	4	-	0.1	-	147	Seepage ponds
7.9	5,112	193	55	1646	234	290	2675	1	-	0	-	234	Stream
7.6	15,420	1000	38	4380	131	2215	7450	1	-	0	-	131	Stream
7.1	118,250	760	82	43399	112	2166	68300	0	-	0.2	-	112	Seep
8.3	15,750	700	50	5043	174	1627	7960	1	-	0.1	-	174	Stream
7.7	3,072	128	39	899	198	191	1550	1	-	0	-	198	Stream
7.3	6,786	720	34	1494	79	1748	2420	1	-	0	-	79	Stream
7.5	10,780	660	43	3054	150	1578	4975	1	-	0	-	150	Stream
7.4	3,154	300	50	685	309	681	1060	1	-	0	-	309	
7.0	10,662	740	32	3140	157	1762	4630	1	-	0.1	-	157	H_2S gas; seep
7.7	8,170	640	51	2155	179	1511	3410	2	-	0	-	179	Stream
7.9	6,588	440	49	1799	165	1010	2870	1	-	0.2	-	165	Brine Creek
7.7	5,678	690	49	1242	186	1560	1870	1	-	0	-	186	Several springs
7.0	17,708	1100	90	5099	280	2091	8500	0	-	0.6	-	280	Quick ground; seep
7.0	2,448	1717	172	12	172	1450	1	0	-	0.4	-	172	H_2S gas; pond
7.5	3,442	550	45	467	244	1327	730	3	-	0.2	-	244	Seepage area and quick ground
7.5	1,928	473	50	27	241	1119	29	0	-	0.2	-	241	

Index No	Mer	Tp	R	Sec	Lsd	Elev ft	Flow Rate L/sec	Meinz.	Aquifer Lithology	Nature of Permeability	Permanence	Mineral Deposit	Field Cond. µmhos/cm²	Field Temp. °C	Field pH
251	4	126	13	18	6	-	-	-	silt, sand	intergranular	yes	salts	7,500	17.0	8.7
252	4	126	14	18	1	-	-	-	gypsum	-	-	salts	>8,000	10.5	7.4
253	4	126	14	18	1	-	-	-	s & g	intergranular	-	salts	>8,000	7.0	6.9
254	4	126	14	20	6	600	-	-	sand	intergranular	-	salts	>8,000	6.5	6.2
255	4	126	14	29	2	-	-	-	-	-	-	salts	>8,000	4.5	6.4
256	4	126	14	29	9	-	-	-	gypsum	-	yes	salts	-	-	-
257	4	126	20	30	11	-	-	-	-	-	-	no	1,000	10.0	7.8
258	5	5	1	29	1	5200	7.6	V	-	-	yes	no	230	10.7	8.4
259	5	7	3	30	12	4180	3.8	V	ls & dolomite	fracture	-	sulfur	-	5.0	-
260	5	7	4	36	12	4700	7.6	V	ls & dolomite	fracture	yes	-	1,020	9.1	7.3
261	5	8	5	9	13	4700	2120.0	II	ls	fracture	yes	no	225	4.9	8.0
262	5	10	3	32	6	4590	37.8	IV	ls	fracture	yes	-	-	6.0	-
263	5	11	3	3	5	4480	3.8	V	ls	fracture	-	-	-	8.0	-
264	5	14	2	10	13	4050	3.8	V	ss	fracture	yes	no	-	2.6	-
265	5	15	1	3	13	4350	5.70	V	-	-	yes	no	445	8.0	-
266	5	15	2	27	13	4450	4.5	V	ss	fracture	yes	no	-	5.8	-
267	5	16	2	22	1	4400	3.8	V	-	cavity	yes	no	-	5.2	-
268	5	16	5	35	13	4850	22.70	IV	-	-	yes	calcareous tufa	365	6.8	-
269	5	18	2	29	1	4140	-	-	clay	-	yes	no	-	14.2	-
270	5	19	8	12	1	7100	22.80	IV	-	-	yes	-	190	3.2	-
271	5	20	1	36	3	3460	-	VIII	-	-	-	-	800	27.2	-
272	5	20	3	35	-	4200	-	-	-	-	-	-	-	-	-
273	5	20	8	13	12	7300	3.8	V	-	-	yes	iron	240	1.9	-
274	5	20	9	36	13	5500	22.30	IV	-	-	yes	-	500	7.1	-
275	5	21	2	25	16	3690	0.23	VI	-	intergranular	yes	-	925	7.8	-

All measurements of dissolved solids and alkalinity given in mg/L.

Lab. pH	TDS	Ca	Mg	Na+K	HCO_3 $+CO_3$	SO_4	Cl	NO_3	SiO_2	Fe	Field Alk.	Lab. Alk.	Remarks
7.9	4,428	205	41	1345	211	362	2140	1	-	0	-	211	Salt River
7.5	80,252	1840	138	27021	193	247	43500	1	-	0.1	-	193	H_2S gas; quick ground
7.0	115,400	1030	148	41288	282	2775	67200	0	-	0.3	-	282	Seep
7.0	314,070	1160	171	118493	122	3802	189000	4	-	0.4	-	122	
6.9	309,780	1320	166	119116	134	3785	192000	3	-	0.2	-	134	
7.7	5,872	680	70	1510	208	1300	2480	0	-	0.3	-	208	Stream; seep
6.9	724	157	19	6	78	381	0	11	-	0	-	78	Preble Creek
7.9	144	32	8	10	156	9	4	1	4.8	0	168	125	Beauvais Lake Provincial Park
8.1	584	50	30	43	224	90	1	2	-	0	-	224	H_2S gas
7.1	334	82	19	7	141	147	4	1	4.6	-	150	113	Turtle Mountain Springs Sulfur bacteria See text, p. 26
6.8	142	38	7	6	124	24	2	1	2.8	-	130	99	Crowsnest Lake Spring Studied by D.E. Ford See text, p. 21
8.1	388	79	26	3	122	208	1	1	-	0	-	122	
7.8	1,054	175	54	7	152	474	4	1	-	0	-	152	Other spring nearby
8.1	432	67	39	43	439	53	4	3	7.3	-	-	351	Concrete catchment
7.8	285	61	30	11	329	13	0	2	6.5	-	-	263	
8.1	313	64	24	24	344	18	4	2	7.3	-	-	275	Rock catchment
8.1	324	68	25	23	342	19	6	8	7.7	-	-	274	Concrete catchment
8.3	239	61	17	3	242	26	0	8	4.2	-	-	194	
7.9	500	112	40	23	503	32	19	14	12.4	-	-	402	Concrete catchment
7.9	130	36	8	0	102	33	2	0	1.5	-	-	82	Storm Creek Springs See text, p. 42
8.0	630	70	46	103	420	186	2	3	13.4	-	-	336	Ponded; seep; H_2S gas
7.4	1,371	250	5	157	516	360	31	0	-	0.1	-	423	Pipe catchment
8.0	146	46	6	2	163	6	2	1	4.3	-	-	130	
8.2	301	66	23	2	161	126	2	0	3.4	-	-	129	
8.1	567	55	41	95	454	132	8	5.2	7.6	-	-	363	H_2S gas; quick ground

Index No	Mer	Tp	R	Sec	Lsd	Elev ft	Flow Rate L/sec	Meinz.	Aquifer Lithology	Nature of Permeability	Permanence	Mineral Deposit	Field Cond. µmhos/cm²	Field Temp. °C	Field pH
276	5	21	9	15	1	5400	7.60	V	ls & dolomite	fracture	yes	calcareous tufa	450	8.5	-
277	5	22	2	3	1	3760	6.10	V	ss	fracture	yes	no	740	8.6	-
278	5	22	5	36	16	4400	7.6	V	-	intergranular	yes	no	515	9.4	-
279	5	22	6	29	7	5100	75.70	IV	ls & dolomite	cavity & fracture	yes	-	650	5.5	-
280	5	22	7	28	10	5750	5.7	V	-	-	yes	calcareous tufa	400	8.2	-
281	5	23	10	10	3	5600	227.0	III	-	-	yes	-	188	5.4	-
282	5	23	10	22	11	5600	7.6	V	s & g	intergranular	yes	no	300	3.2	7.9
283	5	24	6	31	13	4750	15.10	IV	-	-	-	calcareous tufa	-	3.0	-
284	5	24	8	30	5	4280	11.4	IV	s & g	intergranular	yes	no	430	5.7	7.7
285	5	24	9	17	10	4340	3.79	V	dolomite	fracture	yes	no	1,450	10.0	-
286	5	24	9	18	2	4400	3.79	V	ls	fracture	yes	no	360	6.0	-
287	5	25	8	4	7	4260	0.15	VI	sh, s & g	-	yes	no	600	8.0	-
288	5	25	12	24	4	5000	9.1	V	ls & dolomite	fracture	yes	calcareous tufa	1,250	45.4	7.2
289	5	25	12	33	4	5000	12.5	IV	ls	fracture	yes	-	675	20.0	7.6
290	5	25	13	36	3	5000	16.70	IV	ls	fracture	yes	no	305	7.4	8.0
291	5	26	2	20	13	3850	3.8	V	s & g	intergranular	yes	no	605	6.2	7.4
292	5	26	3	29	14	3900	11.36	IV	ss	fracture	yes	calcareous tufa	545	7.3	8.1
293	5	26	4	3	4	3715	3.8	V	gravel	intergranular	yes	calcareous tufa	530	6.5	7.7
294	5	26	11	33	1	4850	15.10	IV	sh & ls	-	yes	no	-	2.5	-
295	5	27	6	10	8	4400	7.6	V	gravel	intergranular	-	calcareous tufa	-	3.5	-
296	5	27	9	36	11	5490	15.10	IV	gravel	intergranular	-	calcareous tufa	-	3.0	-
297	5	27	13	6	5	5365	30.3	IV	sst & sh	cavity	yes	-	470	3.7	7.5
298	5	28	2	14	13	3800	5.0	V	ss	fracture	-	-	-	13.0	-
299	5	28	9	2	4	5490	7.6	V	gravel	intergranular	-	-	-	3.0	-
300	5	28	11	27	16	7500	3.8	V	-	-	-	-	-	0.5	-

All measurements of dissolved solids and alkalinity given in mg/L.

Lab. pH	TDS	Ca	Mg	Na+K	HCO_3 $+CO_3$	SO_4	Cl	NO_3	SiO_2	Fe	Field Alk.	Lab. Alk.	Remarks
8.3	262	61	23	3	239	52	0	0	5.4	-	-	191	
8.1	439	59	40	52	432	48	8	10	8.9	-	-	346	Wooden catchment
7.9	204	46	16	8	237	6	1	2	8.0	-	-	190	Bar K.C. club ranch
7.7	471	118	24	5	246	196	2	0	4.4	-	-	197	Canyon Creek Springs See text, p. 21
7.8	202	52	11	6	227	12	4	0	5.0	-	-	182	
8.0	119	35	5	3	120	12	2	1	2.4	-	-	96	Several springs form stream
7.1	175	44	15	4	134	40	2	1	3.4	0.1	144	107	
7.9	210	48	23	15	220	9	4	0	-	0.1	-	220	Ponded
7.4	236	61	20	6	217	32	4	2	5.1	0	235	174	Bow Valley Provincial Park Several springs
7.8	1,188	214	78	4	117	668	4	0	7.5	0	-	-	
7.6	268	48	14	2	139	48	0	1	4.7	0	-	-	
7.4	286	73	21	10	317	12	2	2	7.5	0	-	-	
7.3	940	215	38	13	137	564	12	0	30.0	0.1	-	110	Banff Upper Hot Spring; H_2S gas; see text, p. 7
7.4	396	73	20	34	154	138	42	2	11.4	0.1	-	123	Sulfur bacteria
7.2	162	33	14	6	141	30	4	1	3.8	0.1	154	113	Vermilion Lakes Hot Spring See text, p. 7
7.6	430	73	43	35	451	43	2	3	8.6	0	484	361	In creek bed
7.9	307	65	32	10	349	7	6	7	8.4	0	370	279	Big Hill Spring Provincial Park
7.4	544	79	47	53	410	138	6	10	9.6	0	441	328	
8.3	100	28	6	6	92	10	4	0	-	0	-	92	Lake Minnewanka spring
7.6	302	56	27	24	276	12	2	0	-	0.1	-	276	
8.0	282	57	10	21	228	8	4	1	-	0.1	-	228	Other springs nearby
-	253	52	20	1	183	80	0	5	4.1	-	-	-	Ink pots (7); quicksand conditions
7.8	372	68	38	31	346	21	5	4	-	0	-	346	
8.1	164	47	10	1	144	14	1	1	-	0.1	-	144	Springs form creek
8.0	110	21	6	0	68	8	2	1	-	0.1	-	68	Other springs nearby

Index No	Mer	Tp	R	Sec	Lsd	Elev ft	Flow Rate L/sec	Meinz.	Aquifer Lithology	Nature of Permeability	Permanence	Mineral Deposit	Field Cond. µmhos/cm²	Field Temp. °C	Field pH
301	5	28	15	7	13	5000	3.8	V	gravel	intergranular	no	iron	300	3.0	-
302	5	28	16	12	7	5000	3.8	V	-	-	no	no	290	-	-
303	5	29	6	35	6	4250	3.8	V	ss	fracture	yes	no	320	4.9	7.1
304	5	29	7	11	5	4500	75.76	IV	ss	fracture	-	-	-	10.0	-
305	5	30	12	20	10	5885	0.76	VI	ss & sh	intergranular	yes	-	-	2.8	7.4
306	5	30	15	3	4	6850	380.0	III	-	-	no	no	-	2.0	-
307	5	31	8	4	4	4590	3.8	V	-	intergranular	-	-	-	4.0	-
308	5	33	20	20	11	4750	379.0	III	ls	fracture	no	no	-	-	-
309	5	34	7	32	6	3980	3.8	V	s	intergranular	-	-	-	4.5	-
310	5	34	21	7	8	5250	23.0	IV	-	intergranular	no	iron	-	-	-
311	5	34	9	19	4	4780	15.1	IV	ss	fracture	-	-	-	6.0	-
312	5	34	9	31	13	4500	7.6	V	-	-	-	-	1,250	6.7	-
313	5	34	10	36	16	4500	7.6	V	ls	fracture	no	-	380	5.6	-
314	5	34	11	22	2	4980	3.8	V	ls & ss	fracture	-	-	-	2.5	-
315	5	34	12	30	13	5100	20.5	IV	-	-	-	-	-	4.0	-
316	5	35	4	25	2	3225	7.6	V	gravel	intergranular	yes	no	555	7.6	7.3
317	5	35	6	26	1	3770	6.06	V	-	-	-	calcareous tufa	-	4.0	-
318	5	35	7	36	13	3700	5.7	V	gravel	intergranular	yes	calcareous tufa	505	4.8	7.5
319	5	35	9	5	4	4200	4.5	V	dolomite	fracture	yes	-	1,455	6.4	7.5
320	5	35	9	35	5	4100	7.6	V	ss	fracture	-	no	-	3.0	-
321	5	35	18	11	11	4800	38.0	IV	gravel	intergranular	-	no	-	3.0	-
322	5	35	19	8	8	4750	75.8	IV	-	intergranular	-	no	-	3.0	-
323	5	35	19	15	4	4550	378.8	III	-	intergranular	yes	no	-	2.0	-
324	5	35	19	23	6	4500	22.7	IV	gravel	intergranular	no	no	260	4.5	-
325	5	35	20	12	5	5400	6.06	V	gravel	intergranular	yes	no	-	3.0	-

All measurements of dissolved solids and alkalinity given in mg/L.

Lab. pH	TDS	Ca	Mg	Na+K	HCO3 +CO$_3$	SO$_4$	Cl	NO$_3$	SiO$_2$	Fe	Field Alk.	Lab. Alk.	Remarks
7.5	199	40	17	10	200	22	2	2	8.0	0.1	-	160	
8.1	171	37	15	12	195	1	2	1	7.2	-	-	156	
6.5	186	42	9	19	190	4	2	4	12.6	0	207	152	
7.2	66	13	3	5	46	11	2	0	-	0.1	-	46	
-	1,146	222	85	18	294	643	10	12	10.8	-	-	-	Panther Spring H_2S gas
7.8	133	33	14	0	146	8	2	0	3.5	0.1	-	117	
7.6	178	45	12	8	161	15	4	1	-	0.1	-	161	Ponded
7.5	119	30	9	2	129	9	2	0	3.2	-	-	103	
7.9	224	56	17	6	204	7	2	1	-	0.1	-	204	Near creek
7.6	180	48	14	4	210	1	2	0	8.1	-	-	168	
7.1	100	8	2	3	26	9	4	1	-	0.1	-	26	
7.9	1,190	-	-	-	-	621	4	0	-	0.2	-	115	H_2S gas
8.1	320	-	-	-	-	50	0	-	-	0.2	-	188	
7.9	130	38	8	8	141	3	4	1	-	0.1	-	141	
7.9	190	43	17	5	142	37	6	1	-	0	-	142	Three ponds
7.3	306	73	26	10	356	9	4	1	9.3	0	372	285	
8.4	100	19	24	6	152	5	0	2	-	0	-	152	Two springs and seepages
7.4	299	83	26	7	334	3	2	3	11.4	0	363	267	
7.6	982	232	59	9	198	576	0	1	7.5	0.1	211	158	
7.8	308	65	20	4	292	8	4	-	-	0.1	-	240	Quick ground in vicinity
7.8	161	37	16	2	154	23	2	1	4.6	0.1	-	123	
7.4	144	32	14	4	129	26	2	0	3.8	-	-	103	
7.9	157	35	16	2	146	26	2	0	4.6	-	-	117	
7.8	123	30	10	2	142	3	2	0	5.2	0.1	-	114	
7.5	129	32	9	2	134	11	6	1	3.0	0	-	107	At Banff-Jasper highway junction

Index No	Mer	Tp	R	Sec	Lsd	Elev ft	Flow Rate L/sec	Meinz.	Aquifer Lithology	Nature of Permeability	Permanence	Mineral Deposit	Field Cond. µmhes/cm²	Field Temp. °C	Field pH
326	5	35	21	5	8	5500	454.0	III	-	intergranular	no	iron	-	-	-
327	5	36	5	5	3	3430	265.0	IV	ss	fracture	yes	calcareous tufa	545	4.7	7.4
328	5	36	7	18	1	3700	75.76	IV	-	-	-	-	-	-	-
329	5	36	8	13	1	3700	7.6	V	gravel	intergranular	yes	no	495	5.9	7.5
330	5	36	13	2	4	5400	7.6	V	gravel	intergranular	yes	-	70	3.3	-
331	5	36	13	25	9	4900	37.90	IV	gravel	intergranular	-	-	-	4.0	-
332	5	36	14	4	13	5500	7.6	V	dolomite	fracture	yes	no	250	3.7	8.0
333	5	36	21	18	16	5700	7.6	V	-	intergranular	no	no	-	-	-
334	5	36	23	4	9	6000	9887.0	II	ls	fracture	no	no	-	2.0	-
335	5	37	5	19	3	3260	287.9	III	gravel	intergranular	yes	no	515	5.0	8.0
336	5	37	6	24	13	3260	758.0	III	gravel	intergranular	yes	no	-	4.5	-
337	5	37	6	26	6	3260	303.0	III	gravel	intergranular	yes	no	-	4.0	-
338	5	37	8	27	11	3500	7.6	V	s & g	intergranular	yes	no	490	5.1	7.5
339	5	37	11	12	7	4500	15.10	IV	dolomite	fracture	yes	-	1,330	6.8	7.6
340	5	37	12	25	-	4500	189.41	III	-	-	-	calcareous tufa	-	10.0	-
341	5	37	13	13	15	4700	0.3	VI	sh	fracture	yes	salts	-	9.5	-
342	5	37	18	15	10	4750	10.4	IV	gravel	intergranular	yes	no	295	4.2	7.9
343	5	37	18	27	7	4600	3.4	V	ls	-	yes	calcareous tufa	440	11.0	-
344	5	37	18	27	7	4500	3.8	V	-	intergranular	yes	no	310	6.6	8.1
345	5	37	22	10	15	5400	15.10	IV	ls & dolomite	cavity and fracture	no	no	340	4.0	-
346	5	37	22	12	3	5500	151.0	III	ls & dolomite	cavity	yes	no	250	2.5	-
347	5	37	22	21	11	6400	15.10	IV	gravel	intergranular	no	iron	265	1.5	-
348	5	37	23	28	13	6900	75.80	IV	-	-	yes	-	79	0.2	8.5
349	5	37	23	35	4	6700	7.6	V	-	-	no	iron	360	11.3	-
350	5	38	12	2	11	4500	26.52	IV	ls	fracture	-	-	-	10.0	-

All measurements of dissolved solids and alkalinity given in mg/L.

Lab. pH	TDS	Ca	Mg	Na+K	HCO_3 $+CO_3$	SO_4	Cl	NO_3	SiO_2	Fe	Field Alk.	Lab. Alk.	Remarks
7.5	246	52	23	3	168	77	2	0	6.8	0.1	-	134	
7.6	301	73	26	9	349	5	4	1	10.2	-	366	279	Raven fish rearing station, large culvert catchments
8.3	352	79	24	2	291	47	5	-	-	0	-	243	
7.3	284	71	23	9	310	14	4	2	8.7	0	329	248	Ricinus Spring
7.4	136	-	-	-	-	17	2	-	-	1.1	-	40	In Elk Creek valley
8.0	272	59	16	2	242	12	4	-	-	0	-	198	Forms waterfall
7.6		41	9	3	142	14	4	4	3.8	0.1	151	236	
7.7	893	182	61	4	171	552	2	1	7.6	0.1	-	137	
6.5	32	9	1	2	32	2	2	0	0.5	0.2	-	25	Big Springs to the east of Mt. Castleguard See text, p. 21
7.9	330	69	21	2	168	73	2	4	-	0	-	168	Stauffer Creek Spring (Butte Spring) See text, p. 34
8.0	348	74	18	2	220	74	4	-	-	0	-	180	Rauch Spring (Butte Spring) See text, p. 34
8.2	264	56	20	1	194	45	4	-	-	0.1	-	145	Edmond's Spring (Butte Spring) See text, p. 34
7.3	309	76	19	11	266	60	2	2	8.7	0	286	213	
7.6	1,122	272	46	6	176	700	4	1	7.3	0.1	188	141	
7.5	2,408	473	128	35	180	1560	8	-	-	0	-	148	Sulfur springs on Fall Creek
7.6	2,300	365	160	16	136	1425	6	-	-	0.2	-	112	Along banks of Ram River
7.5	201	45	13	1	142	48	20	1	3.5	0	150	114	
8.0	227	53	17	5	212	39	2	0	7.5	0.2	-	170	
8.0	213	41	14	3	132	46	40	1	3.9	0	135	106	
7.5	166	67	10	5	137	10	2	2	3.9	0	-	110	
7.6	130	35	10	3	139	7	2	2	3.4	0	-	111	
7.6	130	35	10	3	139	7	2	2	3.4	0	-	111	
7.4	99	25	5	2	76	17	10	2	1.1	2.7	-	61	Columbia Glacier stream water
7.3	198	52	14	2	156	47	2	2	3.5	0.1	-	125	Quick ground Sunwapta Pass Springs See text, p. 42
7.3	2,168	425	128	49	180	1275	4	-	-	0	-	148	H_2S gas

Index No	Mer	Tp	R	Sec	Lsd	Elev ft	Flow Rate L/sec	Meinz.	Aquifer Lithology	Nature of Permeability	Permanence	Mineral Deposit	Field Cond. µmhos/cm²	Field Temp. °C	Field pH
351	5	38	23	5	1	6200	7.6	V	-	-	no	no	260	8.0	8.1
352	5	38	18	1	9	-	4.0	V	ls	cavity and fracture	no	no	174	5.2	-
353	5	39	1	14	7	2950	1.9	V	ss	fracture	yes	no	595	4.9	7.8
354	5	39	7	7	12	3250	18.94	IV	gravel	intergranular	-	calcareous tufa	-	4.0	-
355	5	39	9	31	16	3400	7.6	V	drift/ss	-	yes	calcareous tufa	460	4.1	7.8
356	5	39	15	16	16	4820	15.1	IV	sh	fracture	yes	no	-	-	-
357	5	39	16	32	8	4400	3.80	V	gravel	intergranular	yes	no	670	-	-
358	5	39	20	33	14	6300	75.76	IV	-	-	no	iron	-	4.0	-
359	5	39	23	31	2	6400	7.6	V	-	-	no	iron	-	-	-
360	5	39	24	34	12	5221	7.6	V	-	-	-	no	45	7.6	7.5
361	5	40	11	10	8	3575	11.36	IV	gravel	intergranular	-	calcareous tufa	-	4.0	-
362	5	40	15	29	16	4400	7.6	V	sh	fracture	yes	no	1,400	3.7	7.4
363	5	40	20	31	12	5500	1.90	V	-	-	-	no	-	9.0	-
364	5	40	21	4	13	7000	757.0	III	ls	cavity	yes	no	-	4.0	-
365	5	40	21	25	16	5500	7.6	V	-	intergranular	yes	no	-	3.0	-
366	5	40	24	8	16	5250	3.80	V	-	intergranular	yes	no	60	7.0	8.4
367	5	40	24	19	3	5000	30.3	IV	-	intergranular	yes	no	50	4.0	8.0
368	5	40	25	26	13	4900	3.8	V	gravel	intergranular	-	iron	40	5.2	7.1
369	5	40	25	34	12	5000	7.6	V	gravel	intergranular	yes	no	23	5.8	7.0
370	5	40	26	15	13	4700	4.5	V	-	intergranular	no	no	-	4.0	-
371	5	40	27	30	8	5600	15.1	IV	-	intergranular	no	no	-	-	-
372	5	41	5	15	1	3425	3.8	V	ss	fracture	-	no	-	3.0	-
373	5	41	21	1	11	5500	1.14	V	-	-	-	no	-	13.0	-
374	5	41	21	23	10	5500	-	-	ls	cavity and fracture	-	no	-	-	-
375	5	41	22	29	16	6600	38.0	IV	ls	cavity and fracture	-	no	-	4.0	-

All measurements of dissolved solids and alkalinity given in mg/L.

Lab. pH	TDS	Ca	Mg	Na+K	HCO_3 $+CO_3$	SO_4	Cl	NO_3	SiO_2	Fe	Field Alk.	Lab. Alk.	Remarks
7.6	138	32	12	2	122	25	2	1	3.6	0.1	-	98	Dries up in the winter
7.6	124	29	10	0	98	32	2	1	2.0	0.3	-	78	Along shore of Abraham Lake - very variable flow
7.7	351	40	40	40	395	20	4	8	5.1	0	421	316	Flow increases downstream
8.0	528	83	28	4	388	7	4	-	-	0	-	318	
7.9	299	73	15	9	300	5	40	1	8.2	0	314	240	Trapper's Cabin Spring See text, p. 2
8.0	179	44	12	8	181	16	2	1	7.4	0	-	145	
7.4	359	80	35	13	388	25	2	1	11.0	0.1	-	310	Big Horn Indian Reservation
7.6	251	62	16	3	137	95	2	0	4.2	0.1	-	110	
6.3	38	8	3	0	29	5	2	0	5.4	0.9	-	23	
7.1	63	14	4	3	54	7	2	0	6.9	0.1	58	43	
8.0	300	68	15	4	278	6	4	-	-	0	-	228	Two springs at this location
7.9	882	38	13	312	883	55	20	2	7.3	-	961	706	H_2S gas
6.6	1,832	348	90	125	154	1160	24	0	9.9	0.1	-	123	On Sulphur Mountain thrust fault
7.0	112	28	8	2	85	28	2	0	2.6	0.1	-	68	
7.4	245	59	22	4	200	54	2	1	5.4	0.1	-	160	
6.4	33	7	2	2	24	2	2	0	5.2	0	-	20	Ponded
6.9	34	5	2	2	27	3	4	1	3.5	0	-	22	
6.2	25	3	1	3	10	7	2	1	3.8	0.1	15	8	
5.6	22	2	1	4	12	3	2	1	3.6	0.1	15	10	
6.5	23	3	1	3	15	2	2	1	3.6	0.1	-	12	
6.1	34	4	4	3	32	4	2	0	0.8	0.1	-	25	Ponded
8.3	476	64	29	20	319	11	11	-	-	0	-	295	Three spring outlets
6.5	2,048	426	88	113	142	1268	74	0	9.7	0.2	-	114	
7.5	310	66	29	3	159	124	2	1	7.1	-	-	127	Large pond
7.6	172	39	13	2	120	53	2	1	3.0	0.1	-	96	

Index No	Mer	Tp	R	Sec	Lsd	Elev ft	Flow Rate L/sec	Meinz.	Aquifer Lithology	Nature of Permeability	Permanence	Mineral Deposit	Field Cond. μmhos/cm²	Field Temp. °C	Field pH
376	5	41	22	33	11	6400	11.3	IV	-	intergranular	no	no	-	3.0	-
377	5	41	25	8	2	4900	7.6	V	-	intergranular	yes	no	50	9.0	8.2
378	5	41	25	34	4	6500	378.8	III	-	intergranular	yes	no	-	2.0	-
379	5	41	26	11	12	3800	1.14	V	-	-	no	salts	-	-	-
380	5	41	26	13	2	4800	10.6	IV	-	intergranular	yes	no	115	5.0	8.7
381	5	41	26	31	15	4200	23.0	IV	s & g	intergranular	no	no	310	7.0	8.0
382	5	41	28	34	1	6800	378.0	III	-	intergranular	no	no	-	-	-
383	5	42	6	19	16	3400	3.8	V	-	-	-	calcareous tufa	-	3.0	-
384	5	42	6	30	11	3400	2.3	V	-	-	yes	calcareous tufa	600	5.5	8.0
385	5	42	20	20	5	5200	-	-	-	-	-	no	-	-	-
386	5	42	22	20	10	6000	-	-	-	-	-	no	-	-	-
387	5	42	28	20	9	4100	60.6	IV	-	-	yes	no	65	3.5	8.6
388	5	43	3	10	1	3050	11.36	IV	-	-	-	no	750	6.0	-
389	5	43	20	22	2	5000	2.27	V	g/sh	-	-	calcareous tufa	-	4.0	-
390	5	43	20	27	14	4880	7.60	V	gravel	intergranular	-	calcareous tufa	-	4.0	-
391	5	43	23	4	6	6700	7.6	V	ls	fracture and cavity	-	no	-	2.0	-
392	5	43	24	9	16	6600	379.0	III	-	-	no	no	-	-	-
393	5	43	25	19	8	5500	3.8	V	-	-	no	no	-	2.5	-
394	5	43	26	24	13	5800	45.4	IV	gravel	intergranular	yes	no	85	7.0	8.3
395	5	43	27	4	5	4000	15.10	IV	gravel	intergranular	yes	no	110	6.0	8.7
396	5	43	27	9	6	4000	7.6	V	-	-	yes	no	125	5.0	8.2
397	5	43	27	16	12	3800	0.15	VI	-	-	yes	no	640	9.0	7.9
398	5	44	3	31	14	3250	3.8	V	ss	fracture	yes	calcareous tufa	805	3.9	7.1
399	5	44	6	1	5	3250	3.8	V	-	-	-	-	-	3.8	-
400	5	44	19	33	14	4650	2.3	V	gravel	intergranular	yes	calcareous tufa and iron	440	4.0	-

All measurements of dissolved solids and alkalinity given in mg/L.

Lab. pH	TDS	Ca	Mg	Na+K	HCO_3 $+CO_3$	SO_4	Cl	NO_3	SiO_2	Fe	Field Alk.	Lab. Alk.	Remarks
7.4	162	35	13	3	115	48	2	1	3.1	0	-	92	
5.9	27	6	1	2	24	1	2	0	2.2	0	-	20	
7.5	106	21	10	3	110	12	2	0	2.8	0	-	88	
6.8	208	57	14	6	217	11	2	6	4.3	0.3	-	174	
8.0	68	17	3	3	76	2	2	0	3.3	0	-	61	
8.1	191	52	14	3	207	9	2	0	8.4	0	-	166	
7.3	74	15	7	6	68	9	2	0	2.0	0.1	-	54	
8.2	384	64	34	5	348	8	2	-	-	-	-	298	Another spring nearby
7.6	336	65	25	15	339	13	40	1	9.9	0	380	271	
7.0	172	35	17	2	146	39	2	0	5.5	0	-	117	Ponded; blue holes
7.7	205	47	15	2	127	73	2	0	3.5	0.1	-	102	Ponded; blue holes
6.7	35	7	3	4	29	3	2	1	2.1	0.2	-	23	
8.7	432	-	-	-	-	33	4	-	-	0	-	330	Seepages in vicinity
7.1	214	51	21	4	246	5	2	1	9.2	-	-	197	Large hanging calcareous tufa deposit
7.3	232	57	19	3	268	7	2	1	10.5	0.1	-	214	
7.5	150	35	12	2	110	41	2	1	2.8	0.1	-	88	
7.8	161	37	13	2	102	53	2	1	2.6	0.1	-	82	
7.8	484	123	27	4	142	253	2	1	4.3	0.1	-	114	
7.4	50	10	4	3	44	3	2	1	5.3	0.1	-	35	
7.1	69	15	5	4	68	6	2	1	3.7	0.2	-	54	
7.3	74	13	6	4	44	22	2	0	4.6	0	-	35	
7.5	211	41	22	12	205	11	10	2	13.1	0.2	-	164	
7.1	476	103	38	40	542	23	0	4	2.0	0	582	434	
8.1	460	82	28	27	424	43	4	-	-	0	-	348	Two springs at this site
7.6	214	57	16	6	251	2	2	1	7.0	0.1	-	201	Several discharge points

Index No	Mer	Tp	R	Sec	Lsd	Elev ft	Flow Rate L/sec	Meinz.	Aquifer Lithology	Nature of Permeability	Permanence	Mineral Deposit	Field Cond. µmhos/cm²	Field Temp. °C	Field pH
401	5	44	20	23	3	4800	-	-	ls	fracture and cavity	yes	calcareous tufa and salts	-	-	-
402	5	44	22	22	6	6380	15.1	IV	-	-	yes	calcareous tufa	-	4.0	-
403	5	44	22	22	16	6200	-	-	ls	fracture and cavity	yes	calcareous tufa	-	6.0	-
404	5	44	24	2	16	6000	3.8	V	-	-	-	no	-	5.0	-
405	5	44	24	34	11	5250	7.60	V	gravel	intergranular	yes	no	-	-	-
406	5	44	25	6	2	7600	11.40	IV	ls	intergranular	yes	no	70	0.5	8.3
407	5	44	25	26	10	6000	7.60	V	-	intergranular	-	no	-	3.0	-
408	5	44	26	15	2	5100	75.80	IV	gravel	intergranular	yes	no	220	4.0	8.2
409	5	44	28	2	4	3650	11.40	IV	gravel	intergranular	no	no	125	10.0	8.5
410	5	45	1	9	8	2900	3.80	V	-	-	yes	no	690	6.9	8.6
411	5	45	16	31	12	4390	0.23	VI	ss	fracture	yes	calcareous tufa	440	4.0	-
412	5	45	23	24	2	6000	3.8	V	gravel	intergranular	yes	iron	300	-	-
413	5	45	23	32	11	5850	52.0	IV	coal	fracture	yes	no	895	4.6	7.3
414	5	45	24	18	12	5500	-	-	-	-	yes	calcareous tufa	-	-	-
415	5	45	25	34	11	4700	379.00	III	ls	fracture and cavity	yes	no	-	-	-
416	5	45	26	5	16	4800	75.80	IV	ls & sh	-	yes	no	465	4.0	7.9
417	5	45	26	19	8	7000	348.00	III	ls	fracture and cavity	yes	no	-	3.0	-
418	5	45	27	10	16	4600	3.8	V	ls	fracture	yes	no	220	4.5	-
419	5	45	27	19	16	4500	75.80	IV	s & g	intergranular	yes	no	160	5.0	7.9
420	5	45	27	25	9	5100	75.80	IV	-	-	yes	no	-	-	-
421	5	45	28	15	14	6200	3.00	V	-	-	yes	no	85	5.0	-
422	5	46	22	22	13	5250	6.00	V	sst	-	yes	no	-	4.0	-
423	5	46	23	30	5	5500	15.15	IV	ls & dolomite	fracture	yes	no	255	5.6	7.5
424	5	46	23	31	4	5300	22.73	IV	ls	-	-	-	-	3.5	-
425	5	46	26	28	13	3500	2.30	V	gravel	intergranular	yes	calcareous tufa	-	-	-

All measurements of dissolved solids and alkalinity given in mg/L.

Lab. pH	TDS	Ca	Mg	Na+K	HCO_3 $+CO_3$	SO_4	Cl	NO_3	SiO_2	Fe	Field Alk.	Lab. Alk.	Remarks
6.9	196	50	13	4	220	4	2	0	14.0	-	-	176	Large blue hole
7.6	215	48	14	16	220	19	2	0	8.7	0.3	-	176	
7.1	169	43	10	5	173	17	2	0	7.0	0.3	-	138	Bright blue lakes
7.9	171	43	12	2	146	35	2	1	3.9	0.1	-	117	
7.2	215	57	14	3	156	56	2	1	4.3	0.2	-	125	
6.9	33	6	3	2	32	3	2	1	1.2	0.1	-	25	
7.2	207	51	15	3	129	69	2	0	4.0	-	-	103	
7.2	115	26	7	6	49	44	4	0	4.0	0.4	-	39	
8.0	61	12	4	3	51	9	2	0	4.5	0.1	-	41	Ponded
8.1	683	50	38	76	483	21	8	0	6.7	0	500	802	
7.7	224	60	17	5	261	3	2	0	10.1	0	-	209	
7.4	150	40	11	2	151	18	2	0	3.0	0.1	-	121	
7.4	536	39	13	167	608	8	2	1	7.2	-	631	486	Mountain Park Spring H_2S smell See text, p. 10
7.5	155	34	13	3	127	28	2	1	11.2	0.1	-	102	
7.7	172	44	13	3	137	39	2	0	3.2	-	-	110	
7.8	265	62	18	9	178	80	4	1	4.2	0.2	-	142	
7.3	103	30	6	3	98	11	2	1	2.0	0.1	-	78	
8.2	135	29	14	3	156	5	2	0	4.8	0.6	-	125	
7.9	116	29	9	3	117	10	4	0	3.3	0.1	-	94	Smell around spring (H_2S)
7.3	124	33	9	3	110	20	2	0	2.5	-	-	88	Ink pot type of discharge
6.7	48	10	3	3	39	6	2	1	4.8	0	-	31	
7.2	118	28	8	3	127	6	2	0	7.8	0.2	-	102	
6.9	178	43	12	6	134	43	4	1	3.9	-	135	107	
8.2	124	31	7	6	96	14	2	0	-	0	-	-	
7.4	196	55	14	3	227	3	2	0	6.9	0.1	-	182	

Index No	Mer	Tp	R	Sec	Lsd	Elev ft	Flow Rate L/sec	Meinz.	Aquifer Lithology	Nature of Permeability	Permanence	Mineral Deposit	Field Cond. µmhos/cm²	Field Temp. °C	Field pH
426	5	47	10	14	10	3250	0.76	VI	-	-	-	calcareous tufa	-	4.0	-
427	5	47	10	14	15	3250	-	-	-	-	-	calcareous tufa	-	18.0	-
428	5	47	10	14	15	3250	1.50	V	-	-	-	calcareous tufa	-	8.5	-
429	5	47	24	21	16	5800	3.8	V	-	-	-	-	590	4.0	7.3
430	5	48	23	24	15	4175	3.8	V	-	-	-	-	420	-	7.6
431	5	48	26	4	5	4650	15.10	IV	dolomite	fracture	yes	no	380	3.0	7.3
432	5	48	26	8	14	4600	7.60	V	ls	fracture and cavity	-	calcareous tufa	1,950	51.2	7.0
433	5	48	28	11	1	3350	23.00	IV	s & g	intergranular	no	no	590	6.5	8.1
434	5	48	28	24	2	3275	-	-	sand	intergranular	no	no	350	5.0	8.1
435	5	48	28	25	13	3275	3.8	V	ls	fracture	no	no	-	5.0	-
436	5	49	27	5	11	3500	30.30	IV	s & g	intergranular	yes	no	346	4.0	7.9
437	5	49	27	6	16	3250	23.00	IV	s & g	intergranular	yes	no	520	4.0	7.9
438	5	49	27	13	4	3400	7.6	V	-	-	no	no	335	6.0	8.2
439	5	50	12	9	9	3060	7.6	V	-	-	-	calcareous tufa	-	8.0	-
440	5	50	27	26	8	3500	7.60	V	sand	intergranular	-	no	410	7.6	7.8
441	5	51	17	31	1	3180	3.80	V	sand	intergranular	yes	calcareous tufa	470	4.7	7.6
442	5	51	25	32	6	4000	4.20	V	s & g	intergranular	yes	calcareous tufa	505	4.2	7.8
443	5	52	23	9	14	3900	3.8	V	-	-	-	-	470	-	7.9
444	5	52	26	32	4	3800	3.80	V	gravel	intergranular	yes	calcareous tufa	445	2.9	7.6
445	5	53	22	4	16	3600	18.20	IV	ss	fracture	yes	calcareous tufa	450	9.7	8.4
446	5	53	23	32	11	4100	5.68	V	-	-	-	-	400	-	7.9
447	5	53	26	22	9	3780	4.93	V	-	-	-	-	280	7.0	8.0
448	5	54	15	13	13	2850	7.58	V	-	-	-	-	1,000	4.0	8.2
449	5	54	23	35	9	3850	3.80	V	-	-	-	-	420	-	7.7
450	5	54	24	11	9	4100	7.58	V	-	-	-	-	380	-	7.7

All measurements of dissolved solids and alkalinity given in mg/L.

Lab. pH	TDS	Ca	Mg	Na+K	HCO_3 $+CO_3$	SO_4	Cl	NO_3	SiO_2	Fe	Field Alk.	Lab. Alk.	Remarks
8.4	248	33	29	19	206	30	2	1	12.8	0	-	206	Large tufa mound Little Jacknife Spring See text, p. 9
8.2	272	60	31	13	280	23	3	1	-	0	-	280	Large tufa mound, Jacknife Spring
8.5	252	28	31	21	218	30	2	1	-	0	-	218	
7.8	256	59	24	100	490	65	2	1	9.5	0.8	-	-	
7.7	228	64	12	6	249	23	0	1	6.2	-	-	-	
8.0	164	41	13	5	178	6	4	3	4.9	0.1	-	142	
7.0	1,774	386	64	31	134	1164	14	1	48.4	0.3	-	107	Miette Hot Spring Concrete catchment See text, p. 7
7.8	434	95	34	7	249	167	2	0	6.8	0.1	-	199	
7.9	246	60	18	4	163	76	4	0	3.9	0.1	-	130	
-	-	-	-	-	-	-	-	-	-	-	-	-	Culvert catchment
8.1	201	44	17	10	203	22	4	0	3.8	0.1	-	162	Ponded
7.7	226	56	18	7	232	24	2	1	4.5	0.1	-	186	Ponded
7.8	225	52	14	4	146	75	4	0	3.2	0.2	-	117	
8.1	246	50	21	23	260	6	2	1	-	0	-	260	
7.4	297	74	21	9	263	56	2	0	6.1	-	274	210	Flow rate varies with rainfall. H_2S smell
7.3	261	72	17	8	303	4	2	0	9.2	-	319	242	Pipe used for catchment
7.5	280	77	19	7	327	4	2	1	9.4	0.1	342	262	
8.1	234	68	18	5	305	6	0	1	10.7	0.2	-	-	
7.7	188	48	14	7	207	5	4	0	7.0	0	304	166	
7.6	320	66	20	6	298	4	66	1	11.3	-	310	328	Obed Spring See text, p. 30
8.0	228	70	15	3	293	1	2	0	9.6	-	-	-	
7.5	182	62	13	5	273	9	2	2	9.1	0.3	-	-	
8.0	606	26	11	219	649	54	2	0	8.2	0.1	-	-	
7.8	240	65	19	10	307	9	2	0	8.3	0.1	-	-	
7.9	218	68	15	5	290	2	0	0	9.9	0.1	-	-	

Index No	Mer	Tp	R	Sec	Lsd	Elev ft	Flow Rate L/sec	Meinz.	Aquifer Lithology	Nature of Permeability	Permanence	Mineral Deposit	Field Cond. µmhos/cm²	Field Temp. °C	Field pH
451	5	56	19	16	16	4000	5.68	V	-	-	-	-	175	5.5	8.8
452	5	58	19	14	10	4000	7.58	V	-	-	no	-	-	7.0	-
453	5	58	19	19	1	2730	113.60	III	gravel	intergranular	yes	-	-	4.0	-
454	5	58	27	11	6	3675	8.71	V	-	-	-	-	305	4.0	8.0
455	5	60	13	9	5	2400	37.90	IV	gravel	intergranular	yes	-	-	4.9	-
456	5	60	18	3	8	2620	3.80	V	gravel	intergranular	yes	no	595	5.2	7.5
457	5	60	18	10	4	2750	1.90	V	ss	fracture	yes	no	520	3.9	7.6
458	5	64	18	27	8	2480	22.73	IV	-	-	-	-	-	-	-
459	5	66	25	6	4	2350	0.04	VII	sand	intergranular	yes	-	-	-	-
460	5	67	23	14	13	2350	0.19	VI	clay	intergranular	yes	no	1,675	5.2	8.0
461	5	68	22	19	10	2325	0.09	VII	sand	intergranular	yes	no	1,580	4.8	8.0
462	5	68	26	2	8	2020	0.15	VI	sand, clay	intergranular	yes	iron	-	-	-
463	5	69	2	14	16	1820	3.80	V	sand	intergranular	yes	no	-	5.5	-
464	5	71	1	2	3	1920	1.51	V	-	-	-	iron	-	-	-
465	5	71	6	12	10	2675	-	VIII	-	intergranular	-	salts	-	-	-
466	5	75	5	14	15	3185	-	VI	-	-	-	iron	-	-	-
467	5	81	21	25	16	1835	-	-	-	-	-	-	-	-	-
468	5	82	19	13	1	2040	-	-	-	-	-	-	-	-	-
469	5	82	23	32	3	1850	0.76	VI	gravel	intergranular	yes	no	1,440	3.6	8.1
470	5	82	23	36	16	1140	-	-	-	-	-	salts	-	-	-
471	5	82	24	4	9	1760	-	-	-	-	-	-	1,620	16.0	-
472	5	82	24	14	15	1875	15.20	IV	s & g	intergranular	yes	no	740	4.8	7.7
473	5	82	25	9	7	2050	15.10	IV	gravel	intergranular	yes	no	665	4.7	7.6
474	5	83	23	28	10	2050	3.80	V	gravel	intergranular	yes	no	770	5.2	7.4
475	5	83	23	29	6	2100	3.80	V	gravel	intergranular	yes	no	895	7.8	7.2

All measurements of dissolved solids and alkalinity given in mg/L.

Lab. pH	TDS	Ca	Mg	Na+K	HCO3 +CO3	SO_4	Cl	NO_3	SiO_2	Fe	Field Alk.	Lab. Alk.	Remarks
7.6	116	26	5	4	102	9	0	1	11.7	0.3	-	-	
7.7	278	21	3	0	56	4	0	1	-	0.1	-	-	
8.2	324	67	14	14	226	8	7	2	-	0.2	-	-	
8.1	232	72	13	7	302	6	0	1	7.8	0.2	-	-	
8.0	346	46	10	6	164	6	1	2	-	0.1	-	164	
7.4	283	70	18	14	317	13	2	1	10.1	0	406	254	
7.5	213	51	18	6	237	8	2	0	10.9	0	358	190	Plastic pipes for catchment 5 separate sources
6.7	168	10	3	6	32	4	1	3	-	0.5	-	32	Coming from muskeg area
8.2	1,028	182	40	17	224	400	1	3	-	0.1	-	224	
8.2	1,120	7	6	443	886	214	2	1	11.1	2.1	1112	709	Culvert for catchment, soap holes in area
8.5	1,026	4	1	437	1005	65	4	0	10.5	0.1	1128	822	Wooden catchment
8.2	1,648	136	48	343	584	700	16	2	-	0.1	-	584	Contact springs, slumping in area
8.3	250	61	10	6	206	5	1	3	-	0.2	-	206	Near river
8.2	224	70	16	10	344	5	2	1	6.6	-	-	282	Small creek formed by numerous springs
8.6	1,222	24	8	452	915	249	2	2	24.0	-	-	768	Soap hole
5.8	78	4	1	5	24	6	0	2	6.0	-	-	20	Discharge meadow
7.8	1,468	328	94	39	690	644	18	0	-	0.4	-	565	
7.2	2,120	282	140	-	-	1200	0	1	-	-	-	490	In Harmon valley
7.5	860	120	61	90	439	352	2	3	16.4	0.4	557	351	
8.4	1,426	60	27	394	591	401	78	0	-	0.8	-	500	
8.0	1,398	208	61	55	415	498	5	0	-	0.2	-	340	Ponded area
7.4	445	87	29	30	293	134	2	3	15.3	0.3	313	234	Wooden catchment
7.6	399	83	25	22	290	108	2	2	15.3	0.3	312	232	
7.3	466	104	28	25	315	130	2	5	17.0	0.3	335	252	
7.1	598	119	34	47	305	215	8	8	17.3	0.2	324	244	

Index No	Mer	Tp	R	Sec	Lsd	Elev ft	Flow Rate L/sec	Meinz.	Aquifer Lithology	Nature of Permeability	Permanence	Mineral Deposit	Field Cond. µmhos/cm²	Field Temp. °C	Field pH
476	5	84	21	30	5	1790	0.08	VII	clay	-	yes	iron	2,950	5.2	7.3
477	5	87	25	24	7	2125	0.23	VI	clay	-	yes	salts	2,800	3.4	8.1
478	5	90	2	8	4	-	7.6	V	-	-	-	iron	-	-	-
479	5	90	23	33	13	1590	-	-	-	-	-	-	-	-	-
480	5	93	24	12	13	1800	-	-	-	-	-	-	-	-	-
481	5	94	22	10	3	1300	0.08	VII	s & g	intergranular	-	iron	-	-	-
482	5	103	16	24	13	1700	0.04	VII	sh	-	-	iron and salts	-	-	-
483	5	107	15	24	4	900	0.76	VI	s & g	intergranular	yes	no	1,590	6.2	8.0
484	5	109	15	13	5	950	0.15	VI	sand	intergranular	yes	no	2,100	6.2	7.3
485	5	109	19	34	2	1000	0.15	VI	-	-	-	iron	3,000	-	-
486	5	118	6	2	-	3000	-	-	-	-	-	-	-	-	-
487	6	40	2	10	11	4900	3.80	V	-	-	no	no	-	2.5	-
488	6	40	2	14	11	4990	379.0	III	-	intergranular	no	no	-	2.0	-
489	6	41	1	4	14	4500	11.40	IV	ls	cavity	yes	calcareous tufa	-	4.0	-
490	6	41	1	15	4	4500	7.60	V	-	intergranular	no	no	-	4.0	-
491	6	41	2	33	16	5300	15.10	IV	-	fracture	yes	no	-	3.0	-
492	6	42	1	10	2	4300	378.80	III	-	-	yes	no	-	-	-
493	6	42	2	31	9	6400	7.6	V	-	intergranular	no	no	-	-	-
494	6	43	3	13	7	6400	15.00	IV	-	intergranular	no	no	-	1.0	-
495	6	44	1	11	6	3900	0.37	VI	-	fracture	yes	calcareous tufa	-	-	-
496	6	44	1	24	2	3625	4.50	V	-	fracture	yes	no	250	8.0	8.3
497	6	45	1	14	-	4000	-	-	ls	fracture	-	-	-	7.0	7.7
498	6	45	1	26	3	3385	7.60	V	-	intergranular	yes	no	-	6.0	7.6
499	6	45	1	34	1	3900	-	-	-	-	-	-	-	12.0	-
500	6	45	1	34	8	3300	151.50	III	-	fracture	yes	no	-	9.0	7.4

All measurements of dissolved solids and alkalinity given in mg/L.

Lab. pH	TDS	Ca	Mg	Na+K	HCO_3 $+CO_3$	SO_4	Cl	NO_3	SiO_2	Fe	Field Alk.	Lab. Alk.	Remarks
7.7	2,245	133	90	500	600	1115	80	19	13.1	5.5	748	480	Wooden catchment
7.5	1,990	12	8	716	678	900	2	11	8.0	0.6	756	542	Plastic pipe for catchment
-	-	-	-	-	-	-	-	-	-	-	-	-	
-	1,866	-	-	-	-	404	398	-	-	0.1	-	507	
-	2,718	-	-	-	-	-	1088	4	-	9.0	-	746	
-	6,124	-	-	-	-	3066	448	27	-	0.3	-	190	
-	7,902	-	-	-	-	4459	128	1	-	125.0	-	0	Mudslide area
7.2	1,015	196	80	44	400	471	8	3	16.2	0.6	558	320	
7.6	1,647	236	93	207	425	842	48	2	9.2	2.5	448	340	Ponded
7.2	2,492	91	141	-	-	935	370	1	-	3.3	-	310	Springs on Bushe River
-	2,128	-	-	-	-	884	4	-	-	4.8	-	355	
7.3	78	22	4	2	88	3	2	0	2.2	0.9	-	70	
7.7	74	19	5	2	83	2	2	1	1.8	0.1	-	66	
7.3	145	31	15	2	117	33	2	1	4.1	0.2	-	94	Karst
6.7	41	10	1	3	37	1	2	0	5.2	0.1	-	29	
6.8	86	20	6	4	78	13	2	0	3.3	0.1	-	62	Ponded - Ink pot type of discharge
7.5	114	30	8	3	117	8	2	0	4.7	0	-	94	
6.6	33	7	3	2	34	1	2	0	1.9	0.1	-	27	
5.9	26	3	2	3	10	9	2	0	2.5	0.7	-	8	
7.7	292	67	22	15	310	18	2	0	14.7	0.2	-	248	H_2S gas
7.6	133	26	10	7	122	17	2	1	9.1	0	-	98	Ponded
7.8	101	24	8	1	88	21	2	1	1.6	0.1	-	-	Between 5th and 6th bridges
7.8	157	34	14	3	149	20	6	3	3.9	0	-	119	Ponded
9.4	1,262	3	192	243	899	227	12	3	1.4	0.1	-	955	Ponded
7.6	131	26	10	3	90	39	4	0	4.5	0	-	72	

Index No.	Mer	Tp	R	Sec	Lsd	Elev ft	Flow Rate L/sec	Meinz.	Aquifer Lithology	Nature of Permeability	Permanence	Mineral Deposit	Field Cond. µmhos/cm²	Field Temp. °C	Field pH
501	6	45	1	36	1	3400	7.60	V	ls	fracture	-	-	-	4.5	-
502	6	45	1	36	6	3400	5.68	V	gravel	intergranular	-	-	-	5.5	-
503	6	45	1	36	14	3400	76.00	IV	ls	cavity	yes	no	-	7.0	7.5
504	6	45	1	36	-	3400	36830.00	-	ls	fracture and cavity	yes	no	-	7.8	7.8
505	6	45	4	30	4	6400	151.50	III	-	intergranular	yes	no	-	-	-
506	6	46	1	33	3	3350	7.60	V	s & g	intergranular	yes	no	330	5.0	-
507	6	46	1	34	10	3500	26.50	IV	ls & dolomite	cavity	yes	no	280	4.5	7.5
508	6	47	1	6	16	3450	4.50	V	ls	cavity	yes	no	320	6.0	-
509	6	47	1	9	7	3450	15.10	IV	ls & dolomite	fracture and cavity	yes	-	400	10.0	7.5
510	6	47	1	15	5	3300	53.00	IV	ls	-	yes	no	690	6.5	8.0
511	6	47	1	20	3	3500	76.00	IV	s & g	intergranular	yes	no	230	5.0	-
512	6	47	1	21	13	3300	75.80	IV	ls	-	yes	no	305	5.1	8.2
513	6	47	1	23	11	3300	30.30	IV	ls	fracture	yes	no	220	5.0	7.8
514	6	47	1	34	2	3500	7.60	V	s & g	intergranular	yes	calcareous tufa	495	6.3	8.2
515	6	47	1	35	13	3900	3.30	V	gravel	intergranular	yes	no	460	6.1	8.2
516	6	48	1	5	12	5000	3.80	V	-	intergranular	yes	no	180	3.5	7.3
517	6	48	1	7	2	4500	3.80	V	-	intergranular	yes	calcareous tufa	320	5.0	7.4
518	6	48	1	14	-	3600	-	-	-	-	-	-	-	9.0	-
519	6	49	8	18	7	5480	3.78	V	-	intergranular	yes	calcareous tufa	-	-	-
520	6	50	4	17	11	5000	1.13	V	ls	fracture and cavity	yes	no	-	12.0	-
521	6	50	4	20	4	4900	0.15	VI	ls	fracture and cavity	no	calcareous tufa	-	-	-
522	6	50	5	31	16	5500	-	-	ls & dolomite	intergranular	yes	no	-	-	-
523	6	51	4	31	16	5600	1.14	V	ls & sh	fracture and cavity	yes	calcareous tufa	-	4.0	-
524	6	52	5	20	12	6350	0.38	VI	sst & sh	intergranular	yes	-	-	4.0	-
525	6	53	6	27	7	6150	3.78	V	-	-	-	-	320	4.0	8.1

All measurements of dissolved solids and alkalinity given in mg/L.

Lab. pH	TDS	Ca	Mg	Na+K	HCO_3 $+CO_3$	SO_4	Cl	NO_3	SiO_2	Fe	Field Alk.	Lab. Alk.	Remarks
-	101	29	7	4	92	14	2	0	-	0	-	-	Spring in Maligne Canyon; right side of river
7.8	134	28	8	1	80	14	0	1	-	0.1	-	-	On left bank of Maligne River
7.8	102	25	8	1	93	19	2	1	1.6	0.1	-	74	Fish hatchery Ponded
-	-	-	-	-	-	-	-	-	-	-	-	-	No chemistry Maligne Canyon Springs See text, p. 19
6.5	32	6	3	2	32	2	2	1	1.2	0.1	-	25	Ponded
7.6	132	36	10	3	115	22	4	1	0.6	0	-	92	
7.6	122	30	10	2	122	16	2	0	2.1	0	-	98	
7.7	130	36	10	3	137	9	4	0	1.0	0	-	110	
7.8	261	64	17	8	166	81	4	1	3.6	0	-	133	Slight H_2S odor
7.9	578	92	30	5	124	380	4	0	5.9	4.5	-	99	Ponded
7.4	87	26	5	3	93	3	4	0	0	0	-	74	Small wood weir
7.2	168	44	12	2	132	39	2	1	3.6	0.1	144	106	Named Pretty Creek
7.7	121	33	8	3	127	10	2	1	2.0	0	-	102	Edna Lake Spring
7.6	319	69	28	2	195	114	2	1	7.5	0.1	210	156	
7.3	265	73	20	2	266	31	0	1	7.2	0.1	283	213	
7.3	-	-	-	-	-	-	-	-	-	-	-	-	Vine Creek area (east)
7.8	203	53	17	1	205	22	4	0	4.7	0	-	164	Vine Creek area (west)
7.5	1,633	368	86	8	117	1098	2	0	13.3	0.2	-	94	Seep
7.6	132	36	10	1	141	12	2	1	2.3	-	-	113	
6.8	841	139	48	46	98	484	62	1	7.3	0.3	-	78	
7.7	1,435	314	76	5	188	925	2	3	11.2	0.4	-	150	Boggy area
7.0	214	48	19	2	207	26	0	6	8.4	-	-	166	Sulfur flats, H_2S gas
7.6	1,052	202	79	7	215	643	2	2	8.8	0	-	172	
8.0	228	45	17	4	193	29	0	2	3.4	0.5	-	154	Soap hole in area
7.8	170	49	11	3	185	19	1	0	3.8	0.9	-	148	

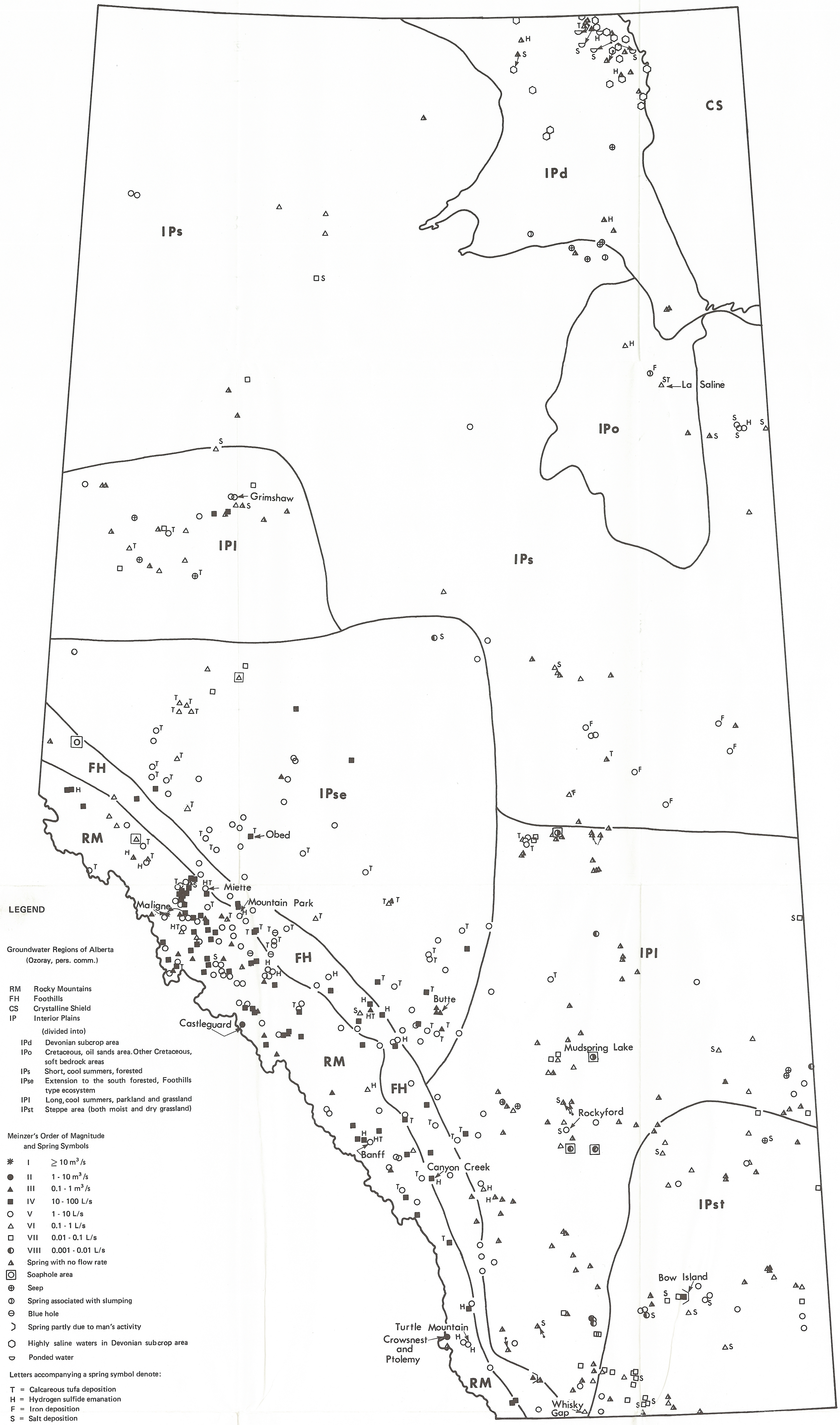
Index No	Mer	Tp	R	Sec	Lsd	Elev ft	Flow Rate L/sec	Meinz.	Aquifer Lithology	Nature of Permeability	Permanence	Mineral Deposit	Field Cond. µmhos/cm²	Field Temp. °C	Field pH
526	6	53	7	22	9	5500	0.38	VI	-	-	-	-	2,650	4.0	7.3
527	6	54	8	13	6	5000	0.23	VI	-	-	-	-	1,800	3.0	7.3
528	6	55	1	13	2	4200	0.22	VI	-	-	-	calcareous tufa and iron	-	-	-
529	6	55	10	3	1	4000	75.80	IV	-	-	-	-	2,500	-	7.1
530	6	56	2	30	1	4480	3.78	V	-	-	-	-	-	3.3	-
531	6	56	5	5	1	5000	37.88	IV	-	-	-	-	580	4.0	7.4
532	6	56	7	5	12	4500	0.76	VI	-	-	-	-	2,650	7.0	7.2
533	6	56	11	19	1	5000	11.36	IV	-	-	-	-	600	4.0	7.1
534	6	56	11	20	8	4800	15.15	IV	-	-	-	-	1,100	4.0	7.3
535	6	57	3	36	15	4200	2.20	V	-	-	-	calcareous tufa	-	-	-
536	6	57	4	1	15	4400	15.15	IV	gravel	intergranular	-	-	-	-	-
537	6	58	4	9	5	4200	1.50	V	-	-	-	calcareous tufa	-	-	-
538	6	59	2	35	1	4150	0.23	VI	-	-	-	calcareous tufa	-	2.2	-
539	6	59	4	3	10	4400	1.13	V	-	-	-	calcareous tufa	-	5.0	-
540	6	60	11	35	9	3650	2.30	V	sand, silt & clay	intergranular	yes	iron	-	-	-
541	6	60	13	28	1	4000	-	-	ss	-	-	-	1,300	9.0	6.8
542	6	61	4	15	8	2750	3.78	V	gravel	intergranular	yes	-	-	-	-
543	6	62	4	14	2	2700	2.30	V	gravel	intergranular	yes	calcareous tufa	-	-	-
544	6	64	1	2	1	2800	0.38	VI	-	-	-	calcareous tufa	-	-	-
545	6	64	1	28	1	2900	0.23	VI	-	intergranular	yes	calcareous tufa and iron	1,080	8.0	-
546	6	64	2	2	3	2925	0.76	VI	-	-	-	calcareous tufa	-	-	-
547	6	64	2	35	12	2750	0.15	VI	-	-	-	calcareous tufa	600	8.0	7.8
548	6	68	11	31	7	2400	3.78	V	-	-	-	-	420	14.0	6.9
549	6	76	1	9	1	1625	-	-	ss	fracture	-	calcareous tufa	-	-	-
550	6	76	4	29	3	2290	0.15	VI	ss	cavity	yes	-	1,245	5.8	8.7

Lab. pH	TDS mg/l	Ca	Mg	Na+K	HCO3 +CO3	SO_4	Cl	NO_3	SiO_2	Fe	Field Alk.	Lab. Alk.	Remarks
6.7	2,452	410	163	19	120	1565	7	0	19.0	0.1	-	96	
6.6	1,640	231	90	118	139	930	135	0	7.7	0.5	-	111	
8.1	230	50	17	23	281	3	2	0	11.1	0	-	225	
7.9	2,266	500	114	3	181	1554	4	0	9.9	0.2	-	115	
8.3	166	47	18	4	193	28	2	2	5.8	0	-	154	
7.6	360	75	24	5	163	179	1	0	6.4	0.3	-	130	
7.3	2,136	310	108	172	292	1076	277	0	10.4	2.0	-	234	
7.9	461	78	31	17	195	223	12	0	4.6	0.1	-	156	
7.6	950	212	41	9	203	577	6	0	4.6	0.2	-	162	
7.8	240	67	16	2	271	3	2	1	7.5	0.1	-	217	
7.5	228	60	15	1	261	5	2	1	11.8	0.1	-	209	Three springs
8.1	218	54	15	5	234	4	2	2	5.7	0.2	-	187	
7.9	216	58	14	3	246	3	2	1	5.9	0.1	-	197	Located on edge of river flats
8.3	221	68	15	3	266	7	4	0	5.3	0	-	213	Three springs
7.9	208	50	14	6	193	37	2	0	4.5	2.2	-	154	Soap hole
7.8	1,431	310	72	12	132	960	4	0	6.5	0.1	-	106	Stinking Springs
8.2	222	57	17	6	266	3	2	1	5.0	0.5	-	213	
8.0	251	68	19	8	298	5	2	0	4.8	0.1	-	238	
8.0	387	43	24	80	427	16	2	2	10.5	0	-	342	
8.0	730	57	15	210	659	110	2	6	7.9	-	-	527	
7.8	354	96	29	10	412	13	2	0	8.5	0.1	-	330	
7.8	300	82	21	7	366	13	2	2	12.2	-	-	293	
8.0	268	80	17	5	334	4	0	0	6.9	0.1	-	267	
7.6	4,276	91	106	1296	1311	1975	200	0	-	7.8	-	1074	Seepage area
7.5	683	5	1	280	534	124	2	3	5.4	0.3	510	427	Culvert used for catchment

Index No	Mer	Tp	R	Sec	Lsd	Elev ft	Flow Rate L/sec	Meinz.	Aquifer Lithology	Nature of Permeability	Permanence	Mineral Deposit	Field Cond. µmhos/cm²	Field Temp. °C	Field pH
551	6	76	8	25	15	2600	0.08	VII	ss	fracture	yes	-	1,640	6.4	8.3
552	6	77	2	21	1	2200	0.45	VI	sand	intergranular	yes	-	1,395	4.4	7.2
553	6	77	5	4	4	2125	-	-	-	-	-	-	-	-	-
554	6	77	6	21	11	2425	-	VIII	-	-	-	-	-	-	-
555	6	78	7	21	12	2350	0.38	VI	-	-	-	calcareous tufa	-	-	-
556	6	79	9	36	1	2400	-	-	-	-	-	-	-	-	-
557	6	80	2	9	6	1350	0.38	VI	ss	fracture	-	-	-	-	-
558	6	80	3	6	10	1200	1.9	V	gravel	intergranular	yes	calcareous tufa	1,490	7.1	8.2
559	6	80	4	7	5	1140	-	-	ss	fracture	-	-	-	-	-
560	6	80	4	9	14	1300	0.08	VII	ss	fracture	-	-	-	-	-
561	6	81	1	35	11	2100	7.60	V	s & g	intergranular	yes	-	490	4.7	7.3
562	6	81	7	12	13	2010	-	-	-	-	-	-	-	-	-
563	6	84	9	5	2	1500	-	-	gravel	intergranular	-	-	-	-	-
564	6	84	9	6	10	1800	-	-	gravel	intergranular	-	-	-	-	-
565	6	84	11	4	3	1700	7.60	V	gravel	intergranular	-	-	-	-	-
566	6	110	8	12	8	1800	4.5	V	s & g	intergranular	-	-	590	9.3	7.7
567	6	110	8	17	14	2100	3.80	V	s & g	intergranular	-	iron	35	8.2	5.7
568	6	121	6	36	-	2240	0.76	VI	-	-	yes	calcareous tufa and iron	1,220	1.3	-

All measurements of dissolved solids and alkalinity given in mg/L.

Lab. pH	TDS	Ca	Mg	Na+K	HCO_3 $+CO_3$	SO_4	Cl	NO_3	SiO_2	Fe	Field Alk.	Lab. Alk.	Remarks
8.0	1,096	4	1	451	876	197	2	2	7.3	0.3	966	701	Barrel used for catchment
7.6	939	89	49	181	598	308	2	2	14.3	0.2	671	478	Pipe used for catchment
7.4	1,672	165	121	247	856	672	45	0	-	13.9	-	702	Wooden catchment
7.7	1,408	36	24	533	1474	111	6	0	-	-	-	1208	Seepage
7.2	7,802	342	1090	561	2089	4235	24	0	-	-	-	1712	
-	3,064	-	-	-	-	792	4	0	-	1.4	-	1238	
8.3	1,508	4	3	584	1146	278	26	2	-	0.2	-	990	
7.3	1,141	81	39	285	515	444	14	10	14.5	0.2	699	412	
8.2	3,160	94	93	864	759	1652	190	0	-	4.5	-	622	Slumping and seepages in the area
8.1	1,750	32	14	592	1094	500	64	1	-	10.9	-	896	Slumping in the area
6.9	302	71	16	14	220	70	2	7	14.2	0.2	238	176	Culvert used for catchment
7.4	2,800	412	165	171	500	1690	0	0	-	1.4	-	410	Seepage area
-	1,280	-	-	-	-	248	10	0	-	0.9	-	835	
-	1,624	-	-	-	-	700	4	1	-	5.4	-	550	
-	760	-	-	-	-	243	8	0	-	0.1	-	352	
7.0	366	87	20	16	188	137	2	2	9.4	2.7	201	150	
5.0	40	6	1	2	5	13	2	4	4.6	1.3	10	4	
7.7	746	154	37	38	434	287	0	0	16.5	-	-	347	Iron oxide mound calcareous tufa farther west and another spring depositing calcareous tufa 1/2 mile west of this location.


CS
IPd
IPs
IPo
La Saline
Grimshaw
IPl
IPs
IPse
FH
RM
Obed
Miette
Mountain Park
Maligne
FH
IPl
Castleguard
Butte
RM
FH
Mudspring Lake
Rockyford
Banff
Canyon Creek
IPst
Bow Island
Turtle Mountain
Crowsnest and Ptolemy
RM
Whisky Gap
LEGEND
Groundwater Regions of Alberta
(Ozoray, pers. comm.)
RM Rocky Mountains
FH Foothills
CS Crystalline Shield
IP Interior Plains
(divided into)
IPd Devonian subcrop area
IPo Cretaceous, oil sands area. Other Cretaceous, soft bedrock areas
IPs Short, cool summers, forested
IPse Extension to the south forested, Foothills type ecosystem
IPl Long, cool summers, parkland and grassland
IPst Steppe area (both moist and dry grassland)
Meinzer's Order of Magnitude and Spring Symbols
I ≥ 10 m³/s
II 1 - 10 m³/s
III 0.1 - 1 m³/s
IV 10 - 100 L/s
V 1 - 10 L/s
VI 0.1 - 1 L/s
VII 0.01 - 0.1 L/s
VIII 0.001 - 0.01 L/s
Spring with no flow rate
Soaphole area
Seep
Spring associated with slumping
Blue hole
Spring partly due to man's activity
Highly saline waters in Devonian subcrop area
Ponded water
Letters accompanying a spring symbol denote:
T = Calcareous tufa deposition
H = Hydrogen sulfide emanation
F = Iron deposition
S = Salt deposition

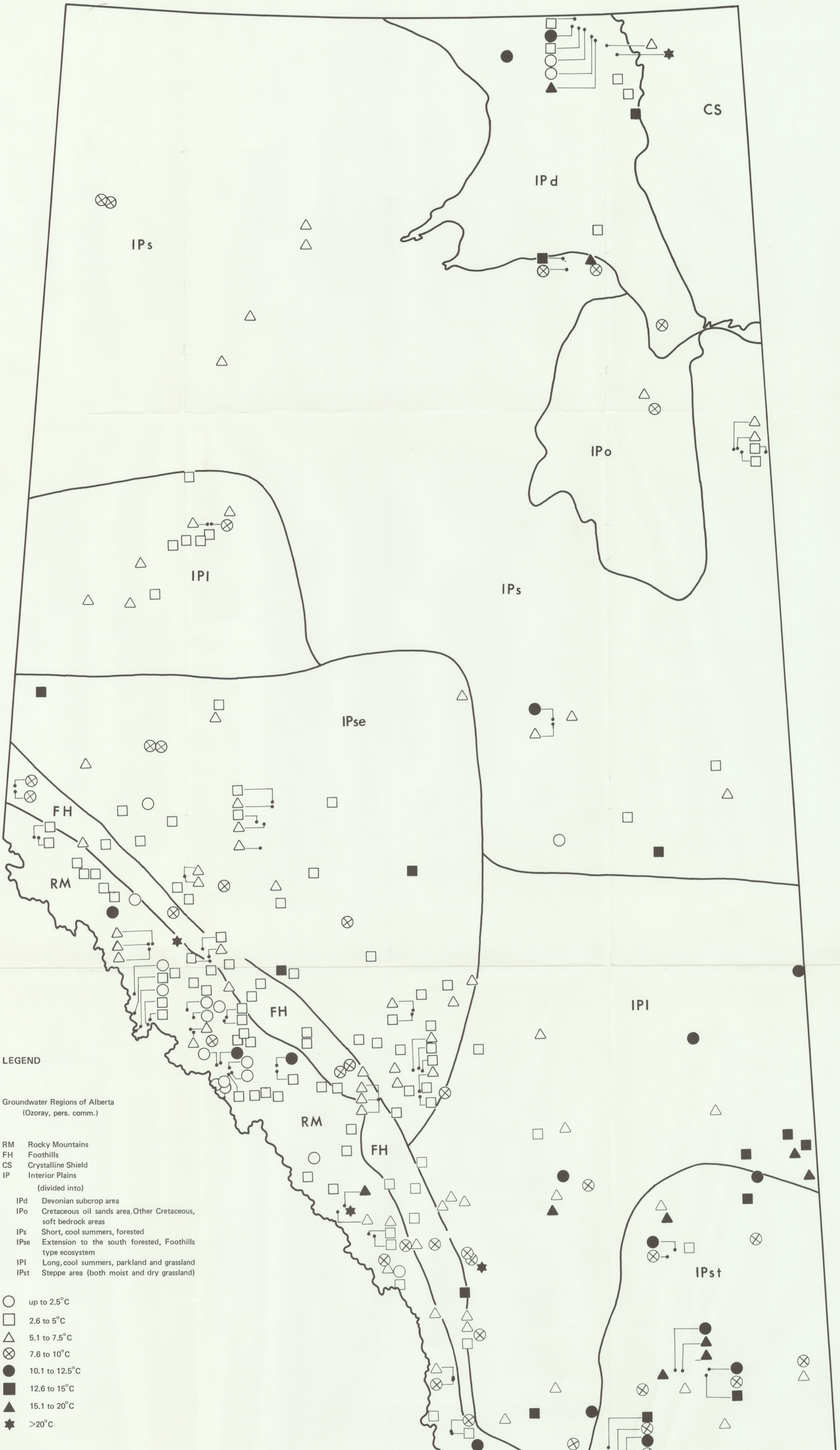
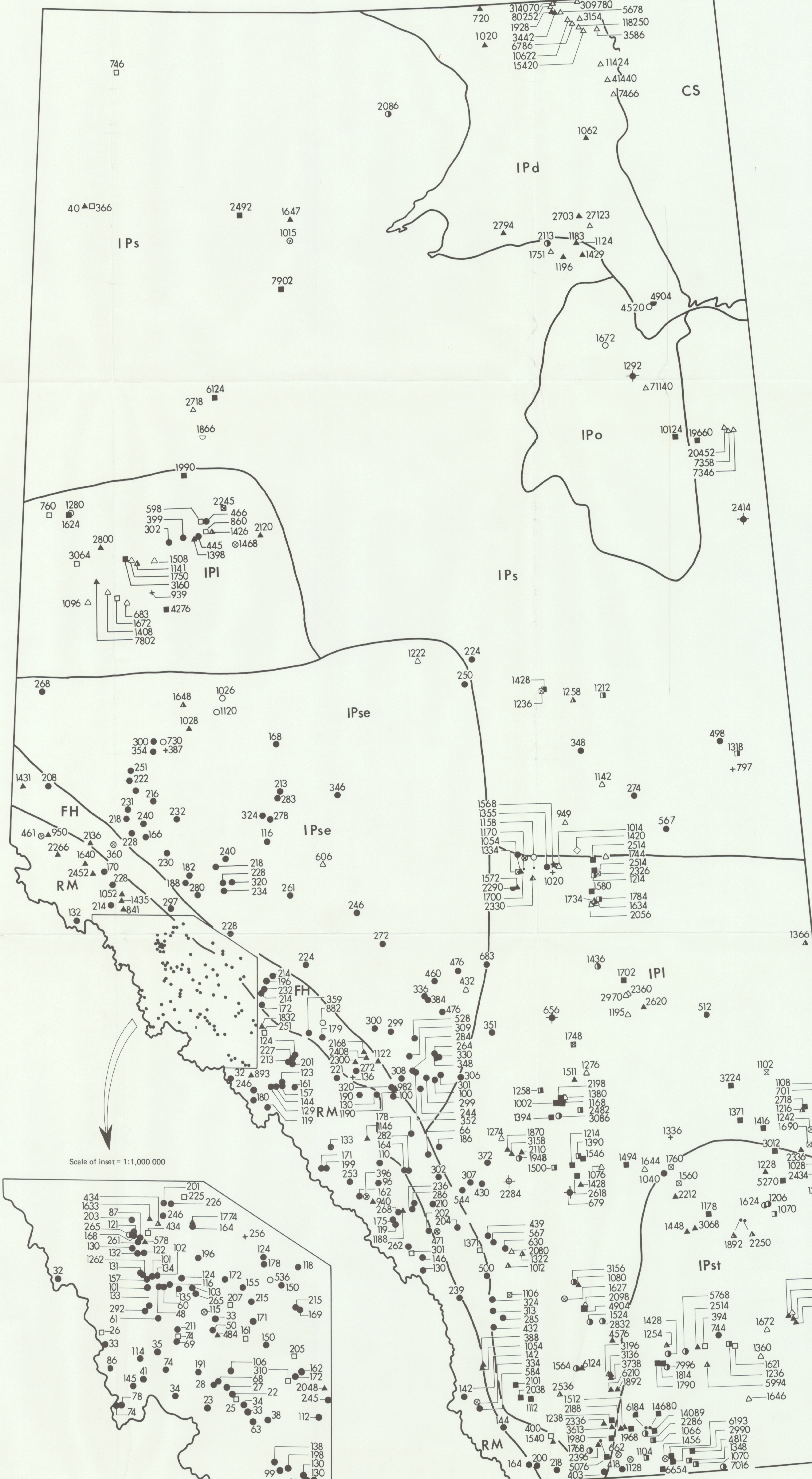


FIGURE 3 - TEMPERATURE OF ALBERTA SPRINGS



LEGEND

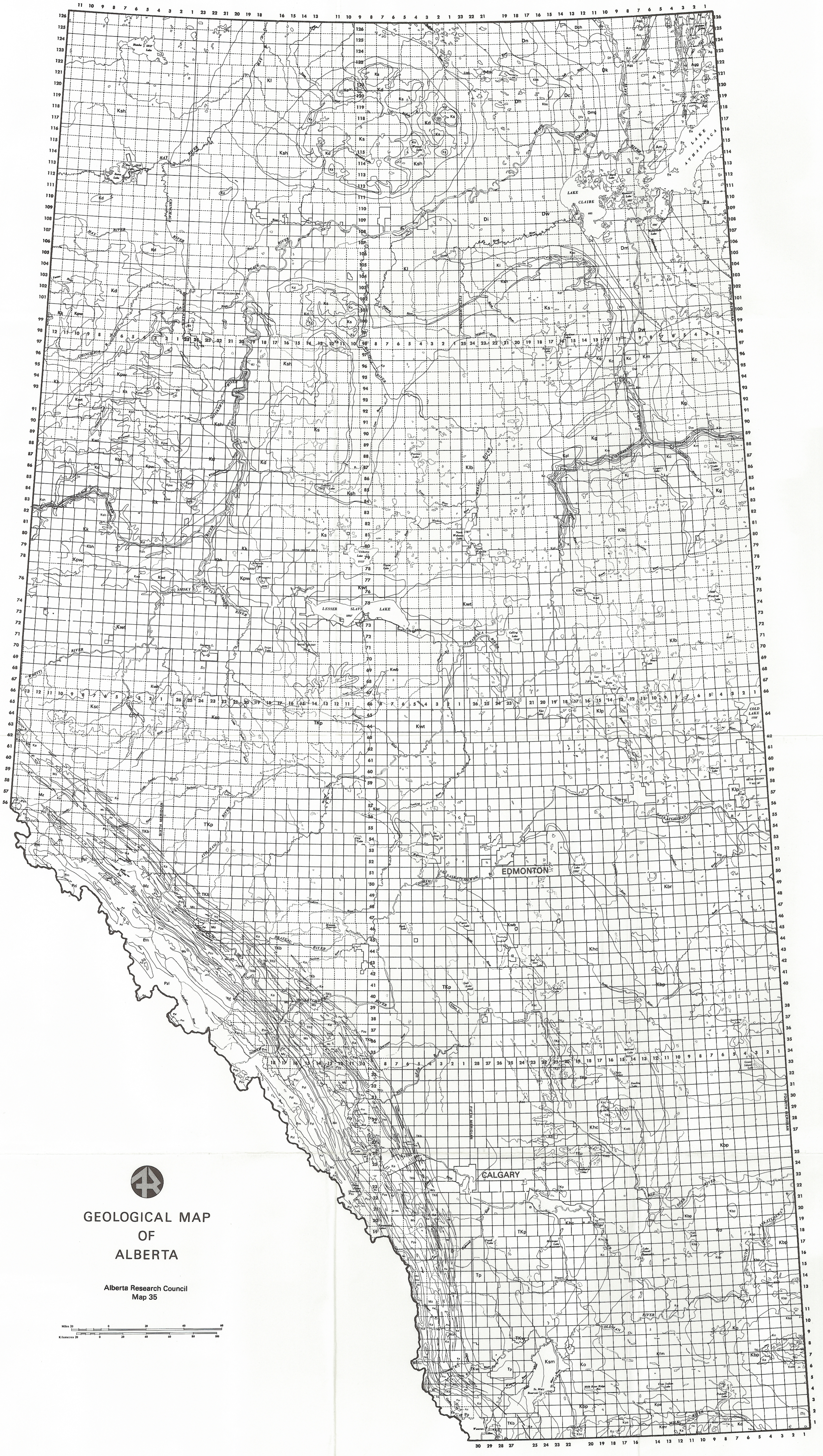
Groundwater Regions of Alberta
(Ozoray, pers. comm.)

RM Rocky Mountains
FH Foothills
CS Crystalline Shield
IP Interior Plains
(divided into)
IPd Devonian subcrop area
IPo Cretaceous oil sands area. Other Cretaceous, soft bedrock areas
IPs Short, cool summers, forested
IPse Extension to the south forested, Foothills type ecosystem
IPl Long, cool summers, parkland and grassland
IPst Steppe area (both moist and dry grassland)

- Ca Mg/HCO_3
- Ca Mg/SO_4
- Na K/SO_4
- Na K/HCO_3
- Na Cl
- Ca Mg/HCO_3, SO_4
- Na K, Ca Mg/SO_4
- Na K/SO_4, HCO_3
- Na K/HCO_3, SO_4
- Ca Mg/SO_4, HCO_3
- Ca Mg Na K SO_4, HCO_3
- Ca Mg/Na K, HCO_3
- Na K/Cl, HCO_3
- Ca Mg, Na K/Cl, HCO_3, SO_4
- Ca Mg/SO_4, Cl, HCO_3
- Ca Mg, Na K/SO_4, Cl
- Na K, Ca Mg/Cl, SO_4, HCO_3
- Soaphole

348 Number beside a spring indicates total dissolved solids in mg/L

FIGURE 4-CHEMICAL TYPES OF ALBERTA SPRINGS



LEGEND FOR BEDROCK GEOLOGY OF ABLERTA
(after Green, 1970)

NORTHERN ALBERTA

Devonian

Upper Devonian

Dg Grosmont Formation
Dmk Mikkwa Formation
Di Ireton Formation
Dw Waterways Formation
Dc Caribou Member, Slave Point Formation

Middle Devonian

Dn Nyarling Formation
Dm Middle Devonian

Proterozoic

Ꝑa Athabasca Formation

Archean

Am Metasedimentary Rocks
Agg Granite Gneiss
Ag Granite
Ap Porphyroblastic Granite

NORTHERN ALBERTA

Devonian

Dh Hay River Formation
Dc Caribou Member, Slave Point Formation

Middle Devonian

Dfv Fort Vermilion Member, Slave Point Formation
Dmg Muskeg Formation
Dk Keg River Formation
Dch Chinchaga Formation
Df Fitzgerald Formation

Archean

A Undivided Plutonic Rocks

ROCKY MOUNTAINS AND FOOTHILLS

Tertiary and Cretaceous

Paleocene and Upper Cretaceous

Tkb Brazeau Formation

Cretaceous

Ka Alberta Group

Mesozoic

Mz Lower Cretaceous, Jurassic and Triassic

Paleozoic

Pzu Upper Paleozoic
Pzl Lower Paleozoic

Proterozoic

Ꝑm Miette Group
Ꝑp Purcell Group

NORTHWESTERN ALBERTA

Tertiary and Cretaceous

Paleocene and Upper Cretaceous

Tkp

Cretaceous

Upper Cretaceous

Kwt Wapiti Formation
Kpw Puskwaskau Formation
Kph Bad Heart Formation
Kk Kaskapau Formation
Kd Dunvegan Formation

Upper and Lower Cretaceous

Ksh Shaftesbury Formation

Lower Cretaceous

Kp Peace River Formation

Kl Loon River Formation

NORTH CENTRAL ALBERTA

Cretaceous

Upper Cretaceous

Kwt Wapiti Formation
Ks Smoky Group
Kd Dunvegan Formation

Upper and Lower Cretaceous

Ksh Shaftesbury Formation

Lower Cretaceous

Kl Loon River Formation

Kb Basal Cretaceous

NORTHEASTERN ALBERTA

Cretaceous

Upper and Lower Cretaceous

Klb La Biche Formation

Lower Cretaceous

Kpl Pelican Formation
Kj Jolifou Formation
Kac Alice Creek Tongue, Grand Rapids Formation
Kg Grand Rapids Formation
Kc Clearwater Formation
Km McMurray Formation

SOUTHWESTERN ALBERTA

Tertiary

Paleocene

Tp Porcupine Hills Formation

Tertiary and Cretaceous

Paleocene and Upper Cretaceous

Tkw Willow Creek Formation

Cretaceous

Upper Cretaceous

Kwb Whitemud and Battle Formations
Ksm St. Mary River Formation
Kbo Blood Reserve Formation
Ko Oldman Formation
Kfm Foremost Formation
Kpa Pakowki Formation
Kmr Milk River Formation
Ka Alberta Group

SOUTHEASTERN ALBERTA

Tertiary

Oligocene

Tc Cypress Hill Formation

Eocene

Ti Intrusives

Tertiary and Cretaceous

Paleocene and Upper Cretaceous

Tkr Ravenscrag Formation

Cretaceous

Upper Cretaceous

Kwb Whitemud and Battle Formations
Ke Eastend Formation
Kbp Bearpaw Formation
Ko Oldman Formation
Kfm Foremost Formation
Kpa Pakowki Formation
Kmr Milk River Formation
Ka Alberta Group

CENTRAL AND EASTERN ALBERTA

Tertiary

Pliocene?

Th Hand Hills Formation

Tertiary and Cretaceous

Paleocene and Upper Cretaceous

Tkp Paskapoo Formation

Cretaceous

Upper Cretaceous

Kwb Whitemud and Battle Formations
Khc Horseshoe Canyon Formation
Kbp BearPaw Formation
Kbr Belly River Formation
Klp Lea Park Formation

FIGURE 30