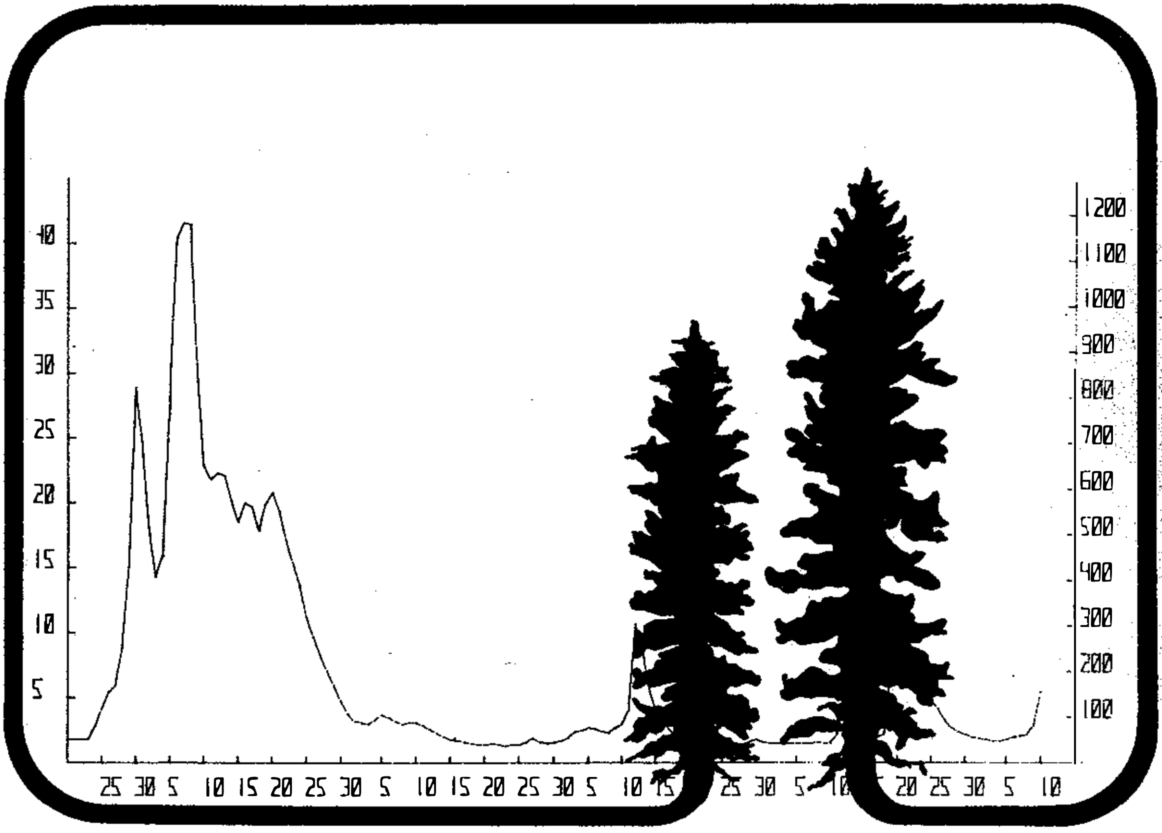
Hydrometeorology of the Hinton-Edson area, Alberta, 1972-1975



G.R. Hillman, J.M. Powell, and R.L. Rothwell

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BY

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ABSTRACT

Data obtained from studies on the North Western Pulp and Power Ltd. lease in the Hinton-Edson area for the purpose of assessing the impact of clear-cut forest harvesting on hydrological and meteorological parameters are compiled in this report. The data provide a reference on precipitation and stream discharge in a form suitable for use by those who have a working interest in the Hinton-Edson area.

Forty-six watersheds within the area are described in terms of location, size, physiography, vegetation, soils, surficial deposits, bedrock, and channel characteristics. Most descriptions are accompanied by an oblique aerial photograph of the watershed. Data from individual watersheds are presented in the form of bar precipitation graphs and hydrographs.

The period of record extends primarily from May to September for 1972 through 1975. Total precipitation maps and precipitation maps for individual storms are presented together with snow course data (depth and water equivalent) for the lease area. The average volume of water contributed by the pulp lease area to the Athabasca River each year is estimated to be $3.76 \times 10^9 \, m^3$, which is equivalent to 266 mm of runoff, or about 50% of mean annual precipitation.

RESUME

Ce rapport contient les données obtenues après des études sur la forêt affermée de la North Western Pulp and Power Ltd. dans le secteur Hinton-Edson pour fins d'évaluer l'influence de la coupe à blanc des forêts sur les paramètres hydrologiques et météorologiques. De telles données constituent une source de renseignements sur les précipitations et le débit des ruisseaux, sous une forme pouvant servir à ceux que le secteur Hinton-Edson intéresse à cause de leur travail.

Les auteurs y décrivent les caractéristiques touchant le site, la grandeur, la physiographie, la végétation, les sols, les alluvions, les fonds rocheux et les lits de 46 bassins-versants. La plupart des descriptions sont accompagnées d'une photographie aérienne oblique du bassin-versant. Les données sur chaque bassin-versant sont présentées sous forme d'hydrogrammes et d'histogrammes de la précipitation.

La période enregistrée s'étend surtout de mai à septembre pour les années 1972 jusqu'à 1975, inclusivement. Des cartes donnant la précipitation totale et celle de tempêtes individuelles sont offertes avec les données relatives à la couche de neige (profondeur et équivalent en eau), pour le terrain affermé. Le volume moyen d'eau venu du dit terrain à la rivière Athabasca chaque année est évaluée à $3.76 \times 10^9 \, m^3$, soit l'équivalent de 266 mm d'eau d'écoulement d'un bassin, ou environ 50% de la précipitation moyenne annuelle.

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INTRODUCTION

This paper is a data compilation and a brief analysis describing the hydrometeorology of the Hinton-Edson area, Alberta. The data base is derived from a series of studies supported by the Canadian Forestry Service and the Alberta Watershed Research Program from 1972 to 1975 to assess the environmental impacts of forest harvesting on specific hydrological and climatological parameters of the area (Environment Canada 1974a; Singh *et al.* 1974; Swanson and Hillman 1977a,b).

The primary objective of this paper is to ensure that the processed hydrological and associated climatological data collected during 1972-75 are available for public use. This is important because the study area, like most of the Alberta Foothills, is largely "unmapped" in terms of hydrologic and climatic data, especially for small watersheds. Data of this nature are constantly in demand by such groups as road builders, fisheries biologists, foresters, engineers, hydrologists, and planners.

A second objective is to provide an evaluation and description of the hydrometeorology of the area that will aid in the use and application of the data. We describe watersheds and their streamflow patterns in terms of precipitation input, physiography, soils, vegetation, and land uses.

This paper is divided into four parts: (1) a general physical description of the study area and its different land uses; (2) a detailed description of the climate of the area, with emphasis on the summer precipitation regimes, including individual storms and intensities, and snow survey data; (3) a detailed description of the hydrology of the area, identifying different types of watersheds, their storm responses, average summer flows, and timing of flows; and (4) a graphical compilation of flow and precipitation data in the form of hydrographs and histograms for 46 watersheds ranging in size from 1 to 50 km^2. The flow data in the compilation are for May to September, or some portion thereof, and are a mixture of instantaneous observations obtained with current meters and continuous records obtained from water level recorders. A physical description of each watershed and an oblique aerial photograph showing its physiography and vegetative cover are also provided.

STUDY AREA AND LAND USES

The study area coincides mainly with the forest management lease area of North Western Pulp and Power Ltd. (NWPP), Hinton, which is located in west-central Alberta, east of Jasper National Park, in the Athabasca River drainage system (Figs. 1 and 2).

Physiography

The area is dominated by two physiographic regions, the Interior Plains and the Western Cordillera. The terminology for the subdivisions of these regions varies considerably (Dumanski *et al.* 1972). On the extreme western boundary the Front Ranges of the Rocky Mountains and the Foothills occur. The Foothills of the Western Cordilleran Region occupy a zone between the Rocky Mountains and the Interior Plains, and consist of a series of approximately parallel ridges of local relief between 1150 and 1675 m, aligned in a northwest-southeast direction. The Interior Plains Region can be subdivided into two zones or divisions, the Edson Lowlands (Roed 1975) or Alberta Plains, consisting of gently undulating or rolling terrain at an elevation of 900 m in the northeast of the area centered on Edson, and the flat tablelands and benchlands of the Alberta Plateau, which abut the Foothills and cover much of the lease area. These tablelands or upland plateau areas are often separated by wide valleys, such as the Athabasca River valley and the Jarvis Lake-Wildhay River valley. Roed (1975) presents a map showing the detailed subdivisions of the Interior Plains Region. Slopes in the Front Ranges and on the benchlands vary from moderate to extreme (15-60%+ slope steepness), while slopes on the tablelands and lowlands vary from nearly level to gently rolling (0-15% slope steepness). Elevations range from 853 m in the eastern portion to about 2621 m in the southwestern part.

Geology

Bedrock geology of the study area, which ranges from Precambrian to Tertiary in age, can be divided into three parts. The eastern part, or Interior Plains Region, is underlain by the Paskapoo Formation of Paleocene age, which consists of weakly consolidated beds of sandstone and siltstone, with interbedded strata of shale, coal, and chert conglomerate (Roed 1975). The rocks underlying the Foothills are sandstones and clastic rocks

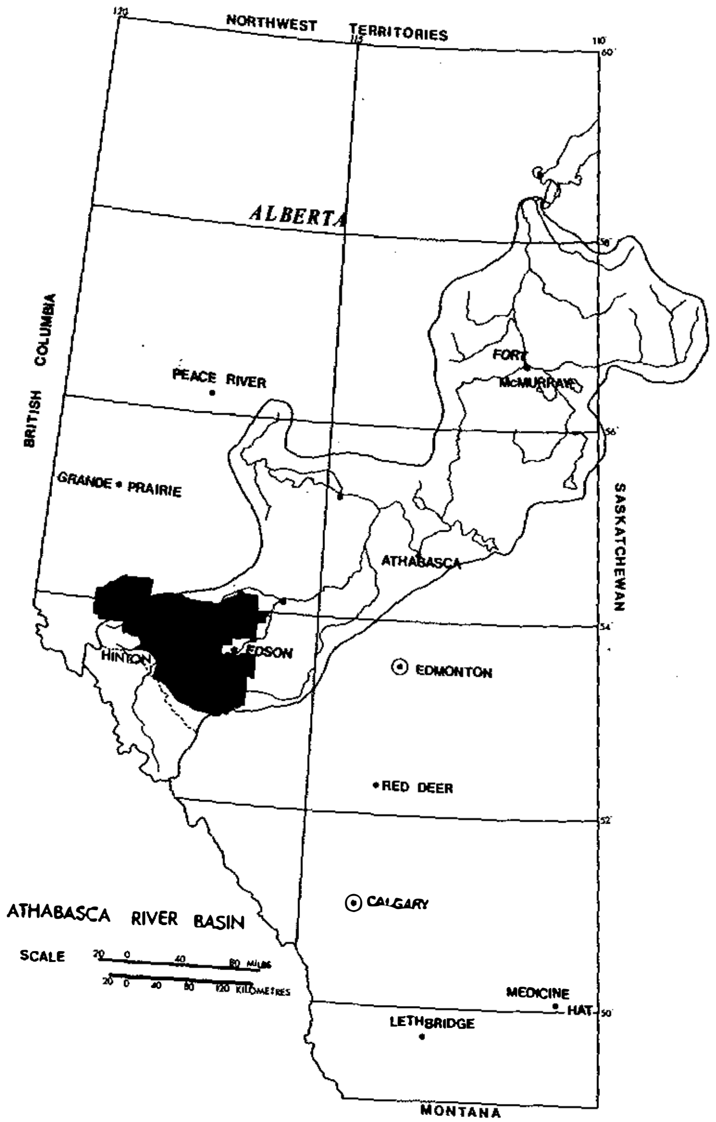


Fig. 1. Location of study area

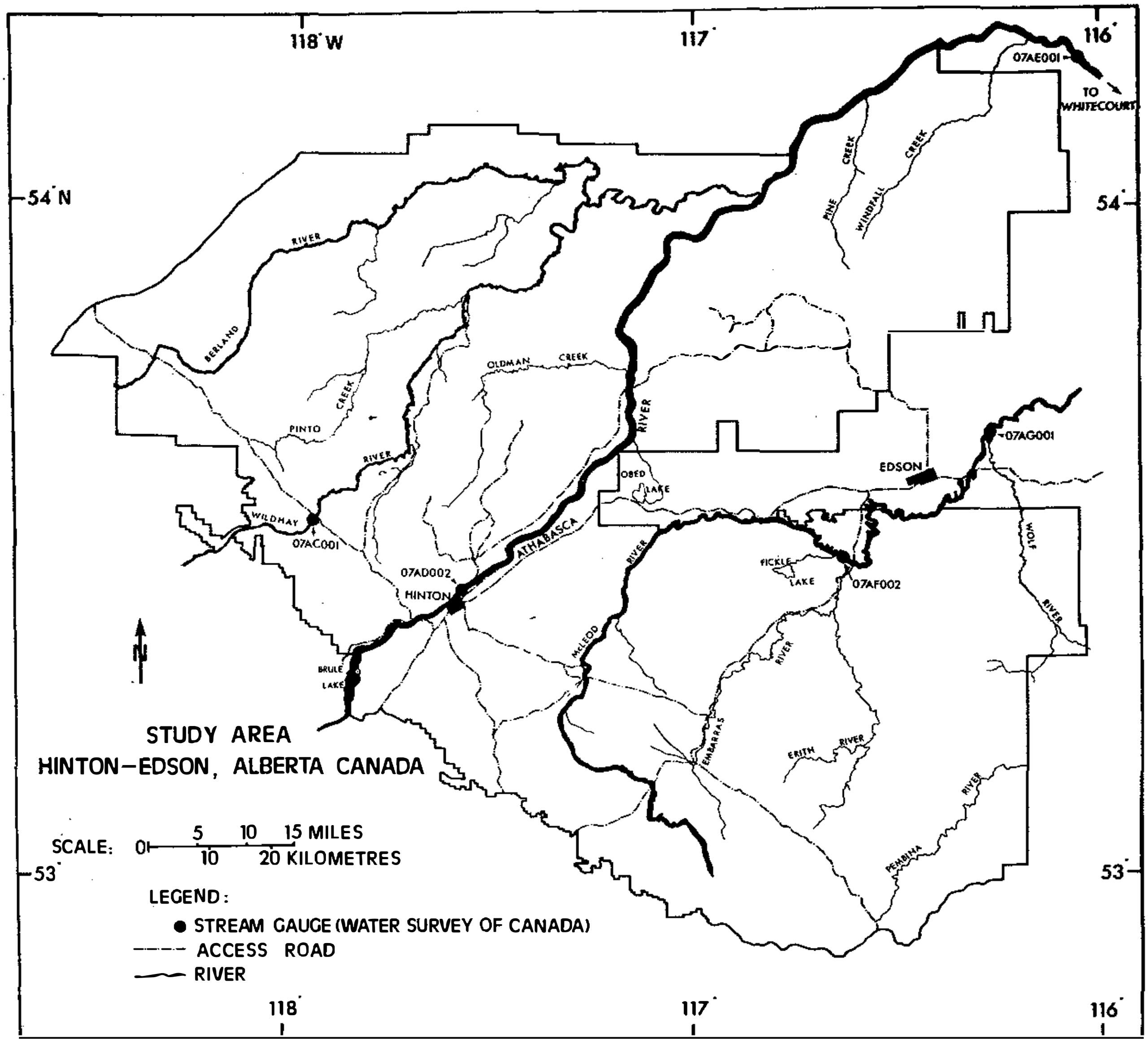


Fig. 2. Major rivers draining lease area

of Late Upper Cretaceous and Tertiary age belonging mostly to the Brazeau Formation and Paleocene (Irish 1965; Roed 1975). Intense folding and faulting along the Foothills have resulted in local, elongated exposures of the Kaskapau, Wapiabi, Cardium, and Blackstone Formations of Early Upper Cretaceous age and the Luscar and Cadomin Formations of Lower Cretaceous age (Irish 1965; Currie 1969). The rocks of the Front Ranges of the Rocky Mountains consist of sedimentary strata, mostly carbonate, argillaceous, and arenaceous limestones of Devonian to Permian age (Mountjoy 1962).

Surficial Deposits

Glaciation in the study area has resulted in numerous moraines and eskers and extensive till, lacustrine, and glaciofluvial deposits (Research Council of Alberta 1970). Roed (1975) indicates four and possibly five glacier advances in the area and recognizes seven glacial tills and three preglacial gravel units of Tertiary-Quaternary age underlying the glacial deposits. The Tableland gravel outcrops on various upland plateau areas and is common near the Mayberne and Obed Lookouts and on High Divide Ridge south of Hinton. Large but fairly local areas of loess or aeolian deposits can also be found in the study area. The only active dune field, with deposits up to 15 m thick, occurs to the east of Brûlé Lake. The major tills of the area are the Obed, Marlboro, Edson, Mayberne, and Robb. The Edson and Mayberne tills are of Laurentide or Continental source, and are north, south, and east of the town of Edson. They are moderately to very stony, with a silty-sandy matrix of low carbonate content. The other major tills are of Cordilleran source and are widely distributed throughout the study area, the Marlboro being the most extensive. The Obed till is very stony with well-rounded metaquartzite cobbles, limestone and sandstone erratics, and has a sand-clay matrix of high carbonate content. The Marlboro and Robb tills are less stony and have silty-clay matrices of moderate carbonate content. The common landform associated with till in the study area is ground moraine with relatively low local relief.

Extensive lacustrine deposits are found in the lowland areas near Edson and in localized areas elsewhere. The deposits vary in thickness from a few metres up to 12 m, with an average thickness of 3 m (Dumanski *et al.* 1972). The deposits vary from fine to medium in texture and moderate to strong in carbonate content (6-25% $CaCO_3$ equiv.). Topography associated with lacustrine deposits varies from gently to undulating rolling hills.

Glaciofluvial deposits occur primarily along river valleys and as isolated deposits such as eskers and kames. These deposits consist of gravels, cobbly gravels, and sands. Paired river terraces, such as the terraces flanking the Athabasca River near Hinton, are the most common landform associated with outwash deposits.

Recent deposits of nonglacial origin include aeolian, alluvial, colluvial, and organic deposits. The latter are quite extensive, with unconsolidated peat accumulations of over 60 cm in some areas. Dumanski *et al.* (1972) mapped the organic deposits as the Fickle or Erith complexes, depending on peat thickness.

Soils

Dumanski *et al.* (1972) have identified the major soil profile types in the area as Orthic Gray Luvisols (two varieties), Bisequa Gray Luvisol, and Eutric Brunisol; their distribution is related to landform, soil reaction, and lithology. The soils are medium to coarse in texture (0.25-1.0 mm diameter of primary particles) with carbonate contents ranging from low to high (1-25% $CaCO_3$ equiv.) and vary from silt loams to loams (Canada Soil Survey Committee 1970). Soils with a calcareous loess content have a Brunisolic Gray Luvisol morphology, and the poorly drained soils of the area are Orthic and Rego Gleysols and Low Humic Eluviated Gleysols (Dumanski *et al.* 1972). Dumanski *et al.* (1972) describe 15 soil associations and three soil complexes for the area. The uniqueness of the Hinton association has also been reported separately (Dumanski and Pawluk 1971). Infiltration rates for the various soil associations on lodgepole pine sites were 14.2 cm/h (standard error 2.0) compared to 2.1 cm/h (standard error 0.3) for spruce-fir sites (Singh 1976 unpubl. data). The soils are considered in general to be highly erodible (Dumanski *et al.* 1972), especially those derived from lacustrine or loess deposits and of low carbonate content. Soil stability, terrain slope, and erosion sensitivity for the area are also presented in the Schulco report (Alberta Lands and Forests 1973).

Vegetation

The entire study area is forested except for small cultivated or pastured areas around Edson and near Hinton. Most of the lease area falls within the Lower Foothills (B.19a) and Upper Foothills (B.19c) Sections of the Boreal Forest Region (Rowe 1972). Dumanski *et al.* (1972), however, considered the forest vegetation in the Alberta Plains or Edson Lowlands area to be dominated by trembling aspen (*Populus tremuloides* Michx.) and the area thus part of the Mixedwood Section (B.18a). The major species are lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.), white spruce (*Picea glauca* (Moench) Voss),black spruce (*Picea mariana* (Mill.) B.S.P.), alpine fir (*Abies lasiocarpa* (Hook.) Nutt.), trembling aspen, and balsam poplar (*Populus balsamifera* L.). On upland well-drained sites, lodgepole pine is most common, often with mixtures of aspen. These two species are widely distributed because of their occurrence following fires. In older stands, white spruce and black spruce are the more predominant species. Black spruce is often found growing on very wet, poorly drained sites (i.e., muskeg areas). Alpine fir is usually found in association with spruce on the elevated benchlands. Dumanski *et al.* (1972) describe some of the prominent understory vegetation found in the various physiographic subdivisions.

Fauna

The study area is one of the prime big game zones in Alberta, with healthy populations of mule deer, moose, elk (wapiti), and black bear. In addition, white-tailed deer, mountain caribou, rocky mountain sheep, mountain goats, and grizzly bear are found in certain areas. Information on the distribution and habitat of these species is given in the Schulco report (Alberta Lands and Forests 1973), which also provides a list of the small mammal, bird, and fish species found in the area, including information on the important furbearing mammals, upland gamebirds, and the fisheries capability of some streams.

Land Use

The study area is sparsely populated. More than 90% of its 16-17 000 population lives in the towns of Hinton, Grande Cache, and Edson. The rest live in small settlements along Highway 16, around Brûlé Lake, Robb, Cadomin, and in the farming area north and northeast of Edson. Principal land uses in the area are forestry, gas and oil, coal, and recreation, although other uses occur.

Forest production dominates the land use pattern of the area. Forestry has been carried out on a sustained yield basis since 1954 with the establishment of NWPP at Hinton (Crossley 1975). In 1968, the company received from the provincial government a forest management agreement area comprising approximately 16 317 km^2, including some exempted areas (Fig. 1). To date the company has been granted permission to operate a forest lease on approximately 8000 km^2 of the agreement area, and annually cuts about 950 000 m^3 of pulpwood from approximately 4500 ha (Crossley 1975; MacArthur 1968). The lease is divided into five working circles, each managed as an entity with its own allowable cut. Each working circle is made up of a number of compartments each to provide an estimated 1.2 million m^3 of wood. Logging is carried out simultaneously in each working circle in a series of four 20-year cutting cycles to allow for complete harvest and regulation of growing stock by the end of the first rotation period (80 years). The pulpwood harvesting method used is clear-cut blocks or strips with tree-length skidding and hauling to the mill. While clear-cut sizes are generally limited to 32 ha for pine and 16 ha for spruce, they have sometimes been increased. Moreover, the intervening uncut strips have sometimes been cleared before the original blocks have regenerated, producing large cleared areas. At present, approximately 65 000 ha, or less than 10% of the lease area, has been harvested (Crossley 1975). However, in some places harvesting has been intensive, so that 20-70%+ of the trees in a given watershed or area have been removed.

To support logging operations for its pulp and sawmill, NWPP has constructed an extensive network of all-weather access and logging roads in its lease area, all converging on Hinton. The average haul distance to the mill at Hinton from all first-cycle compartments is 72 km (Crossley 1975). The roads vary in quality from those designed for continual use throughout the entire rotation period to those designed for a 2- to 3-year period. New roads are continually being constructed 1-2 years in advance of logging as harvesting moves to new areas. Accordingly, each working circle has a mixture of old unused roads, currently used roads, and newly constructed roads.

The region also has a number of small sawmills and wood preserving mills, which range in annual production up to 16 517 m^3. Total timber production in the Edson Forest District in the year 1972-1973 was 1 251 626 m^3 (44 200 834 ft^3), of which nearly a million cubic metres (969 863) was pulpwood (Teskey and Smyth 1975).

The majority of the study area lies within the Green Zone, which was established in 1948, and includes forest lands not available for agricultural development other than grazing. However, some agriculture is carried out around Edson, and a small area primarily devoted to livestock grazing exists near Hinton.

Oil and gas exploration in the Hinton-Edson area first started in the 1950's. Since the early 1960's, however, exploration has accelerated and continued at a high rate; long-term leases for this activity cover half the area, and short-term leases a further 20%. On the average, 15-35 producing wells have been established annually for the past 10-15 years. At present there are three main gas fields in the study area, located north and south of Edson. In addition to these, there is a large number of single or small isolated groups of wells scattered throughout the study area. A single gas processing plant is located at Edson.

In exploration for gas and oil a large number of exploration or "seismic" trails have been constructed in the study area. These trails are usually laid out on the ground as straight lines and extend for great distances over the landscape, without any apparent regard for topographic features. Over 24 140 km of these trails exist on the timber management area alone. These trails can create problems of erosion and sediment, and in some situations divert small springs and side slope streams from their natural drainage paths, but they are not a major sediment source compared to roads (Environment Canada 1974a).

Commercial coal mining in the study area started in 1911 with the coming of the railway to the region. The first mines were located in the "Coal Branch" at Coalspur, Lovett, and Mountain Park; others were developed at Robb, Bryan, Mercoal, Sterco, Coal Valley, Hinton, Drinnan, Pocahontas, and Brûlé. Most of this mining was done by underground methods. Peak production from these early mines occurred about 1930 and again during the Second World War, after which the industry declined to almost nothing in the early 1950's, with the last mine shutting down at Luscar in 1959.

Interest in coal mining was reactivated in the mid-1960's by the potential for exports of coking coal to Japanese markets. The principal mining operations in or near the study area at present are at Luscar, where shipment commenced in 1970, and at Grande Cache, where the town and mine were established in the mid-1960's. Another strip-mining operation is under construction at Coal Valley, and other applications or explorations are in progress. Total coal reserves in the area consist of about 9.5 billion t of coal, of which about half is recoverable (Alberta Environment Conservation Authority 1973).

Commercial limestone quarrying was begun at Cadomin in 1956; sand and gravel leases are scattered throughout the region.

Recreational uses are scattered throughout the area, mostly adjacent to the major roads, especially Highway 16, the major east-west transportation corridor that bisects the area. The provincial government, through its forest service and highways department, maintains a system of recreation areas and campgrounds. The forestry industry has assisted in this development and also developed two hiking and riding trails (Crossley 1975). In the area immediately east of Jasper National Park three private facilities provide accommodation and recreation. There is one major provincial park, the William A. Switzer, in the Jarvis Lake area, and an outdoor recreation center in the same area. Intensive activity sites are the two ski developments, one 19 km south of Hinton and the other just east of the Mayberne Lookout.

Within the area the numerous rivers, streams, and small lakes, many of which are stocked annually with fish, provide a major recreational angling resource. The area also has a history of relatively intensive use for hunting, although wintering range for certain ungulates is limited. The area is not important for waterfowl production, but has numerous species of furbearers and some upland game birds. The Schulco report provides some information on fur production in the 1971-72 season (Alberta Lands and Forests 1973).

CLIMATE

General Climatic Conditions

Most of the study area falls within the Sub-Arctic or Cold snowy forest climate (Dfc) of Köppen (Canada Department of Mines and Technical Surveys 1957). This is a climate with adequate moisture throughout the year with 1 or more months with a mean temperature above 10°C and 1 or more months with a mean temperature below -3.0°C. Most stations in the area have 3 months with a mean temperature above 10°; a few of the stations have a mean July temperature of 15°C or above. All the stations have 5 months with a temperature below -3.0°C except Jasper, which has only 4. The Rocky Mountains on the west of the study area fall within the Tundra climate (ET) zone of Köppen where the mean temperature of the warmest month is below 10°C but above 0°C. In general, the area can be described as having a continental subhumid climate, with long, cold winters modified by short periods of chinook conditions, and short, cool summers.

A factor analytic climatic classification of the area based on 1961-1970 data for the summer period May to September indicated that most of the lease area falls into one zone (Powell and MacIver 1976). Areas of the lease lying outside this zone include the northwest portion, the Athabasca River valley around Hinton and to the southwest, and portions west of Whitecourt and around Edson.

Few year-round long-term climate stations exist in and adjacent to the area: Edson A, Entrance, Jasper, and Whitecourt. Other stations in the area that have operated for short periods or during the summer only (before 1971), have been listed by Powell and MacIver (1976). Dumanski *et al.* (1972) give mean monthly temperatures and quartile precipitation probabilities for Edson and Entrance and comment on other climatic features of the area.

The mean annual daily temperature for the area ranges from 1.0 to 2.9°C, except that a value of -0.4°C is indicated for the short-term station at Muskeg Ranger Station (R.S.) (Environment Canada 1975a). The higher daily mean temperatures occur at the more western stations (Hinton 2.9, Jasper 2.8, Hinton FTS 2.4, Entrance 2.3°C) in the Athabasca River valley, and lower temperatures occur in the east or at higher elevations (Whitecourt 1.0, Shining Bank Ranger Station 1.2, Robb R.S. 1.3, and Edson 1.7°C). July is the warmest month (range 12.3°C at Muskeg R.S. to 15.2°C at Hinton and Jasper) and January the coolest (range -16.1°C at Whitecourt to -11.8°C at Hinton). An extreme maximum temperature of 37.8°C has been recorded at Edson A and Entrance, and an extreme minimum temperature of -51.1°C at Entrance. The mean summer (May to September) temperature over the lease area ranges from below 6°C at the higher levels of the Rocky Mountain Foothills to over 10°C (Powell and MacIver 1976). Mean summer temperatures over 12°C occur at Jasper and Whitecourt.

Frosts can occur in any month, although much of the area does not experience frosts in July. The number of days with frost ranges from 213 at Jasper to 232 at Edson. Longley (1967b) indicated that the frost-free period based on two periods of data (up to 1950 and 1951-1964) was 59 and 74 days at Edson, 44 and 66 at Entrance, 82 and 87 at Mayberne Lookout, and 73 and 88 days at Jasper. He further noted that the frost-free period at Whitecourt Lookout (1201 m) was 104 days, while 460 m lower at Whitecourt in the Athabasca valley it was 75 days. Frost-free periods based on data for the 1941-1970 period (Hemmerick and Kendall 1972) indicate a range for the area of 51 days at Entrance to 101 days at Carrot Creek Lookout. They indicate a difference of 30 days between Whitecourt (64) and Whitecourt Lookout (94).

The mean annual precipitation for the area ranges between 510 and 560 mm, except that Jasper has markedly less (400 mm) (Environment Canada 1975b; Powell 1977). The four long-term stations each record about a third (30.2-34.0%) of the precipitation as snow. Summer precipitation (May to September) generally ranges between 350 and 450 mm. July is the wettest month, although stations close to the Rocky Mountains (Athabasca Lookout, Entrance, Jasper) tend to have a June maximum. March is the driest month, although there is little difference in the averages for the winter months October to April. Forty-five to 50% of the precipitation falls in the months June to August, except at Jasper where only 36% falls in this 3-month period. During this period the number of days per month with measurable precipitation averages close to 14 for all stations. The lowest frequency of occurrence is recorded at Entrance (11), Grave Flats Lookout (12.3), Athabasca Lookout (12.7), and Jasper (13), all in or close to the mountains where convective thunderstorm activity is less. The heaviest recorded rainfall in one day (131.0 mm) occurred at Jasper East Gate on 5 August 1969. Other high values have occurred at Ansell Lookout (108.2 mm), Grave Flats Lookout (105.7 mm), Huckleberry Lookout (107.2 mm), and Jasper (107.7 mm). Pollock and Gaye (1973) indicate that such high 1-day-rainfalls can be expected over most of the area in a 100-year return-period, and even values as high as 150 mm can occur at some stations, e.g., Grave Flats. On 4-5 August 1969, 176.5 mm fell at Grave Flats and 160.8 mm at Lovett Lookout. The highest monthly precipitation total of 291.1 mm occurred at Lovett Lookout in August 1954. Totals of about 280 mm have also been recorded at Mayberne and Whitecourt lookouts.

The average wind speed for the year at Edson and Whitecourt is just over 10 km/h, with individual monthly averages ranging between 8.6 and 12.3 km/h. The peak average wind speeds occur in the months March to June. At Edson most winds occur from the southwest to west (35%), and at Whitecourt from the west to northwest (32%), with also a fair percentage from the east (12%). Both stations recorded calms for 12-14% of the year (Environment Canada 1975c). Several lookout stations in the area have recorded winds in excess of 80 km/h (Alberta Lands and Forests 1973). The entire area is subject to warm chinook winds during the winter, especially in the area along the Athabasca River valley adjacent to the Rocky Mountains. Longley (1967a) indicated that Entrance had an average of 27 days of chinook conditions (defined as a day with a maximum temperature of 4.4°C or above) in the months December to February, Hinton 23, Edson 17, and Jasper 14.

Potential evapotranspiration in the area ranges from 411 mm at Whitecourt Lookout to 445 mm at Whitecourt, based on 1954-1968 data (MacIver *et al.* 1972). The average actual evapotranspiration ranges from 371 mm at Entrance to 409 mm at Edson for the same period based on a soil moisture storage of 101.6 mm at the end of March. Some water deficiency occurs in the Entrance-Hinton-Jasper and Edson-Mayberne areas (usually less than 60 mm), with most of the area experiencing no water deficiency (Powell and MacIver 1976).

The number of degree days above 5.6°C (42°F) ranges from 624 at Whitecourt Lookout to 1002 at Edson (MacIver *et al.* 1972). This range was based on only seven stations in the area and would probably be wider if further stations were considered, especially those at higher elevations. Aston (1969) indicates a yearly average of 1097 growing degree-days above 5.6°C at Jasper.

Edson receives an average of 2000 h of bright sunshine a year. Kendall and Petrie (1962) indicate an average of 8.6 and 18.8 thunderstorm days at Jasper and Whitecourt respectively. McLean (1968) showed the average number of thunderstorms that occurred in the study area from mid-April to mid-October in the years 1963-1968 to range from <10 near Jasper National Park to 25 at Mayberne Lookout. The peak frequency of thunderstorms occurs in July. The incidence of fog at Jasper is very low (2.1 days), but at Whitecourt it is relatively high, 33.7 days, the highest frequency for the Alberta stations listed (Hemmerick 1971).

Precipitation Data

Precipitation data in the summer months, May to September inclusive, were obtained by the use of standard MSC rain gauges, supplemented by a network of recording precipitation gauges. The recording gauges were of various types: weekly Casella natural siphon, MSC tipping bucket operated through a weekly Esterline Angus recorder, Belfort universal gauges, both weekly and monthly, and 15-min Fischer Porter precipitation gauge recorders. The Belfort and Fischer Porter gauges were also maintained through the winter months; most of these gauges were not installed until the summer of 1973.

The number of stations for which precipitation data were obtained is indicated in Table 1, which shows them grouped by working circle or area for the years 1972-1975. Some of the data were obtained from the Atmospheric Environment Service, or from Parks Canada in the case of stations within Jasper National Park, which do not regularly submit data to the Atmospheric Environment Service for publishing in the *Monthly record*. Data were also obtained from the Alberta Forest Service for stations in the Tri-Creek Watershed and from the Forestry Technology School at Hinton for the Cache Percotte Watershed. Stations were maintained at Jarvis Lake (1973-1975) and at Blue Lake Centre (1973) by Alberta Recreation, Parks and Wildlife, and at the old Entrance Ranger Station (1973) by Mrs. W. Mountain in support of this study. In 1975 precipitation data were obtained from the Luscar Mine of Cardinal River Coals Ltd., Hinton. All other stations were maintained by personnel of the Northern Forest Research Centre (NFRC) in support of the hydrology or climatology studies. During certain periods (May to June, 1973 and 1974) precipitation data were collected daily from most of the NFRC stations, especially those associated directly with the hydrology studies, but at other times measurements were usually made at weekly intervals. However, in most cases it is possible to assign values of these weekly catches to particular days or storms in the week, through reference to the regular daily climatological stations in the area, or through use of the recording precipitation gauge network. From Table 1 it is obvious that the densest networks of stations occurred on the Athabasca and McLeod Working Circles in the vicinity of Hinton. Table 1 also shows that the number of standard rain gauge stations varied from 135 to 161 in any one year. Generally this number of stations was not in operation for the full 5-month period, although 90% were in operation from early May to the end of September. Other stations, especially in 1972, were in operation for only 1 or 2 months or for only 4 months because of

Table 1. Number of standard rain gauge stations and recording precipitation gauge stations (in parentheses) in the various working circles on the NWPP lease area and adjacent areas from which data were obtained during the summers of the years 1972-75

Area or Working Circle	Number of Stations 1972		1973		1974		1975	
Athabasca	23	(1)	30	(7)	27	(7)	28	(9)
Berland/ Simonette	6	(0)	8	(1)	11	(1)	10	(2)
Embarras	3	(0)	2	(0)	4	(1)	3	(1)
Marlboro	5	(0)	13	(2)	8	(2)	2	(1)
McLeod	72[1]	(12)	65[1]	(10)	62[1]	(15)	55[1]	(15)
Jasper National Park	11	(0)	11	(0)	8	(0)	4	(0)
Other Adjacent Areas	32[2]	(0)	35[2]	(0)	33[2]	(0)	33[2]	(0)
TOTAL	149	(13)	161	(20)	150	(26)	135	(28)

[1] Includes 15 stations in Tri-Creek Watershed.

[2] Includes 15 stations in Cache Percotte Watershed.

problems of accessibility to certain areas. Figure 3 shows the location of all the precipitation recorders and standard rain gauges used in the study, whether for the whole study period or for shorter periods.

Standard procedures for measuring precipitation were followed as closely as possible at all NFRC stations, but procedures at other stations used is unknown, except that one would expect those in the regular climatological network to be standard. One important deviation from the standard operational procedure for the NFRC stations was that the stations were not measured at a standard time because of the logistics of servicing such a widespread network. For this reason the measured totals for a particular day may not be strictly comparable with totals for stations in the regular network, especially for measurements made during the storm; however, the overall totals for a particular storm period should be comparable. Individual measurements are, however, highly affected by gauge exposure. All gauges were maintained perpendicularly, with the orifice installed approximately 30 cm above the ground. Because of the nature of the terrain being sampled, few gauges were exposed on areas with level ground in the immediate vicinity of the gauge. However, wherever possible, gauges were exposed away from any influence of trees, shrubs, tall ground vegetation, or logging residue. If, during the growing season, gauges became threatened by encroaching vegetation, the vegetation was removed to prevent the possibility of raindrops accumulating on vegetation and entering the gauge. The growing vegetation undoubtedly affected the influence of ground wind speed on the orifice of the gauge as the season progressed.

No adjustment has been made for the fact that the standard rain gauge provides an underestimate of true precipitation. It was also noted that several of the recording

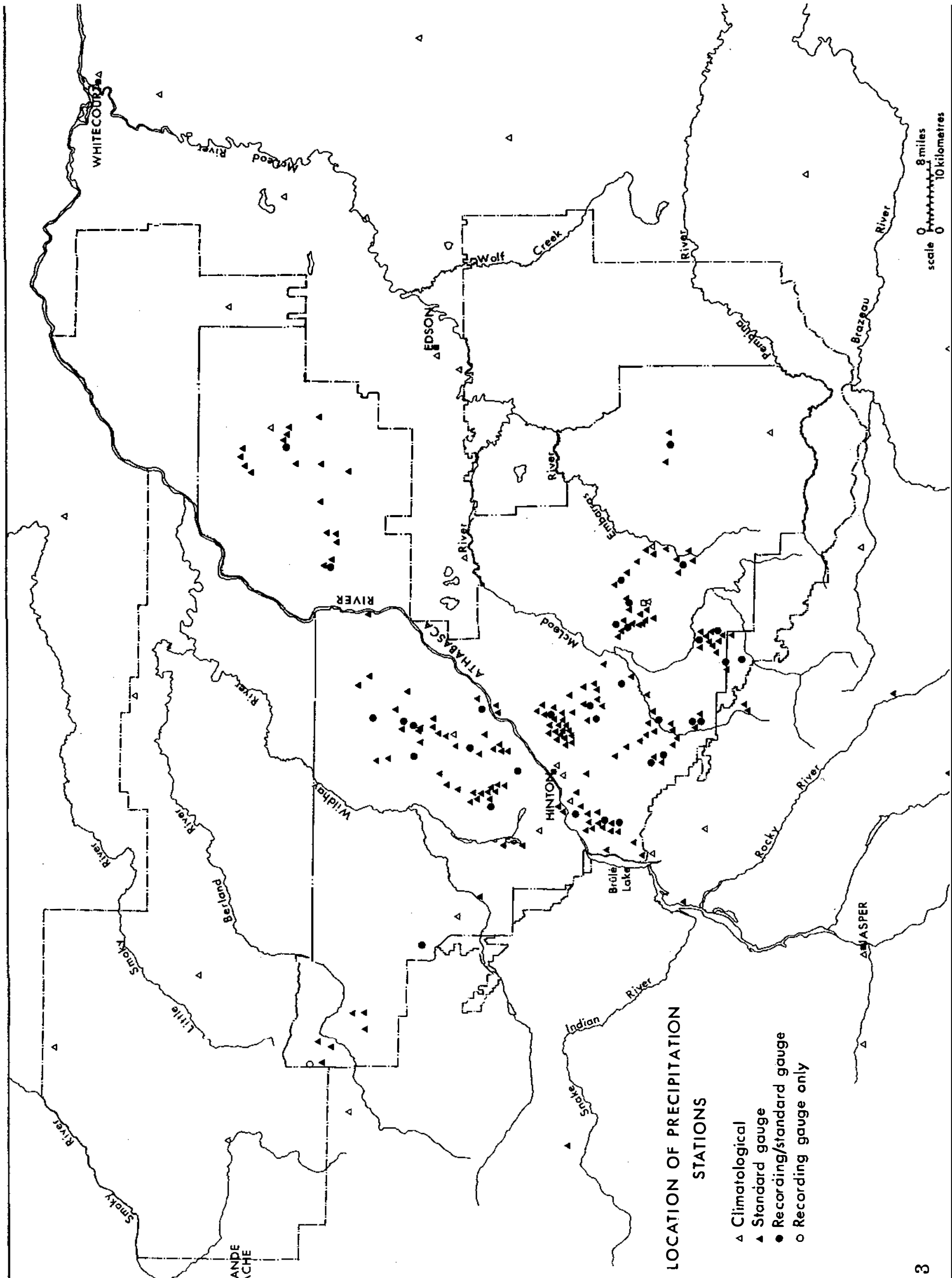

LOCATION OF PRECIPITATION STATIONS
Climatological
Standard gauge
Recording/standard gauge
Recording gauge only
WHITECOURT
McLeod River
Wolf Creek
EDSON
River
ATHABASCA RIVER
HINTON
Brûlé Lake
JASPER
GRANDE CACHE
Smoky River
Little Smoky River
Berland River
Wildhay River
Indian River
Snake
Rocky River
Brazeau River
Pembina River
Embarras River
Mcleod River
scale 0 8 miles
0 10 kilometres

Fig. 3

precipitation gauges gave an underestimate when compared with the standard gauge at the same location. This could be for a number of reasons, including varying height of gauge above ground, turbulence induced by wind, instrument malfunction, or reduced catch under certain conditions.

In the analysis that follows, all available data have been used for a particular storm or period (Figs. 4-24). On the maps, dots have been used to indicate the number of stations and their distribution for any particular event. For the storm events actual measured values for the days of the storm or interpolated totals from a larger accumulated period have been used. In the analysis of seasonal precipitation, some estimated values have been used for certain stations for missing days or short periods. The estimates were obtained from other nearby stations in the network with a complete record for the missing periods. Most of the estimated values are for periods in May or September when some stations, including some fire weather stations of the Alberta Forest Service, were not opened until later in May or were closed before the end of September for a variety of reasons.

Seasonal Precipitation

The summer (May to September) precipitation amounts have been plotted on Figs. 4-7 for the years 1972-1975. The intensity of station coverage was not the same each year, but the isohyetal maps still portray the seasonal distribution for the whole area with greater detail in the areas north and south of Hinton.

Summer seasonal values in the 4 years ranged from 131 mm at Jasper in 1973 to >550 mm at several points in 1972. Most of the lease area had between 300 and 350 mm each year, with higher amounts generally in 1972, and some stations, including much of the McLeod area, with lower amounts in 1975. Jasper and Jasper West Park Gate generally were the stations with the lower amounts. In each year the stations in the Compartment 1 area of the McLeod Working Circle and the adjacent Jasper East Park Gate station were included in the next lowest precipitation area. In two of the years the Athabasca and Mayberne lookouts were among the stations with the highest amounts. The highest amounts recorded in each of the four years were >450 mm, and in two years >500 mm.

For the four years of record, June was the wettest month in two years, July another year, and in 1973, August values were generally higher. However, based on longer-term records, July is the wettest month (Powell and MacIver 1976) in the area. Powell and MacIver (1976) also showed that the summer precipitation over most of the lease area ranged between 380 and 430 mm in the 1961-1970 period, slightly higher than average values for the study years. Grave Flats and Wolf lookouts had summer averages >465 mm in the 1961-1970 period. Again Jasper had the lowest seasonal totals (200 mm). A recent paper (Powell 1977) employing some additional stations for the area indicates a similar pattern of summer precipitation with all the study area receiving between 350 and 450+ mm, except the western fringe and Whitecourt in the northeast, which received <350 mm.

Monthly values for the Belfort and Fischer Porter recording gauges have been listed separately in Table 2. Few of these stations have complete records for the three summers of record. Stations MC0958 and AT1461 situated on the edge of the Athabasca River valley near Hinton and equipped with Belfort gauges indicate average summer totals of 273 and 280 mm respectively. Standard rain gauges maintained at the same stations indicated average summer totals for the same three years of 297 and 314 mm respectively. Thus, Belfort recording gauges probably undercatch by about 10% during the summer period; it is unknown whether this varies during the winter period because no comparable data are available from the study area.

Winter seasonal precipitation values for five winters from the study area are given in Table 3. The table includes data from the regular climatological stations, which are based on daily totals and those from Sacramento-type storage gauges, which generally collect precipitation from mid-October to mid-May each season. The averages generally show higher winter totals in and adjacent to the mountains. The lowest averages occurred at Hinton, and at Edson and Cold Creek Ranger Station in the east of the study area. The available data on winter precipitation for stations with a reasonable length of record for the study area has been mapped by Powell (1977). There is a lack of information for the study area between the Athabasca and Smoky rivers.

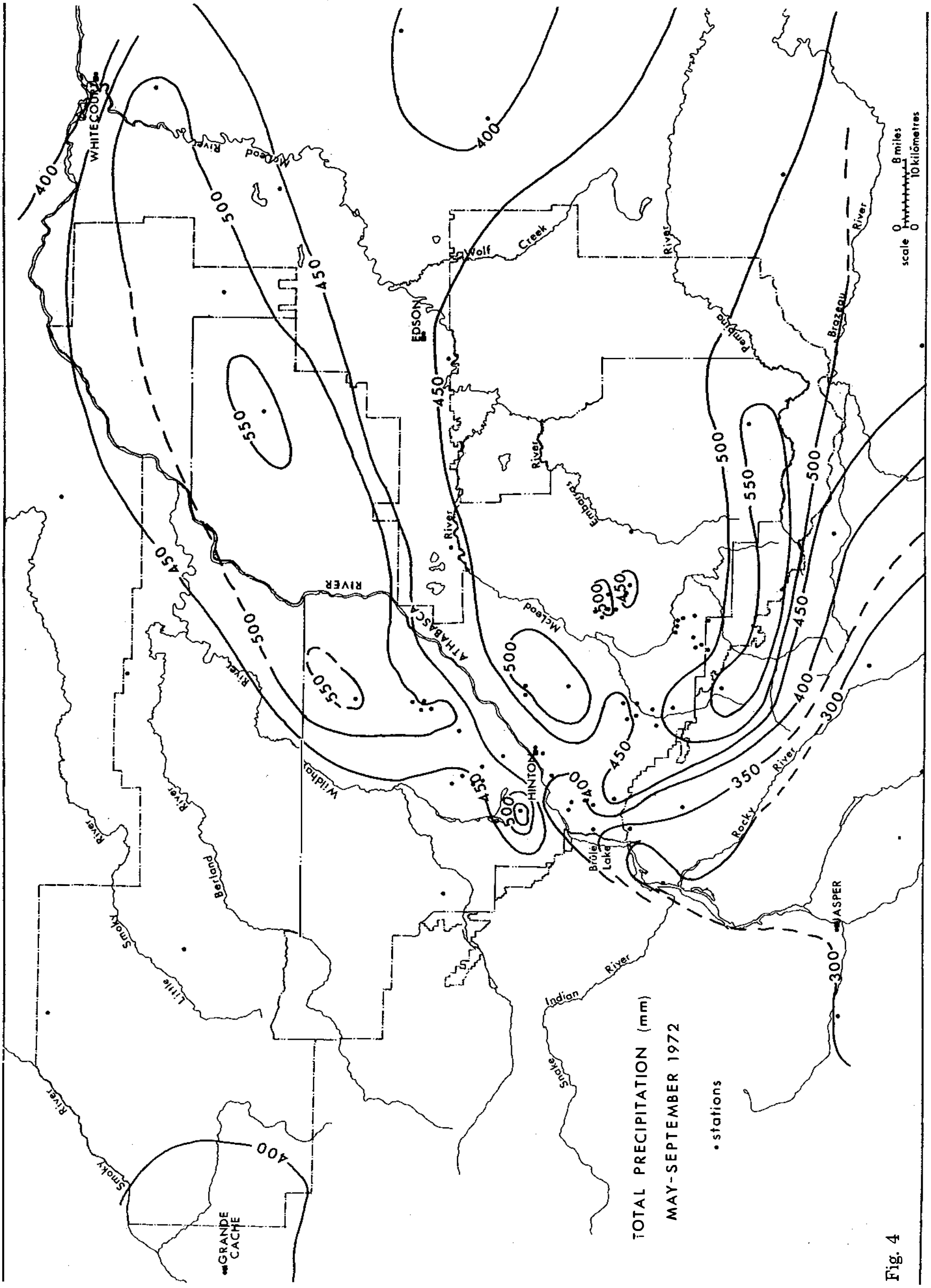

TOTAL PRECIPITATION (mm)
MAY-SEPTEMBER 1972
• stations
scale 0 8 miles
0 10 kilometres
WHITECOURT
EDSON
HINTON
JASPER
GRANDE CACHE
Brûlé Lake
ATHABASCA RIVER
McLeod River
Wolf Creek
Pembina River
Brazeau River
Embarras River
Rocky River
Wildhay River
Berland River
Little Smoky River
Smoky River
Indian River
Snake
300
350
400
450
500
550

Fig. 4

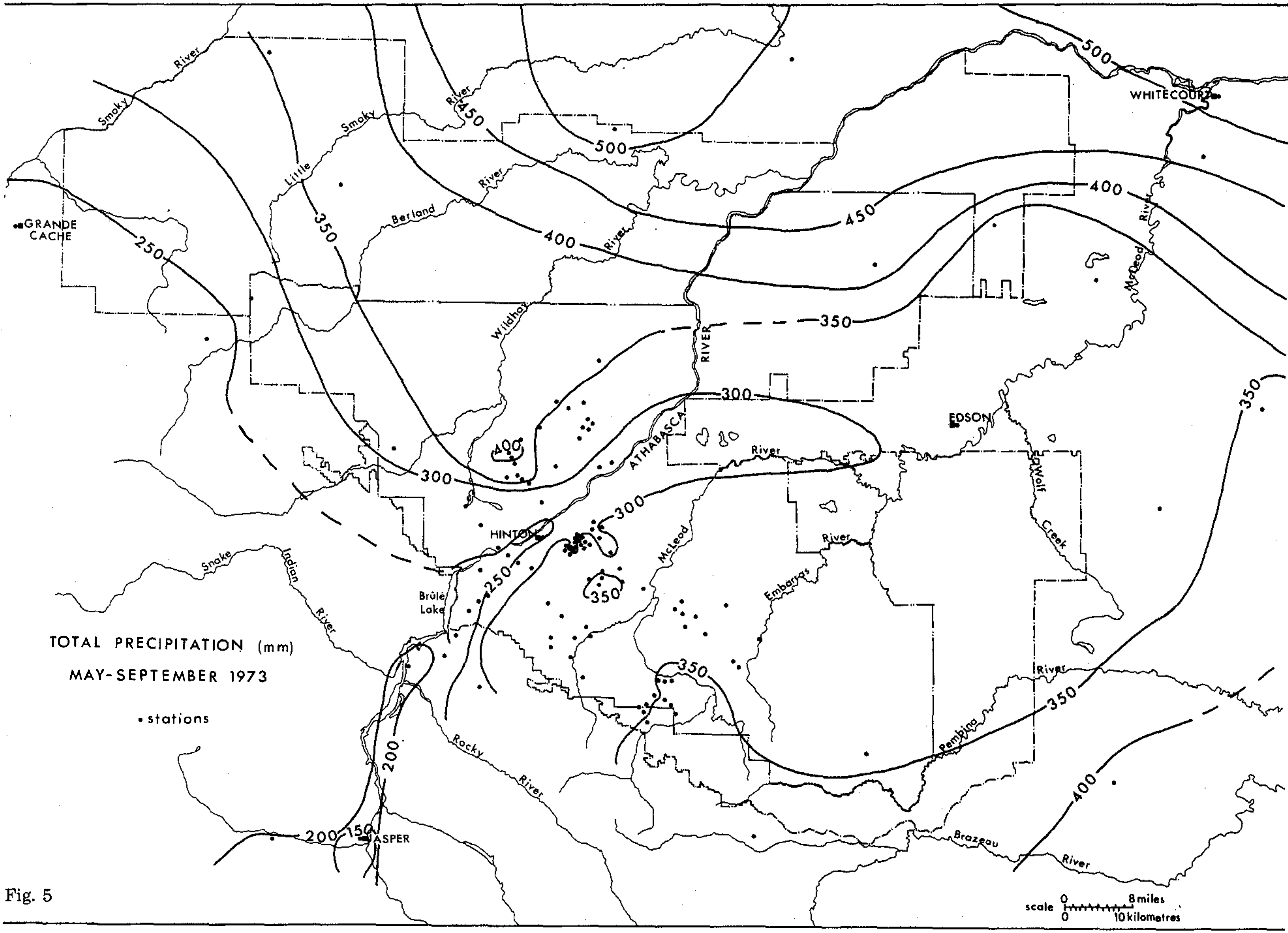

WHITECOURT
EDSON
HINTON
JASPER
GRANDE CACHE
Brûlé Lake
ATHABASCA RIVER
Smoky River
Little Smoky River
Berland River
Wildhay River
McLeod River
Wolf Creek
Embarras River
Pembina River
Brazeau River
Rocky River
Snake Indian River
500
450
400
350
300
250
200
150
TOTAL PRECIPITATION (mm)
MAY-SEPTEMBER 1973
• stations
scale 0 8 miles
0 10 kilometres

Fig. 5

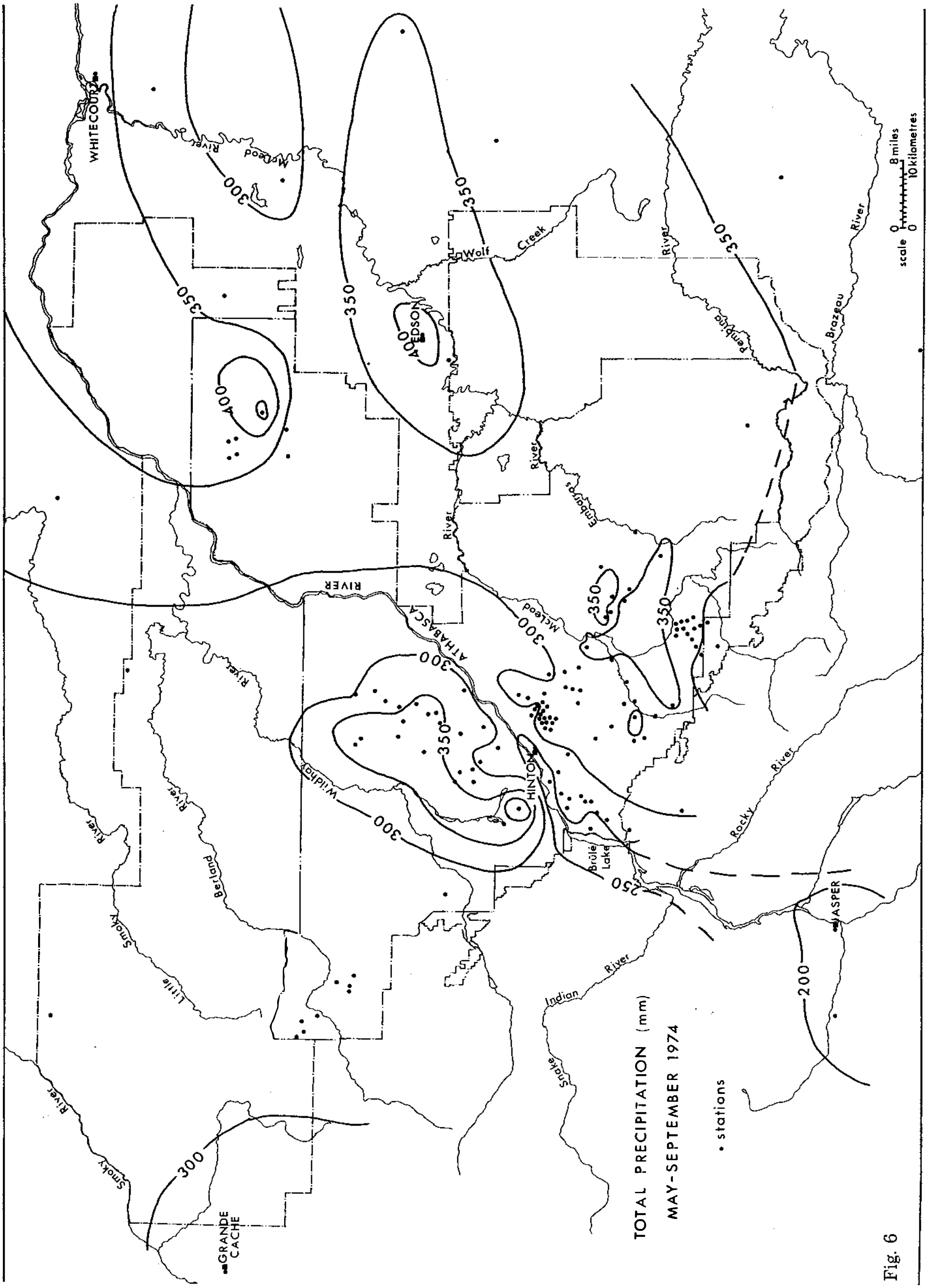
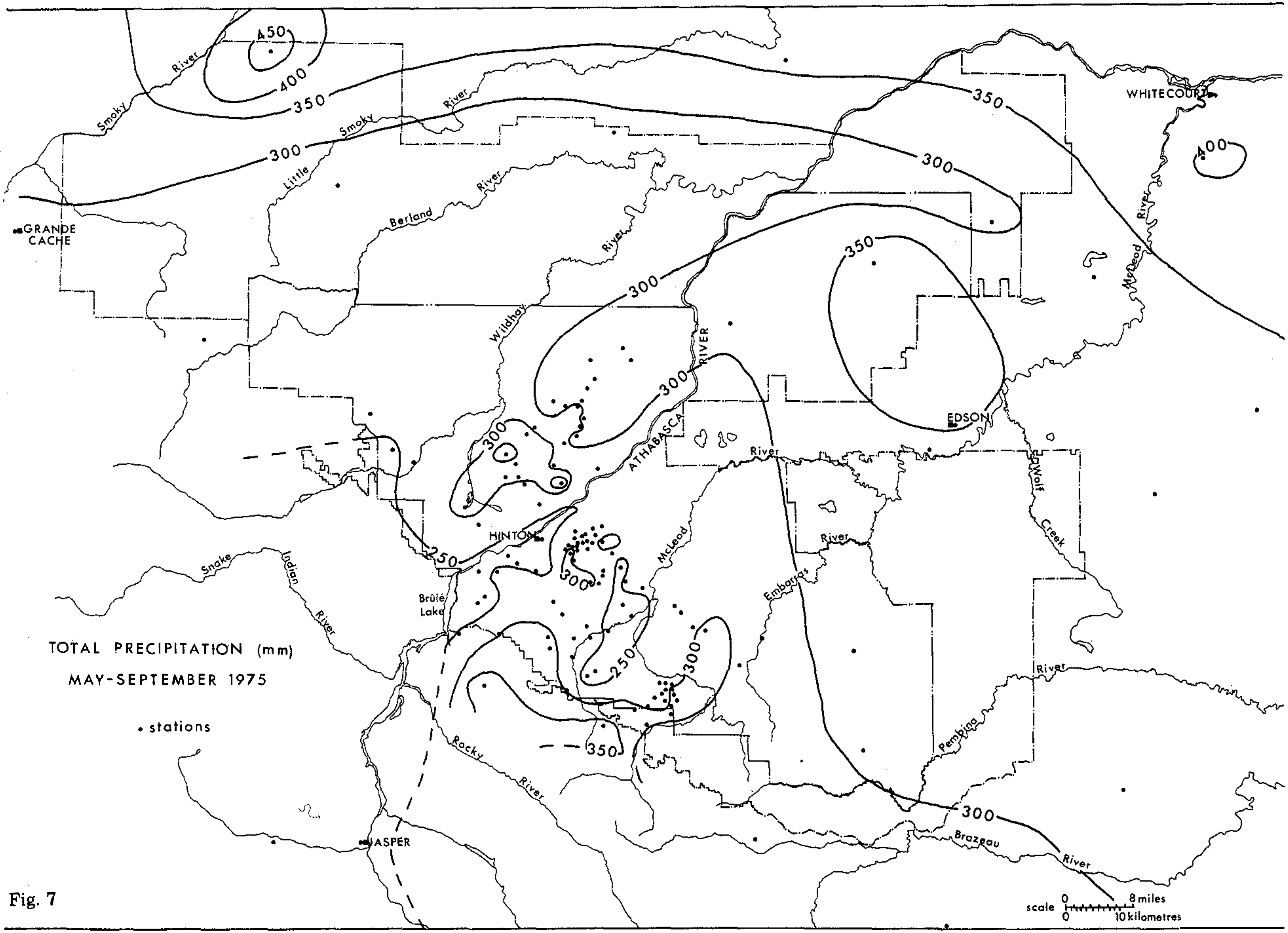

TOTAL PRECIPITATION (mm)
MAY-SEPTEMBER 1974
• stations
WHITECOURT
EDSON
HINTON
JASPER
GRANDE CACHE
Brûlé Lake
ATHABASCA RIVER
McLeod River
Wolf Creek
Embarras River
Pembina River
Brazeau River
Rocky River
Wildhay River
Berland River
Little Smoky River
Smoky River
Indian River
Snake
scale
8 miles
10 kilometres
200
250
300
350
400

Fig. 6



TOTAL PRECIPITATION (mm)
MAY-SEPTEMBER 1975

Fig. 7

Table 2. Monthly precipitation totals (cm) for the year-round recording gauges on the NWPP lease area for the period July 1972 to December 1976

Station	Type of gauge[2]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
							1 9 7 2						
MC 0958	B	-	-	-	-	-	-	0.84*	9.43	8.10	2.11	3.33	1.37[1]
							1 9 7 3						
MC 0268	B	-	-	-	-	-	-	-	-	-	1.07*	1.52	1.47
MC 0567	B	-	-	-	-	-	3.13*	5.06	8.43	2.89	3.15	1.75	1.78
MC 0653	B	-	-	-	-	-	-	-	-	-	-	0.51*	1.42
MC 0958	B	1.27[1]	2.23	2.39	4.96	6.20	5.87	3.69	6.50	4.93	2.97	2.16	0.76
AT 1353	FP							-	1.02*	4.57	*	*	0.25*
AT 1461	B	-	-	-	-	4.06*	9.02	4.37	7.42	3.84	1.93	0.94	0.56
AT 1508	FP	-	-	-	-	-	6.60*	4.06	5.84	0.51*	1.22*	1.62	0.76
AT 1657	B	-	-	-	-	-	-	-	-	-	0.56*	1.12	0.35
MA 0711	B	-	-	-	-	-	8.97	3.86	1.72	6.43	3.28	1.53	1.22
MA 1109	B	-	-	-	-	-	8.21	4.04	1.78	5.33	2.69	1.55[1]	2.16[1]
BE 0131	FP	-	-	-	-	0.00*	8.64	4.57	8.13	8.13	4.06	2.79	1.27
							1 9 7 4						
MC 0268	B	5.06	1.25	0.94	3.64	4.98*	2.42*	7.95	8.56	3.94	2.34	2.16	0.79
MC 0567	B	5.33	1.17	3.35	3.84	8.51	4.50	7.95	5.38	2.42	2.42	2.21	0.66
MC 0653	B	5.87	2.92	3.69	4.01	9.02*	6.18	7.82	7.62	3.89	1.45	2.44	0.64
MC 0958	B	3.61	0.66	2.34	4.47	6.50	3.56	7.75	8.16	4.62	0.45	1.75	0.38
AT 1353	FP	1.78	0.51	0.76	2.54*	*	4.57	7.62	7.62*	3.30*	1.27*	*	*
AT 1461	B	2.52	0.69	1.52	3.15[1]	3.05*	4.45	9.02	8.21	3.50	2.29	1.47	0.43
AT 1508	FP	3.56*	-	2.54*	3.05	6.35	0.76*	2.03*	9.40	3.56	2.29	1.78	0.51
AT 1657	B	3.32	1.98	0.59*	2.16*	6.15*	3.69[1]	10.11[1]	8.97	3.23	5.01	1.37	0.94
MA 0711	B	6.15	4.37	3.10	2.62	5.46	6.58	7.90	4.80	4.26	2.82	1.27	1.30
MA 1109	B	3.28[1]	1.07	2.26	2.57	8.21	3.79	8.16	5.38	3.94	1.40	1.25	1.02
BE 0131	FP	7.37	0.76	2.54*	2.54	8.13	1.52	7.37	6.60	4.06	2.79*	2.54*	1.27
EM	B	-	-	-	-	-	4.06*	7.57	7.92	6.20[1]	0.38*	0.59[1]*	-
							1 9 7 5						
MC 0268	B	1.25	1.75	2.06	3.08	5.84	10.39	3.25	5.23	4.16	2.54	4.95*	[1]
MC 0567	B	1.22	2.29	1.70	2.67	6.70	10.70	2.77	6.07	2.64	-	-	-
MC 0653	B	1.27	2.59	2.37	3.10	6.68	9.09	4.45	4.57	3.13	2.16	3.30	5.21
MC 0958	B	1.05	2.16	1.65	2.42	6.15	8.18	3.33	4.16	2.16	2.08	2.08	3.89
AT 1353	FP	*	*	*	2.03*	4.83	6.35*	3.56	1.52*	2.29*	1.27	1.02[1]	1.02[1]
AT 1461	B	1.25	1.40	0.71	1.65	4.16	9.75	5.48	5.08	2.49	2.16	2.08	4.65
AT 1508	FP	1.27	2.54	1.27	2.03*	5.84	7.62	5.59	5.08	1.78*	-	-	-
AT 1657	B	1.02	2.49*	-	1.78*	5.16	12.37	5.26	6.04	1.91*	2.03	1.60	2.34
MA 0711	B	2.54	1.91	2.62	0.38*	-	-	-	-	-	-	-	-
MA 1109	B	1.67	1.81	1.50	1.45	5.84	11.43	6.94	3.86	1.88	-	-	-
BE 0131	FP	1.78	3.05	2.79	2.79	7.87	8.38	6.10	4.83	0.76*	2.54*	5.33	7.37
EM	B	-	-	-	-	1.27*	9.37	4.26	4.96	1.81	-	-	-
ID3	B	-	-	-	-	-	6.53	2.46*	6.17[1]	3.43	2.29	[1]	[1]
							1 9 7 6						
MC 0268	B	5.97[1]	1.52[1]	2.84	3.05	3.43	7.49	7.75	8.51	2.92	-	-	-
MC 0653	B	2.79	2.29	3.30	1.91	3.56	6.55	7.62	14.35	2.62	-	-	-
MC 0958	B	1.40	2.41	2.74	2.16	2.97	7.24	7.62	13.34	1.14	-	-	-
AT 1353	FP	1.02[1]	3.05	*	1.02	0.76	1.02*	-	-	-	-	-	-
AT 1461	B	1.52	2.16	2.24	1.27	3.56	7.75	7.49	10.80	3.18	2.79	1.14	2.46
AT 1657	B	1.09	2.67[1]	0.13[1]	1.40	3.43	6.22	7.29	16.97	2.54	2.21	0.71	1.91
BE 0131	FP	3.30	3.81	5.33	3.05	4.83	8.89	9.40	13.72	1.27	2.79	0.25*	4.32
ID3	B	[1]	[1]	6.60	3.56	3.56	7.37	5.03	13.08	3.43	-	-	-

- Station not operating

* Missing data

[1] Some of total assigned to preceeding or following month.

[2] B = Belfort Universal Precipitation Gauge; FP = Fischer-Porter

Table 3. Winter season (October-April) precipitation totals (cm) for regular climatological stations and from Sacramento gauges in the study area for the period 1971-72 to 1975-76

Station	1971-72	1972-73	Winter season 1973-74	1974-75	1975-76	Average for 5 years
CLIMATE						
Cold Creek R.S.	-	22.17	-	10.72	13.79	15.56[2]
Edson A	16.56	18.69	19.02	9.12	16.00	15.88
Entrance	19.46	20.83	22.99	11.38	18.87E	18.71
Hinton	-	17.37E	15.67	6.20	14.55E	13.45[1]
Hinton FTS	17.63E	17.73	18.90	7.92	9.75E	14.39
Jasper	19.99	13.59	23.67	11.76	19.08	17.62
Jasper East Gate	22.96E	23.77	40.06E	19.28	32.28	27.67
Jasper West Gate	-	-	-	35.36	33.76E	34.56[3]
Robb R.S.	19.74	-	31.27	12.80	-	21.27[2]
Shining Bank R.S.	17.68	22.43	-	30.68	15.82	21.65[1]
Whitecourt	20.35	17.02	24.13	14.33	20.27	19.22
SACRAMENTO						
Deerlick A	27.2	21.1	20.1	19.8	25.4	22.7
Deerlick C	27.2	26.2	27.2	23.1	27.9	26.3
Eunice B	26.9	24.9	26.4	23.1	29.5	26.2
Eunice D	28.7	28.2	29.7	24.6	29.7	28.2
Wampus B	23.9	23.9	18.5	22.4	27.7	23.3
Wampus F	27.7	28.4	19.1	23.4	31.0	25.9
Wampus G	28.7	-	25.7	22.4	29.0	26.5[1]
Maligne Lake	25.4	31.0	35.6	17.5	25.4	27.0
Marmot Basin	47.0	36.3	53.1	-	42.7	44.8[1]
Miette Hot Springs	28.7	24.6	28.2	15.4	26.2	24.6
Pyramid Mt.	44.2	23.1	60.5	-	68.6	49.1[1]

[1] Four seasons of data only
[2] Three seasons of data only
[3] Two seasons of data only
E Includes some estimated values

Storm Events

Figures 8-24 show major storm events recorded during the summer months May to September for the years 1972-1975. The number of storms and their intensity vary considerably from year to year. For 1973 and 1974 all storms that produced more than 40 mm of precipitation at any point in the study area were mapped (Figs. 10-23). In the other two years only one or two major storms (Figs. 8, 9, and 24) have been mapped. In these years fewer significant major storms occurred. In 1972 both illustrated storms (Figs. 8 and 9) produced totals >150 mm at some locations. The other major storm in 1972 (May 14-18) produced 82 mm of precipitation at Shining Bank R.S., but most of the study area received totals between only 25 and 60 mm. In 1973 intensities above 120 mm were recorded in two storms (Figs. 10 and 15), but in 1974 no storms produced intensities above 80 mm.

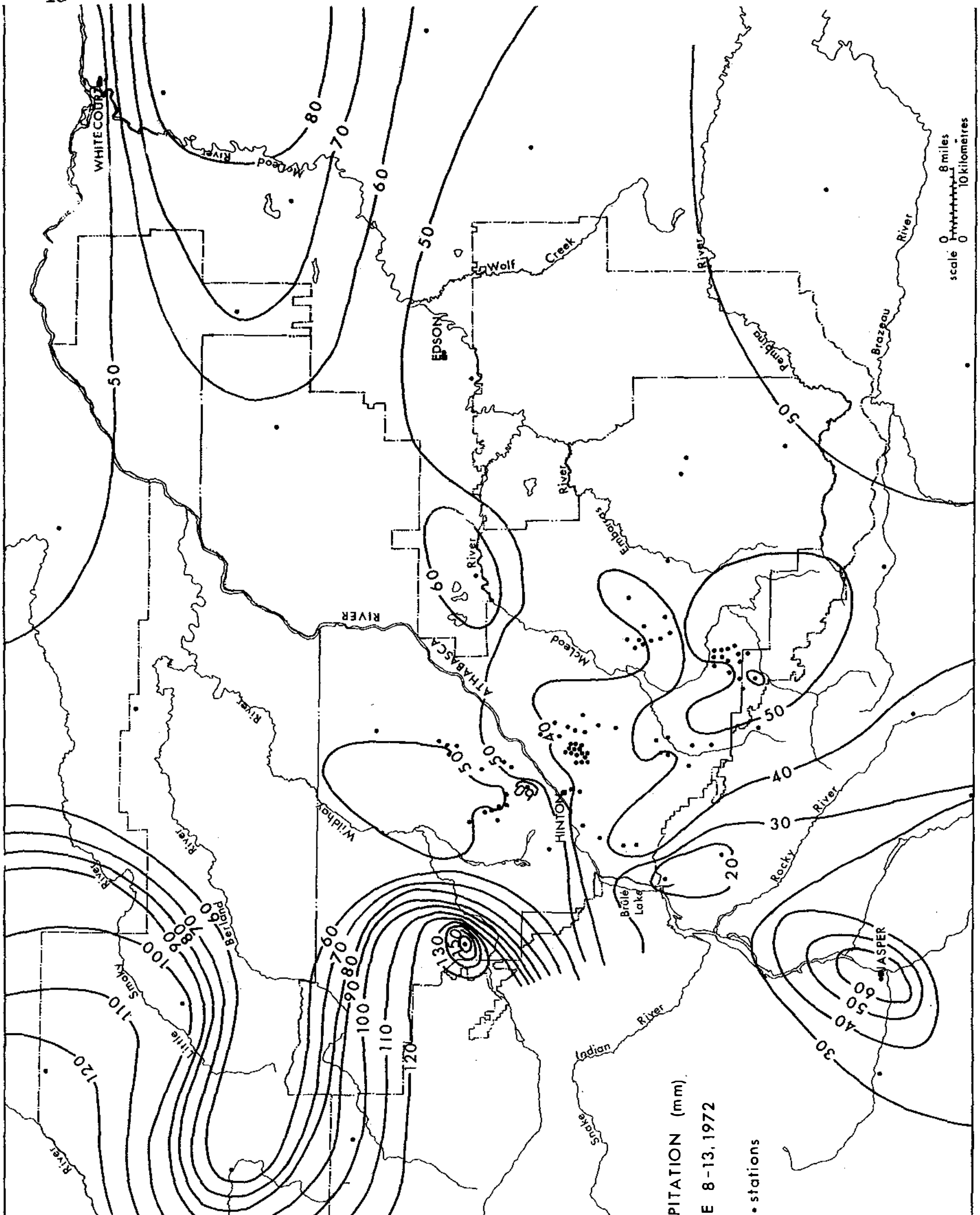

PRECIPITATION (mm)
JUNE 8-13, 1972
• stations
scale 0 8 miles
0 10 kilometres
WHITECOURT
EDSON
HINTON
JASPER
GRANDE CACHE
ATHABASCA RIVER
McLeod River
Wolf Creek
Embarras River
Pembina River
Brazeau River
Wildhay River
Berland River
Little Smoky River
Smoky River
Brûlé Lake
Rocky River
Indian River
Snake Indian River

Fig. 8

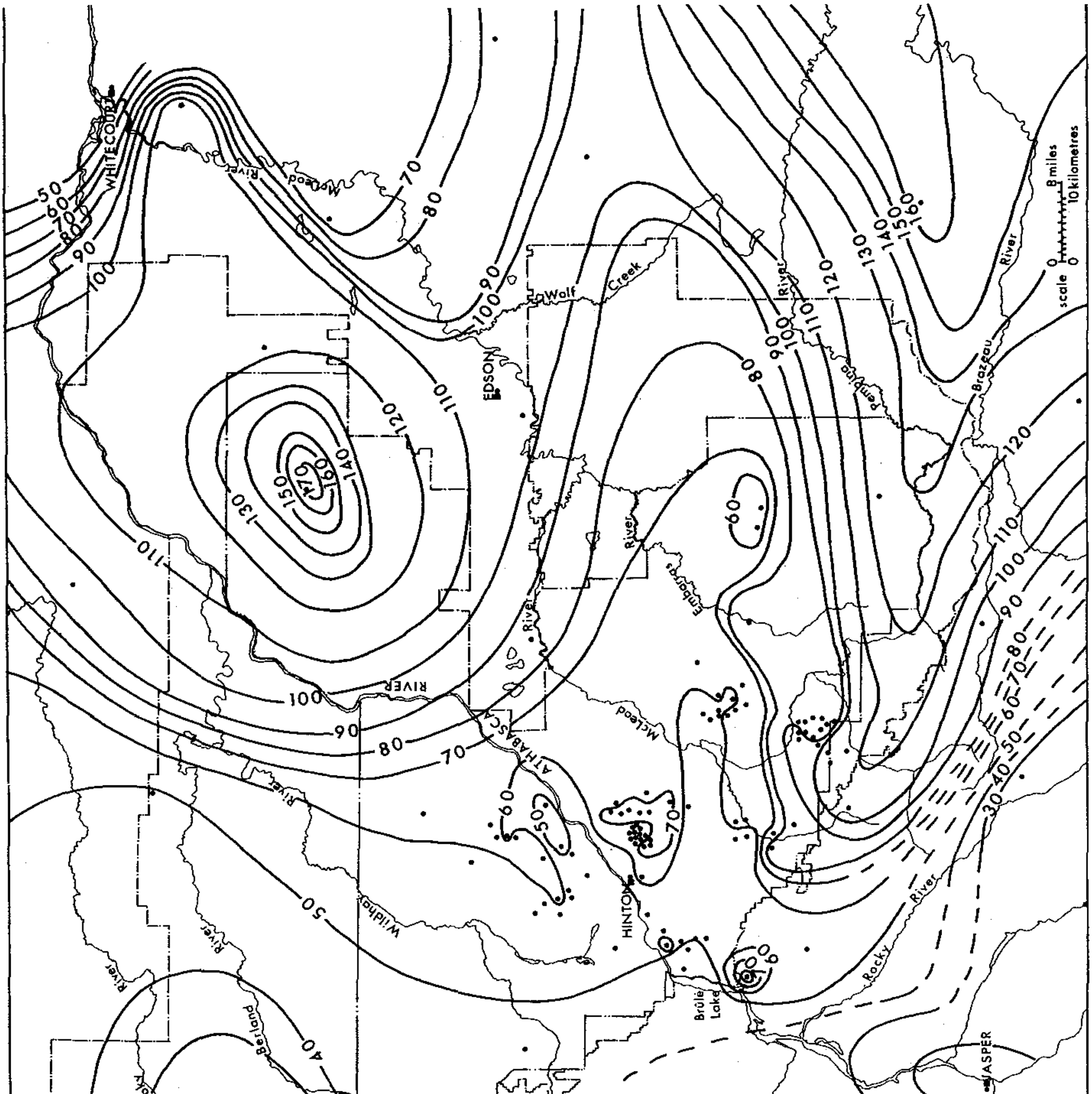
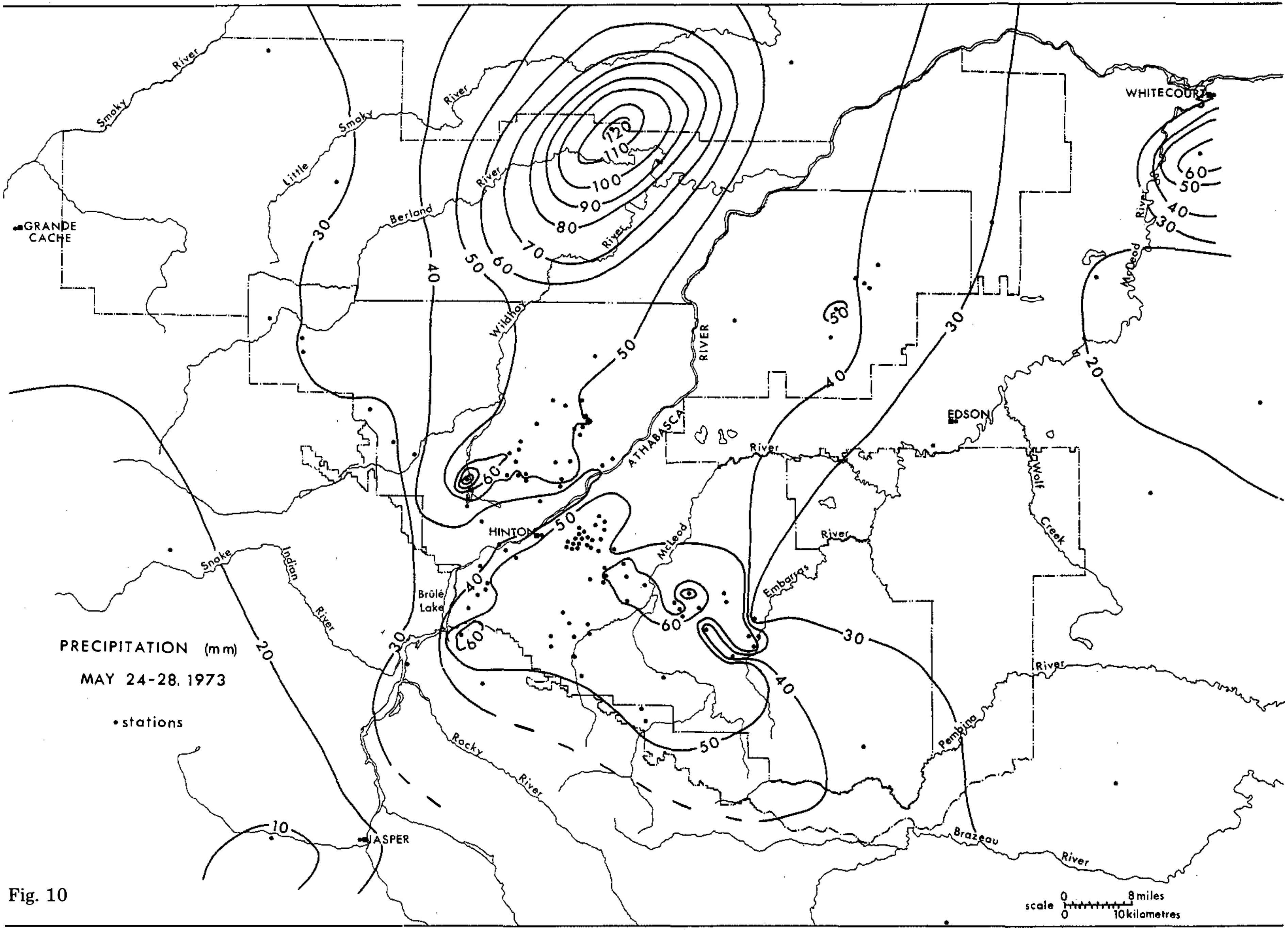
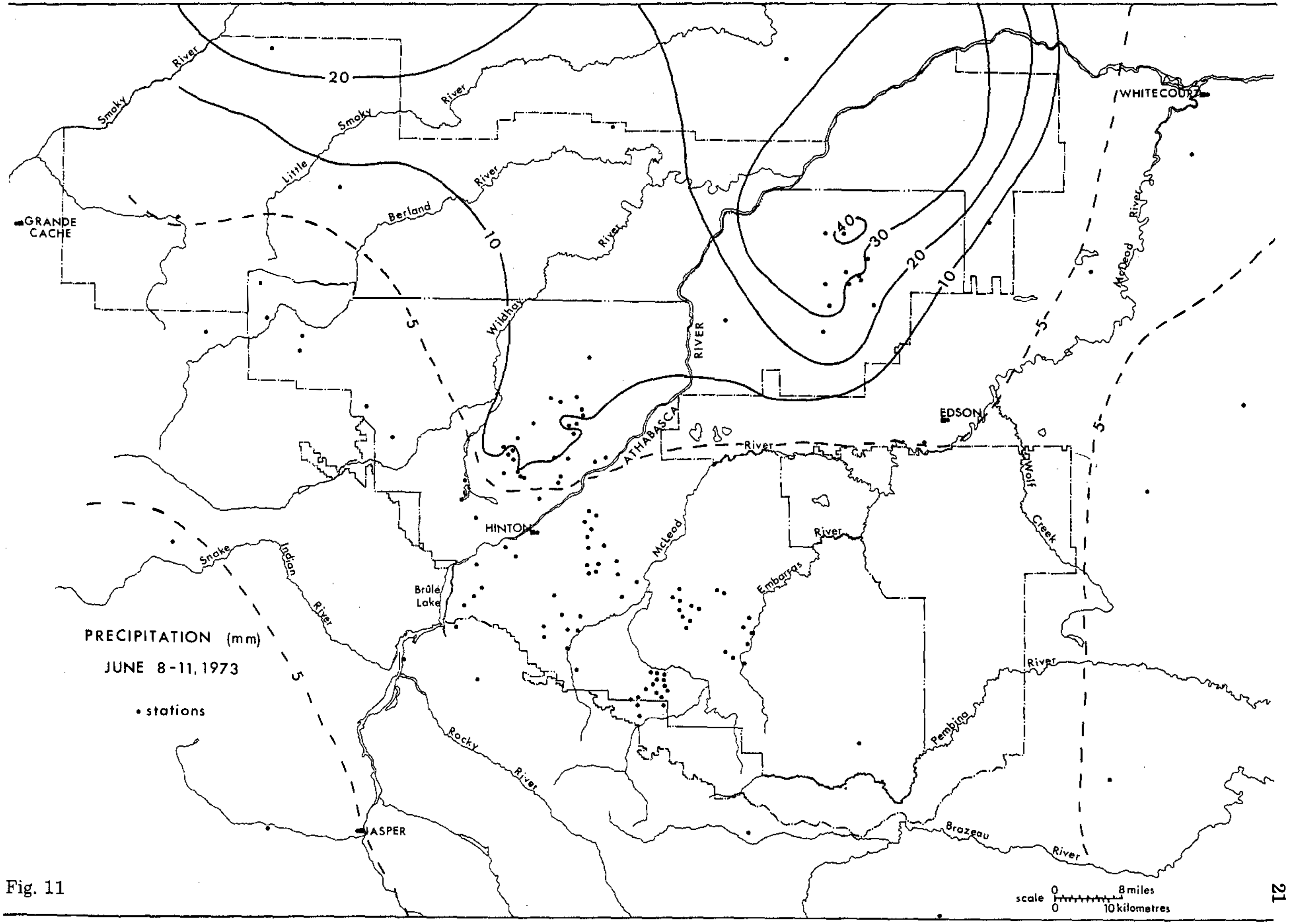

PRECIPITATION (mm)
JUNE 19-26, 1972
• stations
scale 0 8 miles
0 10 kilometres
WHITECOURT
EDSON
HINTON
JASPER
GRANDE CACHE
Brûlé Lake
ATHABASCA RIVER
McLeod River
Wolf Creek
Embarras River
Pembina River
Brazeau River
Rocky River
Wildhay River
Berland River
Little Smoky River
Smoky River
Indian River
Snake Indian River

Fig. 9



PRECIPITATION (mm)
MAY 24-28, 1973
• stations
GRANDE CACHE
WHITECOURT
EDSON
HINTON
JASPER
Brûlé Lake
Smoky River
Little Smoky
Berland River
Wildhay River
ATHABASCA RIVER
McLeod River
Embarras River
Wolf Creek
Snake Indian River
Rocky River
Pembina River
Brazeau River
scale 0 8 miles
0 10 kilometres

Fig. 10



PRECIPITATION (mm)
JUNE 8-11, 1973
• stations
WHITECOURT
EDSON
HINTON
JASPER
GRANDE CACHE
Brûlé Lake
ATHABASCA RIVER
River
Smoky River
Little Smoky River
Berland River
Wildhay River
McLeod River
Embarras River
Wolf Creek
Pembina River
Brazeau River
Rocky River
Snake Indian River
40
30
20
10
5
scale 0 8 miles
0 10 kilometres

Fig. 11

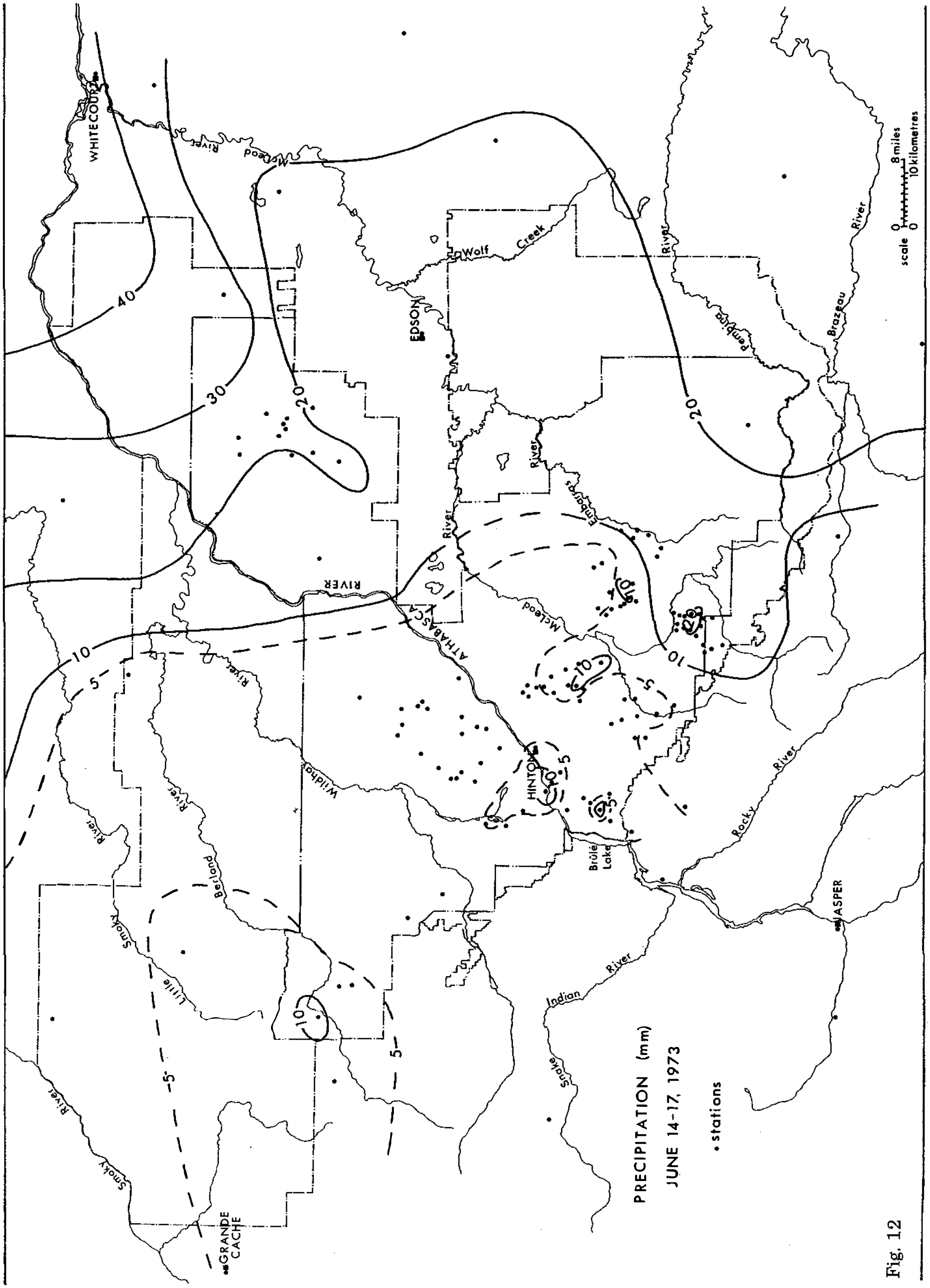

PRECIPITATION (mm)
JUNE 14-17, 1973
• stations
WHITECOURT
EDSON
HINTON
JASPER
GRANDE CACHE
Brûlé Lake
McLeod River
Wolf Creek
Embarras
McLeod
Pembina
Brazeau River
ATHABASCA
RIVER
Wildhay
Rocky River
Indian River
Snake
Berland River
Little Smoky
Smoky River
40
30
20
10
5
scale 0 8 miles
0 10 kilometres

Fig. 12

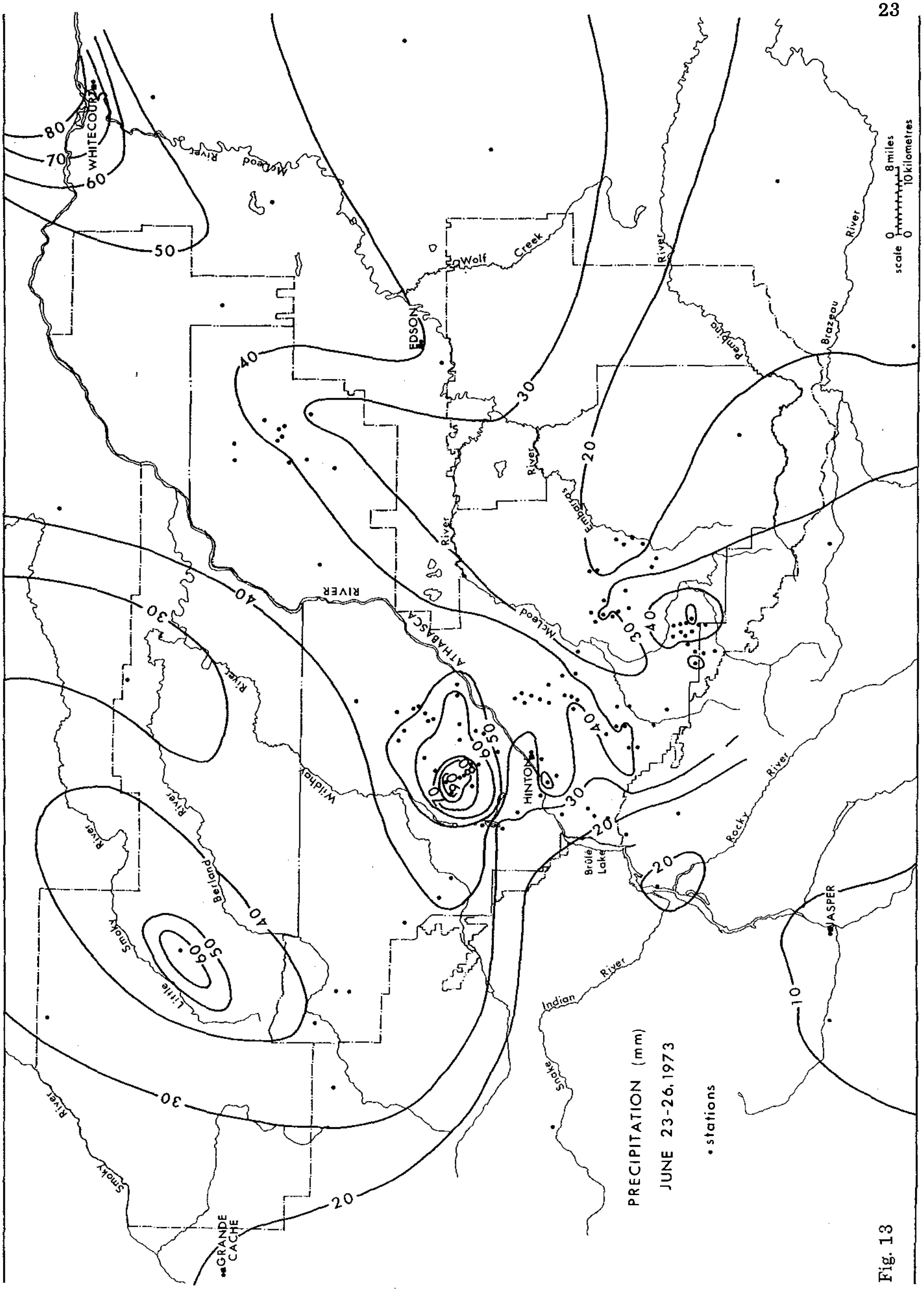

PRECIPITATION (mm)
JUNE 23-26, 1973
• stations
scale 0 8 miles
0 10 kilometres
WHITECOURT
EDSON
HINTON
JASPER
GRANDE CACHE
Brûlé Lake
McLeod River
Wolf Creek
Pembina River
Brazeau River
Embarras River
ATHABASCA RIVER
Wildhay River
Berland River
Little Smoky River
Smoky River
Indian River
Snake Indian River
Rocky River
80
70
60
50
40
30
20
10

Fig. 13

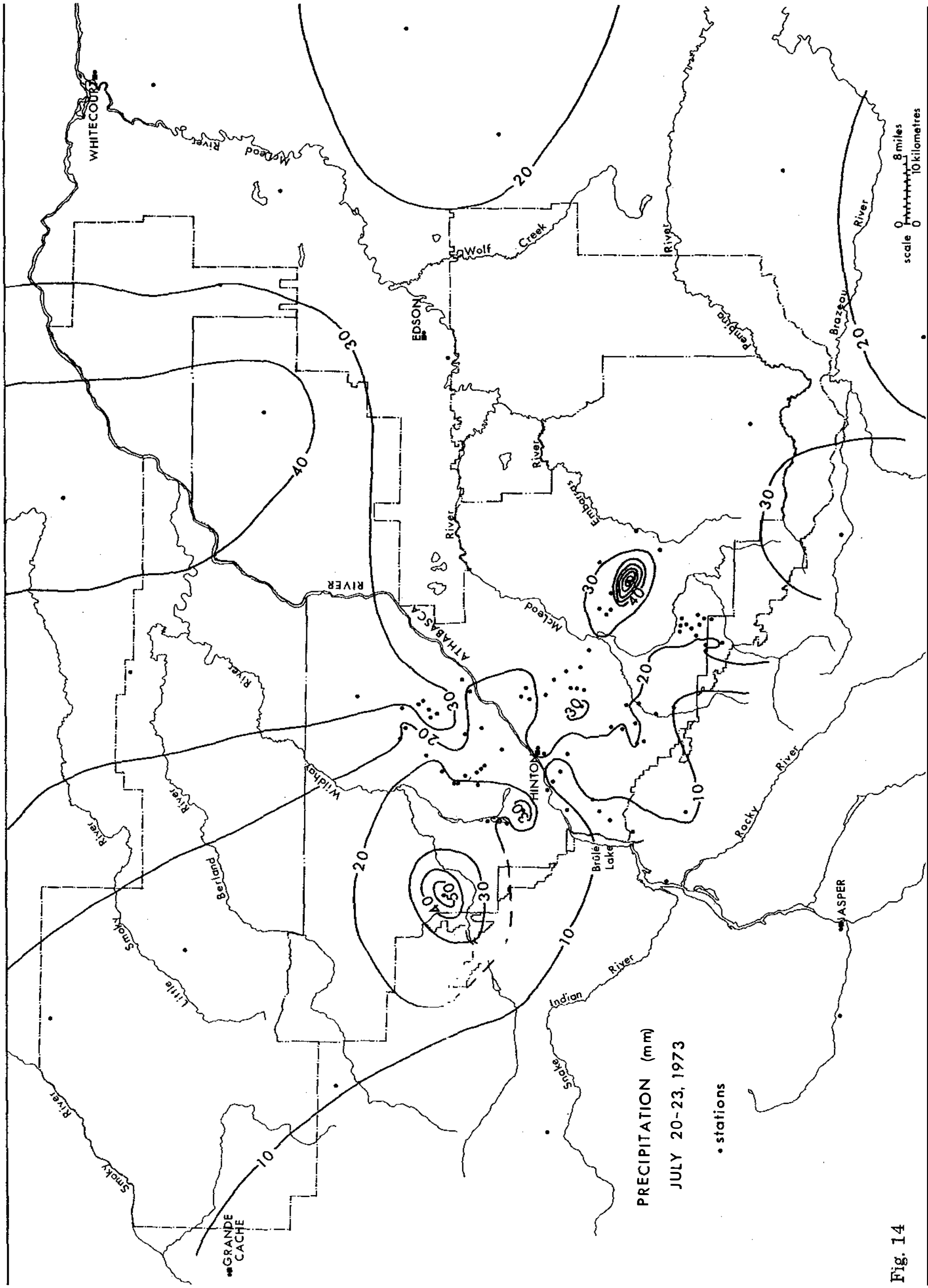

PRECIPITATION (mm)
JULY 20-23, 1973
• stations
WHITECOURT
EDSON
HINTON
JASPER
GRANDE CACHE
Brûlé Lake
ATHABASCA RIVER
McLeod River
Wolf Creek
Embarras River
Pembina River
Brazeau River
Rocky River
Snake Indian River
Wildhay River
Berland River
Little Smoky River
Smoky River
scale 0 8 miles
0 10 kilometres
10
20
30
40
50

Fig. 14

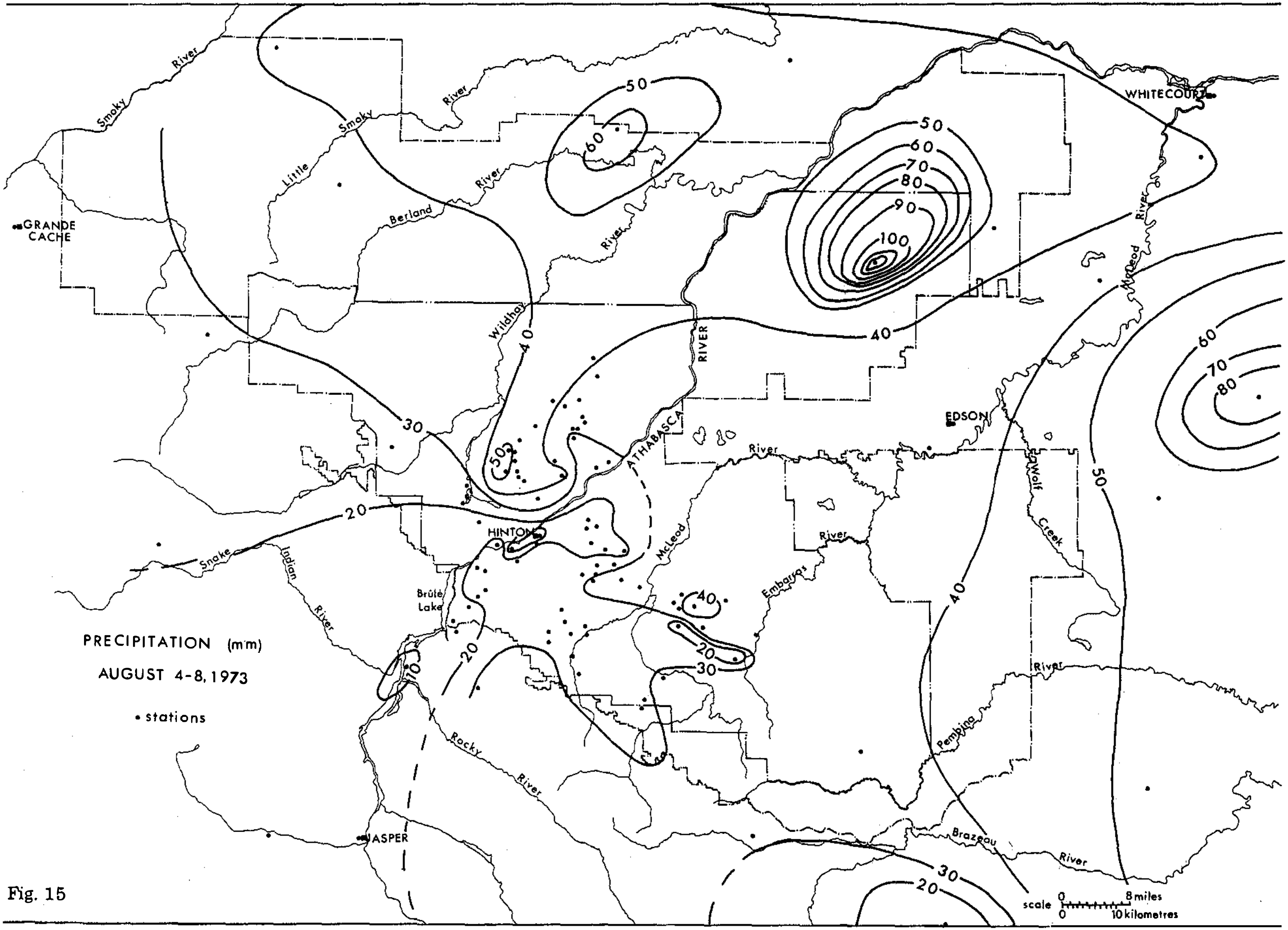
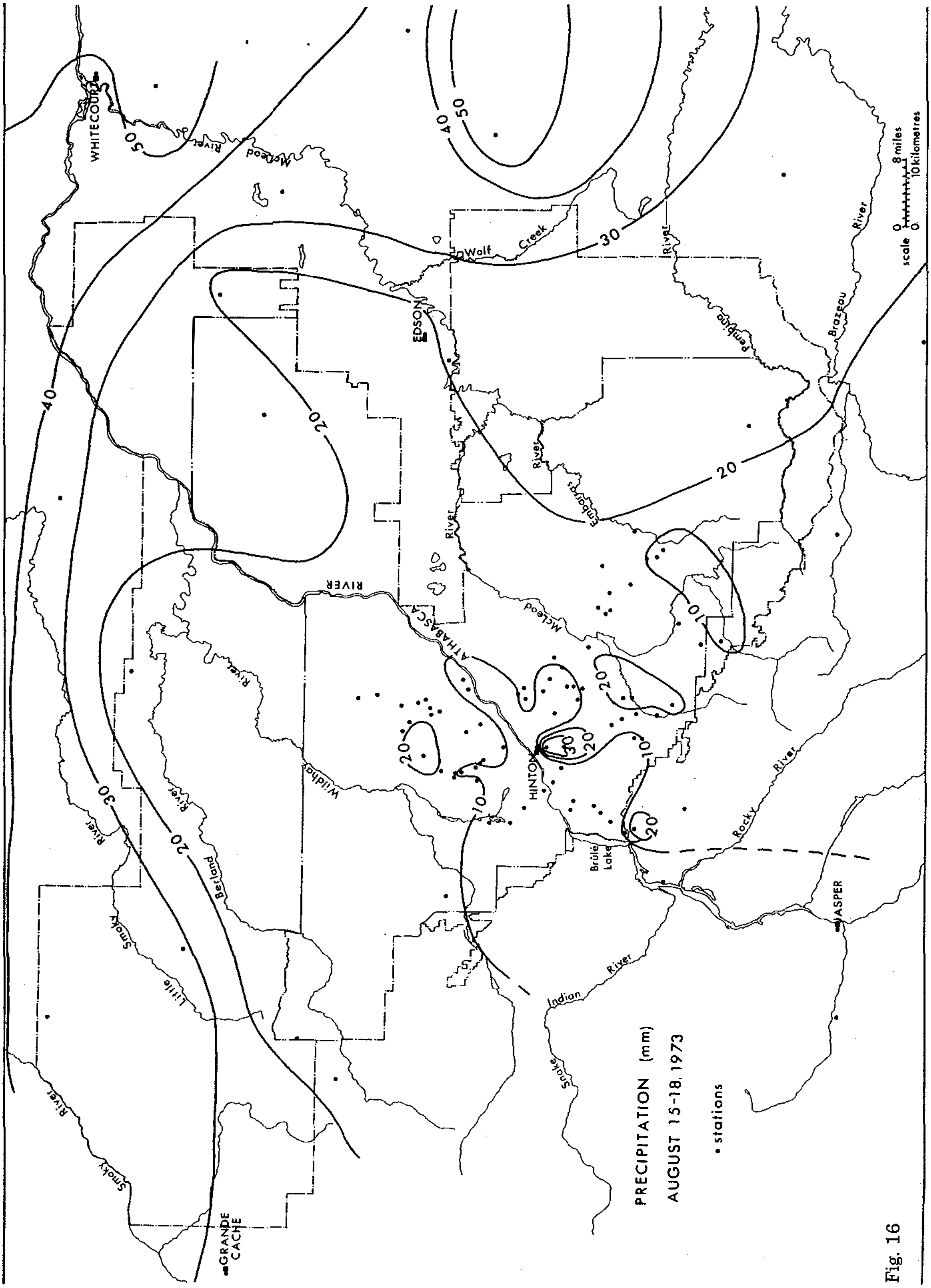
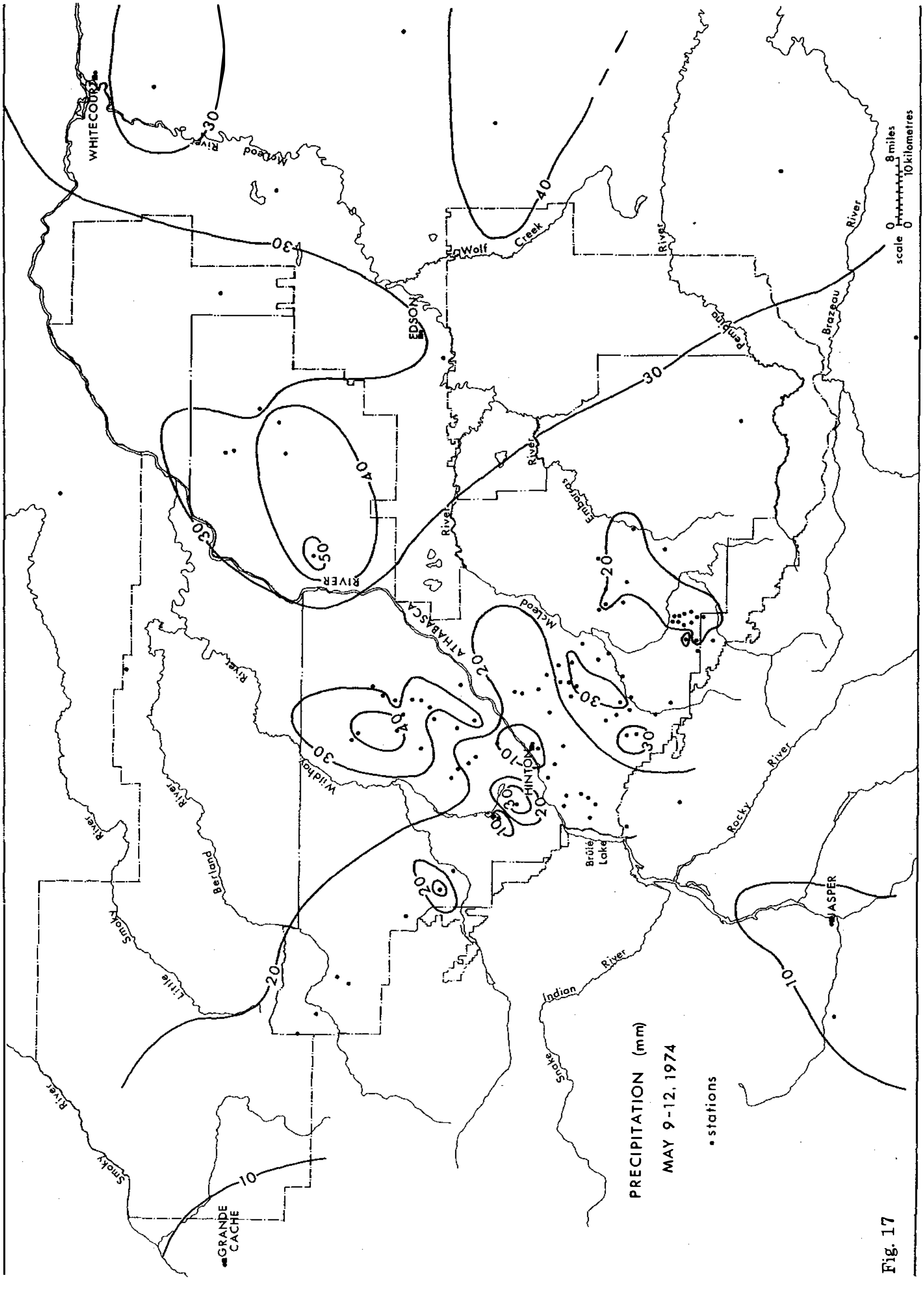

WHITECOURT
GRANDE CACHE
EDSON
HINTON
JASPER
Brûlé Lake
Smoky River
Little Smoky River
Berland River
Wildhay River
ATHABASCA RIVER
McLeod River
Wolf Creek
Embarras River
Pembina River
Brazeau River
Rocky River
Indian River
Snake
PRECIPITATION (mm)
AUGUST 4-8, 1973
• stations
scale 0 8 miles
0 10 kilometres

Fig. 15



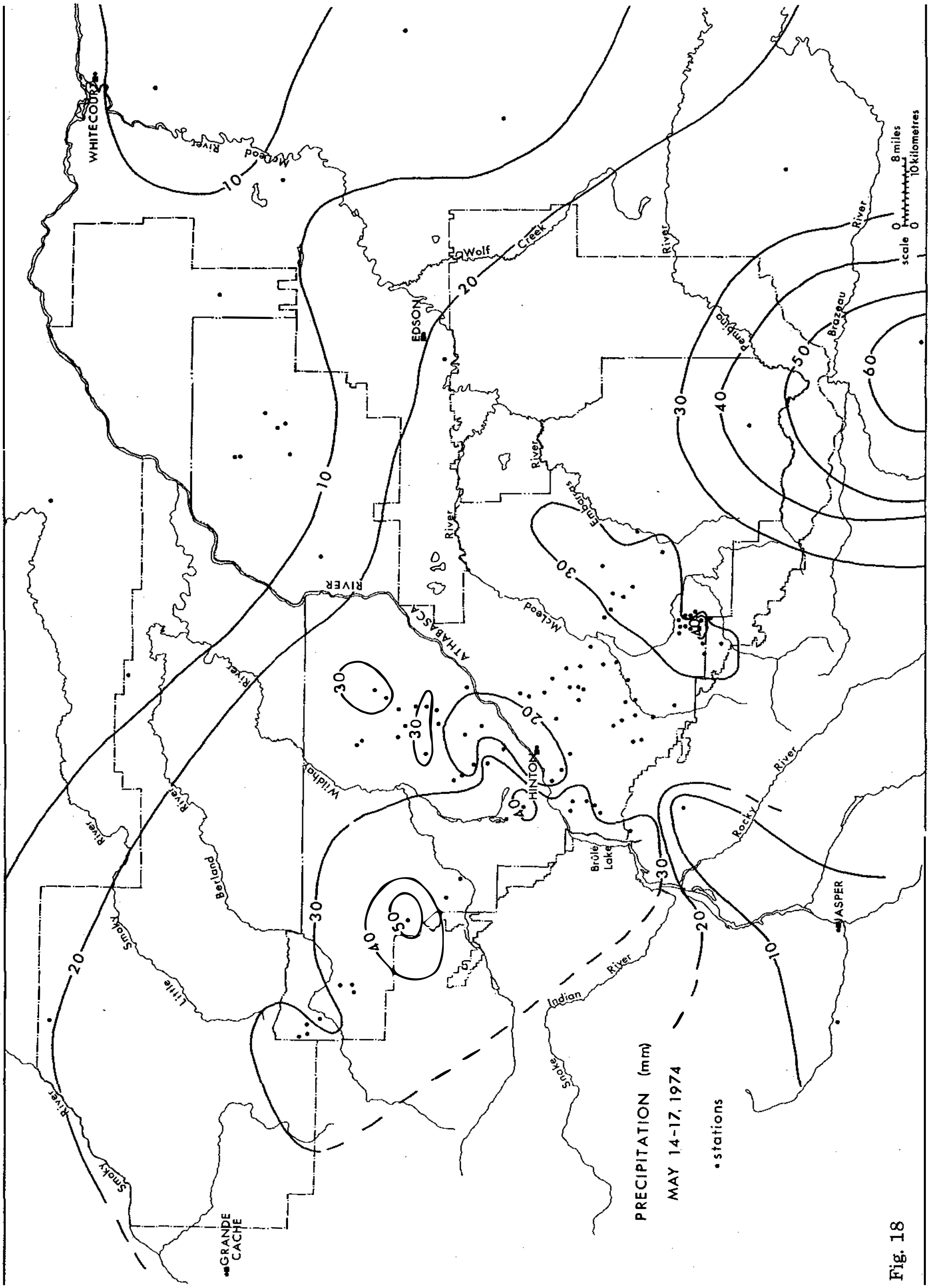
PRECIPITATION (mm)
AUGUST 15-18, 1973
• stations
scale 0 8 miles
0 10 kilometres
WHITECOURT
EDSON
HINTON
JASPER
GRANDE CACHE
Brûlé Lake
ATHABASCA RIVER
McLeod River
Wolf Creek
Embarras River
Pembina River
Brazeau River
Rocky River
Wildhay River
Berland River
Little Smoky River
Smoky River
Indian River
Snake Indian River

Fig. 16



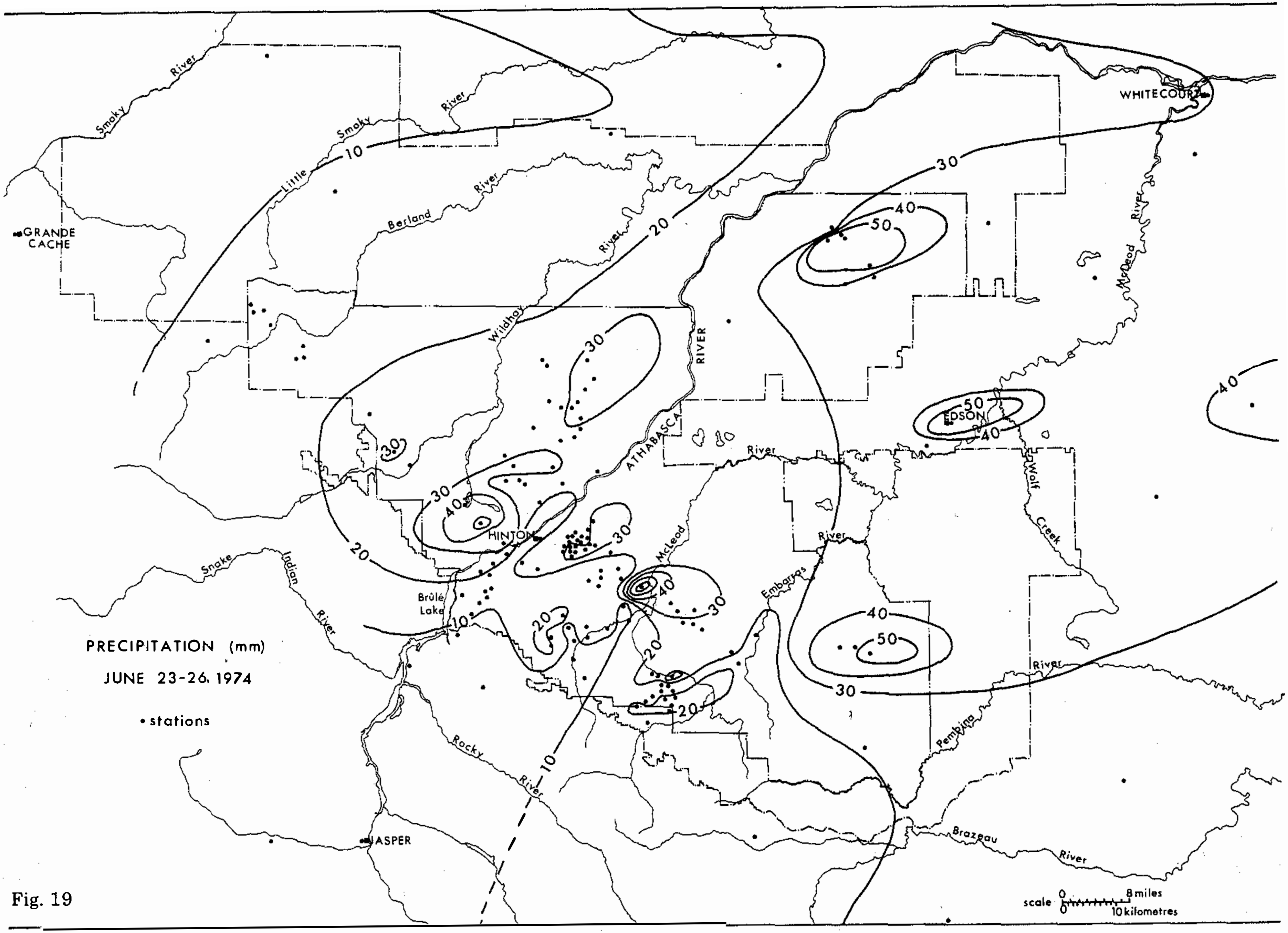
PRECIPITATION (mm)
MAY 9-12, 1974
• stations

Fig. 17



PRECIPITATION (mm)
MAY 14-17, 1974
• stations
WHITECOURT
EDSON
HINTON
JASPER
GRANDE CACHE
Brûlé Lake
ATHABASCA RIVER
McLeod River
Wolf Creek
Embarras River
Pembina River
Brazeau River
Wildhay River
Berland River
Little Smoky River
Smoky River
Indian River
Snake
Rocky River
scale 0 8 miles
0 10 kilometres
10
20
30
40
50
60

Fig. 18



GRANDE CACHE
WHITECOURT
EDSON
HINTON
Brûlé Lake
JASPER
Smoky River
Little Smoky River
Berland River
Wildhay River
ATHABASCA RIVER
McLeod River
Embarras River
Wolf Creek
Pembina River
Snake Indian River
Rocky River
Brazeau River
PRECIPITATION (mm)
JUNE 23-26, 1974
• stations
scale 0 8 miles
0 10 kilometres

Fig. 19

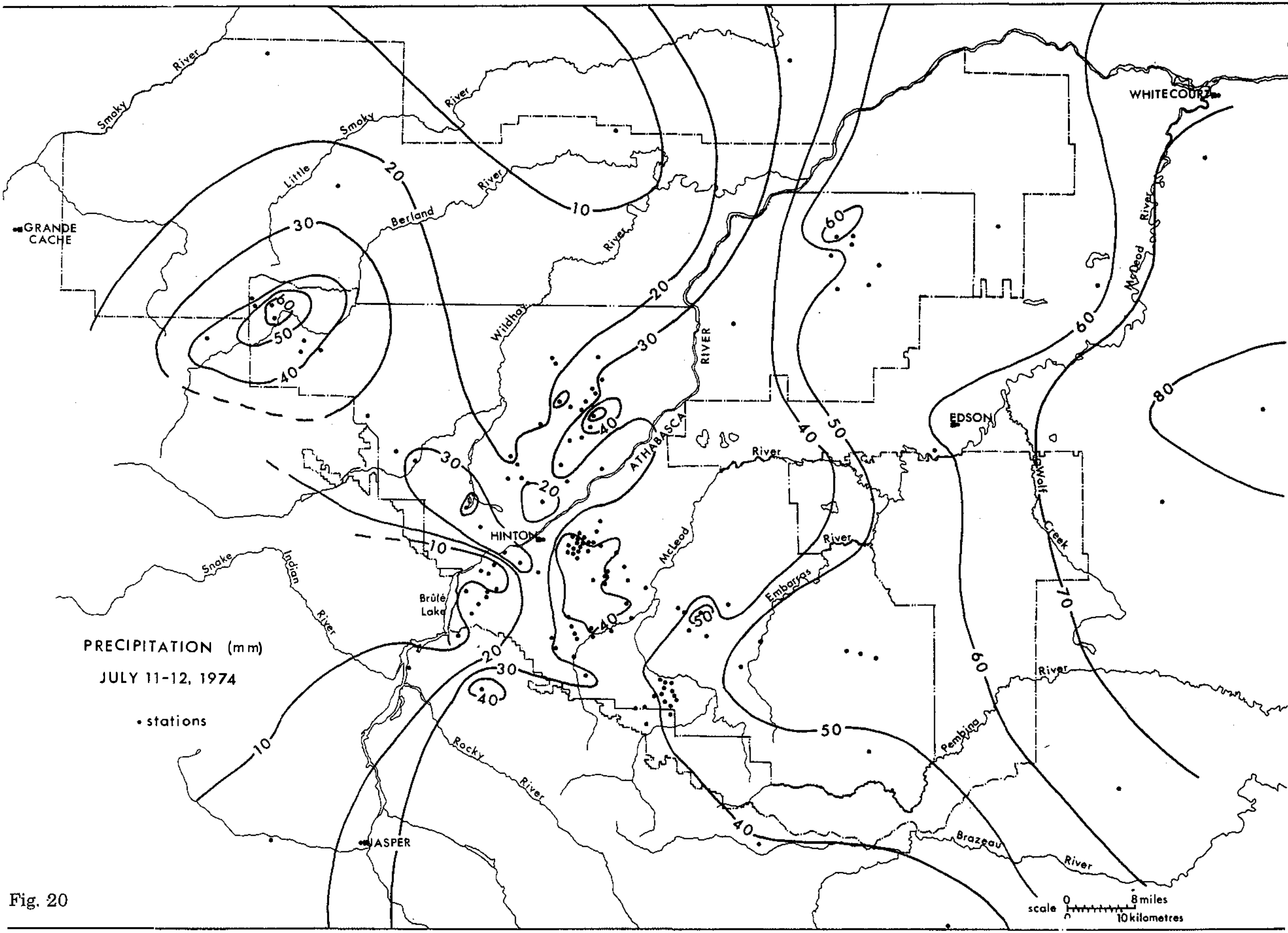

WHITECOURT
GRANDE CACHE
EDSON
HINTON
JASPER
Brûlé Lake
Smoky River
Little Smoky River
Berland River
Wildhay River
ATHABASCA RIVER
McLeod River
Embarras River
Wolf Creek
Pembina River
Brazeau River
Rocky River
Snake Indian River
PRECIPITATION (mm)
JULY 11-12, 1974
• stations
scale 0 8 miles 10 kilometres

Fig. 20

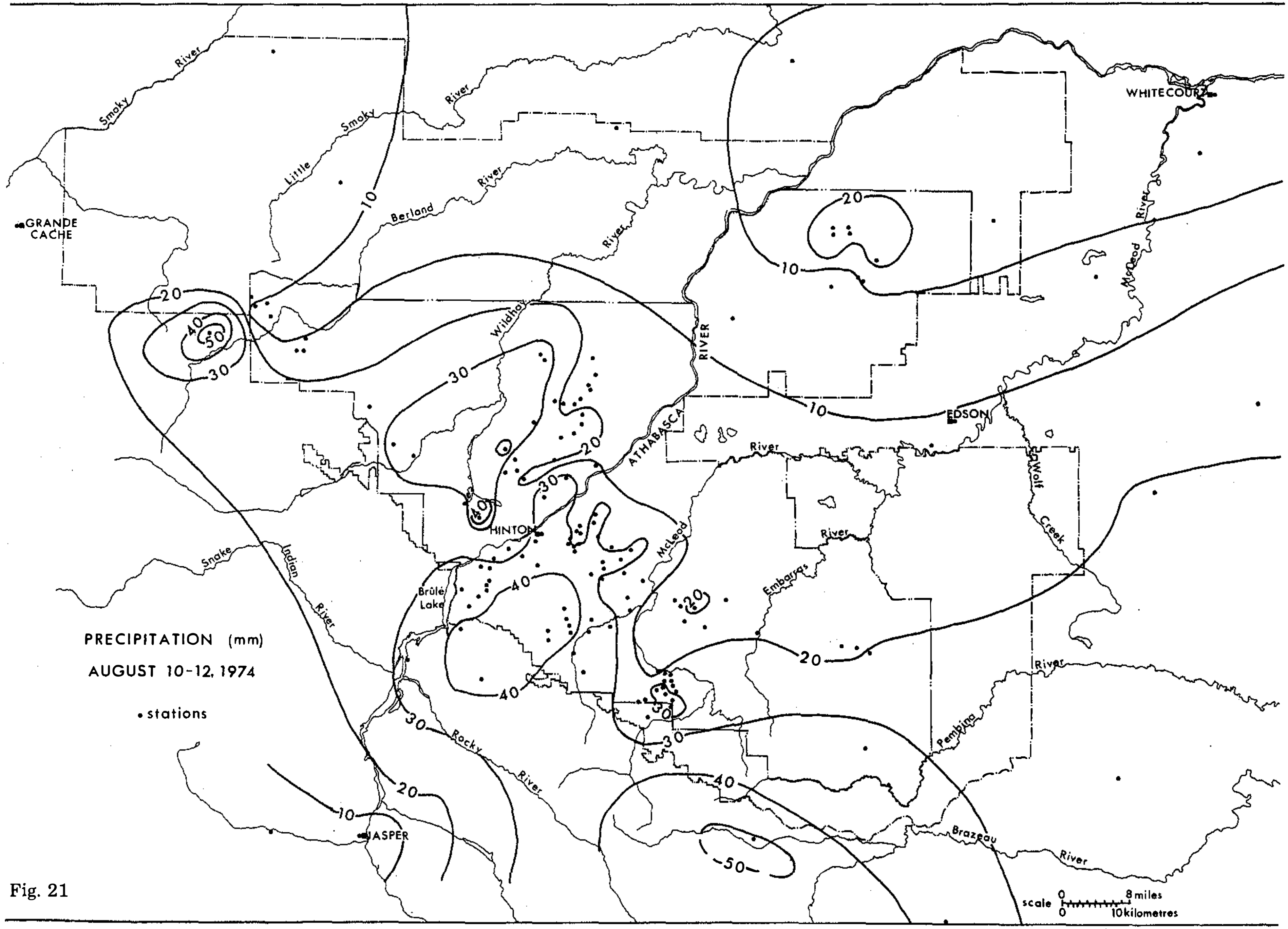

PRECIPITATION (mm)
AUGUST 10-12, 1974
• stations
GRANDE CACHE
WHITECOURT
EDSON
HINTON
JASPER
Brûlé Lake
Smoky River
Little Smoky River
Berland River
Wildhay River
ATHABASCA RIVER
McLeod River
Wolf Creek
Embarras River
Snake Indian River
Rocky River
Pembina River
Brazeau River
10
20
30
40
50
scale 0 8 miles
0 10 kilometres

Fig. 21

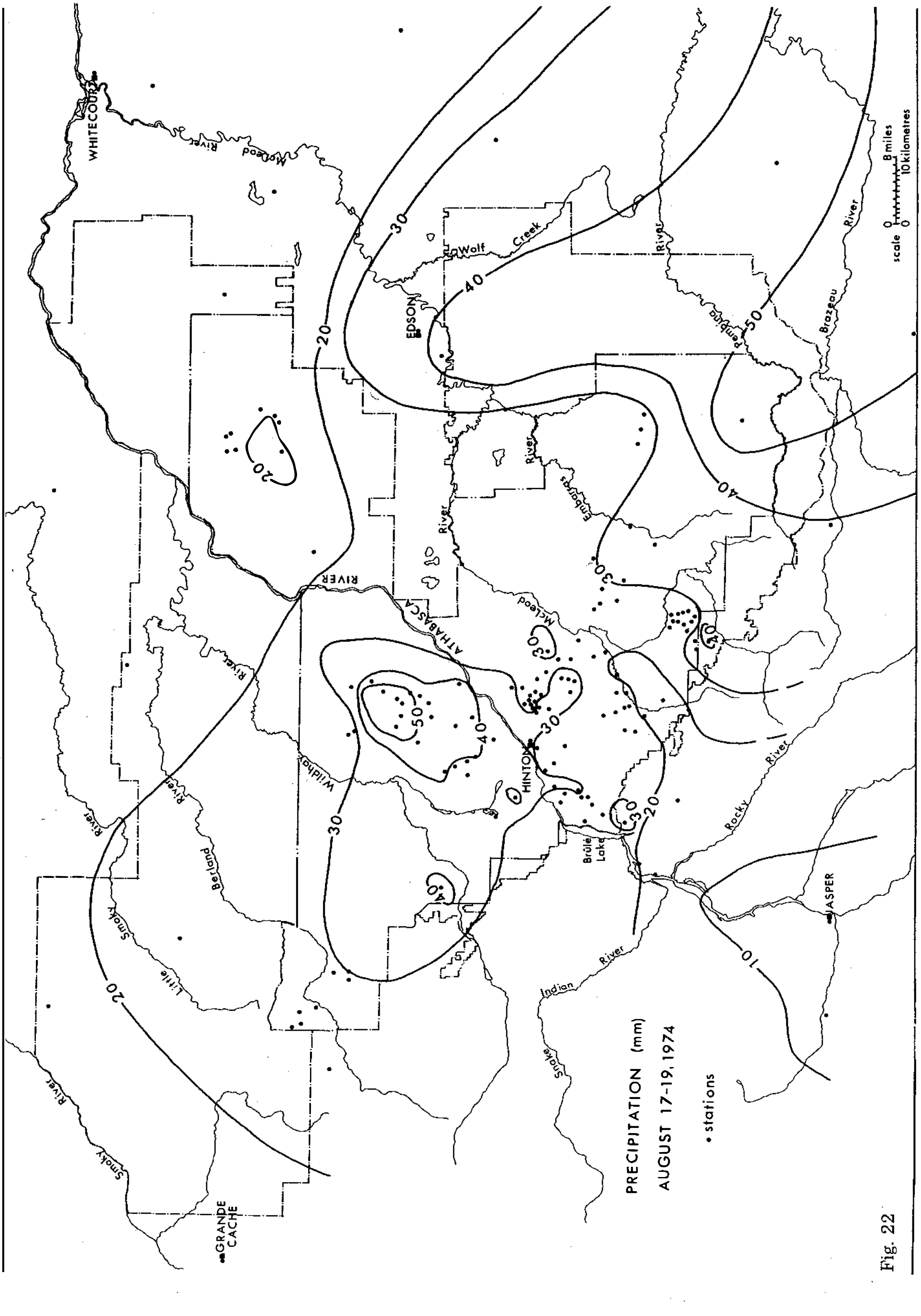
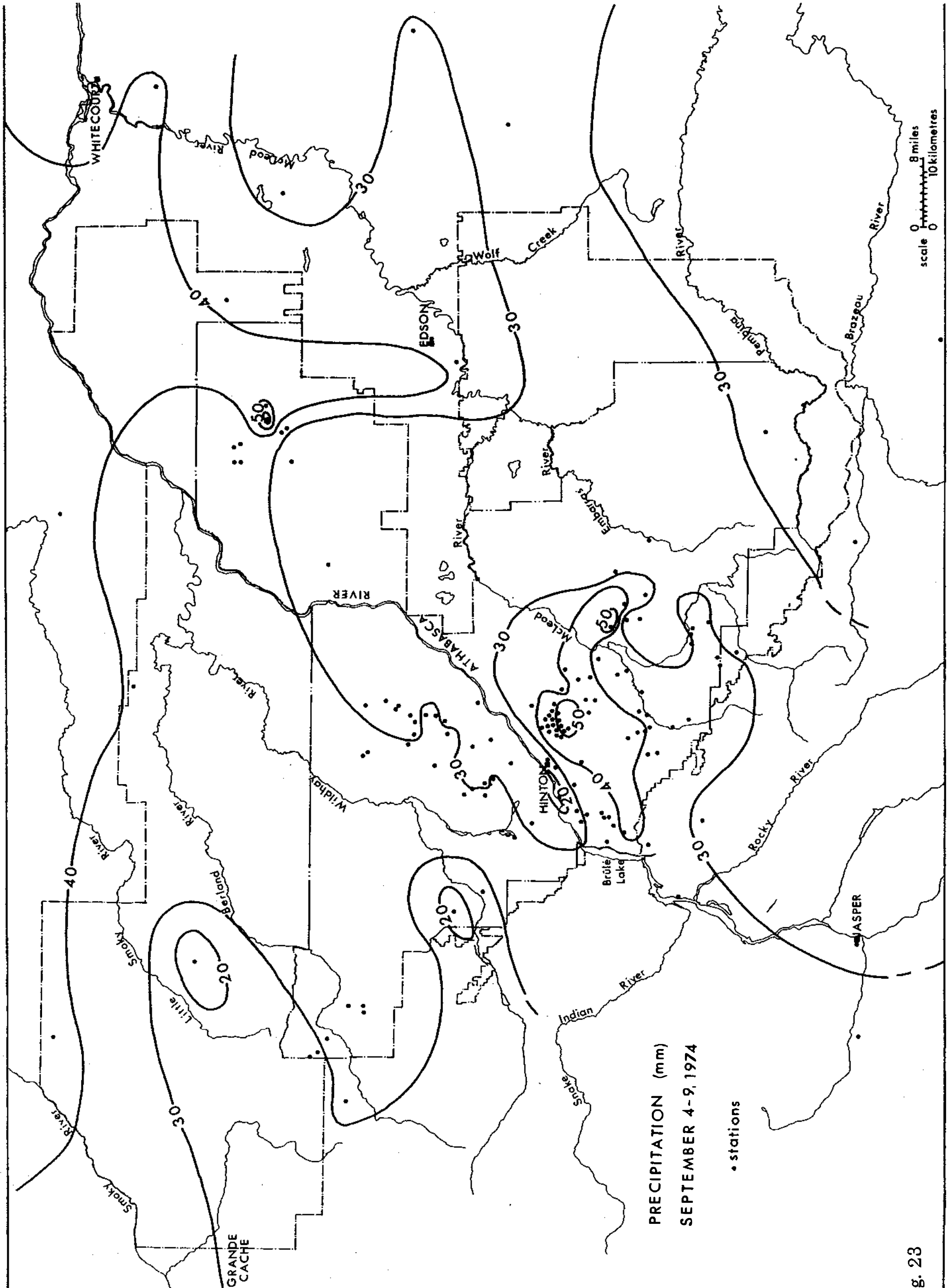
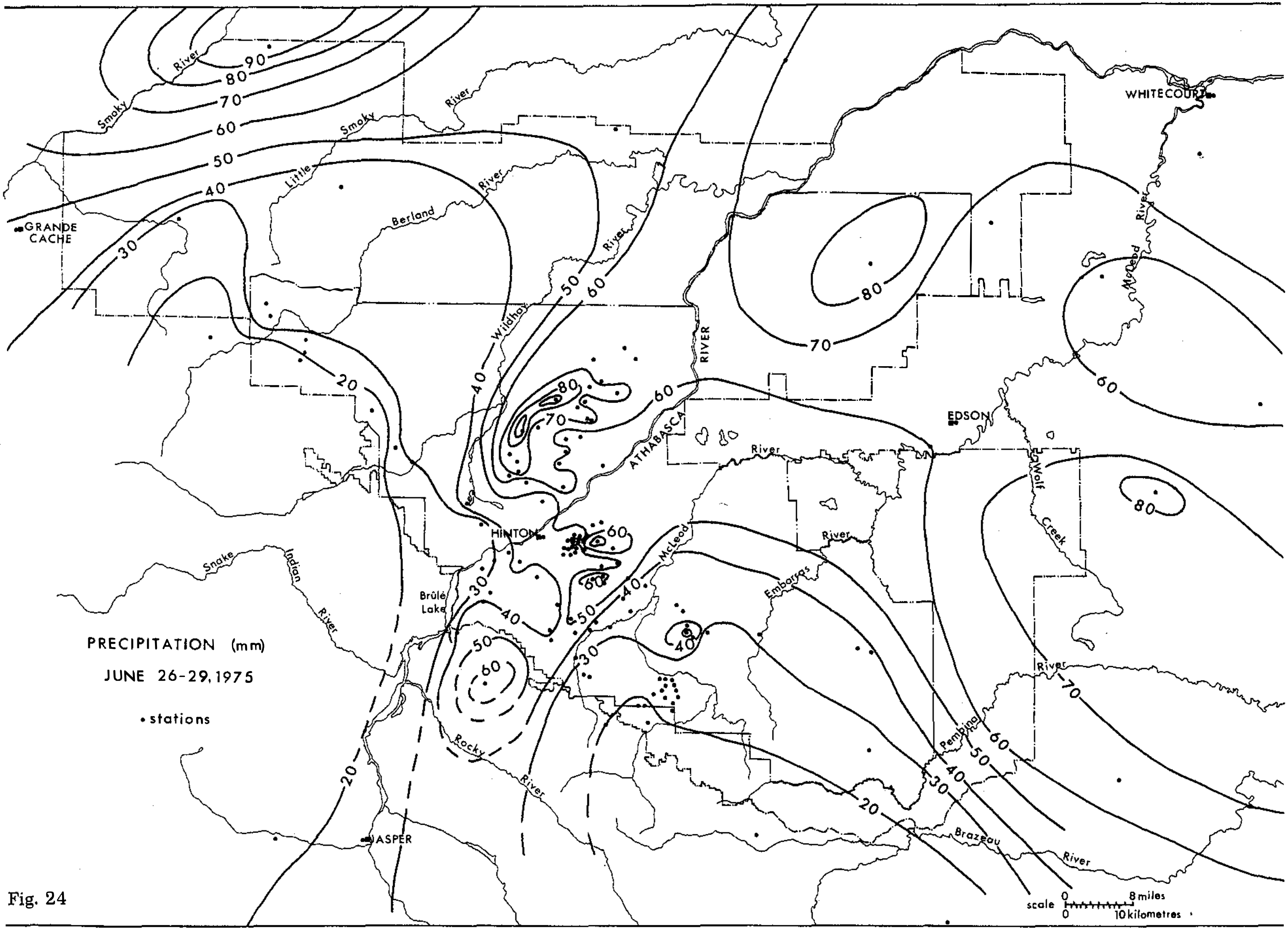

PRECIPITATION (mm)
AUGUST 17-19, 1974
• stations
scale 0 8 miles
0 10 kilometres
WHITECOURT
McLeod River
EDSON
Wolf Creek
HINTON
ATHABASCA RIVER
Wildhay River
Berland River
Little Smoky River
Smoky River
GRANDE CACHE
Embarras River
McLeod
Pembina River
Brazeau River
Rocky River
Brûlé Lake
Indian River
Snake
JASPER
10
20
30
40
50

Fig. 22



PRECIPITATION (mm)
SEPTEMBER 4-9, 1974
• stations

Fig. 23



PRECIPITATION (mm)

JUNE 26-29, 1975

• stations

Fig. 24

The major storm in 1975 (Fig. 24) produced intensities of aroud 90 mm at a number of locations.

A frequency analysis of maximum precipitation in 24 h during major storm events from 1963 to 1972 in a region including the study area (Alberta Lands and Forests 1973) showed that during the summer about 75% of the heaviest 24-h rainfalls exceed 12.7 mm, and 35% exceed 25.4 mm. Such high frequencies were considered to be highly significant in terms of erosion potential.

Snow Survey Data

Winter precipitation accumulates as snow over most of Alberta and especially in the mountains, forming a near-perfect reservoir from which water is released through the spring and summer. Measurement of the water contained in the snowpack just prior to the commencement of melt is a good indicator of subsequent streamflow.

Published snowpack data for the study area are limited to the area south of the Athabasca River. March 1 snow depths south of Hinton average about 38 cm at lower elevations (823-1067 m) and about 69 cm at intermediate elevations (1067-1371 m) (Alberta Lands and Forests 1973). Average duration of the snowpack for much of the area is estimated at 160-180 days. The location of snow courses that have been measured in the area are shown on Fig. 25 (letters a-j); the data are published in *Snow cover data* (Environment Canada 1962-) and *A summary of snow survey measurements Alberta, Saskatchewan and Northwest Territories* (Canada Department of Energy, Mines and Resources [n.d.]).

Snow courses (numbers 1-24, 28-42) were established at various elevations over much of the lease area (Fig. 25, Table 4). Snow courses consisted of a variable number of sampling points spaced 20 or 40 m apart. Often a course was extended into an adjacent residual stand to provide data from forested areas also. Those in the open had from 4 to 70 points, averaging between 20 and 25. Those in the forest had from 1 to 30 points, averaging over 10. A Mount Rose snow tube was used to cut through the full snow depth; the depth was noted and the core was weighed. The core weight indicates the water equivalent of the snowpack.

Snow courses were measured during the winters of 1971-1972 to 1975-1976, although all snow courses were not measured every year (Table 4). The date and number of times of measurement also varied each year, although measurements were generally taken in March and/or early or mid-April to extend over the period of peak accumulation. In the winter of 1973-1974, snow courses were measured at monthly intervals from mid-December to mid-April at 11 locations, with measurements also in the adjacent forest at 10 locations.

Maximum snow depth and water equivalent are summarized for the five years in Table 4. Data for the Cache Percotte Research Basin (snow course numbers 25-27) have also been included. In three of the years the snow surveys run in early April have been summarized, but in 1972 the mid-March survey is tabulated to represent the peak accumulation because later surveys indicated a smaller snowpack. The surveys in the other year may not have been taken at the time of peak snowpack, but represent the only snow survey taken or the one giving most comparable data.

Table 5 gives a summary of snow depth and water equivalent for the years 1973-1976 by working circles although the number of locations sampled each year and in each working circle varied. The average snow depth and water equivalent for the four years were 51.8 cm and 12.8 cm respectively. The snow depth (61.2 cm) and water equivalent (15.9 cm) were considerably higher in the spring of 1974 than in the other three comparable years. In three of the years the highest snow depth and water equivalent were recorded in the Marlboro Working Circle. (No surveys were taken in this area in the fourth year). The lowest snow depths were recorded in the McLeod Working Circle, but in two years the lowest water equivalents were recorded in the Berland Working Circle.

Monthly snow survey data from the 1973-1974 winter are summarized in Table 6, which also shows the values for the open and forest areas separately. Table 7 shows the maximum values for snow depth and water equivalent in the open and forest at nine locations during the 1973-1974 winter. Generally, maximum snow depths were recorded in March, although at some locations they occurred in February and April. In the open, maximum water equivalents usually occurred in

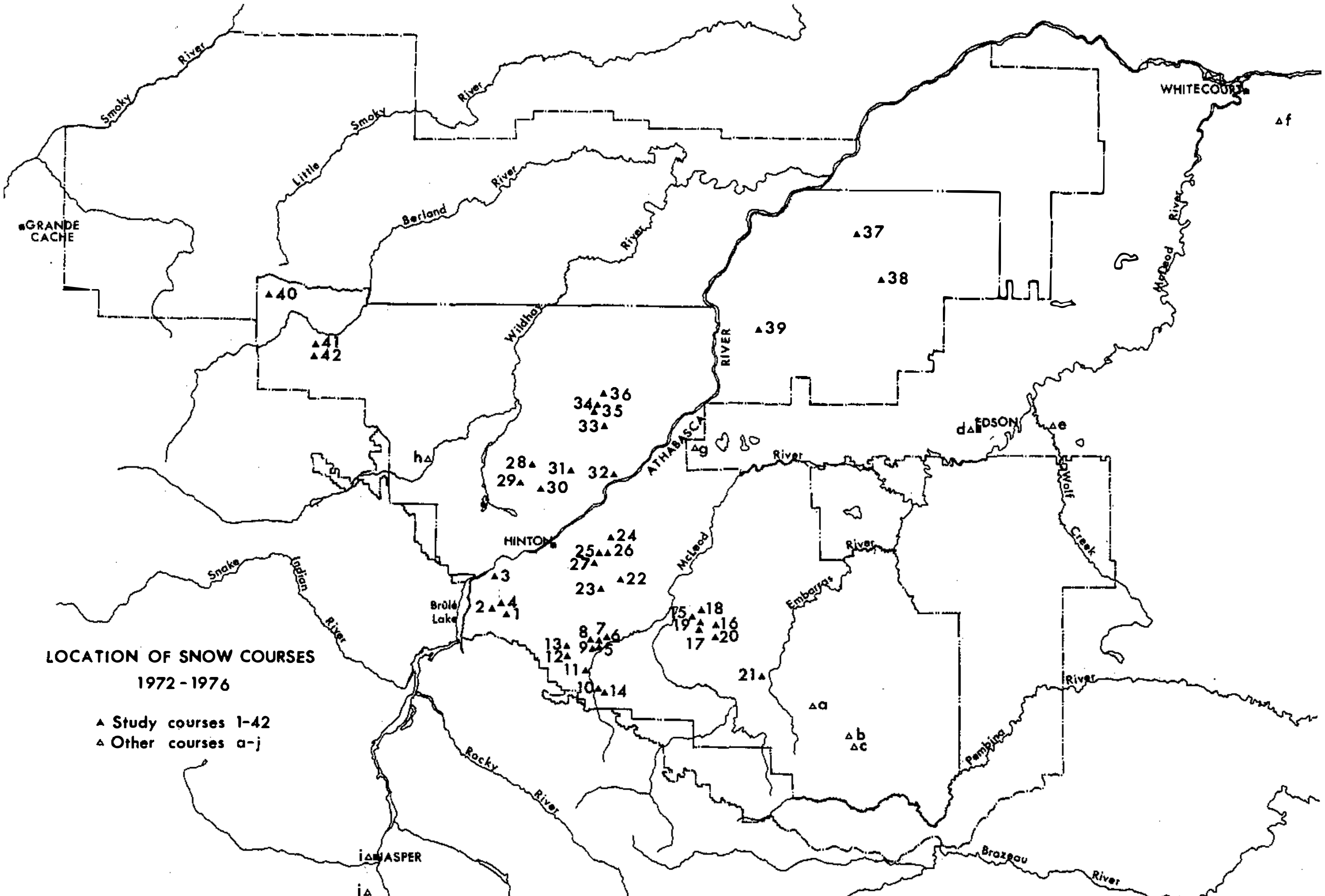

LOCATION OF SNOW COURSES
1972 - 1976
▲ Study courses 1-42
△ Other courses a-j
GRANDE CACHE
HINTON
EDSON
WHITECOURT
JASPER
Brûlé Lake
Smoky River
Little Smoky River
Berland River
Wildhay River
ATHABASCA RIVER
McLeod River
Embarras River
Wolf Creek
Pembina River
Brazeau River
Rocky River
Snake Indian River
scale 0 8 miles
0 10 kilometres

Fig. 25

Table 4. Maximum snow depth and water equivalent, 1972 to 1976 on four working circles on the NWPP lease near Hinton, Alberta

Working Circle, Compartment and Snow Course Number	Elev. (m)	1972 Snow Depth (cm)	1972 Water Equiv. (cm)	1972 Date	1973 Snow Depth (cm)	1973 Water Equiv. (cm)	1973 Date	1974 Snow Depth (cm)	1974 Water Equiv. (cm)	1974 Date	1975 Snow Depth (cm)	1975 Water Equiv. (cm)	1975 Date	1976 Snow Depth (cm)	1976 Water Equiv. (cm)	1976 Date
McLEOD - I																
1	1160	28.2	5.1	11/3	-	-	-	-	-	-	-	-	-	-	-	-
2	1160	25.2	5.1	11/3	-	-	-	-	-	-	-	-	-	-	-	-
3	1100	44.7	5.6	11/3	-	-	-	-	-	-	-	-	-	-	-	-
4	1190	33.8	5.3	11/3	-	-	-	-	-	-	-	-	-	-	-	-
McLEOD - II																
5	1280	52.3	6.1	12/3	37.1	10.9	10/4	46.2	10.9	13/4	31.5	7.4	10/4	41.2	9.9	23/3
6	1340	58.2	6.1	12/3	37.6	9.7	12/4	-	-	-	-	-	-	-	-	-
7	1250	64.3	7.4	12/3	-	-	-	-	-	-	-	-	-	-	-	-
8	1370	40.4	6.4	12/3	-	-	-	-	-	-	-	-	-	-	-	-
9	1340	69.3	7.9	12/3	-	-	-	45.7	13.2	13/4	35.1	8.4	10/4	39.6	8.6	23/3
10	1430	-	-	-	41.7	10.9	10/4	-	-	-	30.7	8.9	10/4	45.4	10.9	24/3
11	1370	54.4	7.1	12/3	-	-	-	-	-	-	-	-	-	-	-	-
12	1460	-	-	-	59.4	16.8	10/4	51.3	14.5	13/4	-	-	-	55.9	14.0	23/3
13	1490	-	-	-	41.9	11.9	10/4	-	-	-	-	-	-	50.0	12.2	23/3
14	1430	-	-	-	-	-	-	-	-	-	-	-	-	56.4	13.6	24/3
McLEOD - VI																
15	1280	58.9	5.8	13/3	46.2	11.2	11/4	51.3	12.2	12/4	36.8	7.4	9/4	57.3	15.8	24/3
16	1250	51.1	6.1	13/3	40.4	11.2	11/4	-	-	-	-	-	-	-	-	-
17	1250	55.4	6.4	13/3	-	-	-	-	-	-	-	-	-	-	-	-
18	1280	51.1	5.8	13/3	-	-	-	-	-	-	-	-	-	-	-	-
19	1280	39.1	5.1	13/3	26.4	6.9	11/4	48.3	14.2	12/4	25.4	6.4	9/4	50.2	12.9	24/3
20	1280	48.0	6.4	13/3	-	-	-	-	-	-	-	-	-	-	-	-
McLEOD - V																
21	1220	-	-	-	-	-	-	48.5	16.3	12/4	-	-	-	-	-	-
McLEOD - IX																
22	1370	48.0	6.1	14/3	53.9	14.7	11/4	-	-	-	-	-	-	-	-	-
23	1430	-	-	-	63.0	13.5	1/3	87.6	21.6	11-12/4	51.8	11.4	10/4	63.5	10.3	25/3
24	1280	-	-	-	-	-	-	53.3	12.5	8/4	24.1	6.1	9/4	38.0	9.8	25/3
25	1250	44.5	8.2	17/2	44.7	9.1	6/3	62.5	15.2	4/4	-	-	-	51.8	13.7	17/3
26	1300	44.5	13.5	11/4	55.9	11.4	6/3	69.9	16.4	4/4	-	-	-	66.8	16.3	17/3
27	1355	47.4	14.8	11/4	64.0	15.0	6/3	73.4	18.6	5/4	-	-	-	75.7	18.2	16/3

Table 4 (cont'd)

Working Circle, Compartment and Snow Course Number	Elev. (m)	1972			1973			1974			1975			1976		
		Snow Depth (cm)	Water Equiv. (cm)	Date	Snow Depth (cm)	Water Equiv. (cm)	Date	Snow Depth (cm)	Water Equiv. (cm)	Date	Snow Depth (cm)	Water Equiv. (cm)	Date	Snow Depth (cm)	Water Equiv. (cm)	Date
ATHABASCA - XIII																
28	1525	-	-	-	61.5	16.0	10/4	64.0	17.5	11/4	-	-	-	66.4	14.6	26/3
29	1525	-	-	-	-	-	-	33.8	8.4	13/3	39.4	7.9	9/4	41.4	8.5	26/3
ATHABASCA - XIV																
30	1340	-	-	-	42.4	8.9	2/3	45.7	7.9	12/4	-	-	-	-	-	-
31	1460	-	-	-	-	-	-	51.3	15.2	11/4	34.8	7.9	7/4	67.0	16.9	25/3
ATHABASCA - XV																
32	1100	-	-	-	-	-	-	55.9	10.7	17/3	-	-	-	38.1	10.8	27/3
ATHABASCA - XVI																
33	1400	-	-	-	48.5	12.5	10/4	64.3	18.0	11/4	39.1	7.8	9/4	43.4	10.5	27/3
34	1400	-	-	-	-	-	-	65.3	19.3	11/4	45.0	10.4	9/4	46.1	12.3	25/3
35	1430	-	-	-	-	-	-	-	-	-	-	-	-	52.7	13.8	25/3
36	1430	-	-	-	-	-	-	-	-	-	-	-	-	59.6	13.1	27/3
MARLBORO - III																
37	1220	-	-	-	51.6	13.2	12/4	88.4	25.9	10/4	49.3	11.7	11/4	-	-	-
MARLBORO - VII																
38	1130	-	-	-	-	-	-	71.9	18.0	10/4	-	-	-	-	-	-
MARLBORO - XI																
39	1040	-	-	-	-	-	-	54.1	12.2	10/4	-	-	-	-	-	-
BERLAND - I																
40	1370	-	-	-	-	-	-	66.0	16.3	9/4	49.0	11.9	8/4	80.6	19.9	26/3
BERLAND - III																
41	1400	-	-	-	46.2	10.2	11/4	53.1	14.0	9/4	36.1	8.6	8/4	45.8	11.6	26/3
42	1460	-	-	-	48.3	12.2	11/4	52.3	12.7	9/4	39.4	8.1	8/4	-	-	-

Table 5. Average snow depth and water equivalent for the years 1973-76 by working circles on the NWPP lease and for the area

Working Circle	No. of Locations (and sampling points) 1973	1974	1975	1976	Snow Depth (cm) 1973	1974	1975	1976	Water Equivalent (cm) 1973	1974	1975	1976
McLeod	13 (271)	11 (179)	7 (163)	13 (162)	47.09	58.01	33.53	53.22	11.78	15.05	7.87	12.78
Athabasca	3 (140)	5 (108)	4 (100)	8 (102)	50.80	58.17	39.62	51.84	12.45	15.49	8.64	12.57
Marlboro	1 (40)	3 (76)	1 (40)	0 (0)	51.56	71.37	49.28	—	13.21	18.80	11.68	—
Berland	2 (75)	3 (76)	3 (85)	2 (37)	47.24	57.15	41.40	63.18	11.18	14.22	9.65	15.73
Area Average or Total	19 (526)	22 (439)	15 (388)	23 (301)	49.17	61.18	40.89	56.08	12.16	15.89	9.40	13.69

Table 6. Monthly snow survey data at 11 locations on the NWPP lease area during the 1973-74 winter

Working Circle and Snow Course Number	DECEMBER			JANUARY			FEBRUARY			MARCH			APRIL		
	Snow Depth (cm)	Water Equiv. (cm)	Date	Snow Depth (cm)	Water Equiv. (cm)	Date	Snow Depth (cm)	Water Equiv. (cm)	Date	Snow Depth (cm)	Water Equiv. (cm)	Date	Snow Depth (cm)	Water Equiv. (cm)	Date
McLEOD															
12 - open	31.24	5.59	15	53.34	10.41	13	65.02	16.76	16	54.10	13.72	15	47.75	14.48	13
- forest	25.15	4.83	15	45.47	8.64	13	61.98	15.75	16	57.91	14.73	15	54.86	14.22	13
18 - open	30.73	5.84	15	43.43	7.62	13	48.51	10.92	16	63.50	15.24	16	48.26	14.22	12
- forest	23.37	4.57	15	30.73	5.84	13	45.47	10.16	16	51.56	11.18	16	—	—	—
20 - open	31.75	4.32	15	47.50	6.86	13	59.94	14.22	16	60.45	13.21	16	53.34	22.86	12
- forest	25.65	2.54	15	36.83	5.84	13	53.09	12.19	16	52.32	10.92	16	43.69	9.40	12
23 - open	32.26	6.35	15	37.85	8.13	13	55.88	12.70	16	54.36	12.45	16	53.09	12.95	8
- forest	23.11	3.81	15	37.08	7.11	13	44.45	9.14	16	49.78	10.67	16	57.15	12.45	8
ATHABASCA															
25 - open	27.69	7.11	15	38.35	13.21	17	40.39	10.16	12	33.78	8.38	13	61.21	16.76	11
27 - open	30.73	5.59	16	33.02	7.11	12	52.32	12.95	13	45.21	9.14	13	51.31	15.24	11
- forest	37.59	6.86	16	54.86	9.91	12	75.69	14.99	13	80.01	16.00	13	—	—	—
28 - open	22.35	4.57	16	40.13	8.13	12	52.83	11.43	13	55.37	11.68	17	—	—	—
- forest	19.30	3.56	16	36.07	5.84	12	53.85	11.18	13	56.13	9.40	17	—	—	—
30 - open	31.24	6.10	16	—	—	—	—	—	—	—	—	—	65.28	19.30	11
- forest	21.34	4.57	16	—	—	—	—	—	—	—	—	—	—	—	—
MARLBORO															
32 - open	30.73	6.10	16	51.82	10.67	12	74.17	13.21	17	75.95	18.80	17	76.45	20.07	10
- forest	24.89	4.83	16	37.59	6.86	12	69.60	13.72	17	65.79	14.99	17	67.06	15.75	10
33 - open	25.91	4.57	16	44.70	7.11	12	60.20	12.45	17	66.29	14.73	17	58.67	13.72	10
- forest	22.61	3.56	16	41.15	7.11	12	56.39	11.18	17	60.45	13.72	17	49.28	10.67	10
BERLAND															
34 - open	42.67	7.87	14	83.57	12.19	15	76.96	16.00	11	77.72	16.26	14	76.45	19.30	9
- forest	28.45	5.59	14	57.15	10.16	15	57.66	12.70	11	66.80	14.48	14	55.63	13.21	9

Table 7. Maximum snow depth and water equivalent in the open and in the forest stand during the winter of 1973-74 on the NWPP lease area

Snow Course	Snow Depth (cm)				Water Equivalent (cm)			
	Open		Forest		Open		Forest	
McLEOD								
12	65.02	Feb. 16	61.47	Feb. 16	16.76	Feb. 16	15.75	Feb. 16
18	63.50	Mar. 16	51.56[1]	Mar. 16	15.24	Mar. 16	11.18[1]	Mar. 16
20	60.45	Mar. 16	53.09	Feb. 16	22.86	Apr. 12	12.19	Feb. 16
23	55.88	Feb. 16	57.17	Apr. 4	12.95	Apr. 8	12.45	Apr. 8
ATHABASCA								
27	52.32	Feb. 16	80.01[1]	Mar. 13	15.24	Apr. 11	16.00[1]	Mar. 13
28	55.37[1]	Mar. 17	56.13[1]	Mar. 17	11.68[1]	Mar. 17	11.18[1]	Feb. 13
MARLBORO								
32	76.45	Apr. 10	67.06	Apr. 10	20.07	Apr. 10	15.75	Apr. 10
33	66.29	Mar. 17	60.45	Mar. 17	14.73	Mar. 17	13.72	Mar. 17
BERLAND								
34	77.72	Mar. 14	66.80	Mar. 14	19.30	Apr. 9	14.48	Mar. 14
Summary of no. of maximums in each month	Feb. 3 Mar. 5 (1[1]) Apr. 1		Feb. 2 Mar. 5 (3[1]) Apr. 2		Feb. 1 Mar. 3 (1[1]) Apr. 5		Feb. 3 (1[1]) Mar. 4 (2[1]) Apr. 2	

[1] Not taken in April.

April, but in the forest more maximum water equivalents occurred in March. As with snow depth, some maximum values for water equivalent were recorded in each of the three months February to April.

Table 8 shows the average snow depths and water equivalents for the open areas and the adjacent forest area for four years in the four working circles. In the Berland and Marlboro Working Circles values in the forest were always lower than in the open areas, but in the other two working circles values in the forest were sometimes higher than in the open area. In fact, in each of the four years snow depths in the forest in the Athabasca Working Circle were higher than in other working circles, but in two of those years the water equivalent values were slightly lower than those occurring in the open. An average for the whole lease area, giving equal weight to the averages from each working circle, indicated that snow depths in the forest were lower than in the open, and water equivalent values lower in three of the four years, although 1976 may have been different if values had been obtained from the Marlboro Working Circle.

HYDROLOGY

The hydrology of an area is influenced primarily by climate, geology, vegetation, and the activities of man. The climate of the Hinton-Edson area is such that the average annual precipitation is approximately 520 mm, about a third of which falls as snow. The climate is also an expression of the geologic influences prevailing in the area. Physiography, topography, aspect, drainage area, surficial materials, and soil development are all factors controlled by geology and, to some extent, climate. In the Hinton-Edson area, the proximity of the mountains is an important influence.

Geologic influences can be examined in the perspective of the time at which streams start to open up in the spring. In the winter,

Table 8. Average snow depth and water equivalent in the open and forest stand in the years 1973-76 at comparable locations in four working circles on the NWPP lease area

	Snow Depth (cm)											
	1973			1974			1975			1976		
Working Circle	Open	Forest	Diff.	Open	Forest	Diff.	Open	Forest	Diff.	Open	Forest	Diff.
McLeod	40.13	43.69	+ 3.56	51.05	45.72	-5.33	30.73	27.18	-3.56	52.90	55.55	+2.65
No. of locations	6	6		4	4		3	3		5	5	
Athabasca	50.80	51.31	+0.51	62.23	69.34	+7.11	36.07	56.39	+20.32	49.10	56.70	+7.60
No. of locations	3	3		2	2		1	1		4	4	
Marlboro	56.39	46.74	-9.65	77.98	67.31	-10.67	56.90	41.40	-15.49	—	—	—
No. of locations	1	1		3	3		1	1				
Berland	53.59	33.78	-19.81	64.52	53.85	-10.67	55.12	38.35	-16.76	69.10	54.83	-14.27
No. of locations	2	2		2	2		1	1		2	2	
Average	50.29	43.94	-6.35	64.01	59.18	-4.83	44.70	40.89	-3.81	57.03	55.69	-1.34

	Water Equivalent (cm)											
	1973			1974			1975			1976		
Working Circle	Open	Forest	Diff.	Open	Forest	Diff.	Open	Forest	Diff.	Open	Forest	Diff.
McLeod	10.67	11.94	+1.27	16.51	10.67	-5.84	7.62	6.35	-0.51	11.06	14.17	+3.11
No. of locations	6	6		4	4		3	3		5	5	
Athabasca	12.70	12.19	-0.51	17.78	17.27	-0.51	6.86	11.18	+4.32	11.18	15.91	+4.73
No. of locations	3	3		2	2		1	1		4	4	
Marlboro	14.22	11.94	-2.29	21.08	16.26	-4.83	14.48	9.65	-4.83	—	—	—
No. of locations	1	1		3	3		1	1				
Berland	12.95	7.62	-5.33	16.26	12.70	-3.56	13.46	9.65	-3.81	16.93	13.28	-3.65
No. of locations	2	2		2	2		1	1		2	2	
Average	12.70	10.92	-1.78	18.03	14.22	-3.81	10.67	9.14	-1.52	13.06	14.43	+1.22

small streams on the lease area are completely covered by ice and may be frozen solid. Usually, however, a small base flow is maintained during the winter months. About the middle of April the snow begins to melt, and flow under the ice in stream channels increases. These flow increases first become evident on clear-harvested south-facing watersheds located on benchlands, eg. watersheds 7 and 45 (see page 56)[1] Soon afterwards snowmelt runoff commences from the Athabasca and the Mayberne Tableland watersheds, eg. 22-25 and 42-45, respectively. However, the Mayberne streams show flow increases slightly earlier than do those of the Athabasca because the Mayberne Tableland is farther removed from the influence of the mountains. The last streams to open up are located in the higher-elevation watersheds of the Berland working circle, in the Rocky Mountain Foothills, close to the mountains (watersheds 1-5).

As a user of water, the forest plays an important role in controlling the redistribution of water and its subsequent concentration and return to the sea. As a corollary, any disturbance to the forest will also have some impact on the hydrological system, since the hydrological processes associated with the forest--interception, evaporation, and transpiration--will also be affected. Furthermore, if large numbers of trees are removed, as is the case in forest harvesting, new snow distribution and melt patterns may be established (Johnson *et al.* 1971). This will have an effect on streamflow. It has been demonstrated that forest clear-cutting on the NWPP lease area has resulted in an increase in spring runoff from snowmelt of over 50% (Swanson and Hillman 1977a,b).

The hydrographs of small streams, which together with the precipitation data for the area form the basis for this compilation (see next section), show that the hydrology of the Hinton-Edson area is dominated by the snowmelt-runoff relation. Snowmelt in this area generally begins between the middle and the end of April, and the streams start to rise during early May. Most of the snowmelt runoff occurs during May and early June, peaking some time during the latter part of May.

As mentioned earlier, the study area is part of the Athabasca River system (Fig. 1), which flows northeast through Alberta and is in turn part of the Mackenzie River system. Major tributaries to the Athabasca in the study area are the relatively shallow and fast-flowing McLeod, Berland, Wildhay, Embarras, Little Berland, and Erith rivers, and Oldman Creek (Fig. 2). The largest of these tributaries, the McLeod River, also flows northeast, joining the Athabasca River at the town of Whitecourt beyond the confines of the pulp lease area. Roughly speaking, the lease area on the north side of the Athabasca River is drained by the Athabasca, and the lease area on the south side is drained by the McLeod.

Water Survey of Canada (WSC) maintains several stream gauges on the major rivers (Fig. 2) and smaller creeks within or near the lease area. On the Athabasca River, one gauge (WSC station 07AD002) is located at Hinton, and another (07AE001) is situated near Windfall Creek--just a few kilometres downstream from the point where the Athabasca leaves the lease area, and upstream from Whitecourt. Gauging stations are also operational on the McLeod River near Whitecourt, near Wolf Creek (07AG001), and above the Embarras River (07AF002); and on the Wildhay River (07AC001), near Hinton. Small streams in the area gauged by Water Survey of Canada include two in the Cache Percotte Forest: Cache Percotte (07AD003) and Whiskeyjack (07AD004) creeks; and the three streams which constitute Tri-Creek, i.e., Deerlick (07AF004), Eunice (07AF005), and Wampus (07AF003).

Most of the area drained by the McLeod River upstream from its Wolf Creek confluence (Fig. 2) lies within the pulp lease area. The Athabasca River, on the other hand, drains over 10 000 km^2 of mountains and foothills before entering the lease area at the exit from Brûlé Lake. It rises in regions of high precipitation and is fed by high elevation snowfields and glaciers.

Figure 26 shows the 1974 hydrographs for the Athabasca and McLeod rivers and Pine Creek (watershed 44). The hydrograph for Pine Creek is more like that of the McLeod

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[1] Any subsequent reference to watershed numbers implies that the watershed is tabulated under this number on page 56 and is described in the next section on watershed data and descriptions.

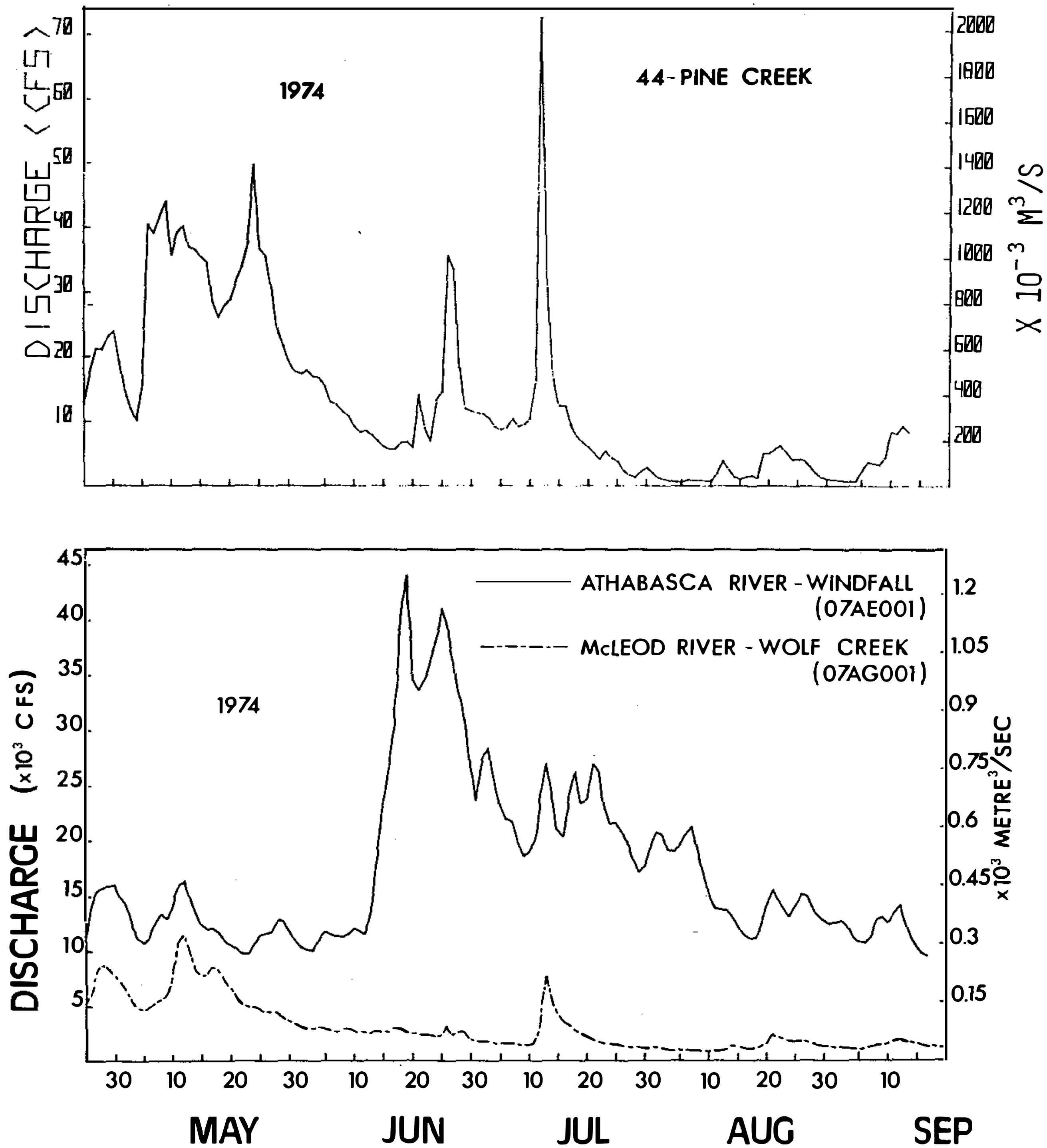


Fig. 26. Streamflow data for Athabasca River, McLeod River, and Pine Creek, 1974 (includes data supplied by Water Survey of Canada).

than the Athabasca River. For some time periods, such as late April to late May and 10-15 July, all three hydrographs have marked similarities. An important point to remember here is that flows from the McLeod River enter the Athabasca River downstream from the Windfall gauge and in no way influence flow at that gauge.

The shape of the hydrograph for Pine Creek is typical of small streams on the lease area. During the snowmelt season, flows from many small streams on the lease area combine to contribute to the characteristic shape of the spring runoff hydrograph for the McLeod River (southeast part of lease area) and the May hydrograph for the Athabasca River (northwest part of lease area). It is for this reason that the hydrographs are similar for all three streams during this period.

In June, a totally different picture is apparent. Most of the snow is gone from the lease area by early June, and the hydrographs for Pine Creek and McLeod River show that, except for the effects of an occasional rainstorm, recession is taking place. The Athabasca River hydrograph, on the other hand, indicates that a large volume of water flows past the Windfall gauge during June. Most of this water originates from the snowfields and glaciers in the mountains west of the lease area and completely dominates precipitation-runoff relations. Occasionally, heavy rainstorms such as the one which occurred in August 1969 produce runoff in the Athabasca and McLeod rivers comparable to or exceeding that normally produced as snowmelt runoff.

A rough estimate of the total flows contributed to the Athabasca River system by most of the pulp lease area can be obtained by adding flows measured at the Wolf Creek gauge on the McLeod River to the difference between flows measured at the Windfall and Hinton gauges on the Athabasca River. Data for these stations for the April to August 1974 period are shown in Fig. 27 and serve to support the comments made regarding Fig. 26. Plots of mean monthly flows (March to October 1961-1974) for the Hinton and Windfall gauges on the Athabasca River are presented in Fig. 28. They show that the flow regime described for 1974 is similar to the flow regime averaged over time. The similarity is less than expected, however, because of the averaging effects of high and low flow years.

Table 9 shows total annual, maximum, and minimum daily flows for the Athabasca River (Hinton and Windfall) and the McLeod River (near Wolf Creek) during the period 1961-1976. Table 10 gives the amount of water contributed by the lease area to the Athabasca River system each year during the same period. Table 11 provides runoff data for the period 25 April-15 September 1955-1976 for the Athabasca and McLeod rivers and Wolf Creek. A map showing annual water yields obtained from different parts of the province, prepared by Alberta Environment, is presented here as Fig. 29. Tables 9-11 are intended to show the long-term trends of flow from the lease area.

The mean annual runoff values given in Table 9 reflect the water-yielding characteristics of the upstream area. Thus, the highest mean value is obtained for the Athabasca River at Hinton (537 mm) and the lowest for the McLeod River near Wolf Creek (193 mm). Figure 29 shows that the drainage area upstream from the Hinton gauge is one of the highest water-yielding areas in the province. The drainage area upstream from the Wolf Creek gauge on the McLeod River is a moderate water-producing area. The runoff value obtained for the Windfall gauge lies between those of the Hinton and McLeod River gauges. This can be expected because flows past the Windfall gauge originate from both high and moderate water-yielding areas upstream. The mean annual runoff for Wolf Creek (07AG003--not shown in Table 9) is 131 mm, considerably lower than the three values given in Table 9. Wolf Creek drains the eastern edge of the lease area, which according to Fig. 29, is among the lowest water-producing parts of the lease area.

During the 1961-1976 record period the highest total annual flows occurred in 1965, when 11.26, 6.70, and 2.28 billion m^3 of water flowed past the Windfall, Hinton, and McLeod River (near Wolf Creek) gauges respectively (Table 9). The lowest annual volumes for the Athabasca River were recorded in 1970, when totals of 5.85 and 4.45 billion m^3 were measured at the Windfall and Hinton gauges. A low of 0.60 billion m^3 was recorded for the McLeod River (near Wolf Creek) in 1975.

The maximum and minimum daily flows recorded at the Windfall gauge on the Athabasca River during the 16-year period were 2130

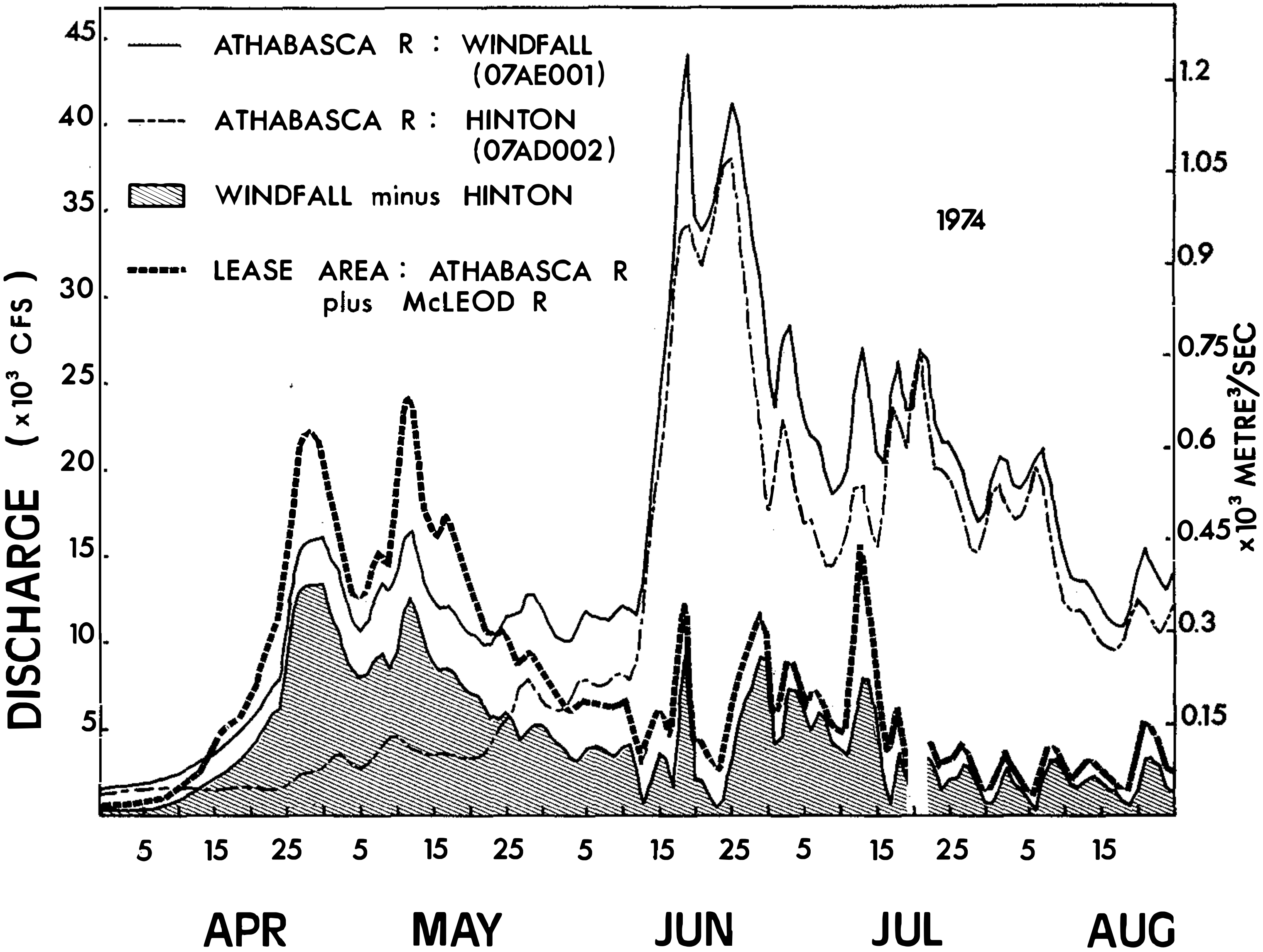


Fig. 27. Estimate of flow in the Athabasca River system originating from the pulp lease area (from data supplied by Water Survey of Canada).

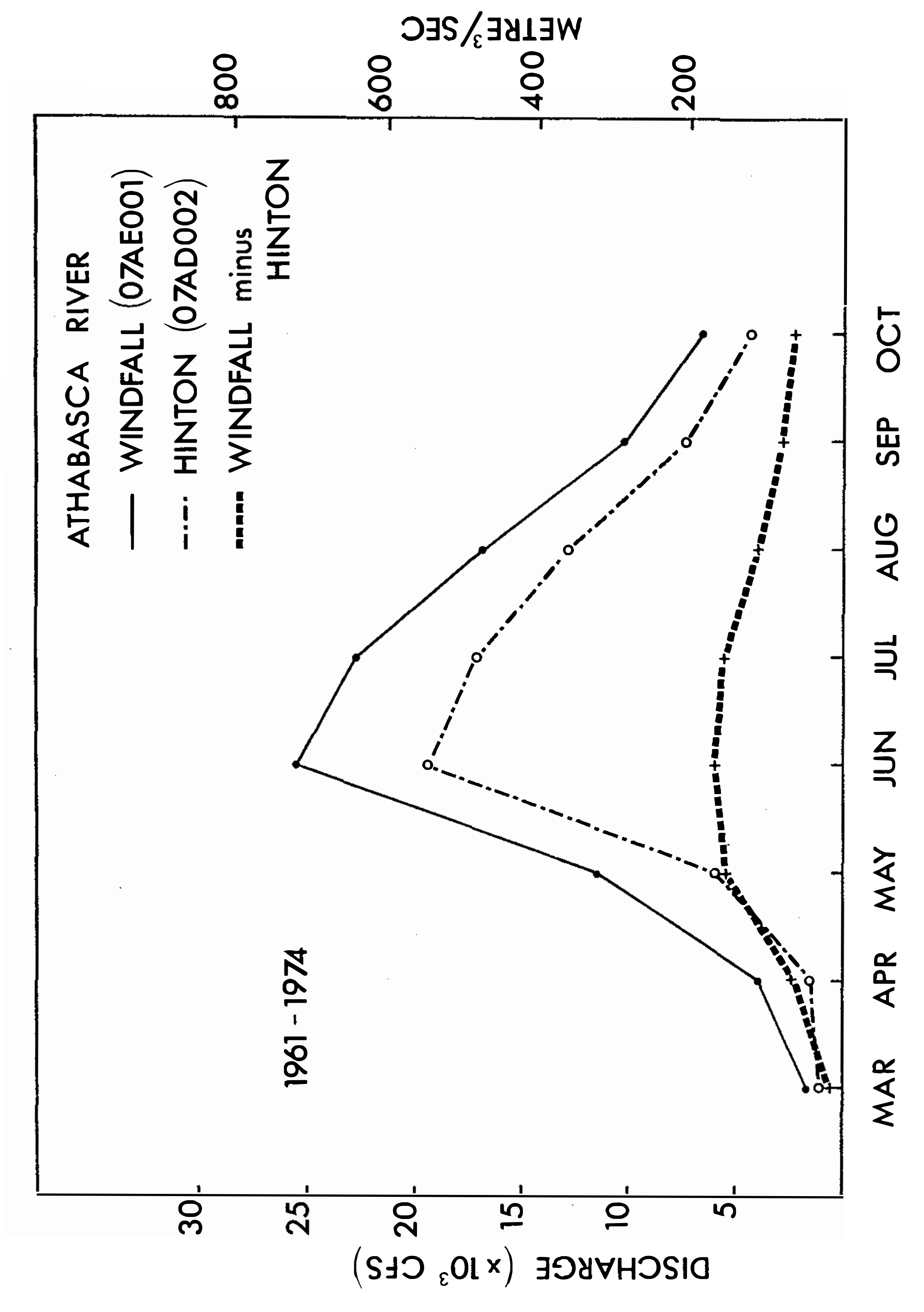


Fig. 28. Mean hydrographs for the Athabasca River during the period 1961-1974 showing estimated contributions from the pulp lease area (from data supplied by Water Survey of Canada).

Table 9. Annual flow data for Athabasca and McLeod rivers, 1961-1976 (from data supplied by Water Survey of Canada)

	Athabasca River						McLeod River		
	Windfall gauge 07AE001 Drainage area: 18 100 km^2			Hinton gauge 07AD002 10 400 km^2			Wolf Creek gauge 07AG001 6420 km^2		
Year	Annual flow (x10^9 m^3)	Max. flow (m^3/s)	Min. flow (m^3/s)	Annual flow (x10^9 m^3)	Max. flow (m^3/s)	Min. flow (m^3/s)	Annual flow (x10^9 m^3)	Max. flow (m^3/s)	Min. flow (m^3/s)
1961	7.40	949	36.0	5.28	804	19.7	0.79	186	3.40
1962	8.10	966	32.8	5.16	765	11.0	1.21	241	4.25
1963	7.45	917	29.7	5.48	719	10.8	0.85	272	2.27
1964	8.35	1230	23.4	5.53	844	15.0	1.44	371	2.46
1965	11.26	2130	30.3	6.70	900	15.7	2.28	838	4.13
1966	9.60	1190	38.5	6.01	765	17.2	1.73	481	5.10
1967	7.83	1170	28.2	6.23	855	24.4	0.93	274	3.09
1968	7.48	1180	29.4	6.03	1000	27.5	1.04	129	1.70
1969	7.08	1760	31.1	5.56	997	31.1	1.38	1400	4.53
1970	5.85	946	34.5	4.45	776	19.8	0.68	368	4.47
1971	8.97	1700	32.6	5.86	895	21.5	1.84	617	3.34
1972	8.82	1870	37.4	6.14	1200	27.8	1.75	1040	5.38
1973	7.18	1170	51.0	4.85	963	29.7	1.20	292	7.93
1974	7.97	1250	42.5	5.85	1070	26.9	1.31	326	4.84
1975	5.92	850	39.6	4.60	736	28.3	0.60	177	3.57
1976	7.92	1042	42.2	5.60	640	21.0	0.81	175	3.57
Mean	7.95	1270	35.0	5.58	871	21.7	1.24	449	4.0
M.A.R.[1]	439 mm			537 mm			193 mm		

[1] Mean annual runoff

Table 10. Total annual flow data for Athabasca River, McLeod River, and pulp lease area, 1961-1976 (from data supplied by Water Survey of Canada)

Year	(a) Athabasca River (Windfall - Hinton) 7744 km^2 [1] ($\times 10^9$ m^3)	(b) McLeod River (Wolf Creek) 6420 km^2 ($\times 10^9$ m^3)	(c) = (a) + (b) Lease area 14 164 km^2 ($\times 10^9$ m^3)
1961	2.12	0.79	2.91
1962	2.94	1.21	4.15
1963	1.97	0.85	2.82
1964	2.82	1.44	4.26
1965	4.56	2.28	6.84
1966	3.59	1.73	5.32
1967	1.60	0.93	2.53
1968	1.45	1.04	2.49
1969	1.52	1.38	2.90
1970	1.40	0.68	2.08
1971	3.11	1.84	4.95
1972	2.68	1.75	4.43
1973	2.33	1.20	3.53
1974	2.12	1.31	3.43
1975	1.32	0.60	1.92
1976	2.32	0.81	3.13
Mean	2.36	1.24	3.60
M.A.R.[2]	305 mm	193 mm	255 mm

[1] Drainage area

[2] Mean annual runoff

Table 11. Runoff (mm) measured at selected stations on the Athabasca River, the McLeod River, and Wolf Creek during the period 25 April-15 September 1955-1976 (from data supplied by Water Survey of Canada)

Year	Athabasca R. (Windfall minus Hinton) 7744 km²	McLeod River 07AF002 above Embarras River 2620 km²	McLeod River 07AG001 near Wolf Creek 6420 km²	Wolf Creek 07AG003 at Highway 16 906 km²
1955		199	152[2]	76
1956		114	95[2]	44
1957		174	153[2]	79
1958		183	161	71
1959		187	125	50
1960	181[1]	185	145	77
1961	139	102	75	30
1962	243	193	133	70
1963	175	125	100	67
1964	256	212	156	105
1965	486	334	287	215
1966	339	239	210	128
1967	181	168	124	70
1968	134	165	120	69
1969	152	248	178	112
1970	116	113	86	61
1971	325	259	240	204
1972	237	224	210	188
1973	210	178	138	96
1974	206	202	163	138
1975	127	99	75	54
1976	207	143	90	71
Mean	218	184	146	94

[1] The value for 1960 is the difference in flow between the Windfall gauge and the Entrance gauge (07AD001). The drainage area upstream from the Entrance gauge is 10 100 km²

[2] Obtained from gauge on McLeod River, near Edson (07AG002--drainage area: 5440 km²)

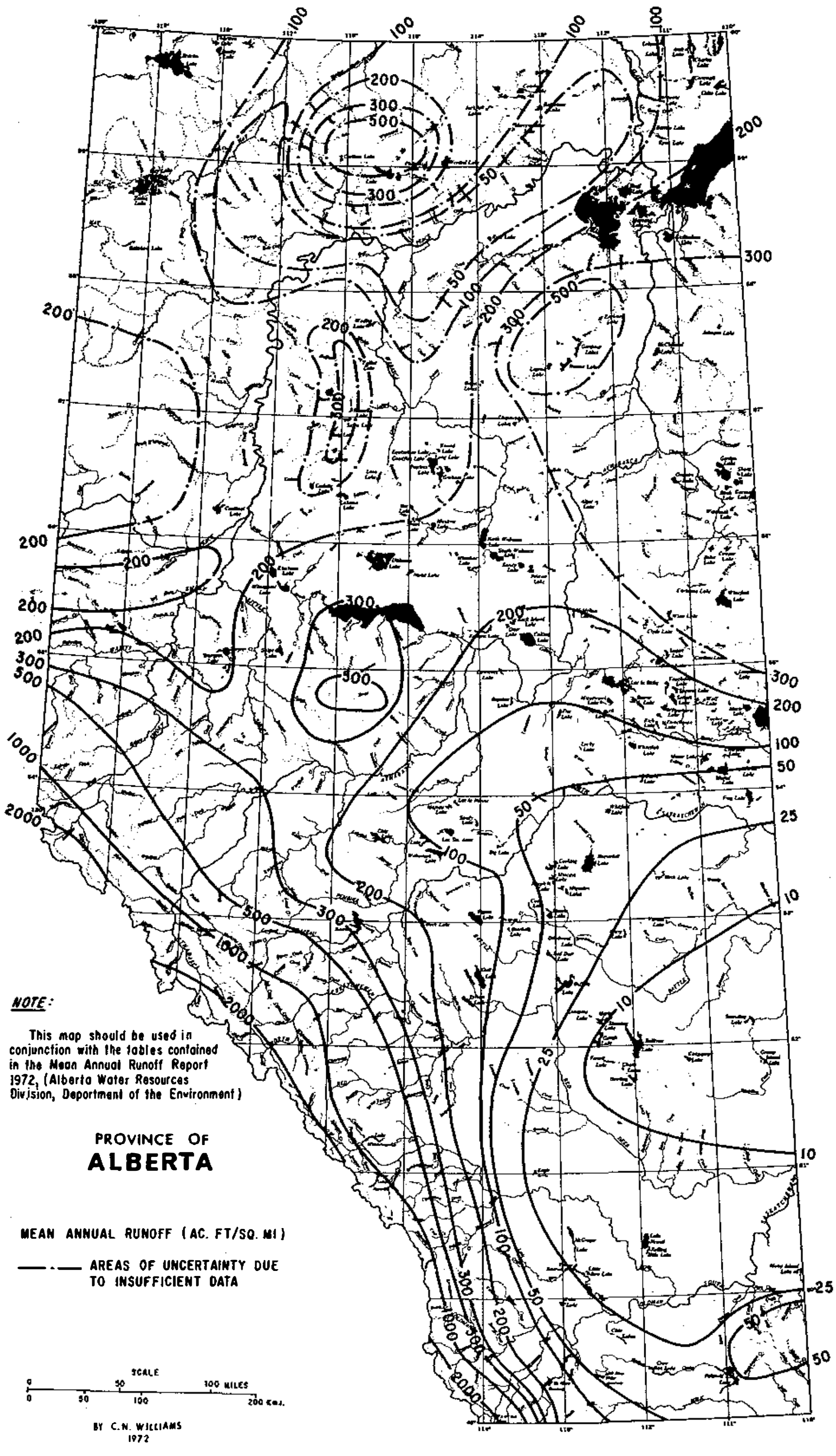


Fig. 29. Mean annual runoff map for the Province of Alberta (prepared by Alberta Environment).

(in 1965) and 23.4 m^3/s (1964) respectively. The corresponding 16-year averages are 1270 and 35.0 m^3/s. At the Hinton gauge, the maximum daily flow was recorded in 1972 (1200 m^3/s) and the minimum in 1963 (10.8 m^3/s). The corresponding 16-year averages are 871 and 21.7 m^3/s. On the McLeod River, the maximum daily flow was obtained at the Wolf Creek gauge in 1969 (1400 m^3/s) and the minimum in 1968 (1.70 m^3/s). The average maximum daily flow is 449 m^3/s, and the minimum is 4.0 m^3/s.

Although the record period 1955-1976 only for the McLeod River, near Wolf Creek (07AG001) is shown in Tables 9-11, the actual record goes back to 1915. If these older data also are used to compute the long-term averages, the mean annual flow is 1.2 x $10^9 m^3$, equivalent to 187 mm of runoff. The mean maximum daily flow for this period is 406 m^3/s, and the highest daily flow recorded remains at 1400 m^3/s (7 August 1969). Mean seasonal (25 April-15 September) runoff is 143 mm, or about 76% of mean annual runoff.

Long-term mean annual runoff values for other stations on the lease area are given in the Schulco report (Alberta Lands and Forests 1973). Thus, 244 mm of runoff are reported for the McLeod River above the Embarras River (1955-72), 259 mm for the Wildhay River near Hinton (1965-72), and 254 mm for Wampus Creek near Hinton. The same report also gives the recorded extremes of annual flow relative to the mean annual flow. For the Athabasca River at Hinton, the extremes range from 78 to 117% of normal. The corresponding range at Windfall is 72 to 138%. The recorded extremes for the McLeod River above Embarras River are 56 and 176% of normal.

Table 10 shows that the estimated mean annual runoff for the lease area during 1961-1976 is 255 mm, or about 50% of mean annual precipitation. The highest annual flow (484 mm) occurred in 1965, and the lowest (136 mm) in 1975. About 30% of the annual flow at the Windfall gauge originates from the lease area.

In order to make a comparison between the 1972-1975 data compiled in this report and the long-term record, data have been tabulated (Table 11) for certain streams on the lease area for the period 25 April-15 September 1955-1976. The most complete set of streamflow data obtained during 1972-1975 was for 18 watersheds for the period 25 April-15 September 1974 (Swanson and Hillman 1977a). The average size of these watersheds is 16 km^2, and the average total runoff for the period was 167 mm.

Table 11 shows the mean seasonal runoff values decreasing from left to right. The mean value for the 18 watersheds (167 mm) falls between the two values for the McLeod River (184 and 146 mm). This reflects the fact that the majority of the pulp lease is contained within the moderate water-yielding areas.

The Schulco Report (Alberta Lands and Forests 1973) indicates that flows for the May to mid-September period for four streams (Athabasca, Wildhay, and McLeod rivers, and Wampus Creek) on the lease area represent between 75 and 82% of the total annual flow. If the seasonal value of 167 mm for the 18 watersheds is compared with the estimated total annual flow from the lease area (255 mm in Table 10), the comparative value is 65%.

The hydrographs presented in the next section show that each year during the May to September period, two or three rainstorms have a significant effect on streamflow, producing a rapid rise in stream water levels. Examples of such storms are those which occurred 24-28 May 1973, 23-26 June 1973, 11-12 July 1974, and 26-29 June 1975.

Several factors influence the effect of rainfall on streamflow: the intensity and duration of the storm, its distribution over the watershed, and antecedent soil water. Antecedent soil water in turn is affected by the rapidity at which storms follow one another. Thus, a series of moderate storms occurring close together in time may produce a much greater increase in streamflow than will a large storm following in the wake of a period of dry weather. In the latter case, much of the water may serve only to "prime" the soil. An example of this is given in the 1973 data where the fairly large storm of 4-8 August has considerably less effect on streamflow than does the somewhat lesser storm of 23-26 June.

Information on the hydrogeology of the Hinton-Edson area is limited, but is available for five small basins within the lease area. Currie (1969, 1976) discussed the hydrogeology of the Tri-Creek watershed (Deerlick, Eunice, and Wampus creeks), and Stevenson

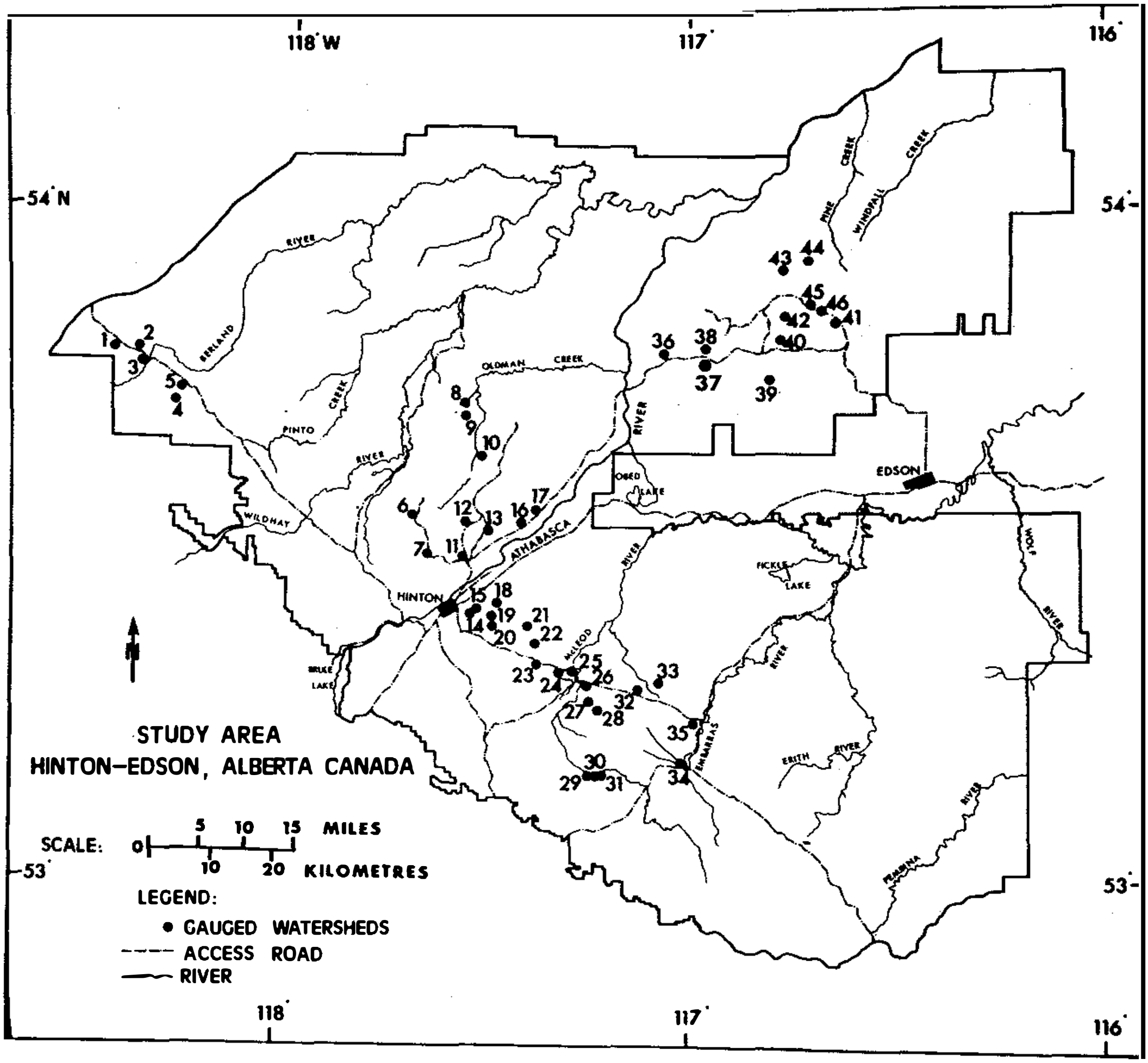


Fig. 30. Location of gauged watersheds on study area

(1969) described that of Cache Percotte and Whiskeyjack basins, near Hinton. According to Stevenson, the average annual precipitation of 587 mm over Cache Percotte is distributed as follows: 76.0% forms evapotranspiration, 16.1% forms streamflow, and 7.9 forms basin leakage or underflow. The corresponding figures for Whiskeyjack basin, which has a mean annual precipitation of 617 mm, are 66, 24.8, and 9.2% respectively.

WATERSHED DATA

Data for this compilation were obtained from 46 watersheds scattered throughout the study area. The watersheds range in size from 1 to 50 km^2 and are drained by streams varying from first to fifth order. A list of watersheds (page 56) and their approximate locations (Fig. 30) are given. The list also serves as an index to the watershed descriptions given at the end of this section (pages 61-167).

The data from each watershed usually consist of hydrographs for the late April to September flow period (1-4 years of record) and accompanying precipitation bar graphs. Few data were obtained for the late fall and winter because this period was outside the terms of reference for the impact studies. Snow course data for a few of these watersheds are presented in the "Climate" section. A brief physical description of each watershed and either an oblique aerial photograph showing the physiography of the watershed or a photograph of the stream at its gauging site are presented together with hydrographs and precipitation data. The aerial photographs were taken 11 March and 21-22 July 1976. The legal description for each watershed refers to the location of the stream gauge. The approximate location of the stream gauge on the oblique photo is indicated by a circle. Definitions of terms used in the descriptions are given on pages 57 through 60.

Since the precipitation data collection and analysis program was discussed in detail in the "Climate" section, no further elaboration on precipitation data collection is required here. The following discussion will deal primarily with the hydrometric data collection program.

The streamflow data were obtained using standard hydrometric gauging procedures, including both instantaneous and continuous methods. Instantaneous measurements were obtained using a current meter, and continuous records were obtained by means of water level recorders and stage-discharge relations. During 1974, 18 stations were equipped with a Leupold-Stevens A-35 water level recorder emplaced in an instrument shelter mounted on a 1.8-m high, 45.7-cm diameter culvert that served as the stilling well. A lesser number of stations were so equipped in other years. Thus, the flow data obtained in this way during 1974 were the most comprehensive set of hydrometric data collected in the area during the period of record.

Permanent stream gauging stations are maintained by Water Survey of Canada (Environment Canada 1974b) on both the major rivers (Fig. 2) and on several smaller streams located in the study area. Flows from five of the watersheds listed on page 56 (watersheds 14, 15, 29, 30, 31) are measured by means of permanent gauging structures and monitored by Water Survey of Canada.

The highest instantaneous flow recorded for any small gauged watershed on the lease area during the 1972-1975 period was 10.28 m^3/s for Wampus Creek (watershed 29) on 25 June 1972. The mean daily flow for Wampus on that day was 6.91 m^3/s. Flows of less than 0.03 m^3/s were recorded for many of the watersheds during dry periods.

The hydrographs shown in this section were machine-plotted from processed data using the Hewlett Packard (HP) 9820A Calculator and the HP 9862A Calculator Plotter. The calculator was programed to produce a plot for any 145-day period and provided for full utilization of the vertical scale (cubic feet per second). This ensured that the same size plotting area would be maintained throughout. The calculator was also programed to provide an equivalent metric scale in cubic metres per second.

The watershed, year, and type of data for each hydrograph are identified by an alpha-numeric expression. The first number identifies the watershed, the second number the year in which data were collected, and the letters C or D indicate respectively whether the data are continuous or discrete. The notation C/D indicates that the plot consists of a mixture of continuous and discrete data.

In general, continuous (C) data are obtained from water level recorders and plotted as mean daily flows. In such cases, the peaks shown are *mean daily flows*, but the *maximum instantaneous flows* are printed above the peak to which the maximum flow contributes. Frequently, this printed value is also the maximum flow for the entire 145-day period. The term discrete (D) is applied to instantaneous measurements that were obtained by measuring the flow with a current meter. In such cases the plotted values are actual instantaneous values rather than mean daily flows.

WATERSHED DESCRIPTIONS

List of watersheds

DEFINITION OF TERMS USED IN WATERSHED DESCRIPTIONS

Drainage: Name of watershed.

Location: Legal description to nearest quarter section.

Area: Size of watershed in square kilometres and square miles.

Aspect: General aspect or exposure of the watershed as a whole. Does not consider individual slopes within the watershed. This aspect corresponds to general flow direction of the stream.

Elevation: Maximum and minimum elevations (msl) of watershed above or at gauging site, given in metres and feet.

Physiography: Terminology taken from thesis by Roed (1968) on the surficial geology of the Hinton-Edson Area. Definitions of Tableland, Benchland, Lowland, etc. are given on page 58.

Vegetation: General identification of forest cover and extent of forest harvesting in watershed at time of data collection.

For several watersheds, the stated amount of forest cover removed does not appear to be supported by the corresponding oblique aerial photograph. This apparent discrepancy is due to age of cut and new forest growth and the low angle at which the photograph was taken.

Old cuts are not as conspicuous on photograhs as new ones because they are masked by new forest or other vegetative growth. The percentage of forest cover removed was determined from planimetric maps (as if viewed vertically). An oblique aerial photo will tend to show less of the cutover areas than actually exists.

Abbreviations: Pl--lodgepole pine, Sw--white spruce, Sb--black spruce, A--aspen.

Soils: Terminology taken from Dumanski *et al.* (1972). Descriptions on page 59.

Infiltration rates obtained from unpublished data provided by Dr. T. Singh, Canadian Forestry Service, Northern Forest Research Centre.

Surficial Deposits: Identified from map of surficial geology of the Hinton-Edson Area, prepared by the Research Council of Alberta (1970). Descriptions of dominant deposits given on page 60.

Bedrock: Obtained from available geology reports and maps (Irish 1965, Currie 1976).

Stream Channel: Measurements obtained in the field and from topographic maps.

Stream gradient: maximum elevation of perennial channel minus outlet elevation divided by stream channel length.
Stream order: a hierarchical ranking system where fingertip tributaries at the head of a stream are designated as first-order streams. Two first-order streams join to form a second-order stream, two second-order streams join to form a third-order stream, and so on.
Perennial channel length: Total length of channel containing flow throughout the year. Determined from planimetric maps.
Stream width-depth: Measurements for an average flow condition taken from current meter notes.

Abbreviations: N/A--Information pertaining to a particular category is not available.

PHYSIOGRAPHIC UNITS
(Roed 1968)

Rocky Mountain Front Ranges

The Rocky Mountain Front Ranges consist of a number of northwesterly trending ranges and valleys composed of a succession of overthrust sheets lying between southwesterly dipping faults. . . . Spectacular cliffs, u-shaped valleys and alpine sculpture characterize the Front Ranges, the high ranges of which are mostly bare of overlying surficial material .

Rocky Mountain Foothills

The Rocky Mountain Foothills lie along the eastern margin of the Front Ranges in a narrow, northwesterly trending belt. The Foothills are underlain by folded and faulted sandstones and shales that are Mesozoic in age. . . . A structurally controlled trellis drainage pattern is developed only in the southern part of the Foothills in the area. In the northern part of the area, in the vicinity of Entrance, drainage bears very little relation to known structural grain. . . . Another striking feature of the Foothills in the area is the presence of several poorly defined terraces. . . .

Tablelands

The term tablelands has been applied by Bayrock (in Lindsay *et al.*,1960, p. 38) in Alberta to highlands which have relatively steep-sided slopes and flat tops. . . . Relative relief between lowlands and tablelands is generally from 1,000 to 2,000 feet [300-600 m] in the area. . . . All parts of the tablelands in the area have been affected by glaciation. Thick drift deposits, meltwater channels, and other glacial features have only slightly modified the tablelands. Boundaries outlining various tablelands are not drawn along topographic contours; instead they are drawn so as to outline major landforms that have a similar form characterized by similar geologic features.

Benchlands

Benchlands are defined generally as areas between a tableland and a lowland and are characterized by remnant isolated terraces. . . . In the present area benchlands form a dominant feature of the physiography. Two or three distinct benches or ill-defined terrace levels can be detected in most benchlands. . . . No gravel has been found on benchland terraces.

Lowlands

The only lowland outlined in the Edson-Hinton area is the Edson Lowland, which is characterized by low relief and occupies a low area relative to benchlands and tablelands. The lowland is underlain by deposits composed of gravel, till and glaciolacustrine sediments which rest on a bedrock surface of low relief. . . .

DESCRIPTION OF SOIL ASSOCIATIONS
(from map by Dumanski *et al.* 1972)

Mayberne--developed on till; medium-textured, dark yellowish brown till of Continental origin, weakly calcareous; topography varies from undulating to strongly rolling; found at elevations generally exceeding 1000 m, usually exceedingly cobbly.

Marlboro--developed on till; medium-textured, yellowish brown to light olive brown till of Cordilleran origin; moderately to weakly calcareous; topography varies from undulating to hilly.

Obed--developed on till; medium- to coarse-textured, olive brown to grayish brown till of Cordilleran origin; moderately to strongly calcareous; topography varies from undulating to strongly rolling; generally exceedingly cobbly.

Robb--developed on till; medium-textured, grayish brown to olive brown till of Cordilleran origin mixed with colluvial materials; variable lime content; topography varies from gently rolling to hilly.

Tri-Creek--soil developed on lacustrine materials; fine- to medium-textured, olive brown to very dark grayish brown material; moderately to weakly calcareous; topography varies from undulating to strongly rolling; generally found as eroded lacustrine terrace deposits bordering drainage channels.

Blackmud--developed on water-laid, sandy materials; coarse-textured, olive brown to grayish brown sand to sandy loam; moderately to weakly calcareous; topography varies from undulating to moderately rolling; sandy deposit is greater than 50 cm thick and contains isolated, well rounded pebbles; some areas may be re-sorted by wind.

Lodge--developed on thin, superimposed deposits overlying till or lacustrine materials; overlay (sand or silt) less than 50 cm thick; topography varies from undulating to moderately rolling; the underlying material is usually till but may also be lacustrine material.

Jarvis--developed on gravelly materials; coarse-textured, yellowish brown to olive brown gravels and sands; weakly to moderately calcareous; topography varies from undulating to strongly rolling; material is generally exceedingly cobbly.

Summit--developed on preglacial materials; coarse-textured olive brown sands and gravels; weakly to noncalcareous; topography varies from gently undulating to moderately rolling; material is exceedingly cobbly; found only on elevated plateaus or tablelands.

Maskuta--developed on preglacial materials; medium- to fine-textured light olive brown to yellowish brown material derived from the weathering of shales, sandstones, and/or conglomerates; lime content is locally variable; topography varies from gently rolling to very hilly; material is sometimes stony.

Erith--soils strongly affected by poor internal drainage; generally peaty but peat accumulation is less than 60 cm; found in depressional areas and on lower sideslope positions.

Fickle--organic soils; peat accumulation exceeds 60 cm; found in depressional areas and occasionally on lower sideslope positions.

Alluvium (AV)--soils found on floodplains of major rivers and streams; exceedingly variable in texture, color, and morphology.

River Bank (RB)--strongly eroded, continuous landforms formed by recent or historical river erosion.

TILL DESCRIPTIONS
(Roed 1968)

Obed

Average thickness of this till is 4.9 m; maximum observed thickness is 44.2 m.

Lithology is uniform--very stony, pebbles with mode of 3.8 cm; boulders up to 0.9 m in diameter. Pebbles composed of limestone, orthoquartzite, feldspathic orthoquartzite.

Textural classification of the till is mainly clay loam, but categories of loam and sandy loam also occur.

Carbonate content ranges from 18 to 30% with mean of 20 for seven samples.

Landforms associated with Obed till include drumlins, flutings, grooves, lateral moraine, lobate end moraine, and "circles".

Marlboro

Most widespread till in the area. Ranges in thickness from 0.3 m on the uplands to over 30 m in buried valleys, but the most common thickness is about 3 m.

Lithology of till shows wide range throughout the area. Moderately stony, containing pebbles with a mode of 2.5 cm diameter; cobbles up to 15 cm in diameter are present.

Texturally the till is classified as clay but has categories of clay loam, loam, and sandy loam.

Carbonate content average 13%.

Landforms associated with the Marlboro till include lobate end moraines, intersecting till ridges, grooves, drumlins, and flutings.

Mayberne

Average thickness of till on Mayberne tableland is less than 1.5 m. Ranges in thickness from 0 to 6 m.

Lithology--moderately stony to very stony with a pebble mode of 3.8 cm diameter, but the till contains boulders up to 1.8 m across.

Texturally classified as a loam and clay loam.

Carbonate content is very low, the average being 2% for three samples.

Landforms associated with the Mayberne till are mainly ground moraines. Some crescent-shaped end moraines form narrow ridges 3-4.5 m high and are up to 15 m wide at their bases.

WATERSHED NO. 1

Drainage: Vogel Creek

Location: Section NE 25, Twp. 55, Range 04, W6M

Area: 11.1 km^2 (4.3 mi^2) **Aspect:** SE

Elevation: Max. 1646 m (5400 ft); Min. 1478 m (4850 ft)

Physiography: Rocky Mountain Foothills and Berland Tableland.

Vegetation: Pl, Sw, Sb, shrub meadow near stream channel.

Soils:

Associations: N/A

Infiltration (cm/h): N/A

Surficial Deposits: N/A

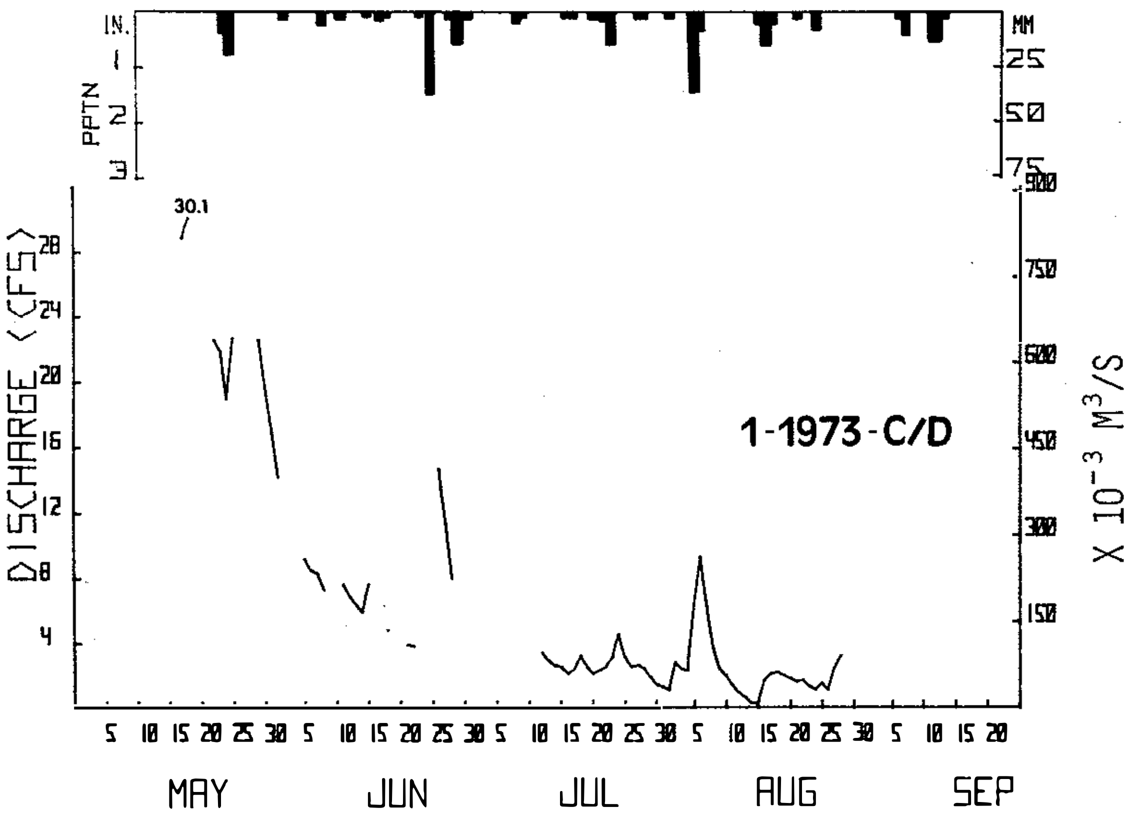
Bedrock: LATE UPPER CRETACEOUS AND TERTIARY.
Paleocene and Brazeau Fm undivided: sandstone, shale, conglomerate, and coal seams.

Stream Channel:

Gradient: 1%; *Order:* 2

Perennial channel length: 7.6 km (4.7 mi)

Stream width-depth: 2.0 by 0.5 m (6.5 by 1.5 ft)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PPTN
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DISCHARGE (CFS)
X 10^{-3} M^3/S
1-1973-C/D
MAY
JUN
JUL
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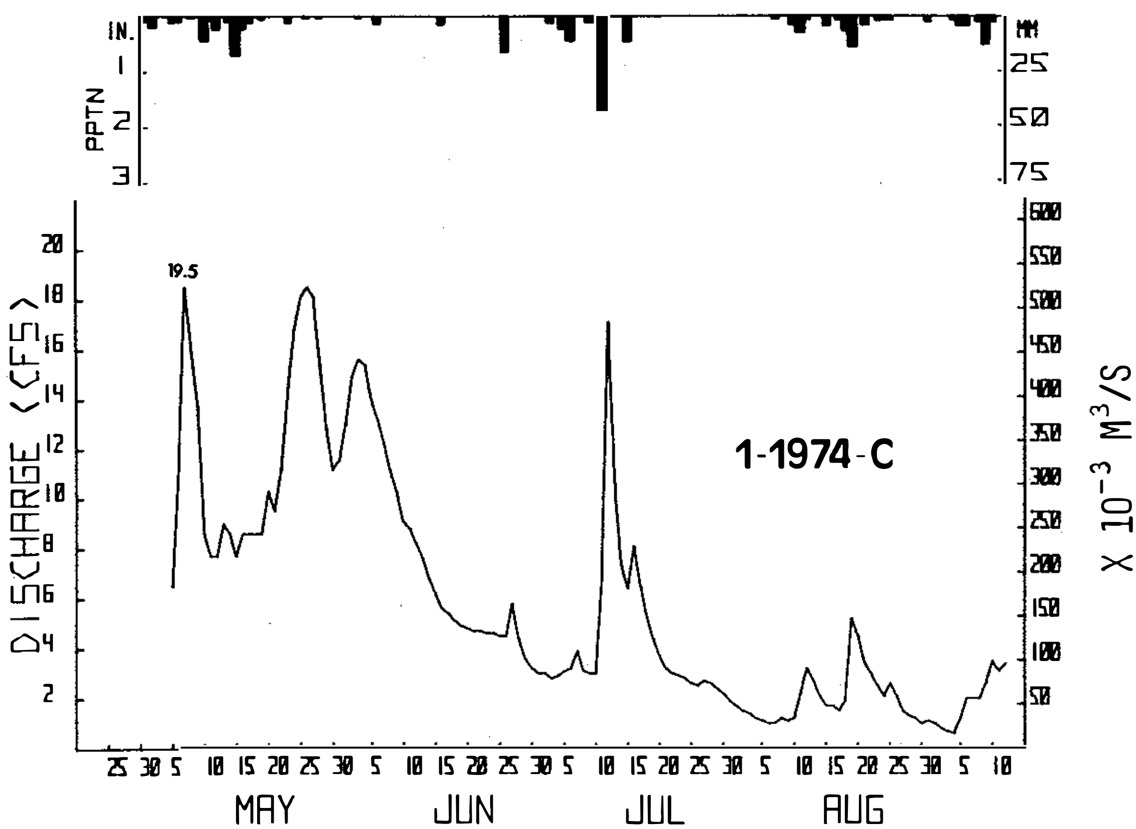
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MM
19.5
DISCHARGE (CFS)
X 10^{-3} M^3/S
1-1974-C
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WATERSHED NO. 2

Drainage: Hendrickson Creek

Location: Section SW 27, Twp. 55, Range 03, W6M

Area: 22.0 km^2 (8.5 mi^2) **Aspect:** SE

Elevation: Max. 1615 m (5300 ft); Min. 1417 m (4650 ft)

Physiography: Rocky Mountain Foothills and Berland Tableland.

Vegetation: Pl, Sw, Sb, shrub meadow near stream channel.

Soils:

Associations: N/A

Infiltration (cm/h): N/A

Surficial Deposits: N/A

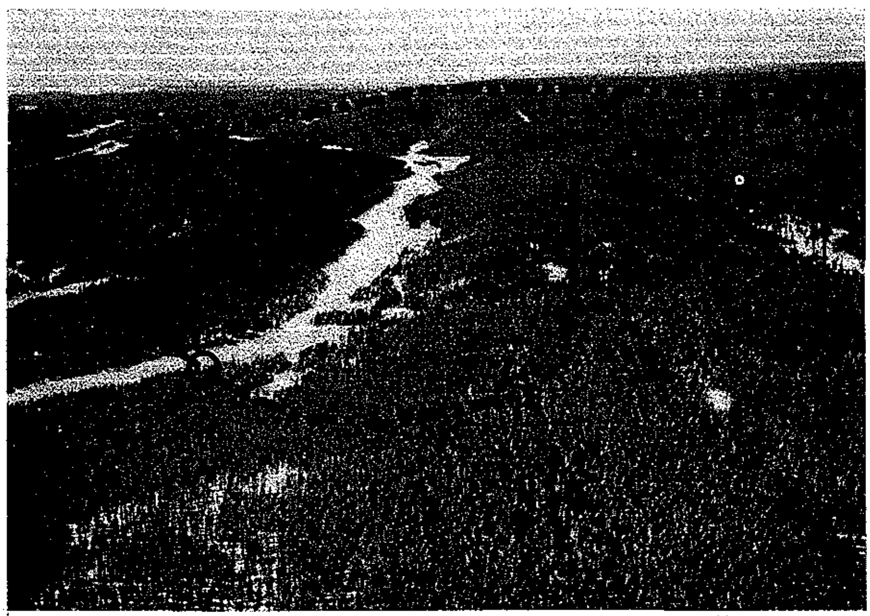
Bedrock: LATE UPPER CRETACEOUS AND TERTIARY. Paleocene and Brazeau Fm undivided: sandstone, shale, conglomerate, and coal seams.

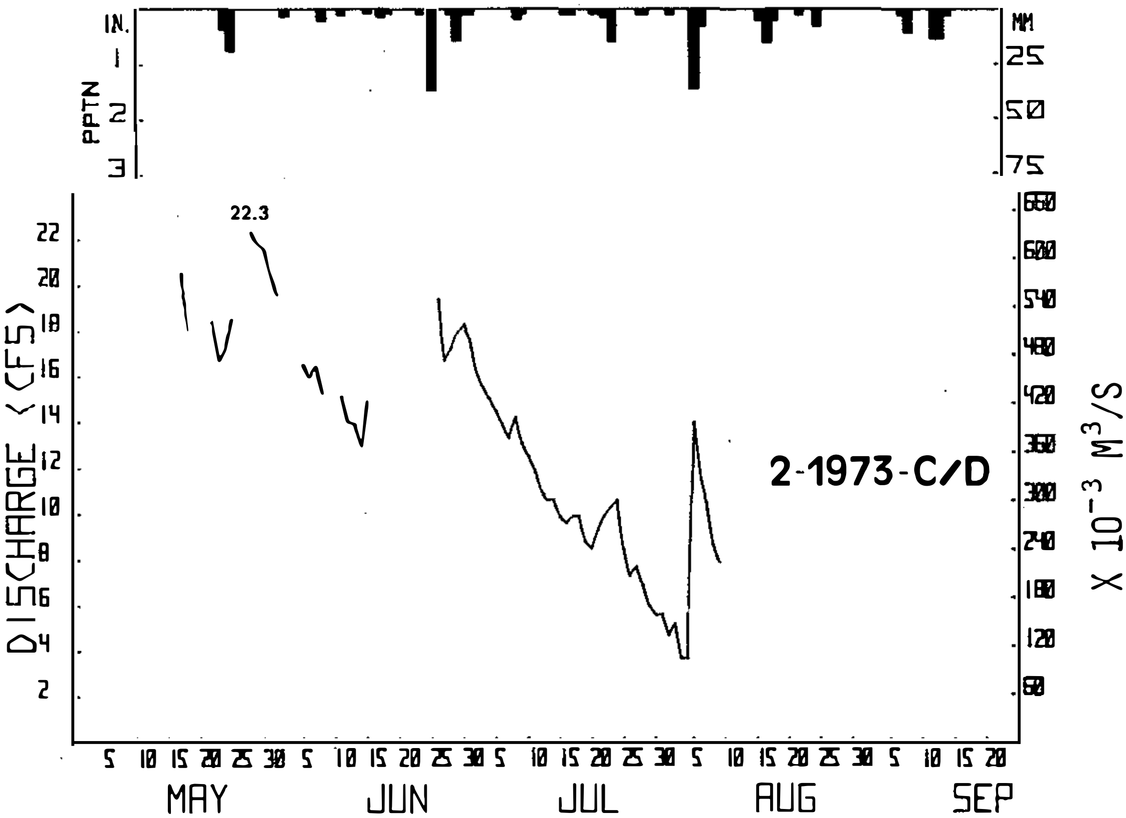
Stream Channel:

Gradient: 1%; *Order:* 3

Perennial channel length: 14.6 km (9.1 mi)

Stream width-depth: 2.9 by 0.3 m (9.5 by 1.0 ft)

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DISCHARGE (CFS)
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180
240
300
360
420
480
540
600
660
X 10^{-3} M^3/S
2-1973-C/D
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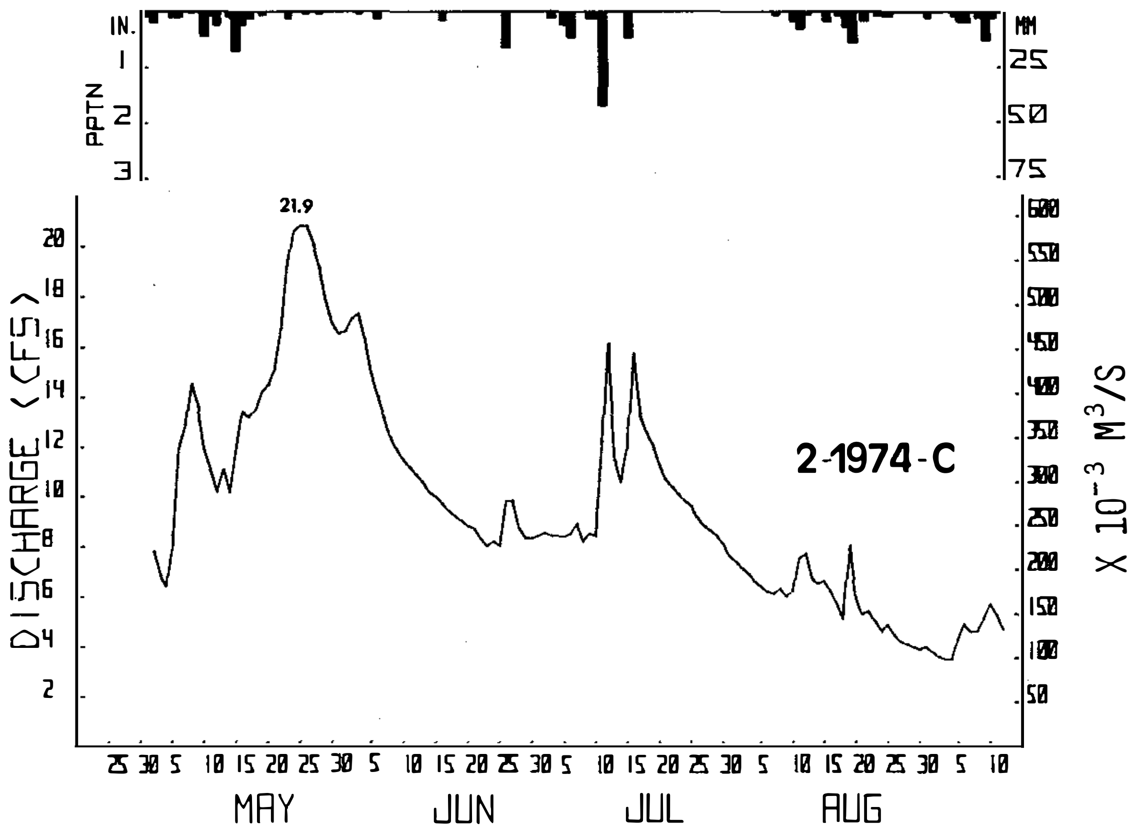
MAY
JUN
JUL
AUG
SEP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PPTN
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DISCHARGE (CFS)
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600
X 10^{-3} M^3/S
2-1974-C
25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10
MAY
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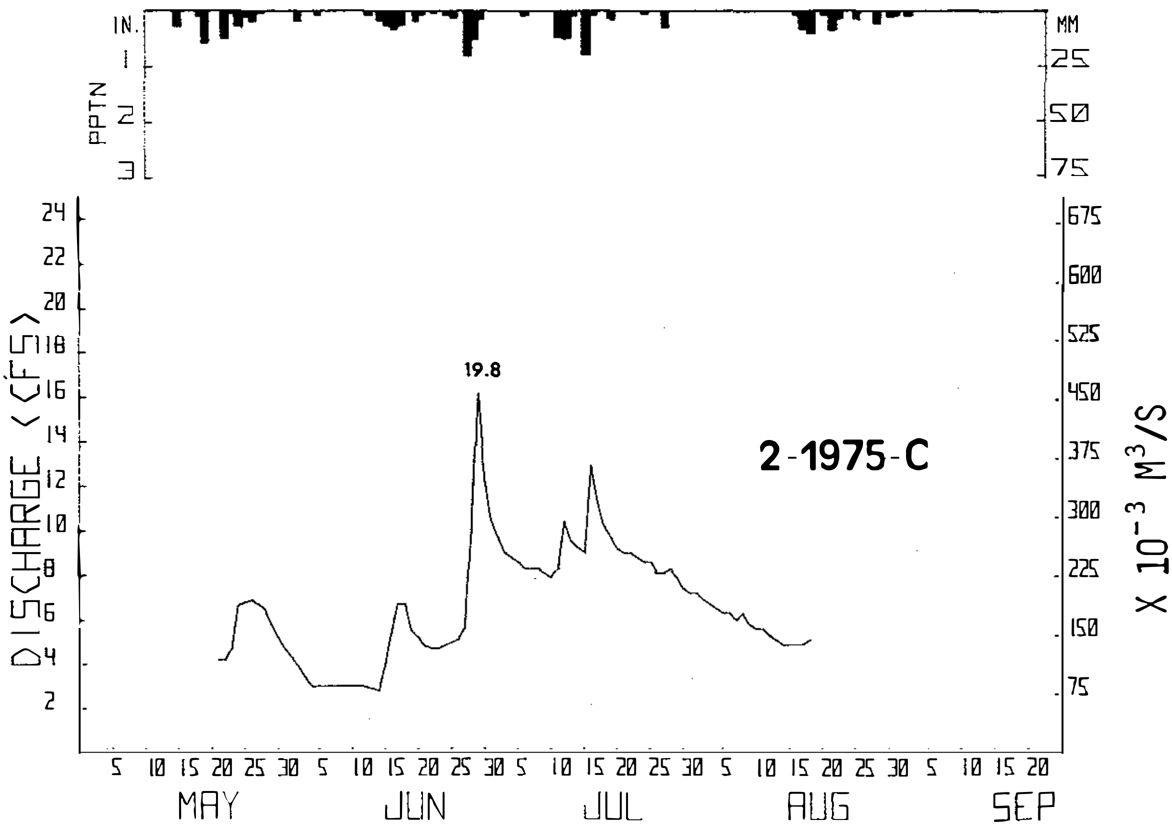
JUL
AUG



IN.
PPTN
MM
DISCHARGE (CFS)
X 10^-3 M^3/S
19.8
2-1975-C
MAY
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WATERSHED NO. 3

Drainage: Cabin Creek

Location: Section SW 22, Twp. 55, Range 03, W6M

Area: 12.7 km^2 (4.9 mi^2) **Aspect:** NE

Elevation: Max. 1768 m (5800 ft); Min. 1402 m (4600 ft)

Physiography: Rocky Mountain Foothills and Berland Tableland.

Vegetation: Pl. Shrub meadow near stream channel.

Soils:

Associations: N/A

Infiltration (cm/h): N/A

Surficial Deposits: N/A

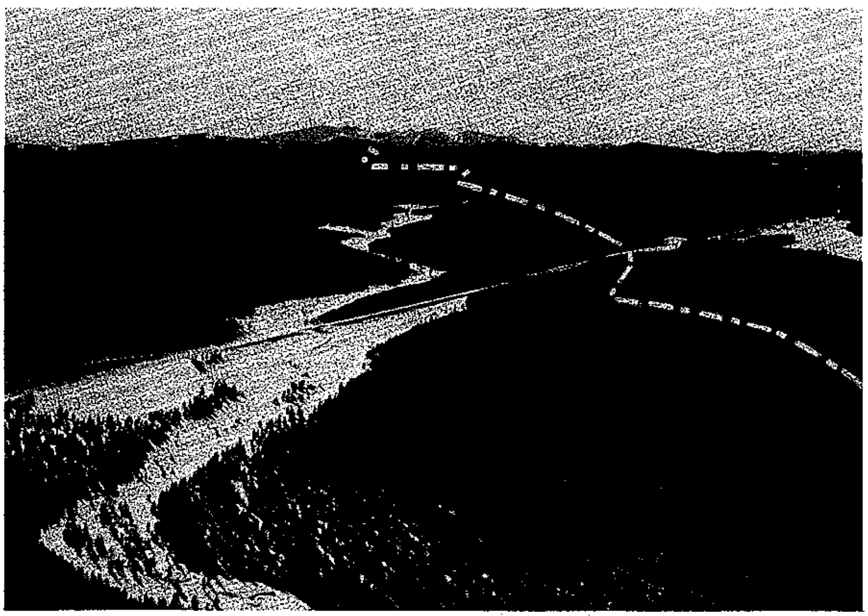
Bedrock: LATE UPPER CRETACEOUS AND TERTIARY.
Paleocene and Brazeau Fm undivided: sandstone, shale, conglomerate.
Wildhay Fault and anticline near SW boundary of watershed.

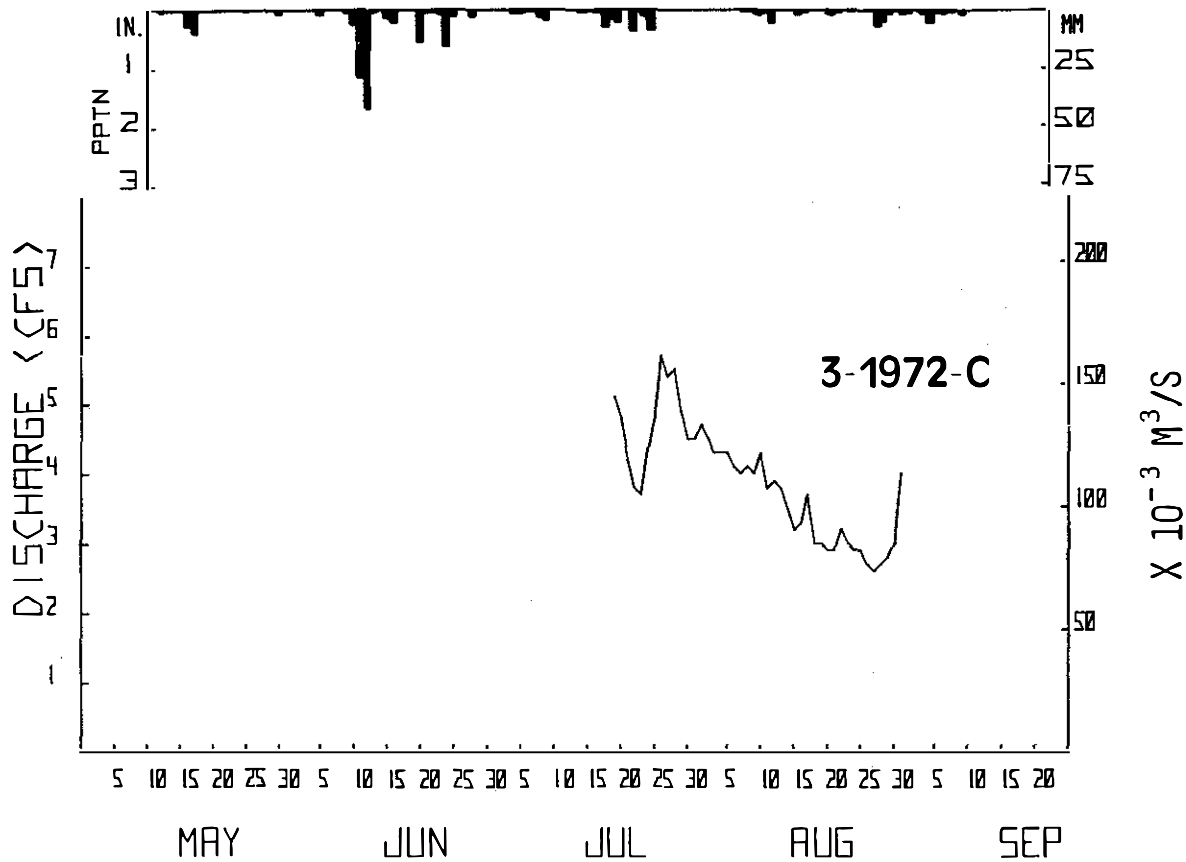
Stream Channel:

Gradient: 2%; *Order:* 3

Perennial channel length: 5.1 km (3.2 mi)

Stream width-depth: 3.5 by 0.3 m (11.5 by 1.0 ft)

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DISCHARGE (CFS)
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150
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3-1972-C
X 10^{-3} M^3/S
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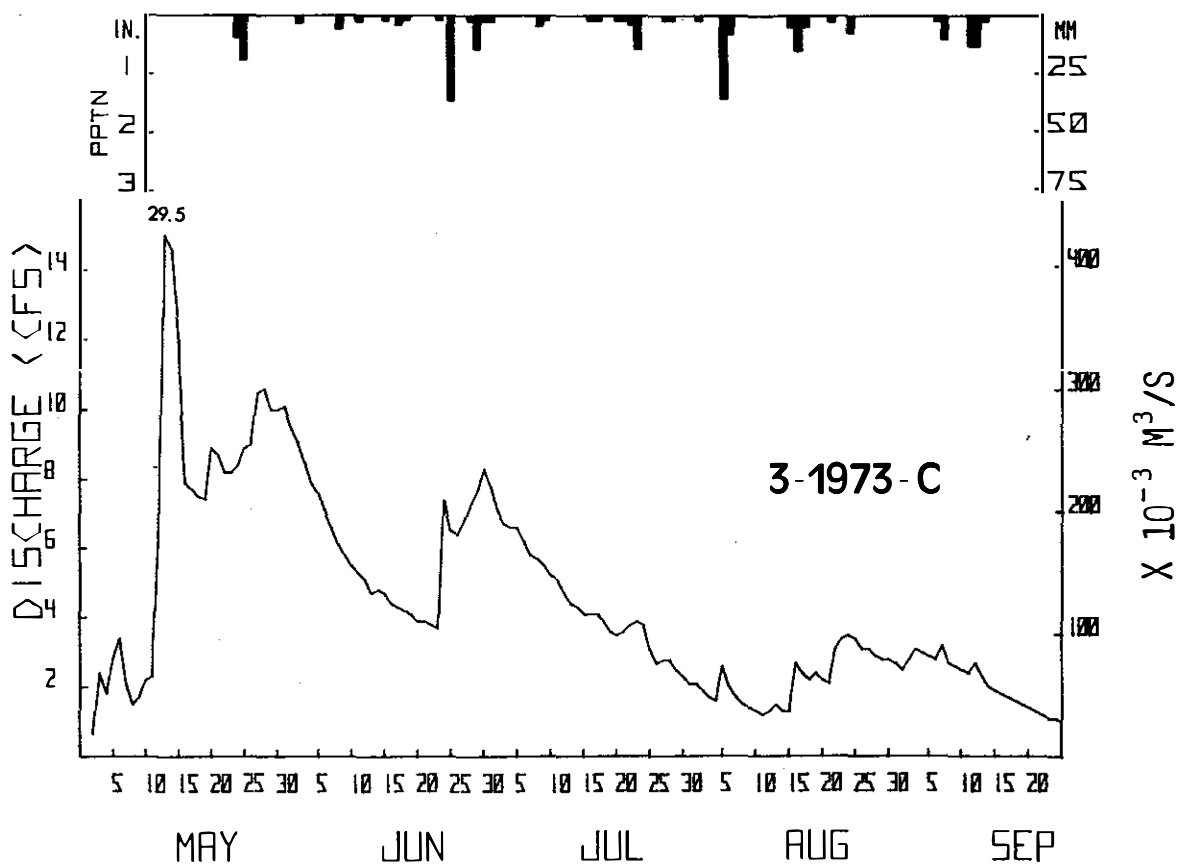
MAY
JUN
JUL
AUG
SEP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PPTN
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29.5
DISCHARGE (CFS)
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14
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200
100
3-1973-C
X 10^{-3} M^3/S
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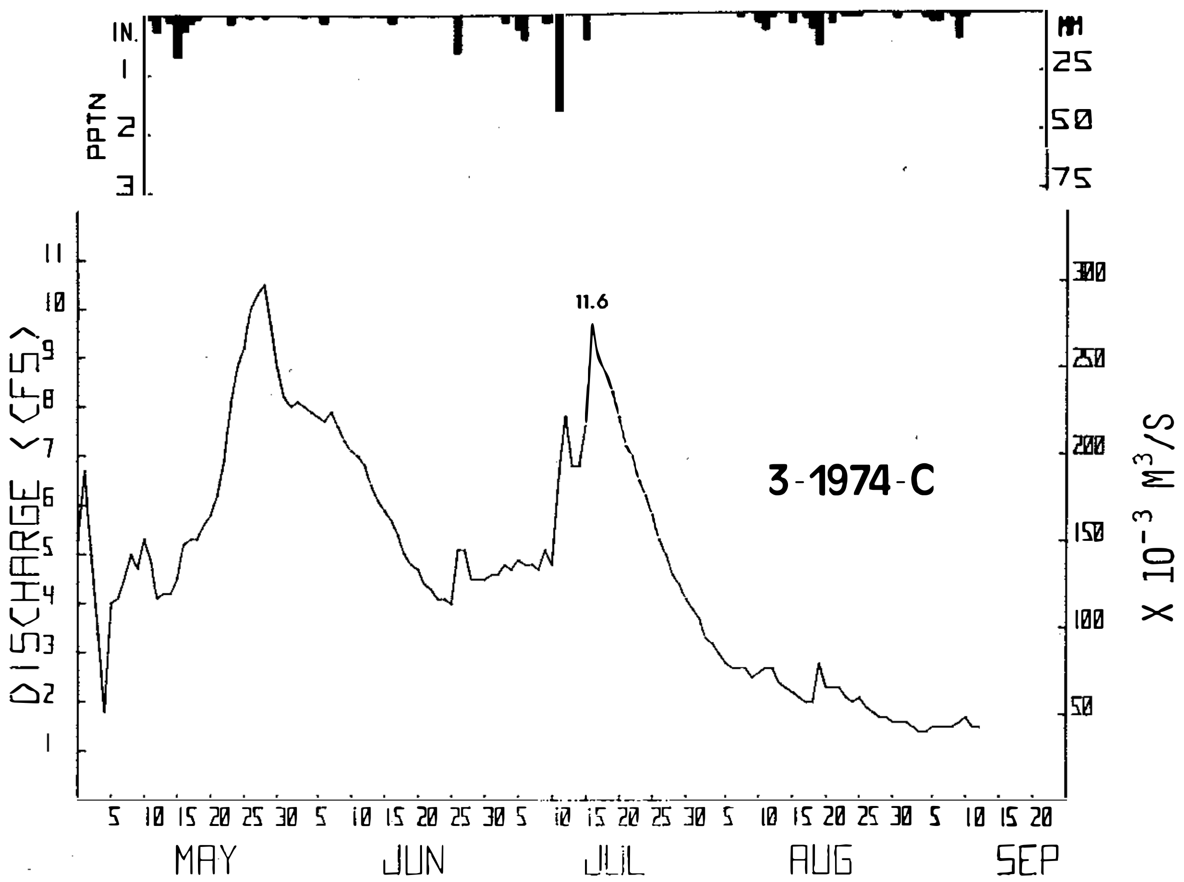
MAY
JUN
JUL
AUG
SEP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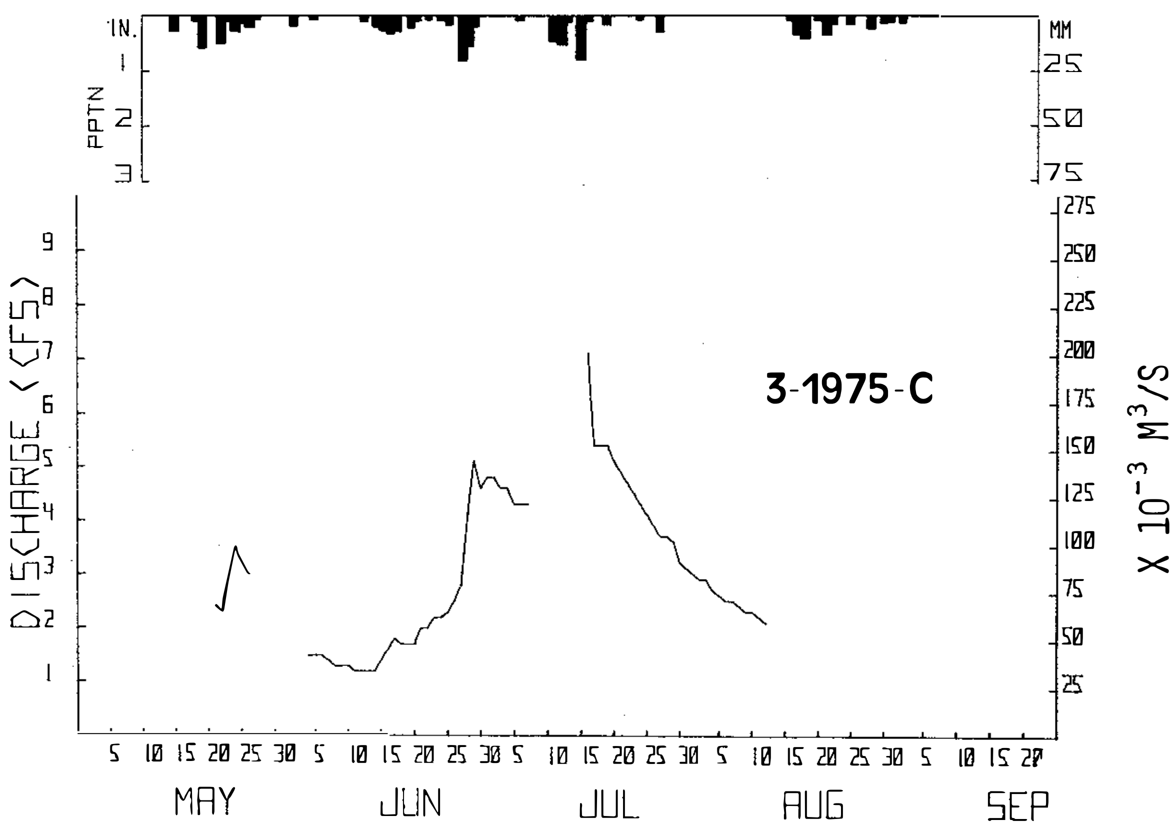
DISCHARGE (CFS)
X 10^-3 M^3/S
11.6
3-1974-C
MAY
JUN
JUL
AUG
SEP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IN.
MM
DISCHARGE (CFS)
X 10^-3 M^3/S
3-1975-C
MAY
JUN
JUL
AUG
SEP

WATERSHED NO. 4

Drainage: Fox Creek—1

Location: Section SE 31, Twp. 54, Range 02, W6M

Area: 12.2 km^2 (4.7 mi^2) **Aspect:** NE

Elevation: Max. 1737 m (5700 ft); Min. 1372 m (4500 ft)

Physiography: Rocky Mountain Foothills and Berland Tableland.

Vegetation: Pl, Sw. 61% of forest cover removed as of December, 1974. Shrub meadow near stream channel.

Soils:

Associations: N/A

Infiltration (cm/h): N/A

Surficial Deposits: N/A

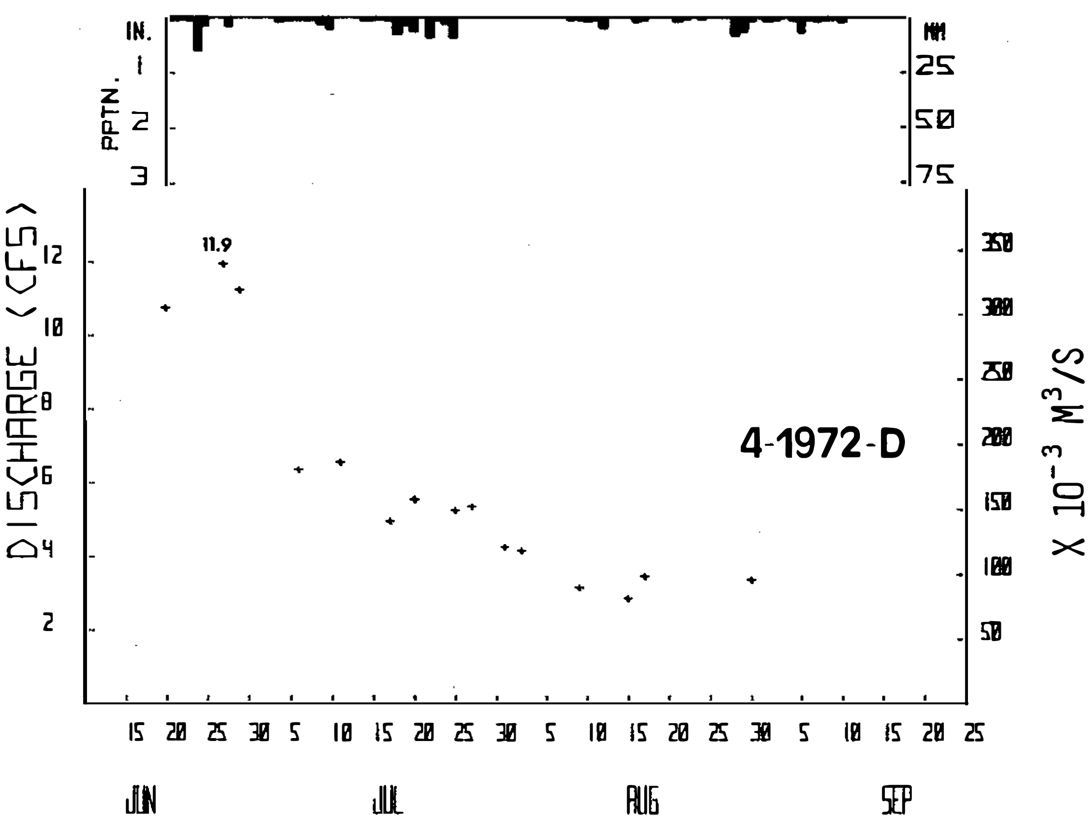
Bedrock: LATE UPPER CRETACEOUS AND TERTIARY.
Paleocene and Brazeau Fm undivided. Wildhay Fault near SW boundary.
UPPER CRETACEOUS. Wapiabi Fm: shale, sandy shale, minor sandstone.

Stream Channel:

Gradient: 3%; *Order:* 3

Perennial channel length: 4.0 km (2.5 mi)

Stream width-depth: 2.1 by 0.2 m (7 by 0.7 ft)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MM
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X 10^{-3} M^3/S
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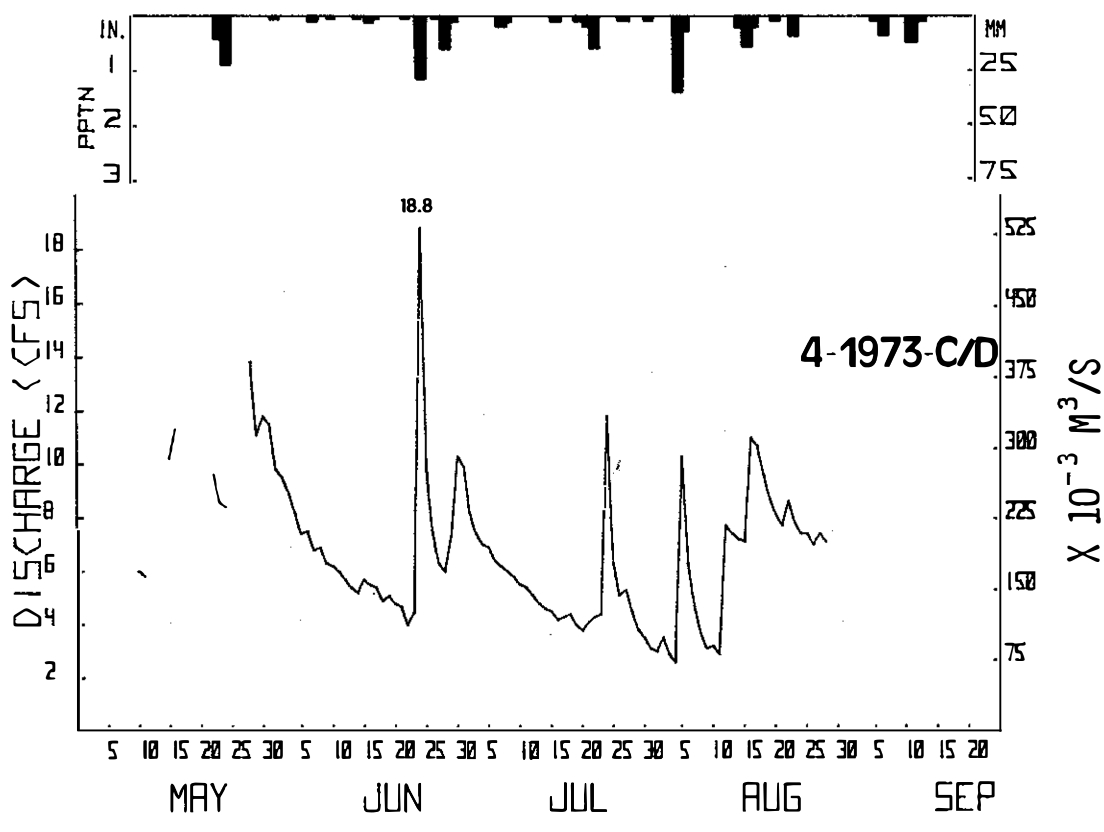
4-1972-D
JUN
JUL
AUG
SEP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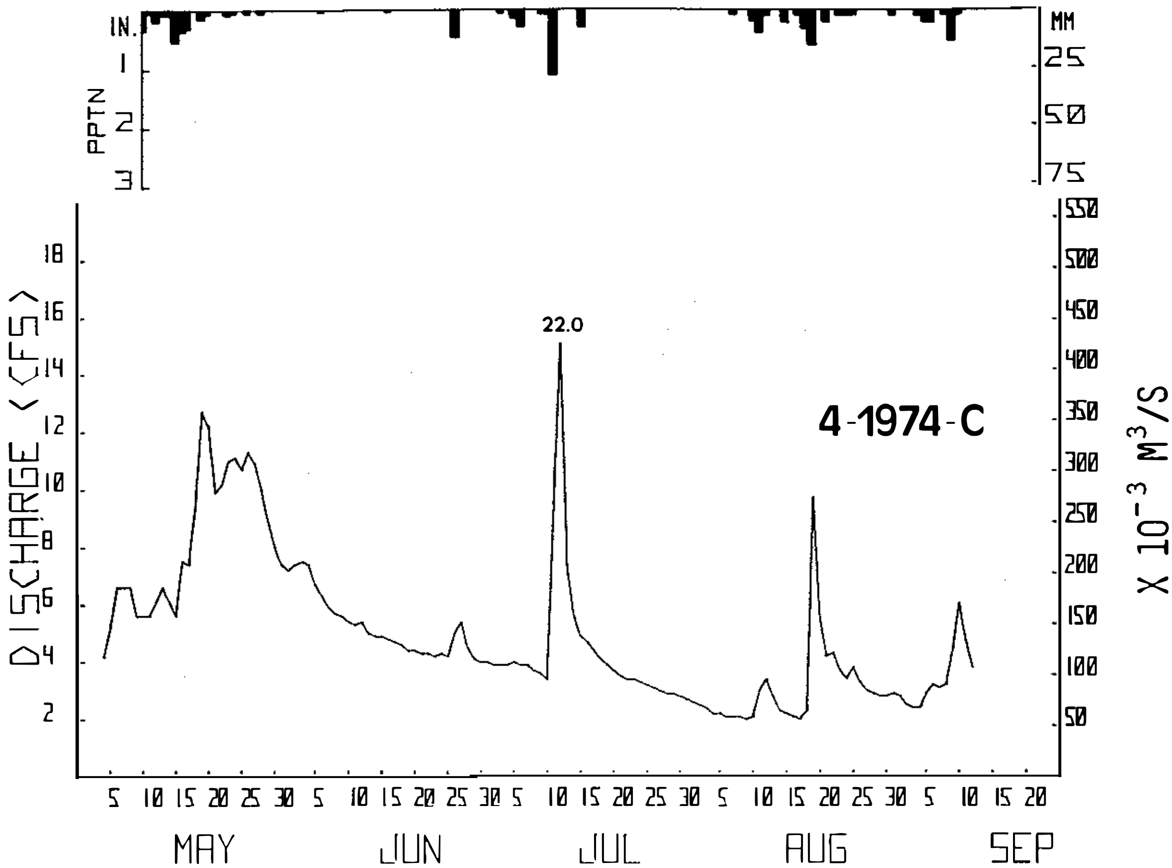
4-1973-C/D
MAY
JUN
JUL
AUG
SEP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DISCHARGE (CFS)
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4-1974-C
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100
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250
300
350
400
450
500
550
X 10^{-3} M^3/S
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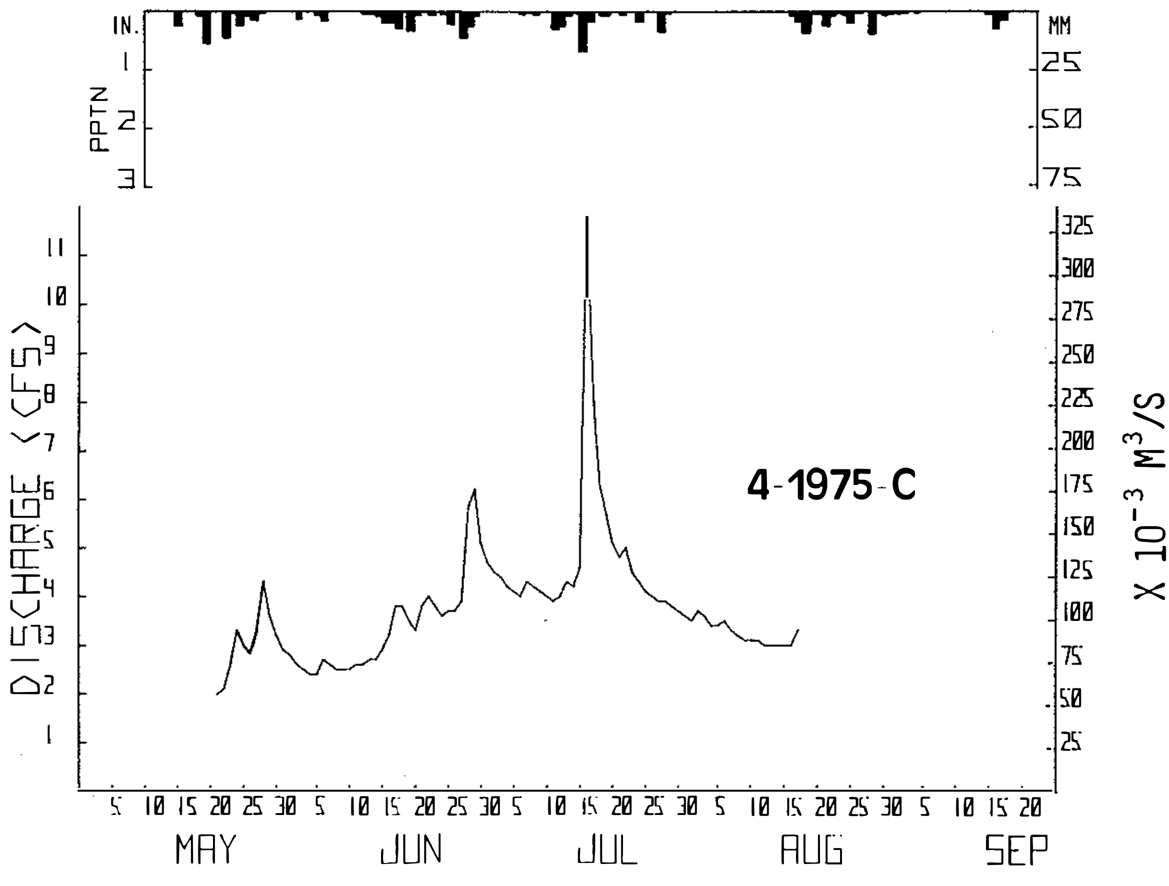
MAY
JUN
JUL
AUG
SEP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PPTN
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25
50
75
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125
150
175
200
225
250
275
300
325
X 10^{-3} M^3/S
5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20
MAY
JUN
JUL
AUG
SEP

WATERSHED NO. 5

Drainage: Fox Creek—2

Location: Section SW 05, Twp. 55, Range 02, W6M

Area: 18.1 km^2 (7.0 mi^2) **Aspect:** SE

Elevation: Max. 1524 m (5000 ft); Min. 1372 m (4500 ft)

Physiography: Rocky Mountain Foothills and Berland Tableland.

Vegetation: Pl, Sw. 60% of forest cover removed as of December, 1974. Shrub meadow near stream channel.

Soils:

Associations: N/A

Infiltration (cm/h): N/A

Surficial Deposits: N/A

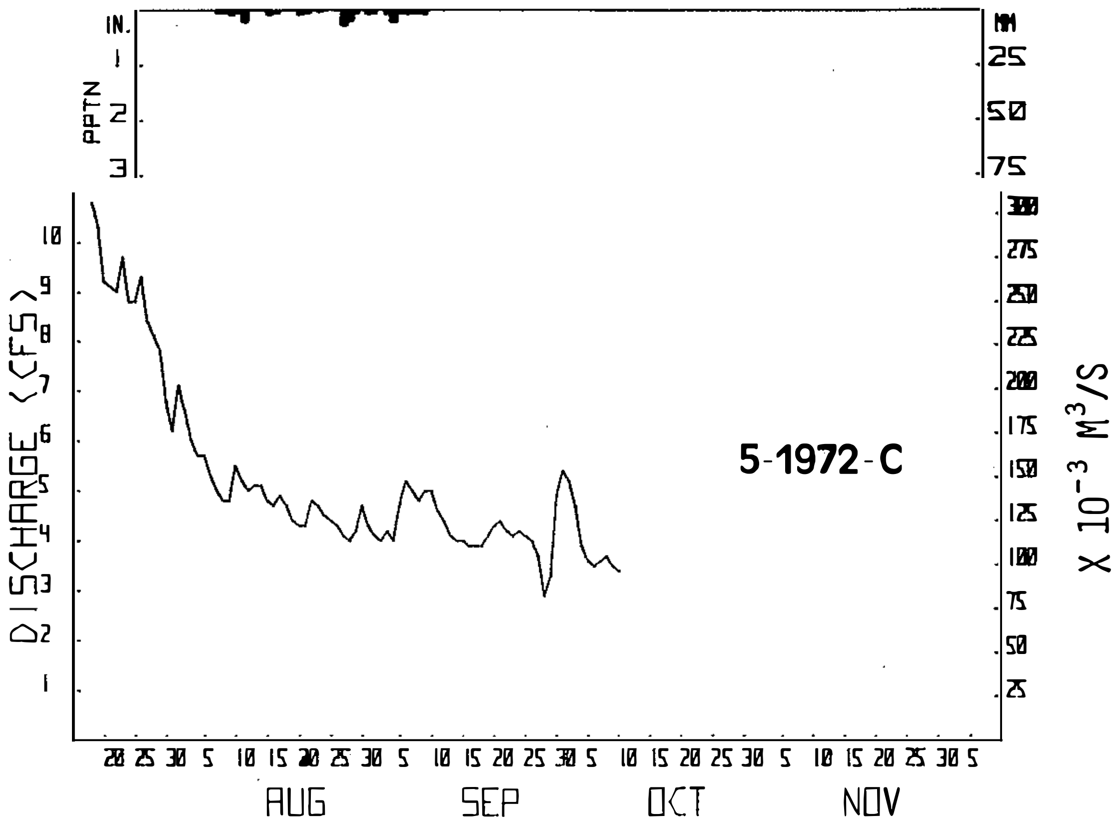
Bedrock: LATE UPPER CRETACEOUS AND TERTIARY. Paleocene and Brazeau Fm undivided: sandstone, shale, conglomerate, and coal seams.

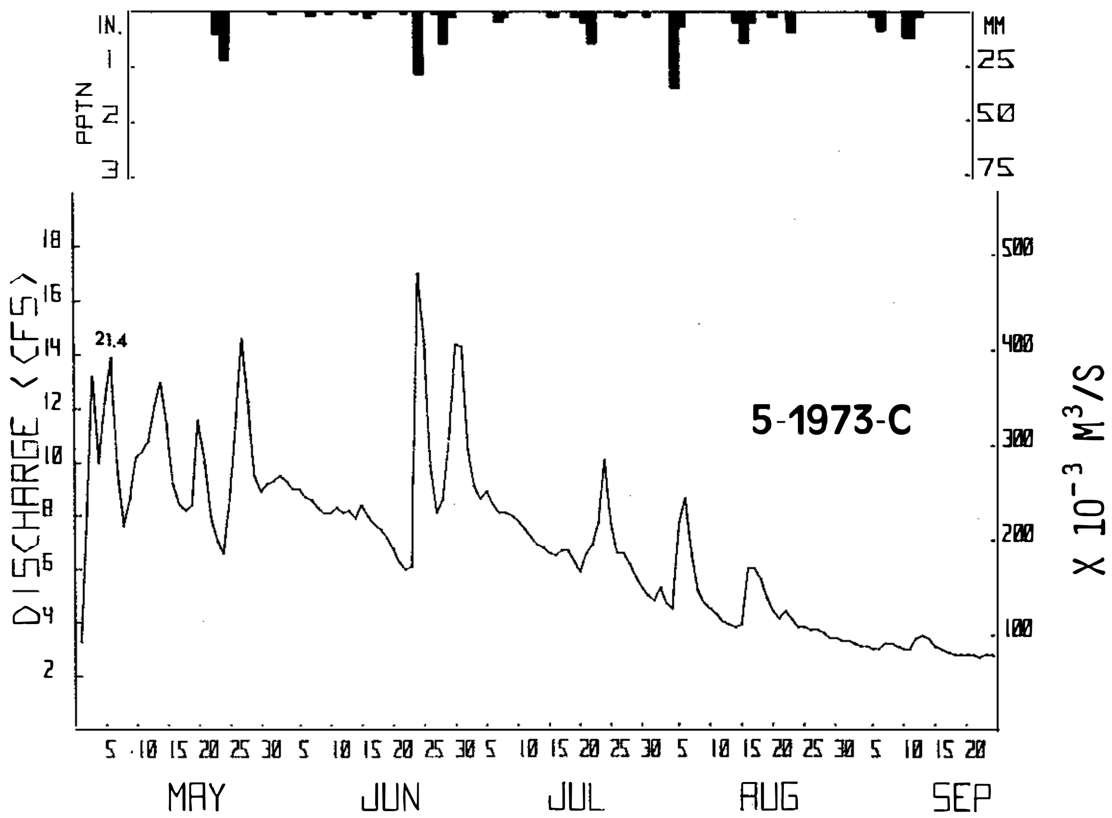
Stream Channel:

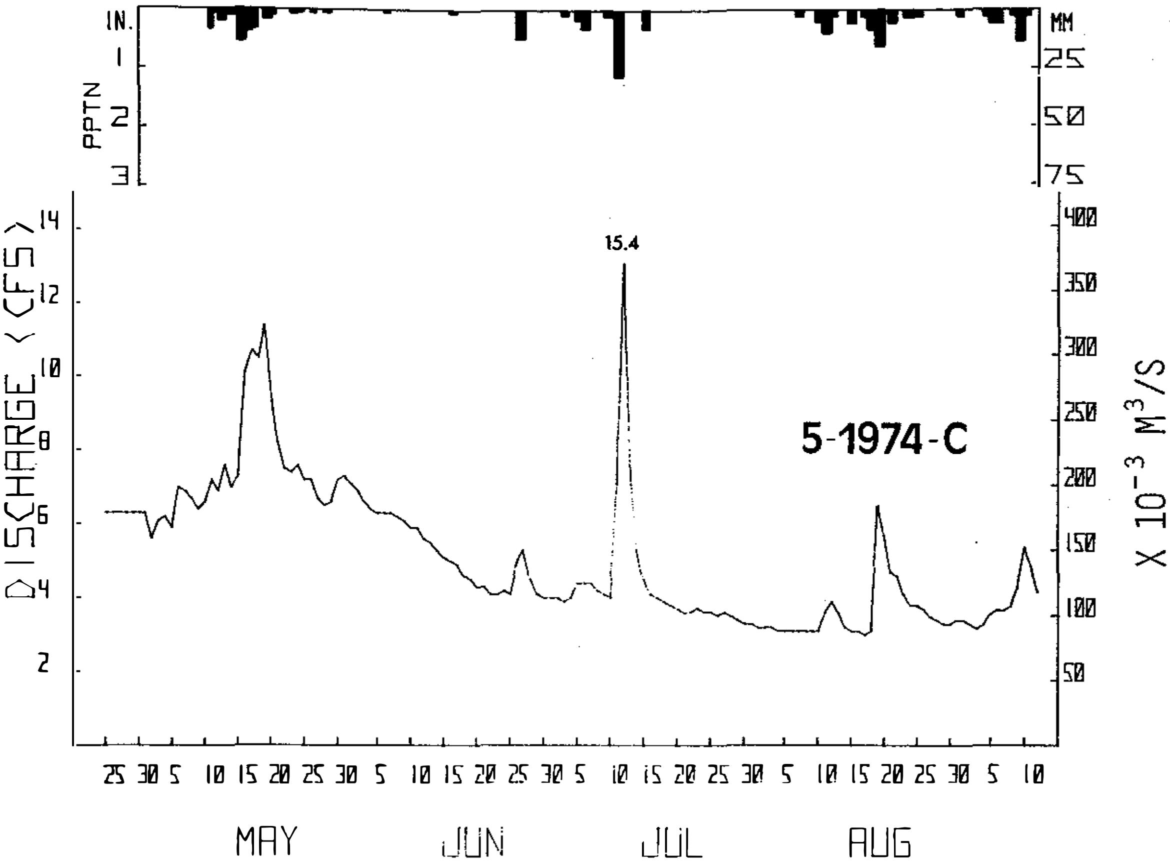
Gradient: 1%; *Order:* 3

Perennial channel length: 7.6 km (4.7 mi)

Stream width-depth: 1.8 by 0.2 m (6.0 by 0.7 ft)


IN.
PPTN
MM
DISCHARGE (CFS)
X 10^-3 M^3/S
5-1972-C
AUG
SEP
OCT
NOV


IN.
PPTN
MM
DISCHARGE (CFS)
21.4
X 10^-3 M^3/S
5-1973-C
MAY
JUN
JUL
AUG
SEP


IN.
1
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PPTN
MM
25
50
75
DISCHARGE (CFS)
14
12
10
8
6
4
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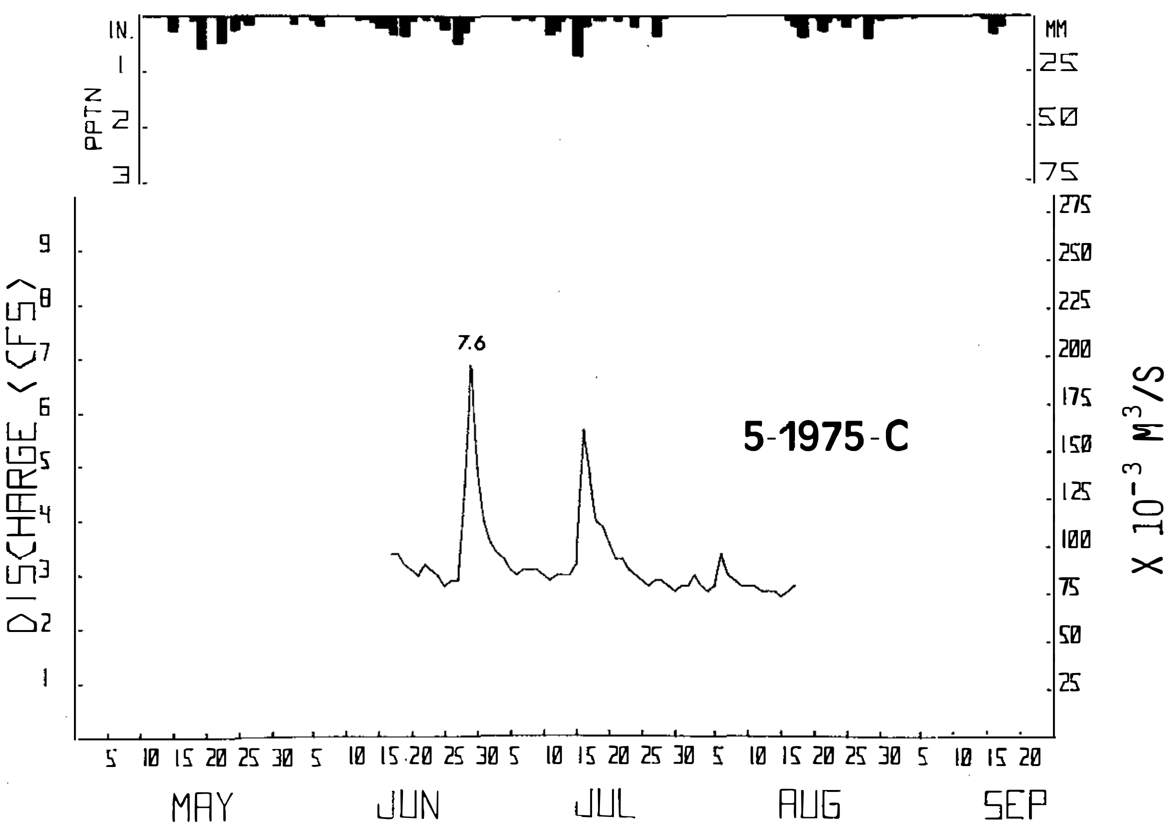
350
300
250
200
150
100
50
X 10^{-3} M^3/S
15.4
5-1974-C
25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10
MAY
JUN
JUL
AUG


IN.
1
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PPTN
MM
25
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75
DISCHARGE (CFS)
9
8
7
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5
4
3
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1
275
250
225
200
175
150
125
100
75
50
25
X 10^{-3} M^3/S
7.6
5-1975-C
5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20
MAY
JUN
JUL
AUG
SEP

WATERSHED NO. 6

Drainage: Oldman Creek—1

Location: Section NW 30, Twp. 52, Range 25, W5M

Area: 16.3 km^2 (6.3 mi^2) **Aspect:** NE

Elevation: Max. 1524 m (5000 ft); Min. 1448 m (4750 ft)

Physiography: Athabasca Tableland.

Vegetation: Sw. 93% of forest cover removed as of December, 1974.

Soils:

Associations:	Marlboro	Fickle
Infiltration (cm/h):	4 to 5	0.5

Surficial Deposits: Marlboro Till with till ridges. Organic deposits (peat) near stream channel. Cordilleran erratics near southern boundary.

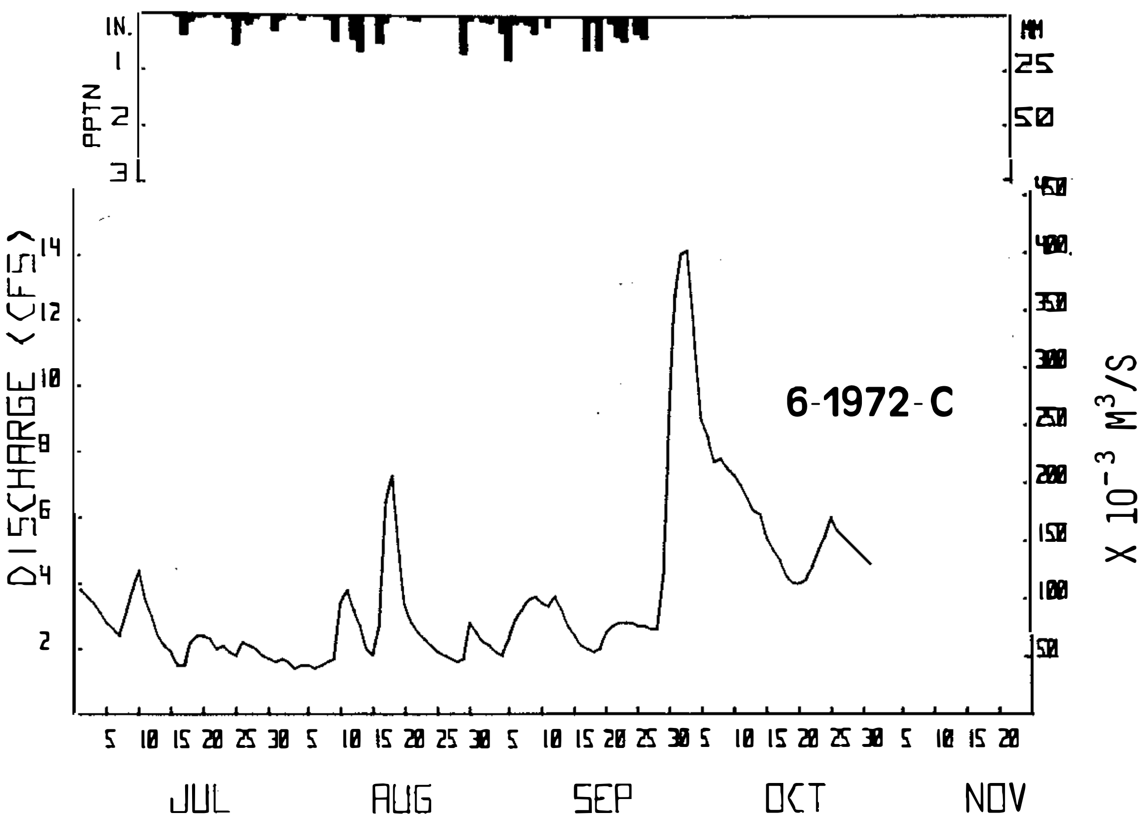
Bedrock: TERTIARY
Paleocene: sandstone, shale, minor conglomerate, and coal seams.

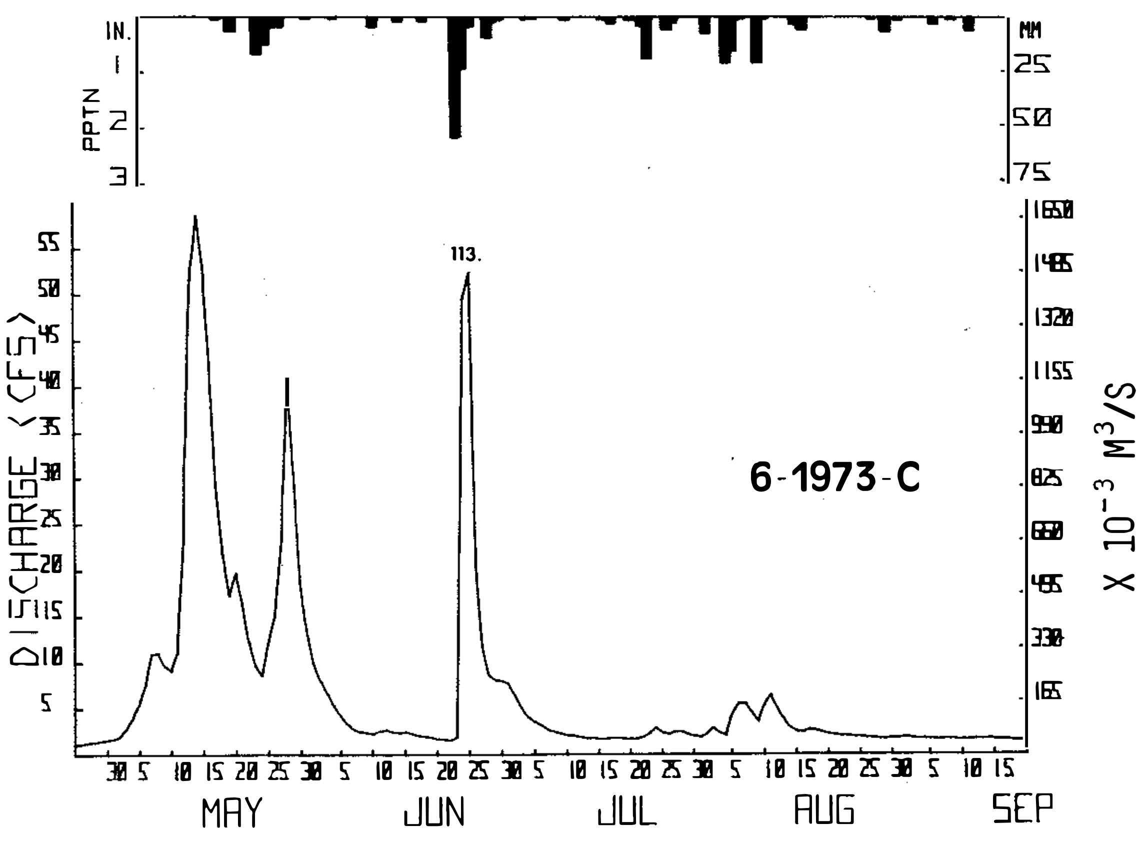
Stream Channel:

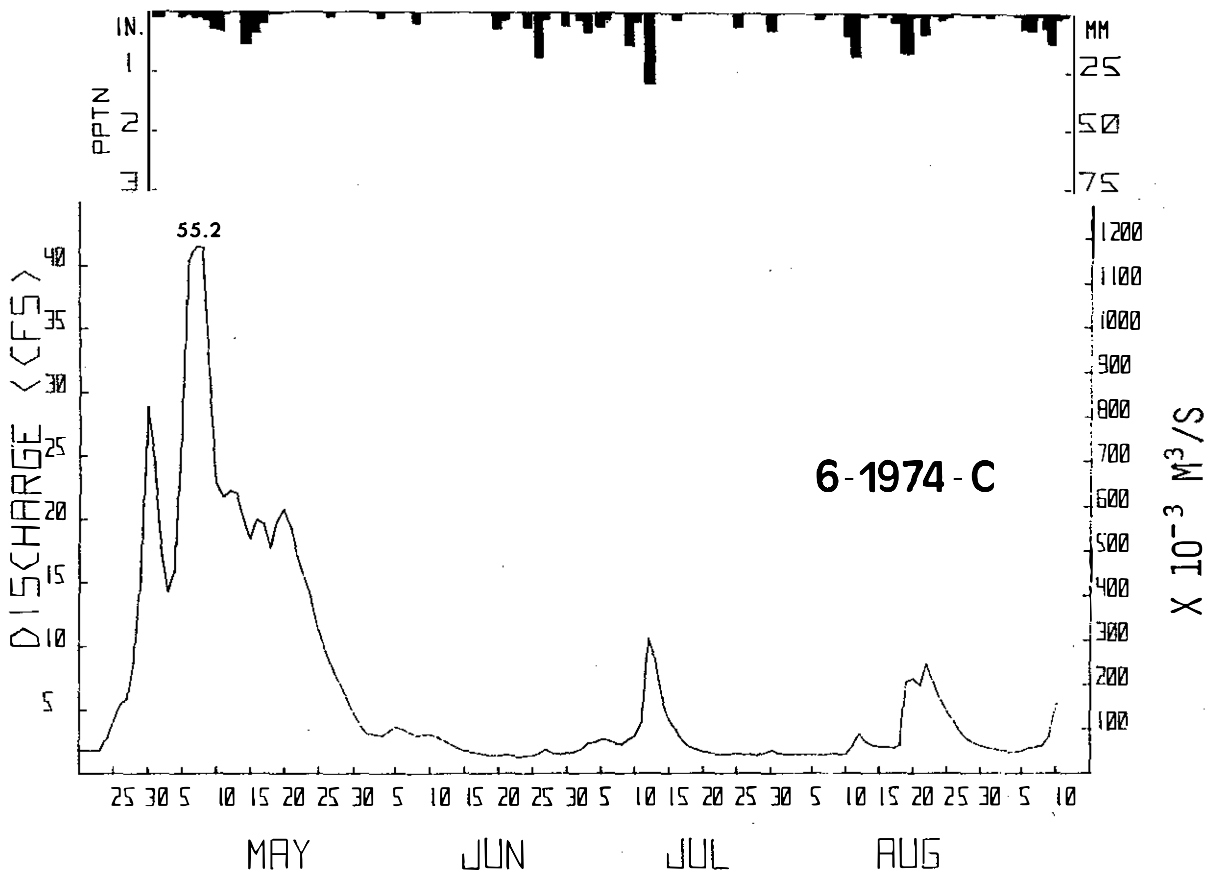
Gradient: 2%; *Order:* 3

Perennial channel length: 3.2 km (2.0 mi)

Stream width-depth: 1.8 by 0.2 m (6.0 by 0.8 ft)


IN.
PPTN
MM
DISCHARGE (CFS)
X 10^{-3} M^3/S
6-1972-C
JUL
AUG
SEP
OCT
NOV


IN.
PPTN
MM
DISCHARGE (CFS)
X 10^{-3} M^3/S
113.
6-1973-C
MAY
JUN
JUL
AUG
SEP


IN.
1
PPTN 2
3
MM
25
50
75
55.2
DISCHARGE (CFS)
40
35
30
25
20
15
10
5
1200
1100
1000
900
800
700
600
500
400
300
200
100
X 10^{-3} M^3/S
6-1974-C
25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10
MAY
JUN
JUL
AUG

WATERSHED NO. 7

Drainage: Fish Creek

Location: Section NW 08, Twp. 52, Range 25, W5M

Area: 11.7 km^2 (4.5 mi^2) **Aspect:** S

Elevation: Max. 1524 m (5000 ft); Min. 1311 m (4300 ft)

Physiography: Athabasca Benchland.

Vegetation: Sw. 76% of forest cover removed as of December, 1974.

Soils:

Associations:	Marlboro	Erith	Fickle	RB
Infiltration (cm/h):	4 to 5	0.5	0.5	N/A

Surficial Deposits: Mostly Marlboro Till, but some Obed Till near outlet (stream gauge). Till ridges.

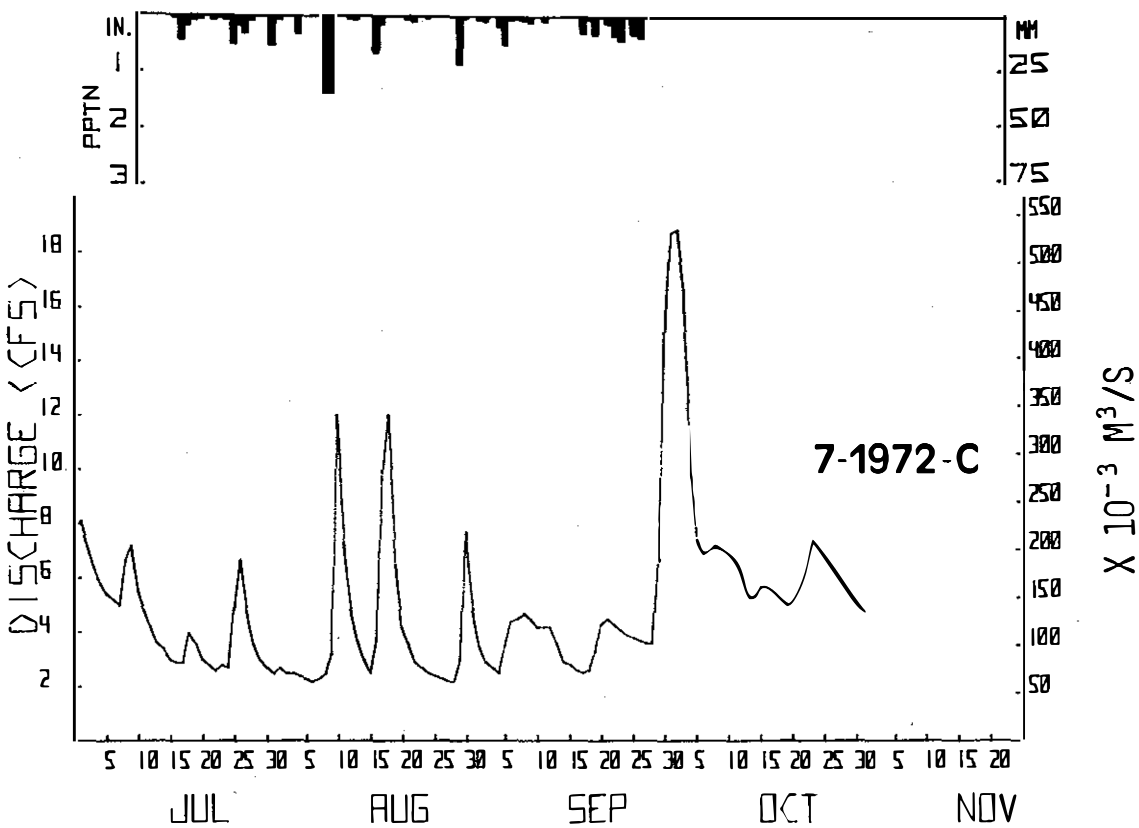
Bedrock: TERTIARY.
Paleocene: sandstone, shale, minor conglomerate, and coal seams.

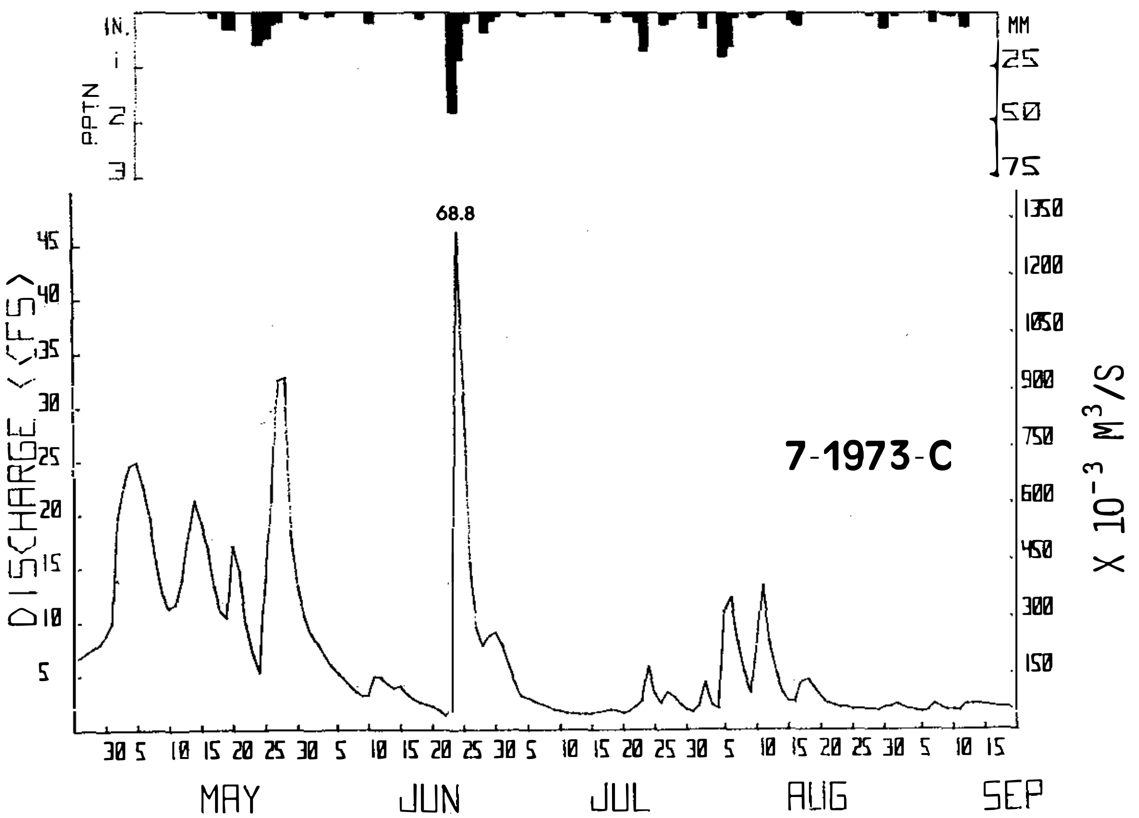
Stream Channel:

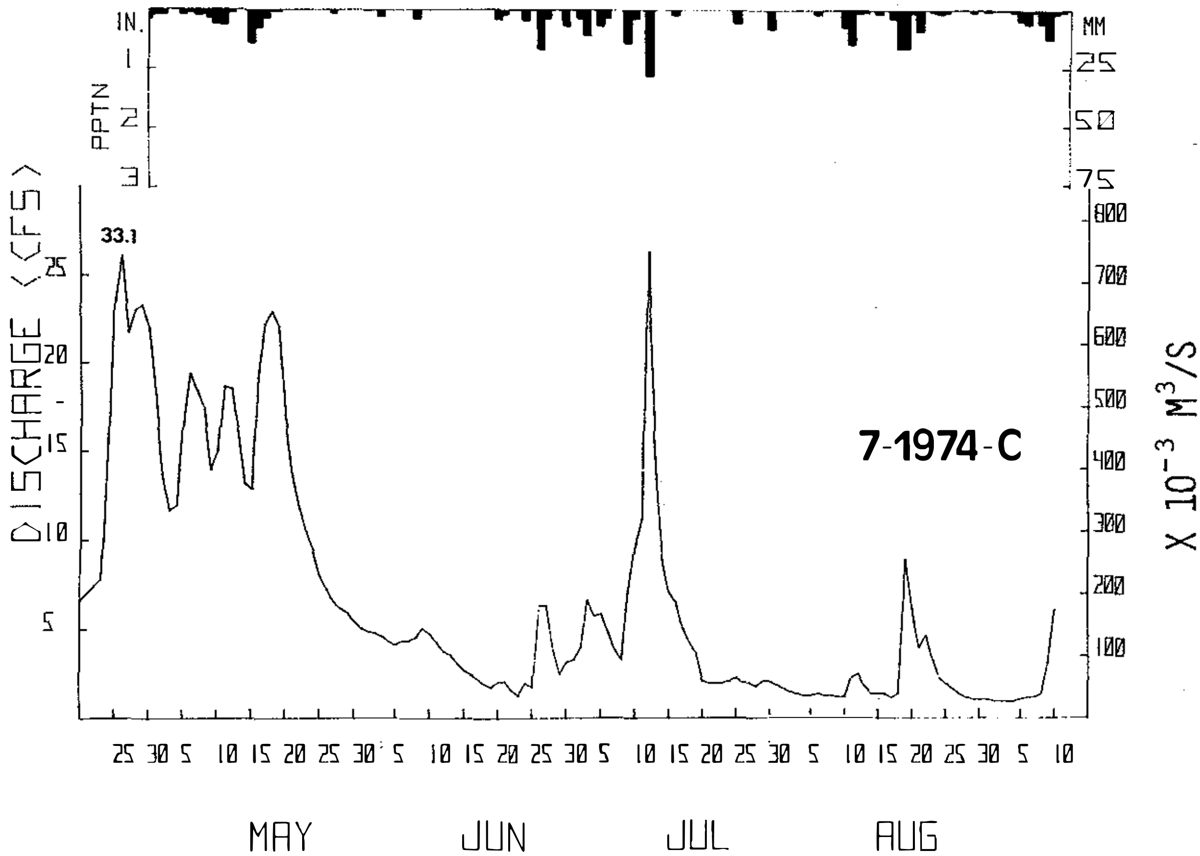
Gradient: 2%; *Order:* 3

Perennial channel length: 2.3 km (1.4 mi)

Stream width-depth: 2.3 by 0.2 m (7.5 by 0.8 ft)


IN.
PPTN
MM
DISCHARGE (CFS)
X 10^-3 M^3/S
7-1972-C
JUL
AUG
SEP
OCT
NOV


IN.
PPTN
MM
68.8
DISCHARGE (CFS)
X 10^-3 M^3/S
7-1973-C
MAY
JUN
JUL
AUG
SEP



IN.
1
2
3
PPTN
MM
25
50
75
DISCHARGE (CFS)
33.1
25
20
15
10
5
800
700
600
500
400
300
200
100
X 10^{-3} M^3/S
7-1974-C
25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10
MAY
JUN
JUL
AUG

WATERSHED NO. 8

Drainage: Oldman Creek—2

Location: Section NE 26, Twp. 54, Range 25, W5M

Area: 16.8 km^2 (6.5 mi^2) **Aspect:** NE

Elevation: Max. 1402 m (4600 ft); Min. 1189 m (3900 ft)

Physiography: Athabasca Tableland.

Vegetation: Pl, Sw, Sb.

Soils:

Associations:	Marlboro	Fickle	Lodge	Blackmud
Infiltration (cm/h):	4 to 5	0.5	N/A	N/A

Surficial Deposits: Marlboro Till with many till ridges.

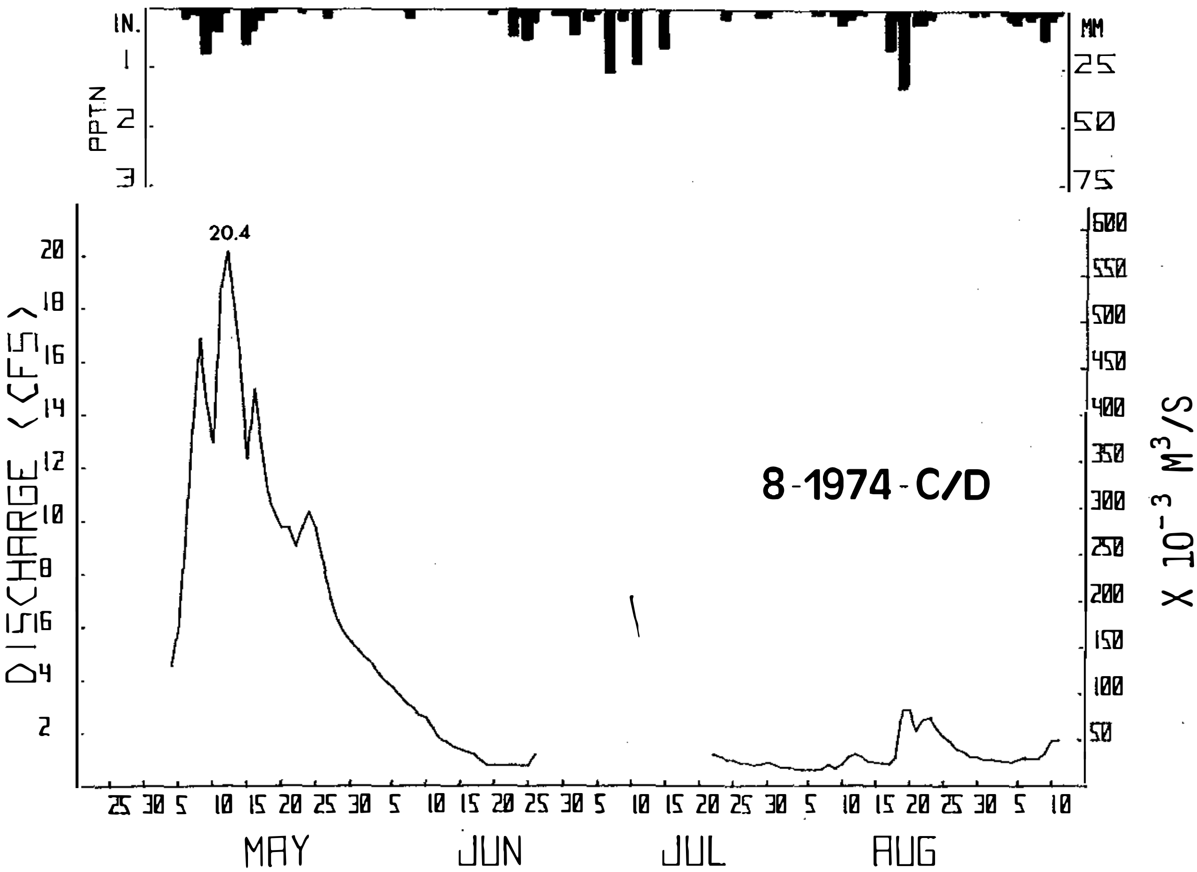
Bedrock: TERTIARY.
Paleocene: sandstone, shale, minor conglomerate, and coal seams.

Stream Channel:

Gradient: 2%; *Order:* 3

Perennial channel length: 3.4 km (2.1 mi)

Stream width-depth: 2.1 by 0.3 m (7.0 by 1.0 ft)


IN.
1
2
3
PPTN
MM
25
50
75
20.4
DISCHARGE (CFS)
20
18
16
14
12
10
8
6
4
2
600
550
500
450
400
350
300
250
200
150
100
50
X 10⁻³ M³/S
8-1974-C/D
25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10
MAY
JUN
JUL
AUG

WATERSHED NO. 9

Drainage: Oldman Creek—3

Location: Section NE 23, Twp. 54, Range 25, W5M

Area: 14.5 km^2 (5.6 mi^2) **Aspect:** NE

Elevation: Max. 1402 m (4600 ft); Min. 1219 m (4000 ft)

Physiography: Athabasca Tableland.

Vegetation: Pl, Sw, Sb.

Soils:

Associations:	Marlboro	Fickle	Erith
Infiltration (cm/h):	4 to 5	0.5	0.5

Surficial Deposits: Marlboro till with many till ridges.

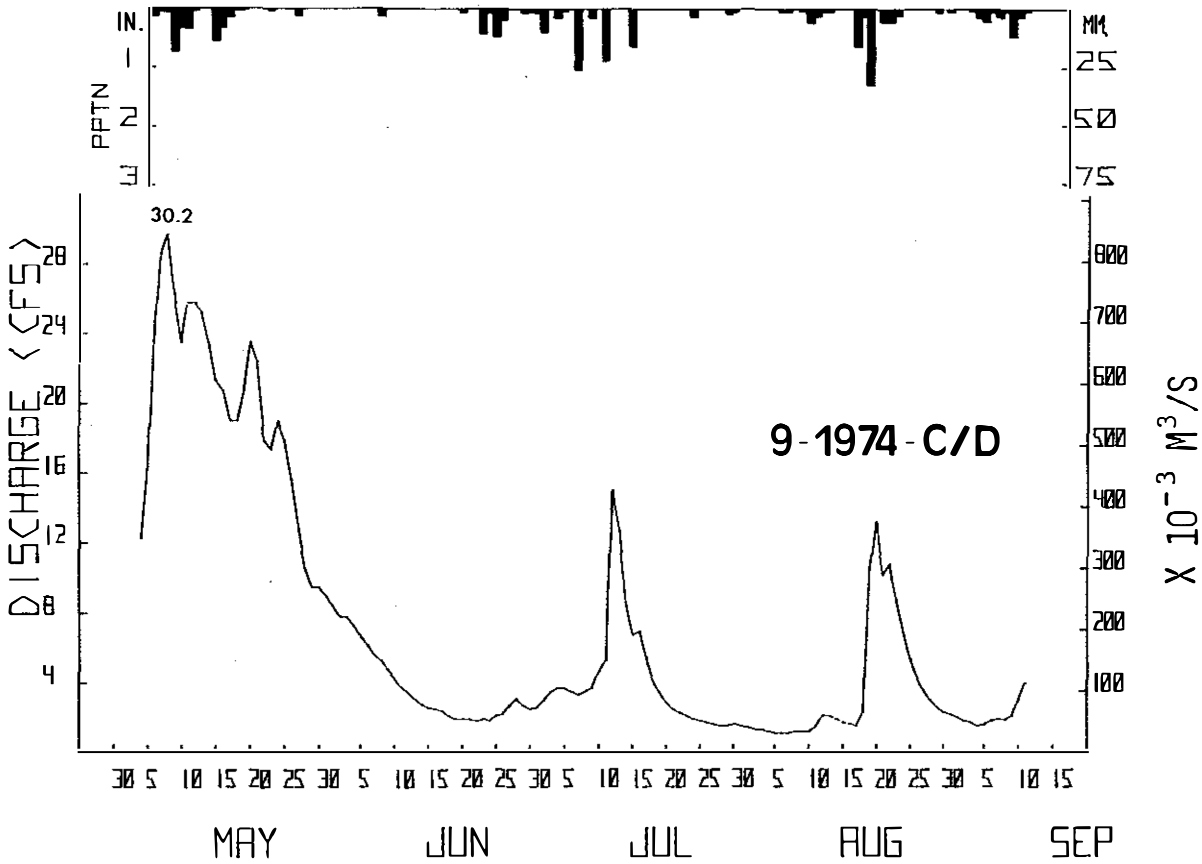
Bedrock: TERTIARY.
Paleocene: sandstone, shale, minor conglomerate, and coal seams.

Stream Channel:

Gradient: 2%; *Order:* 3

Perennial channel length: 3.9 km (2.4 mi)

Stream width-depth: 2.1 by 0.2 m (7.0 by 0.8 ft)


IN.
1
PPTN 2
3
MM
25
50
75
30.2
DISCHARGE (CFS)
28
24
20
16
12
8
4
800
700
600
500
400
300
200
100
X 10^-3 M^3/S
9-1974-C/D
30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15
MAY
JUN
JUL
AUG
SEP

WATERSHED NO. 10

Drainage: Oldman Creek—4

Location: Section NW 31, Twp. 53, Range 24, W5M

Area: 19.7 km^2 (7.6 mi^2) **Aspect:** NW

Elevation: Max. 1585 m (5200 ft); Min. 1273 m (4175 ft)

Physiography: Athabasca Tableland.

Vegetation: Sw, Sb, Pl. 37% of forest cover removed as of December, 1974.

Soils:

Associations:	Erith	Marlboro
Infiltration (cm/h):	0.5	4 to 5

Surficial Deposits: Marlboro Till.

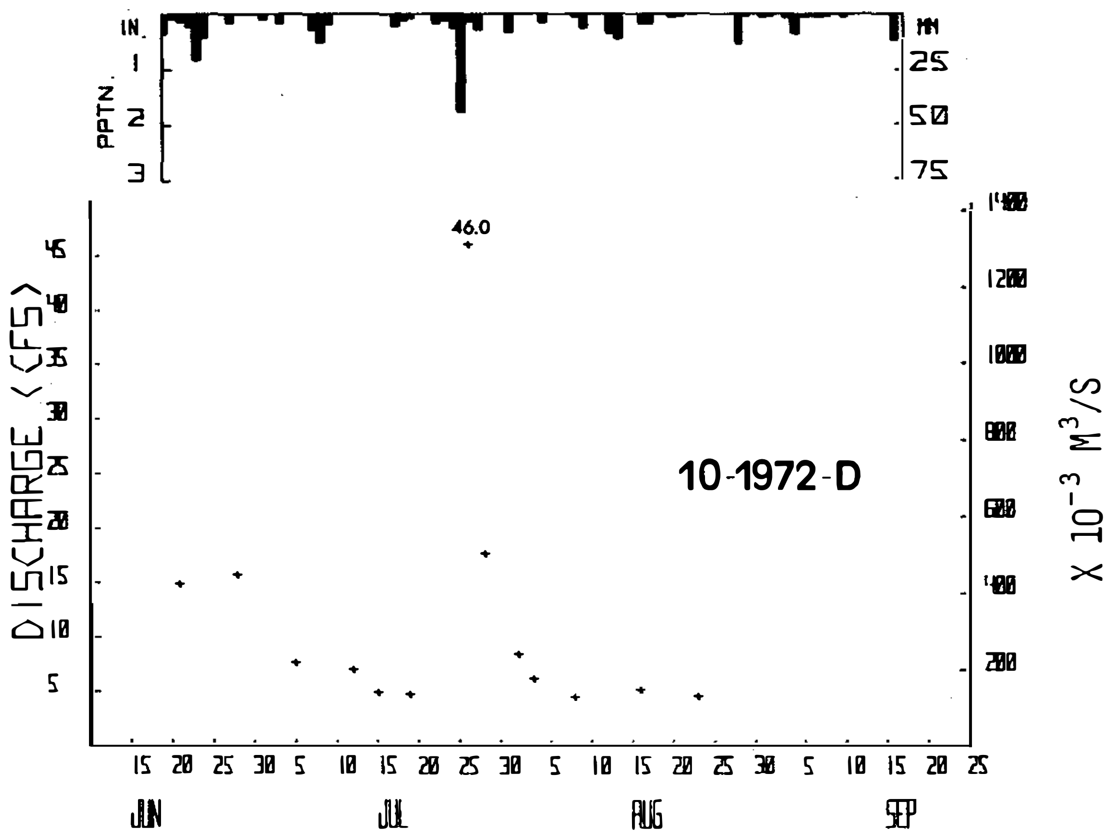
Bedrock: TERTIARY.
Paleocene: sandstone, shale, minor conglomerate, and coal seams.

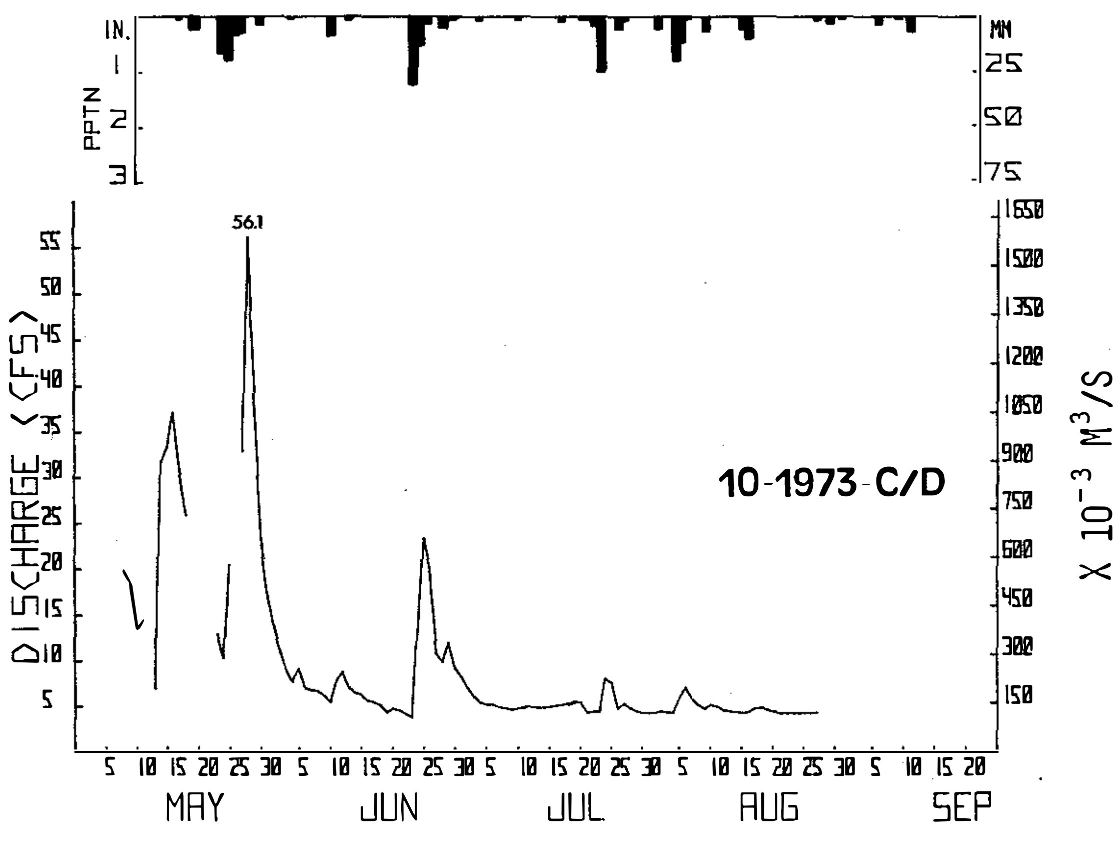
Stream Channel:

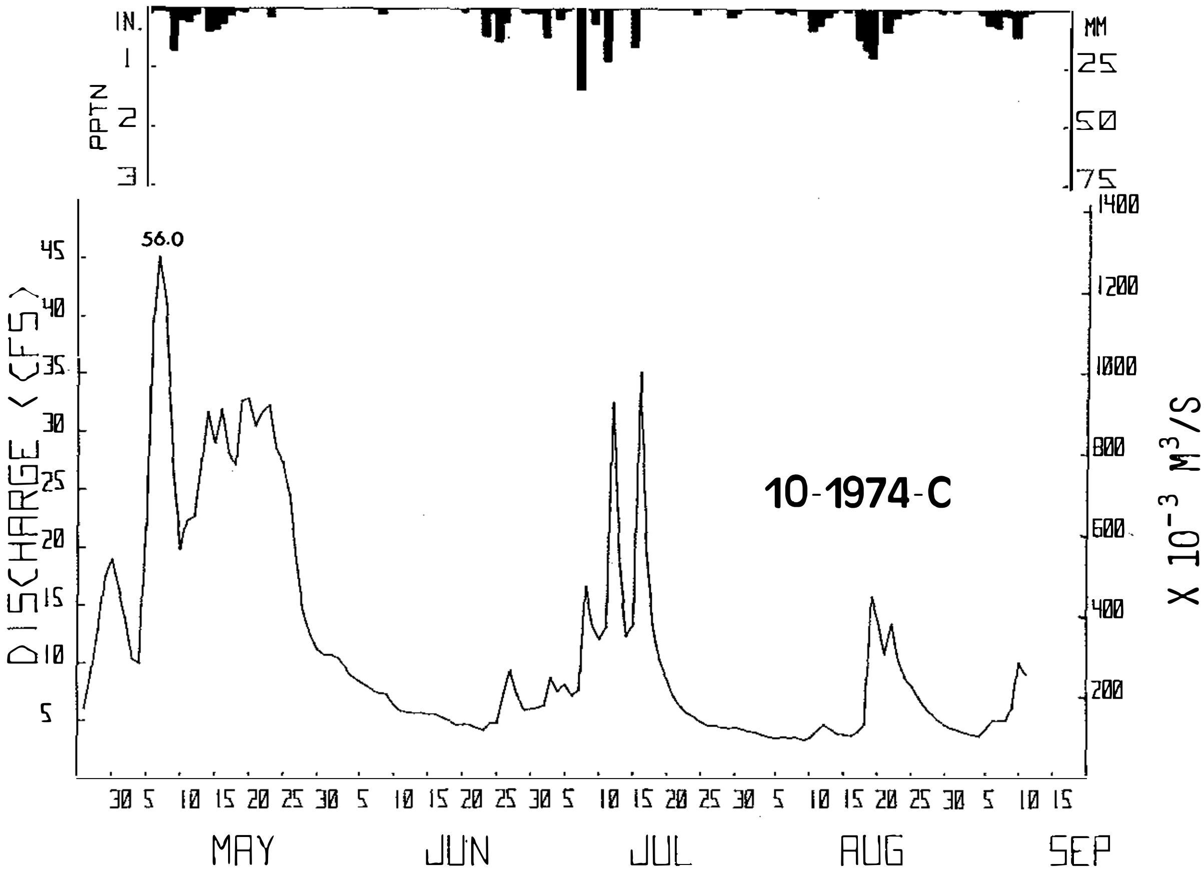
Gradient: 3%; *Order:* 4

Perennial channel length: 6.6 km (4.1 mi)

Stream width-depth: 2.7 by 0.2 m (9.0 by 0.8 ft)


IN.
PPTN
MM
25
50
75
46.0
DISCHARGE (CFS)
X 10^{-3} M^3/S
10-1972-D
JUN
JUL
AUG
SEP


IN.
PPTN
MM
25
50
75
56.1
DISCHARGE (CFS)
X 10^{-3} M^3/S
10-1973-C/D
MAY
JUN
JUL
AUG
SEP


IN.
1
2
3
PPTN
MM
25
50
75
DISCHARGE (CFS)
5
10
15
20
25
30
35
40
45
56.0
1400
1200
1000
800
600
400
200
X 10^{-3} M^3/S
10-1974-C
30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15
MAY
JUN
JUL
AUG
SEP

WATERSHED NO. 11

Drainage: Tiecamp Creek

Location: Section NW 19, Twp. 52, Range 24, W5M

Area: 1.6 km^2 (0.6 mi^2) **Aspect:** E

Elevation: Max. 1372 m (4500 ft); Min. 1189 m (3900 ft)

Physiography: Athabasca Benchland.

Vegetation: Pl, Sw, Sb. 38% of forest cover removed as of 1973.

Soils:

Associations: Obed

Infiltration (cm/h): 5 to 20

Surficial Deposits: Obed Till.

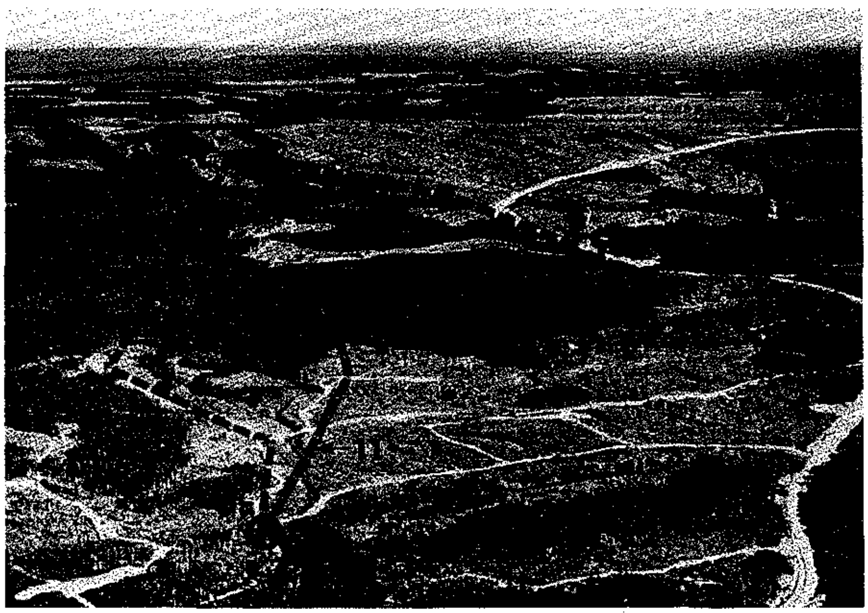
Bedrock: TERTIARY.
Paleocene: sandstone, shale, minor conglomerate, and coal seams.

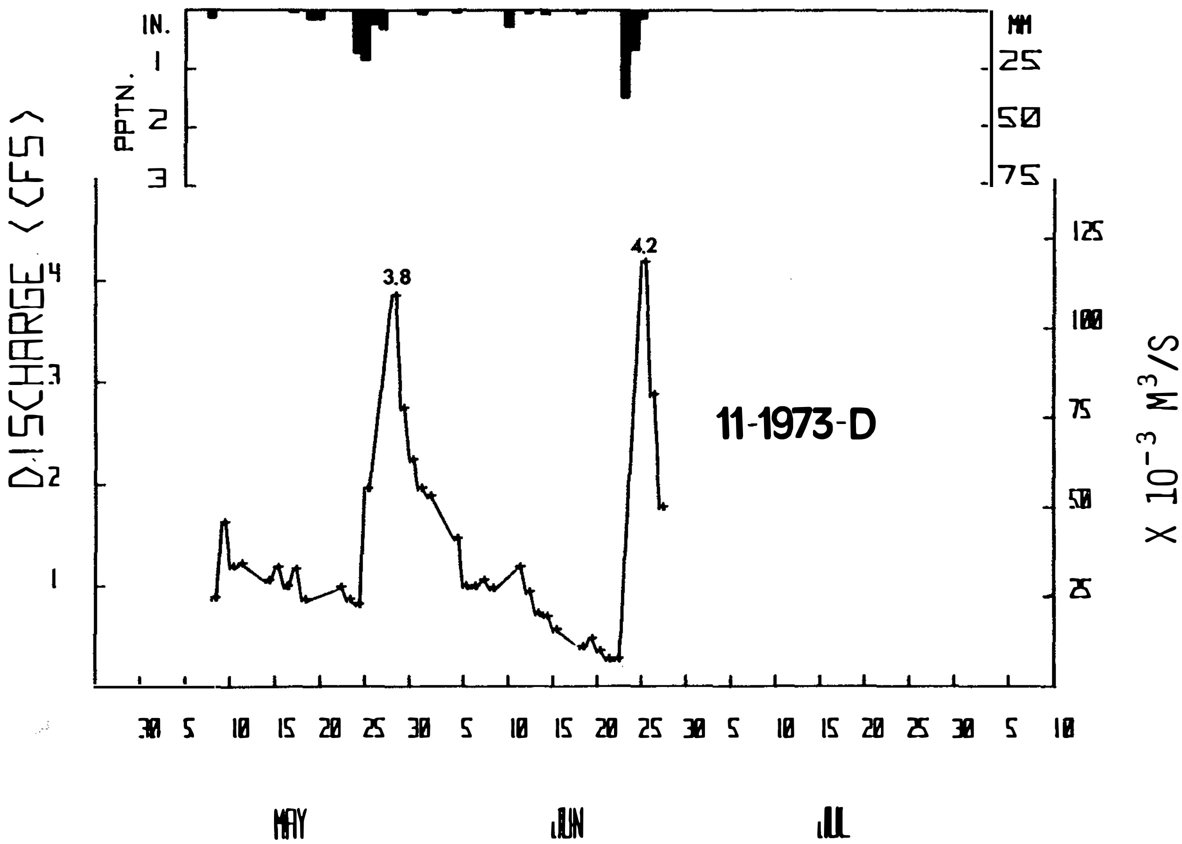
Stream Channel:

Gradient: 7%; *Order:* 2

Perennial channel length: 1.6 km (1.0 mi)

Stream width-depth: 0.8 by 0.3 m (2.6 by 1.0 ft)




IN.
MM
PPTN.
DISCHARGE (CFS)
X 10^-3 M^3/S
3.8
4.2
11-1973-D
MAY
JUN
JUL

WATERSHED NO. 12

Drainage: Canyon Creek—1

Location: Section 13, Twp. 52, Range 25, W5M

Area: 4.9 km^2 (1.9 mi^2) **Aspect:** E

Elevation: Max. 1433 m (4700 ft); Min. 1311 m (4300 ft)

Physiography: Athabasca Benchland.

Vegetation: Pl, Sw, Sb. 70% of forest cover removed as of 1973.

Soils:

Associations: Obed

Infiltration (cm/h): 5 to 20

Surficial Deposits: Obed Till and Marlboro Till.

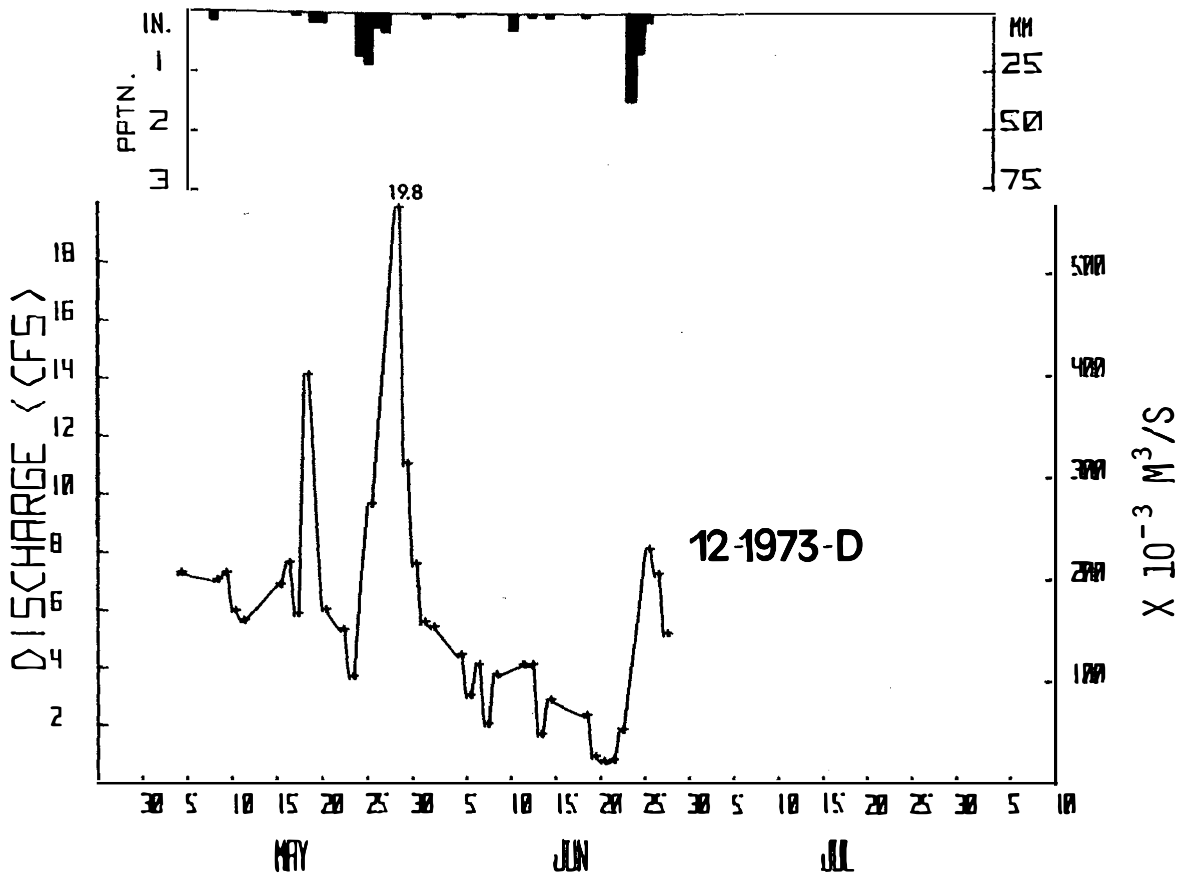
Bedrock: TERTIARY.
Paleocene: sandstone, shale, minor conglomerate, and coal seams.

Stream Channel:

Gradient: 2%; *Order:* 2

Perennial channel length: 8.5 km (5.3 mi)

Stream width-depth: 1.8 by 0.3 m (6.0 by 1.0 ft)


IN.
PPTN.
1
2
3
MM
25
50
75
19.8
DISCHARGE (CFS)
18
16
14
12
10
8
6
4
2
500
400
300
200
100
X 10^{-3} M^3/S
12-1973-D
30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10
MAY
JUN
JUL

WATERSHED NO. 13

Drainage: Canyon Creek—2

Location: Section 19, Twp. 52, Range 24, W5M

Area: 14.0 km^2 (5.4 mi^2) **Aspect:** E

Elevation: Max. 1433 m (4700 ft); Min. 1189 m (3900 ft)

Physiography: Athabasca Benchland.

Vegetation: Pl, Sw, Sb. 71% of forest cover removed as of 1973.

Soils:

Associations: Obed

Infiltration (cm/h): 5 to 20

Surficial Deposits: Obed Till.

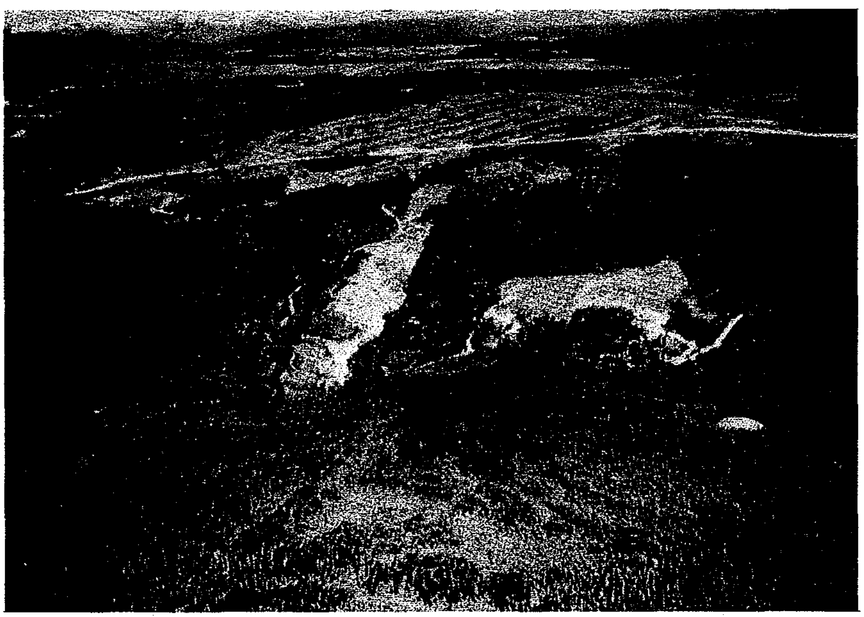
Bedrock: TERTIARY.
Paleocene: sandstone, shale, minor conglomerate, and coal seams.

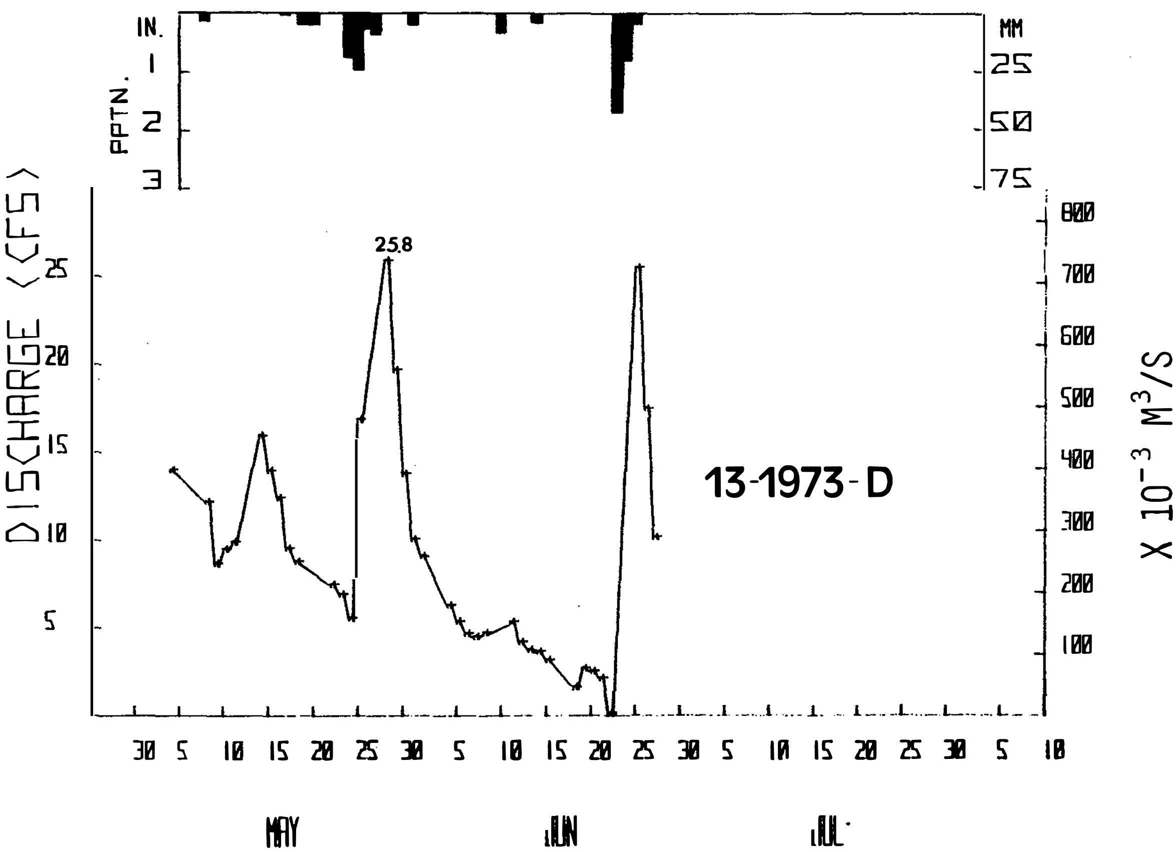
Stream Channel:

Gradient: 4%; *Order:* 3

Perennial channel length: 5.3 km (3.3 mi)

Stream width-depth: 2.1 by 0.5 m (7.0 by 1.5 ft)





IN.
MM
PPTN.
1
2
3
25
50
75
DISCHARGE (CFS)
25.8
25
20
15
10
5
800
700
600
500
400
300
200
100
X 10^-3 M^3/S
13-1973-D
30
5
10
15
20
25
30
5
10
15
20
25
30
5
10
15
20
25
30
5
10
MAY
JUN
JUL

WATERSHED NO. 14

Drainage: Whiskeyjack Creek

Location: Section NW 06, Twp. 51, Range 24, W5M

Area: 3.1 km^2 (1.2 mi^2) **Aspect:** NW

Elevation: Max. 1417 m (4650 ft); Min. 1189 m (3900 ft)

Physiography: Athabasca Benchland.

Vegetation: Sw, Sb, Pl, A.

Soils:

Associations: Obed

Infiltration (cm/h): 5 to 20

Surficial Deposits: Marlboro Till and Obed Till.

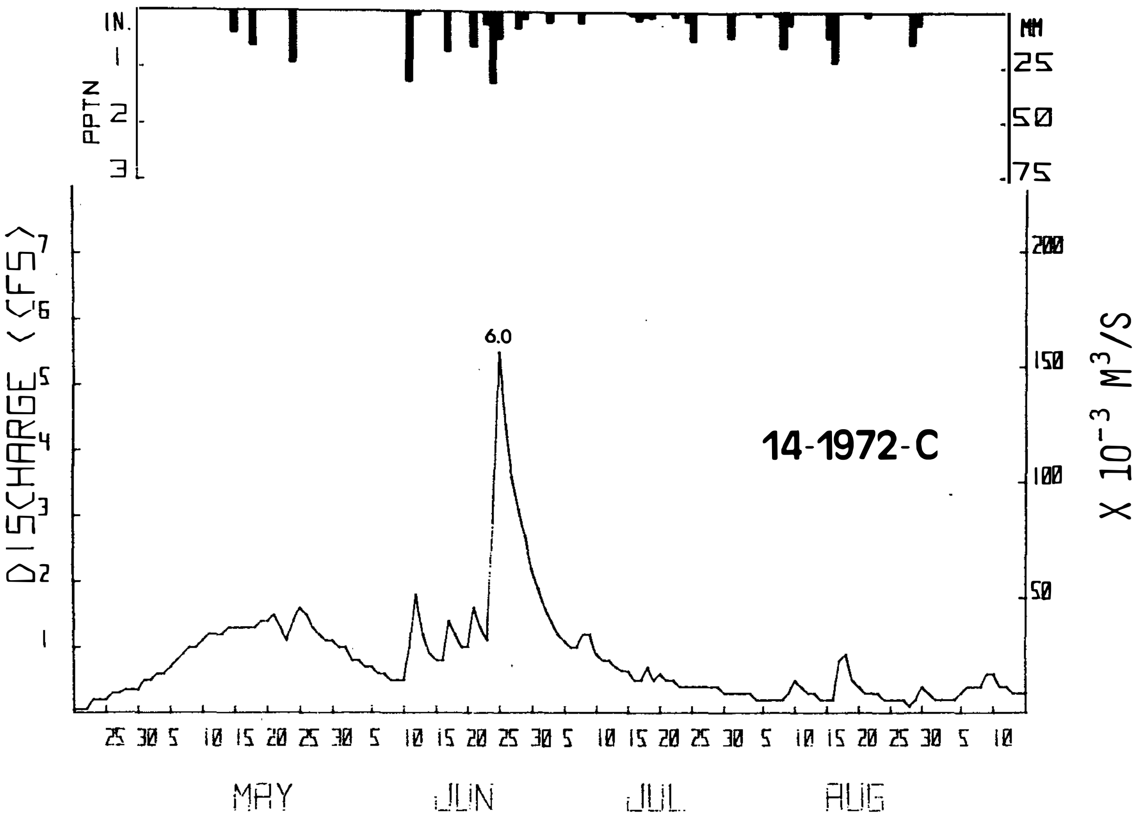
Bedrock: LATE UPPER CRETACEOUS.
Brazeau Fm: sandstone, shale, conglomerate, minor coal seams, and ash beds.

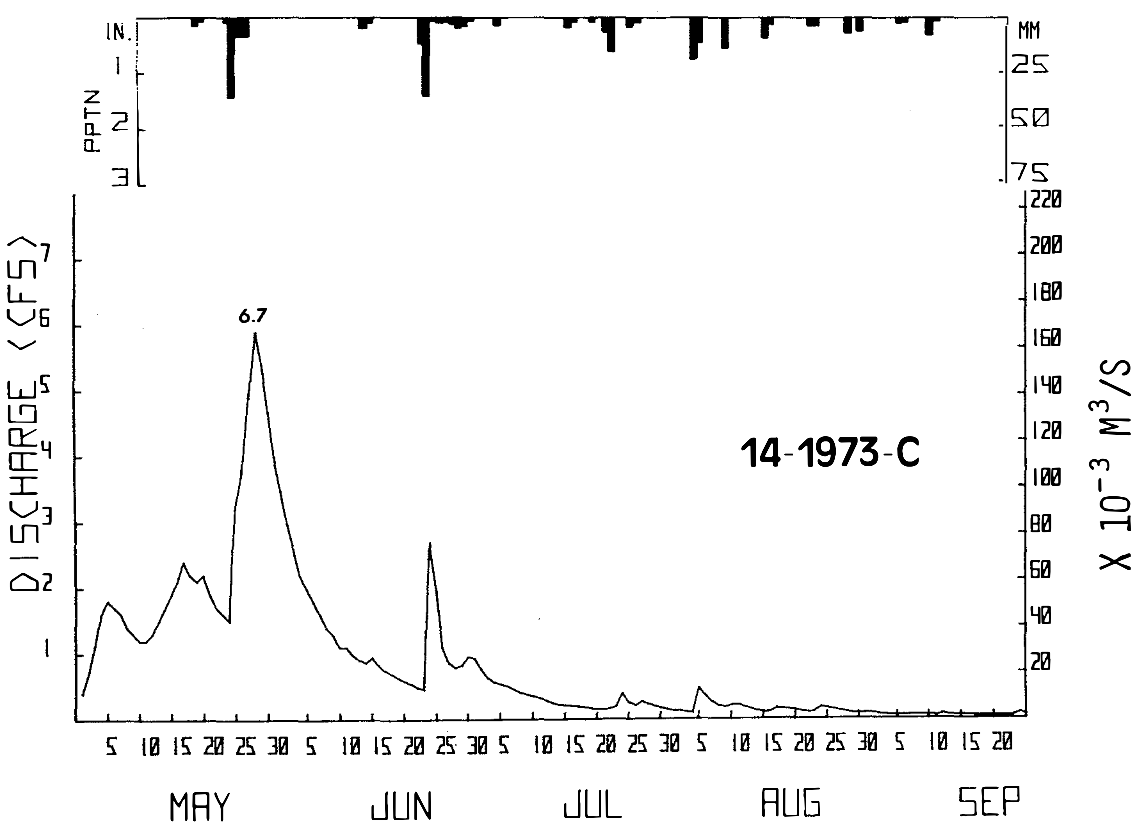
Stream Channel:

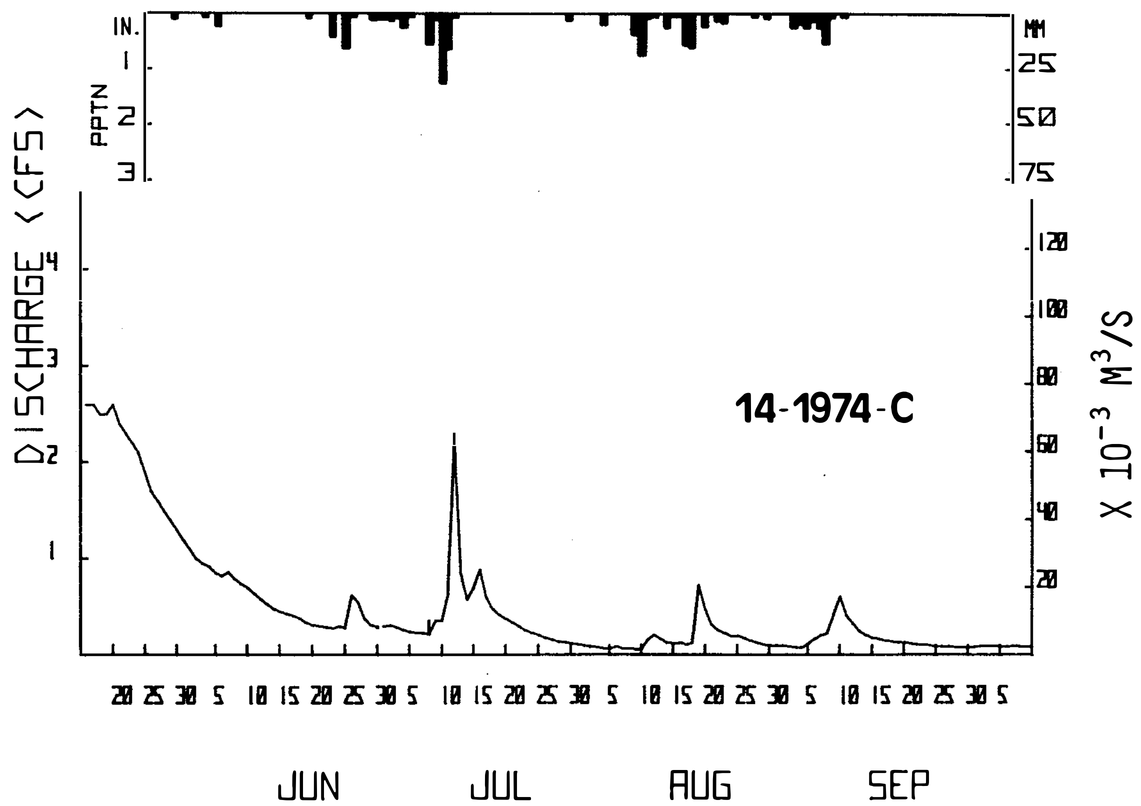
Gradient: 6%; *Order:* 2

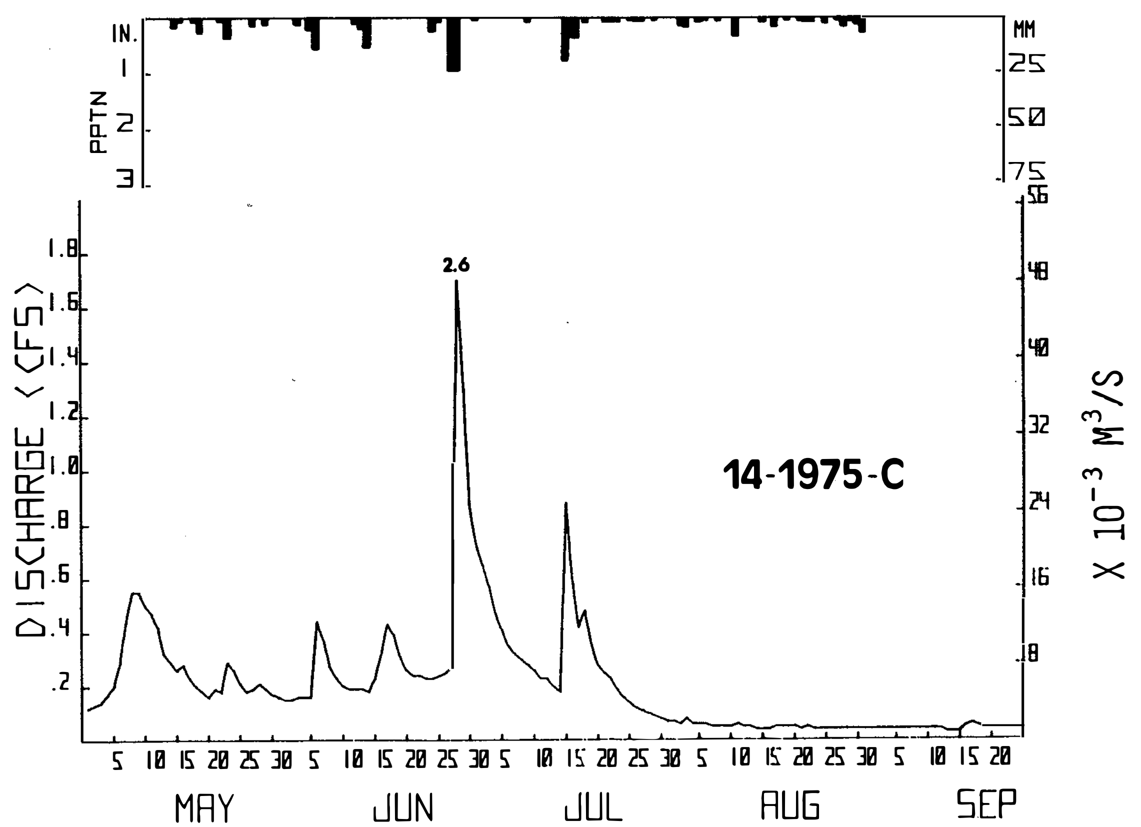
Perennial channel length: 3.5 km (2.2 mi)

Stream width-depth: N/A


IN.
1
2
3
PPTN
MM
25
50
75
DISCHARGE (CFS)
1
2
3
4
5
6
7
6.0
14-1972-C
X 10^{-3} M^3/S
50
100
150
200
25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10
MAY
JUN
JUL
AUG


IN.
1
2
3
PPTN
MM
25
50
75
DISCHARGE (CFS)
1
2
3
4
5
6
7
6.7
14-1973-C
X 10^{-3} M^3/S
20
40
60
80
100
120
140
160
180
200
220
5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20
MAY
JUN
JUL
AUG
SEP


IN.
PPTN
MM
DISCHARGE <CFS>
X 10^-3 M^3/S
14-1974-C
JUN
JUL
AUG
SEP


IN.
PPTN
MM
DISCHARGE <CFS>
X 10^-3 M^3/S
2.6
14-1975-C
MAY
JUN
JUL
AUG
SEP

WATERSHED NO. 15

Drainage: Cache Percotte Creek

Location: Section SW 17, Twp. 51, Range 24, W5M

Area: 6.7 km^2 (2.6 mi^2) **Aspect:** NNW

Elevation: Max. 1372 m (4500 ft); Min. 1158 m (3800 ft)

Physiography: Athabasca Benchland.

Vegetation: Sw, Sb, Pl, A.

Soils:

Associations:	Obed	Erith	Fickle	RB
Infiltration (cm/h):	5-20	0.5	0.5	N/A

Surficial Deposits: Marlboro Till and Obed Till.

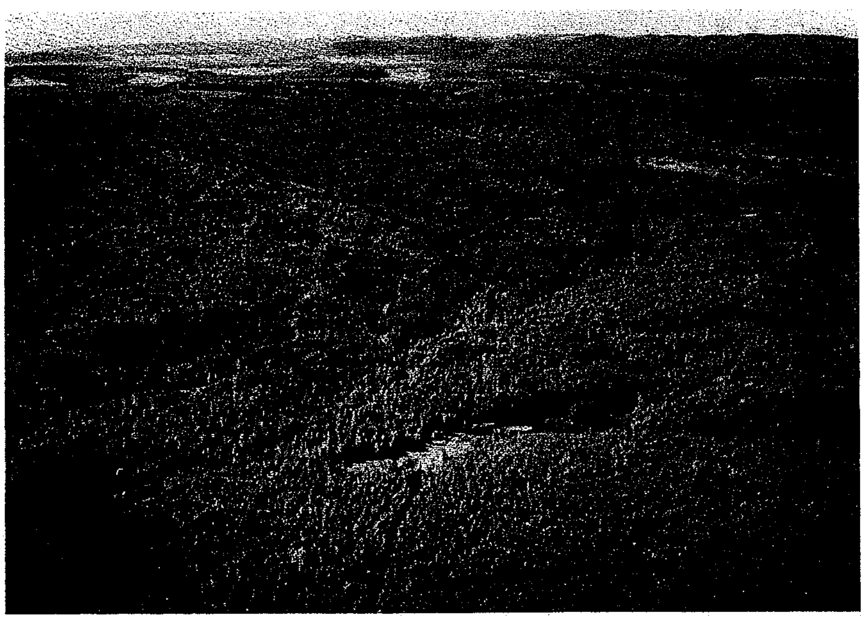
Bedrock: NE half of watershed—TERTIARY, Paleocene: sandstone, shale, minor conglomerate. SW half of watershed—LATE UPPER CRETACEOUS, Brazeau Fm: sandstone, shale, conglomerate, minor coal seams.

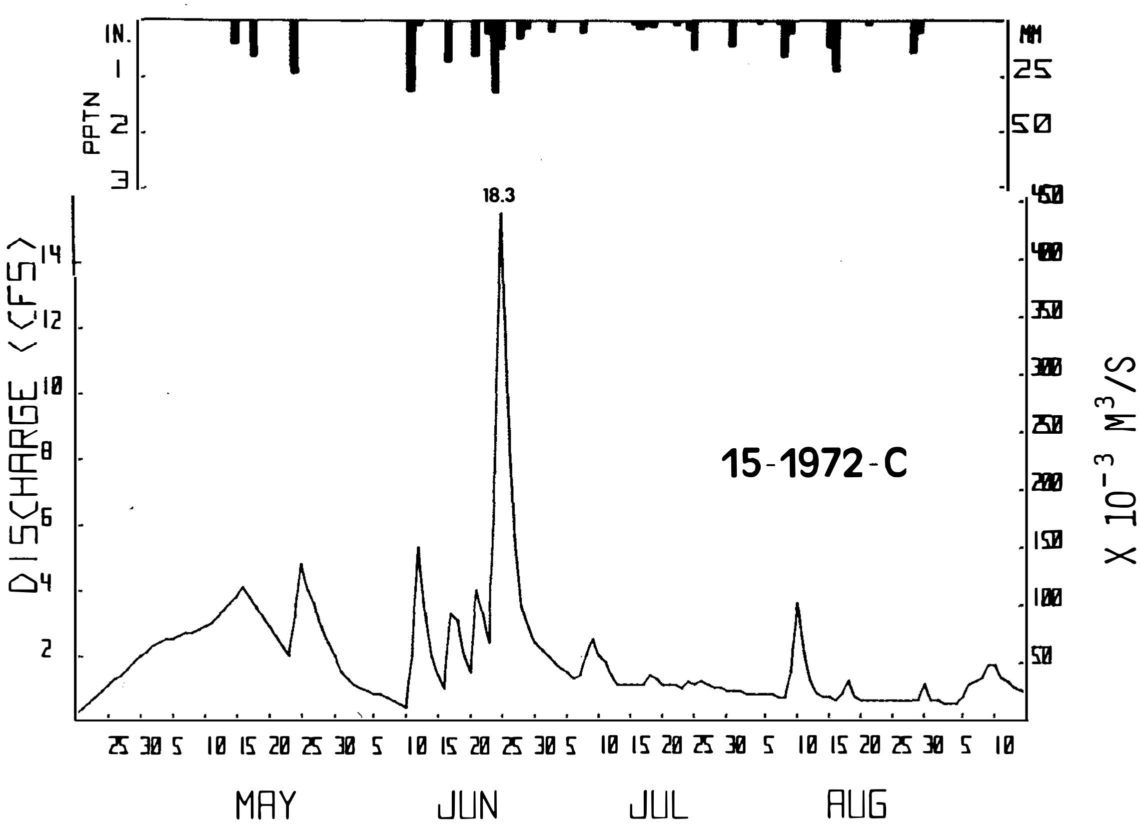
Stream Channel:

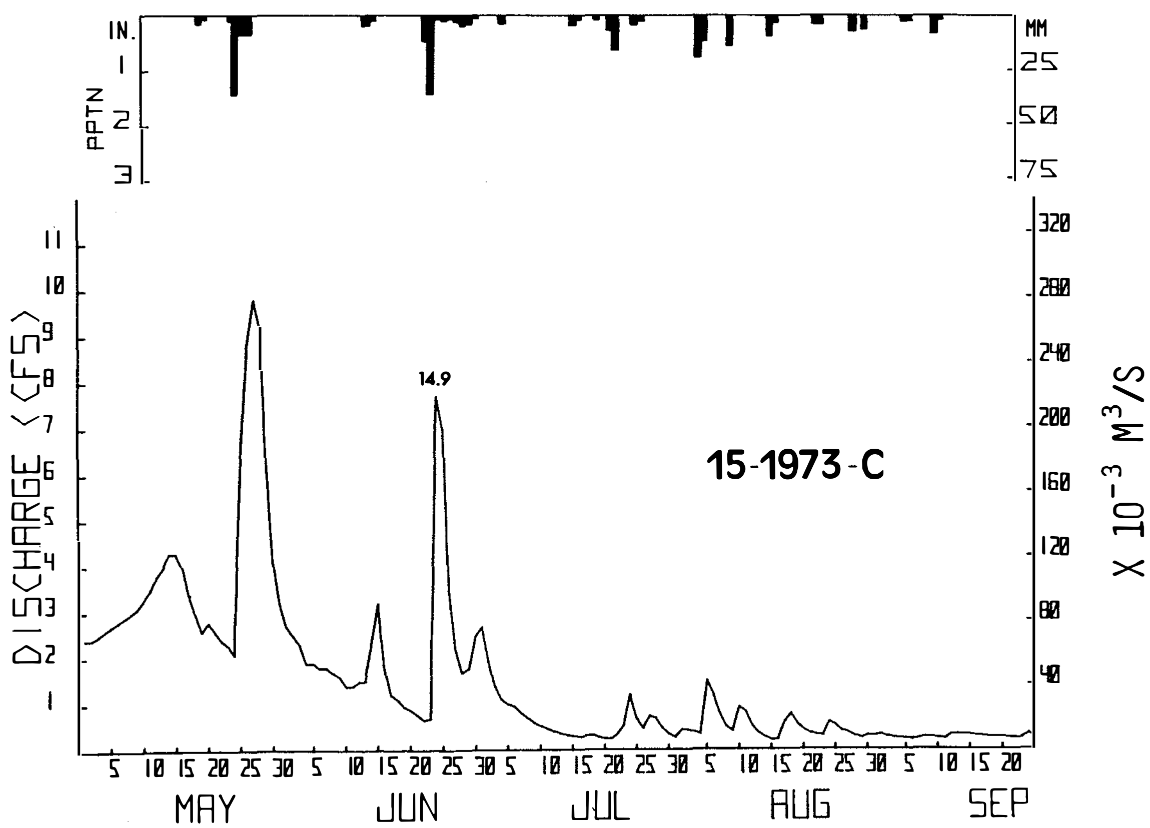
Gradient: 6%; *Order:* 2

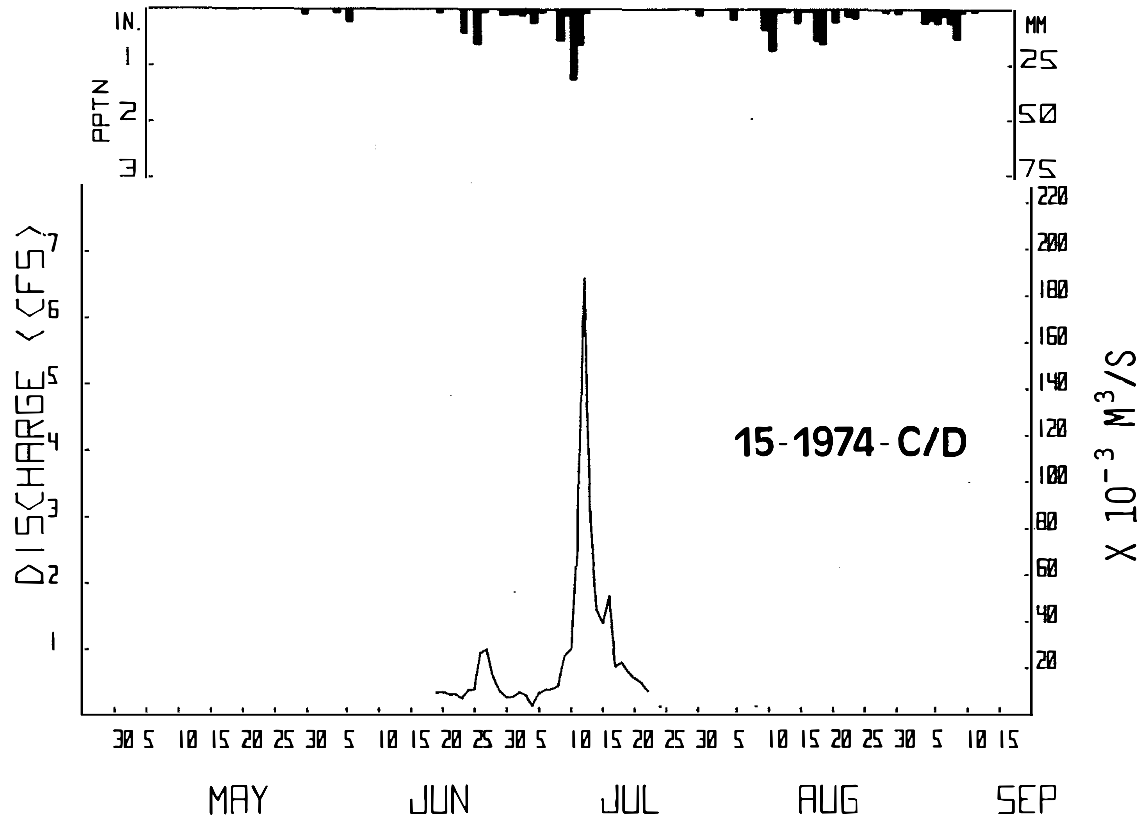
Perennial channel length: 5 km (3.1 mi)

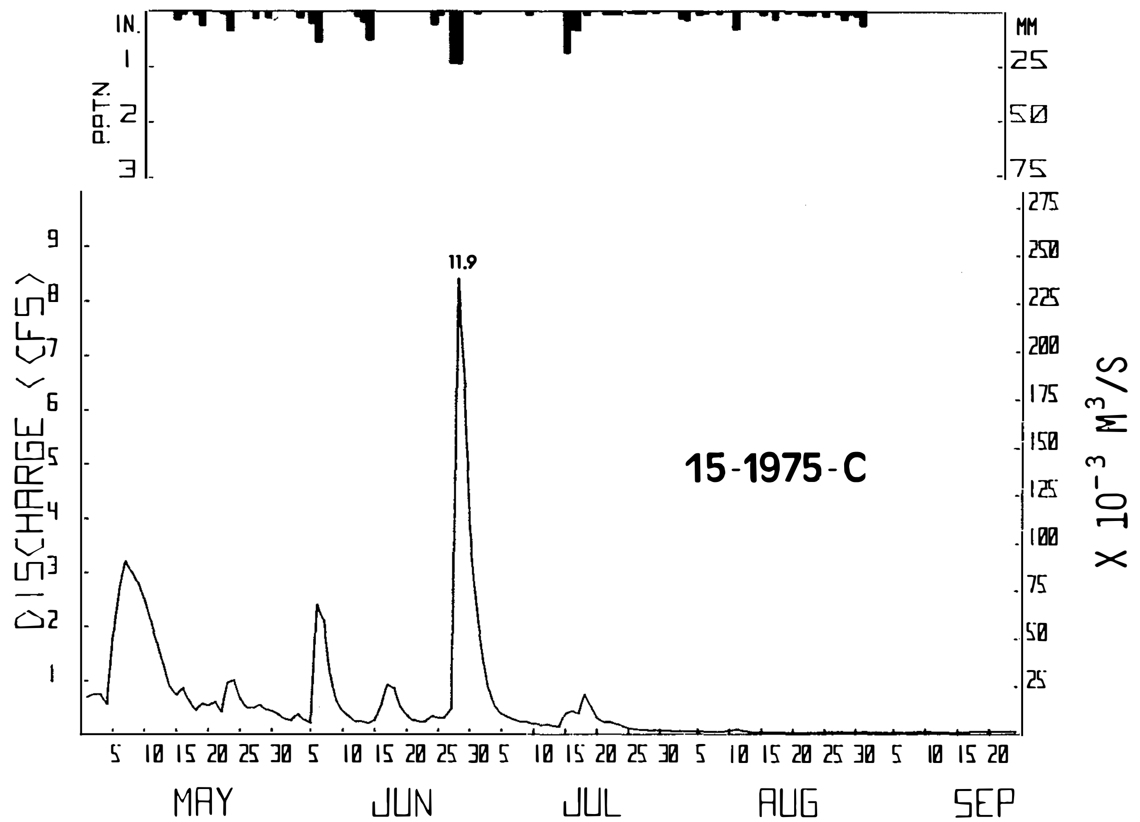
Stream width-depth: N/A




IN.
1
2
3
PPTN
MM
25
50
18.3
DISCHARGE (CFS)
14
12
10
8
6
4
2
450
400
350
300
250
200
150
100
50
X 10^{-3} M^3/S
15-1972-C
25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10
MAY
JUN
JUL
AUG


IN.
1
2
3
PPTN
MM
25
50
75
14.9
DISCHARGE (CFS)
11
10
9
8
7
6
5
4
3
2
1
320
280
240
200
160
120
80
40
X 10^{-3} M^3/S
15-1973-C
5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20
MAY
JUN
JUL
AUG
SEP


IN.
PPTN
MM
DISCHARGE (CFS)
15-1974-C/D
X 10^{-3} M^3/S
MAY
JUN
JUL
AUG
SEP


IN.
PPTN
MM
DISCHARGE (CFS)
11.9
15-1975-C
X 10^{-3} M^3/S
MAY
JUN
JUL
AUG
SEP

WATERSHED NO. 16

Drainage: Canyon Creek—3

Location: Section SW 26, Twp. 52, Range 24, W5M

Area: 36.3 km^2 (14.0 mi^2) **Aspect:** E

Elevation: Max. 1433 m (4700 ft); Min. 975 m (3200 ft)

Physiography: Athabasca Benchland.

Vegetation: Pl, Sw, Sb. 30% of forest cover removed as of 1973.

Soils:

Associations: Obed

Infiltration (cm/h): 5 to 20

Surficial Deposits: Obed Till.

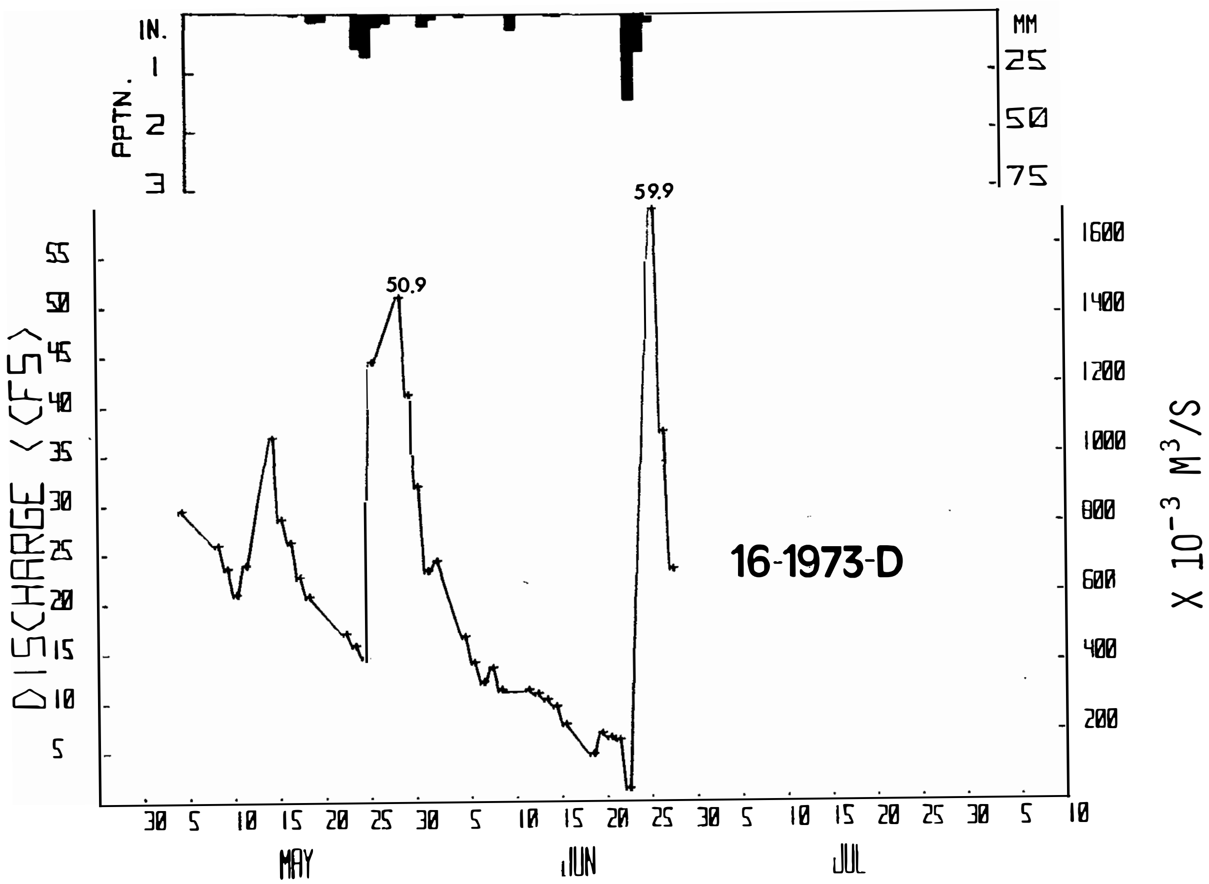
Bedrock: TERTIARY.
Paleocene: sandstone, shale, minor conglomerate, and coal seams.

Stream Channel:

Gradient: 2%; *Order:* 4

Perennial channel length: 10.9 km (6.8 mi)

Stream width-depth: 4.6 by 0.5 m (15 by 1.5 ft)


IN.
PPTN.
1
2
3
MM
25
50
75
59.9
50.9
DISCHARGE (CFS)
55
50
45
40
35
30
25
20
15
10
5
1600
1400
1200
1000
800
600
400
200
X 10^-3 M^3/S
16-1973-D
30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10
MAY
JUN
JUL

WATERSHED NO. 17

Drainage: Unnamed Creek—1

Location: Section 25, Twp. 52, Range 24, W5M

Area: 12.4 km^2 (4.8 mi^2) **Aspect:** S

Elevation: Max. 1402 m (4600 ft); Min. 975 m (3200 ft)

Physiography: Athabasca Benchland.

Vegetation: Pl, Sw, Sb.

Soils:

Associations: Obed

Infiltration (cm/h): 5 to 20

Surficial Deposits: Obed Till.

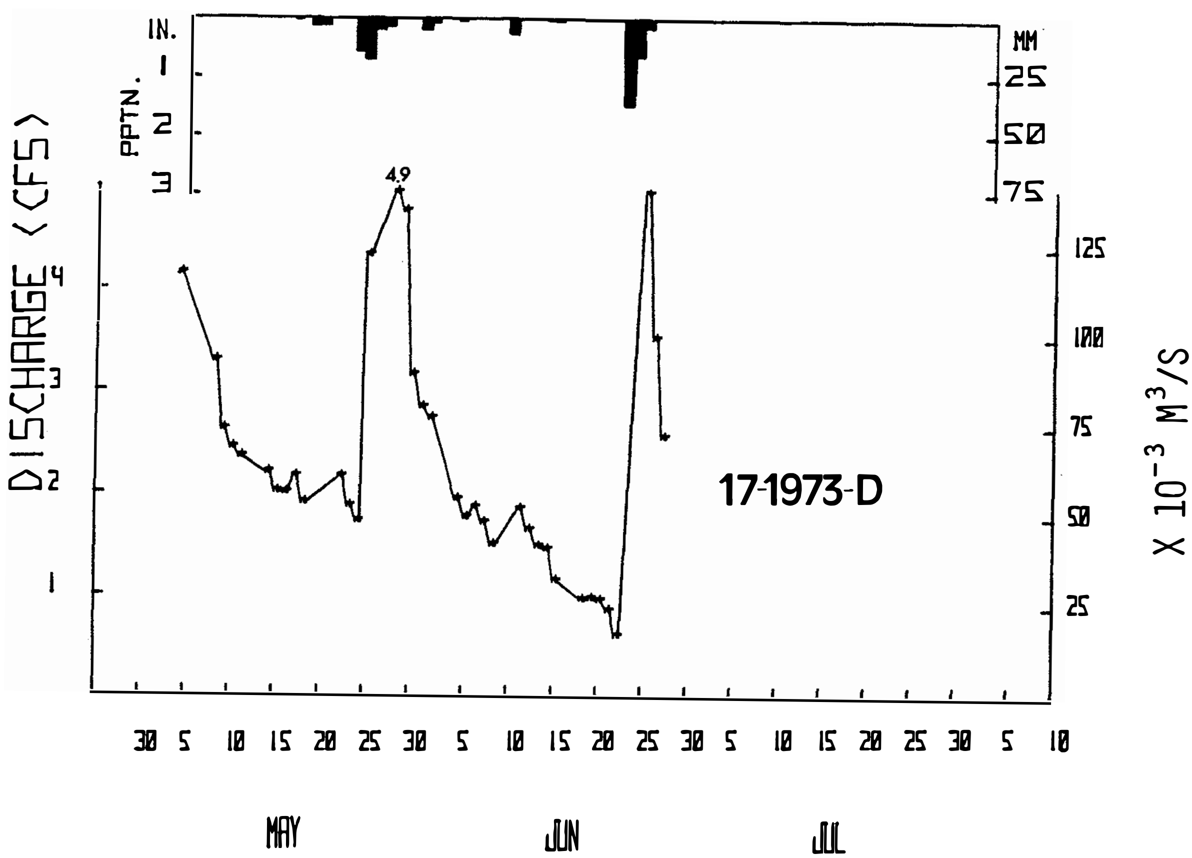
Bedrock: TERTIARY.
Paleocene: sandstone, shale, minor conglomerate, and coal seams.

Stream Channel:

Gradient: 4%; *Order:* 4

Perennial channel length: 6.4 km (4.0 mi)

Stream width-depth: 1.2 by 0.3 m (4.0 by 1.0 ft)



IN.
PPTN.
1
2
3
MM
25
50
75
4.9
DISCHARGE (CFS)
4
3
2
1
125
100
75
50
25
X 10^-3 M^3/S
17-1973-D
30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10
MAY
JUN
JUL

WATERSHED NO. 18

Drainage: McPherson Creek—1

Location: Section NW 15, Twp. 51, Range 24, W5M

Area: 2.8 km^2 (1.1 mi^2) **Aspect:** S

Elevation: Max. 1419 m (4655 ft); Min. 1257 m (4125 ft)

Physiography: Athabasca Tableland. Dominant features: glacial flutings and ground moraine.

Vegetation: Pl, Sw, Sb. 45% of forest cover removed as of 1973.

Soils:

Associations:	Marlboro	Fickle
Infiltration (cm/h):	4 to 5	0.50

Surficial Deposits: Marlboro Till and Obed Till.

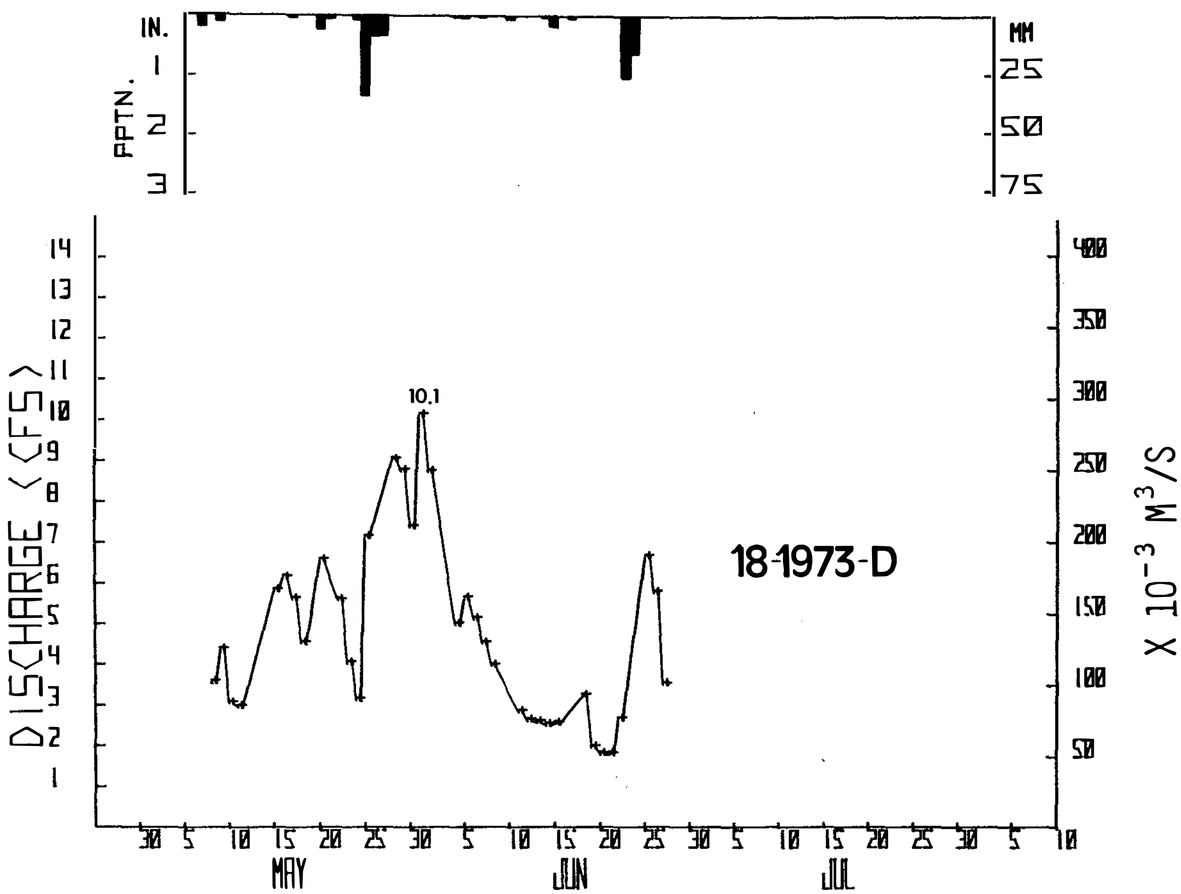
Bedrock: TERTIARY.
Paleocene: sandstone, shale, minor conglomerate, and coal seams.

Stream Channel:

Gradient: 4%; *Order:* 1

Perennial channel length: 1.6 km (1.0 mi)

Stream width-depth: 1.5 by 0.6 m (5.0 by 2.0 ft)


IN.
PPTN.
MM
25
50
75
DISCHARGE (CFS)
X 10^{-3} M^3/S
10.1
18-1973-D
MAY
JUN
JUL

WATERSHED NO. 19

Drainage: McPherson Creek—2

Location: Section 10, Twp. 51, Range 24, W5M

Area: 4.1 km^2 (1.6 mi^2) **Aspect:** E

Elevation: Max. 1402 m (4600 ft); Min. 1311 m (4300 ft)

Physiography: Athabasca Tableland. Dominant features: glacial flutings and ground moraine.

Vegetation: Pl, Sw, Sb. 100% of forest cover removed as of 1973.

Soils:

Associations: Obed

Infiltration (cm/h): 5 to 20

Surficial Deposits: Marlboro Till.

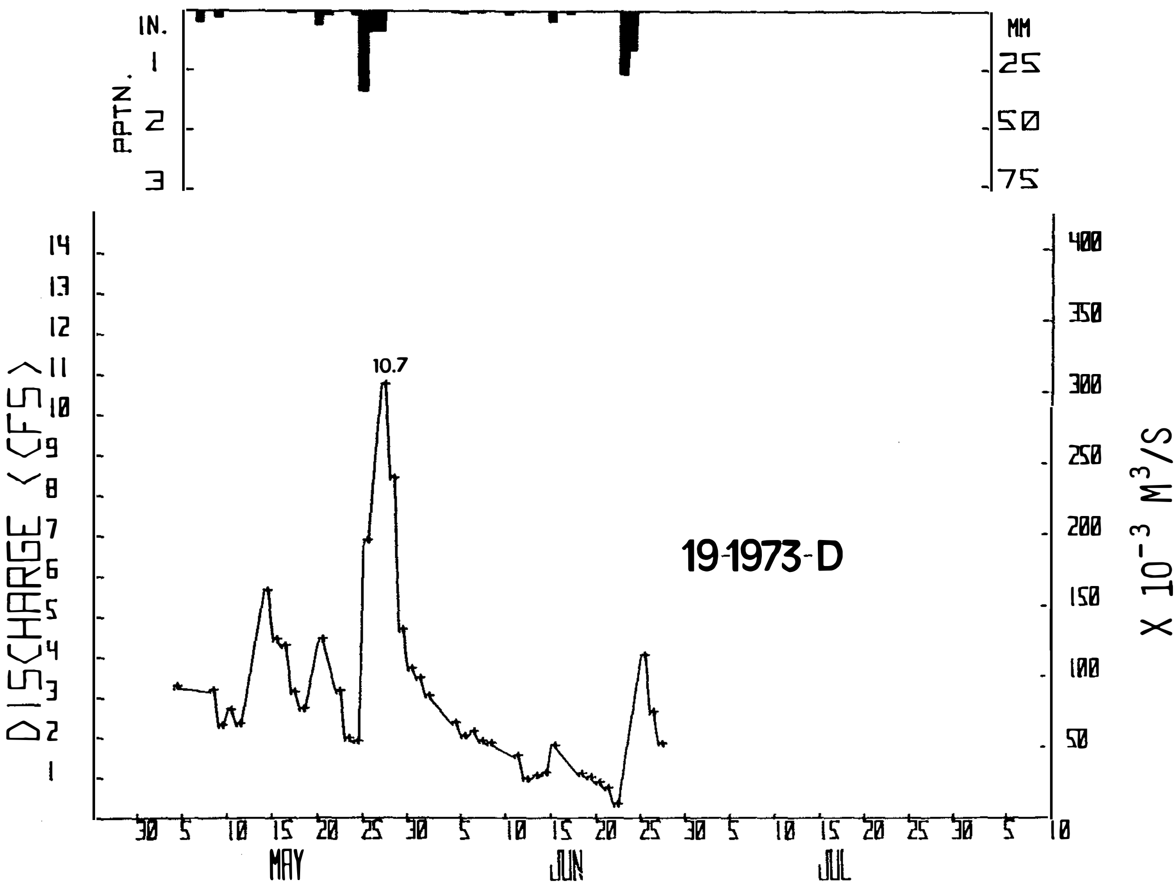
Bedrock: TERTIARY.
Paleocene: sandstone, shale, minor conglomerate, and coal seams.

Stream Channel:

Gradient: 2; *Order:* 1

Perennial channel length: 0.8 km (0.5 mi)

Stream width-depth: 1.2 by 0.4 m (4.0 by 1.4 ft)


IN.
MM
PPTN.
1
2
3
25
50
75
DISCHARGE (CFS)
X 10^{-3} M^3/S
10.7
19-1973-D
MAY
JUN
JUL

WATERSHED NO. 20

Drainage: McPherson Creek—3

Location: Section NE 03, Twp. 51, Range 24, W5M

Area: 3.6 km^2 (1.4 mi^2) **Aspect:** NE

Elevation: Max. 1463 m (4800 ft); Min. 1295 m (4250 ft)

Physiography: Athabasca Tableland. Dominant features: glacial flutings and ground moraine.

Vegetation: Pl, Sw, Sb. 25% of forest cover removed as of 1973.

Soils:

Associations: Obed

Infiltration (cm/h): 5 to 20

Surficial Deposits: Marlboro Till.

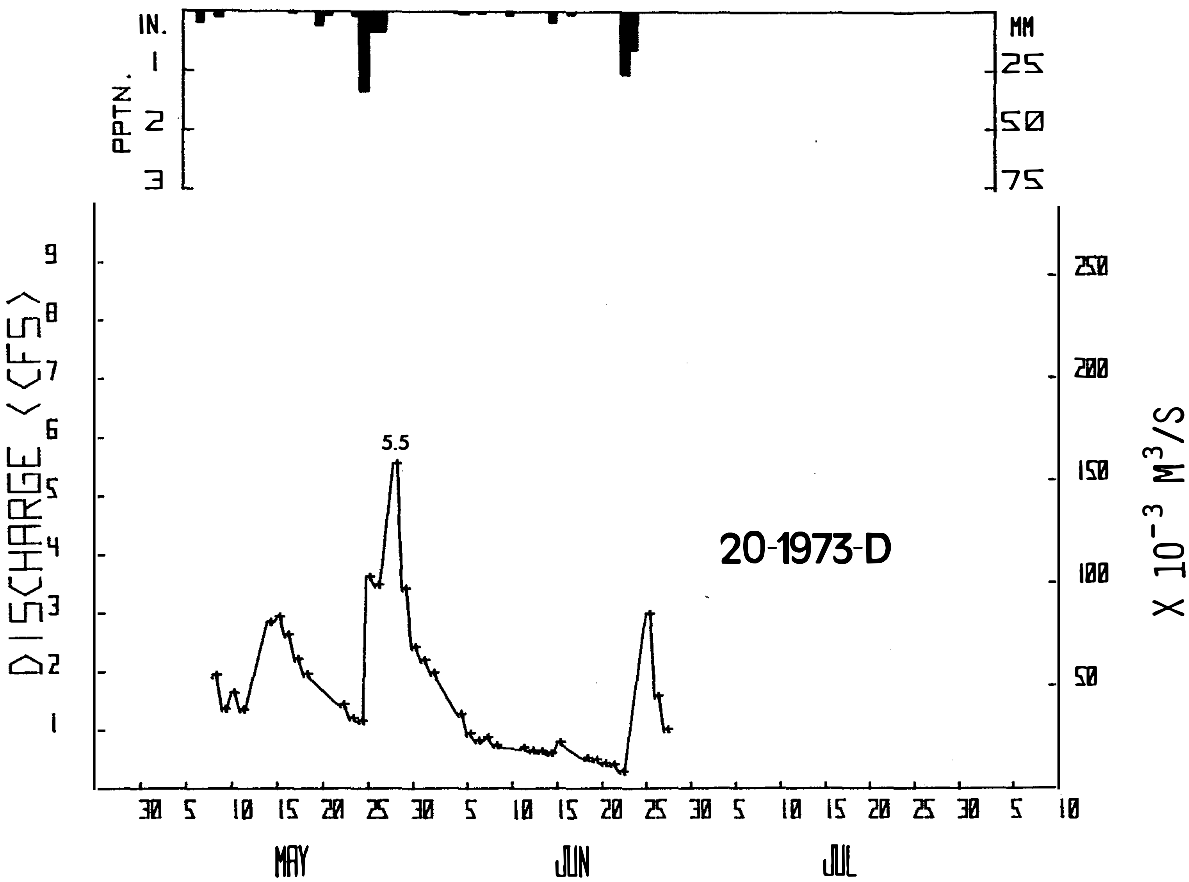
Bedrock: TERTIARY.
Paleocene: sandstone, shale, minor conglomerate, and coal seams.

Stream Channel:

Gradient: 2%; *Order:* 1

Perennial channel length: 3.9 km (2.4 mi)

Stream width-depth: 2.1 by 0.4 m (7.0 by 1.3 ft)


IN.
MM
PPTN.
DISCHARGE (CFS)
X 10^-3 M^3/S
5.5
20-1973-D
MAY
JUN
JUL

WATERSHED NO. 21

Drainage: McPherson Creek—4

Location: Section SE 01, Twp. 51, Range 24, W5M

Area: 1.8 km^2 (0.7 mi^2) **Aspect:** NW

Elevation: Max. 1417 m (4650 ft), Min. 1250 m (4100 ft)

Physiography: Athabasca Tableland. Dominant features: glacial flutings and ground moraine.

Vegetation: Pl, Sw, Sb. 93% of forest cover removed as of 1973.

Soils:

Associations:	Marlboro	Erith
Infiltration (cm/h):	4 to 5	0.5

Surficial Deposits: Marlboro Till.

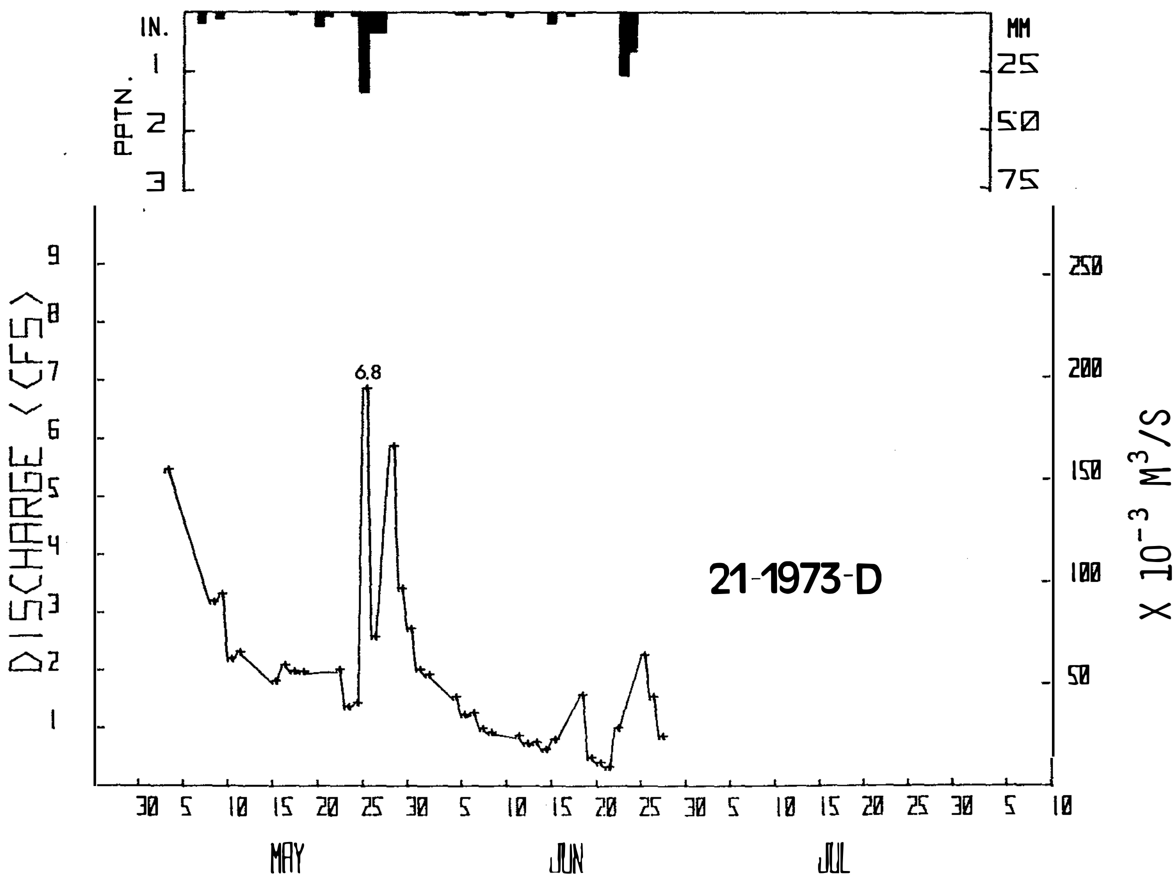
Bedrock: TERTIARY.
Paleocene: sandstone, shale, minor conglomerate, and coal seams.

Stream Channel:

Gradient: 5%; *Order:* 1

Perennial channel length: 1.6 km (1.0 mi)

Stream width-depth: 1.8 by 0.2 m (6.0 by 0.7 ft)


IN.
MM
PPTN.
1
2
3
25
50
75
DISCHARGE (CFS)
9
8
7
6
5
4
3
2
1
6.8
250
200
150
100
50
X 10^{-3} M^3/S
21-1973-D
30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10
MAY
JUN
JUL

WATERSHED NO. 22

Drainage: Quigley Creek

Location: Section SW 25, Twp. 50, Range 24, W5M

Area: 16.8 km^2 (6.5 mi^2) **Aspect:** ESE

Elevation: Max. 1433 m (4700 ft); Min. 1273 m (4175 ft)

Physiography: Athabasca Tableland.

Vegetation: Pl, Sw, meadows near stream channel. 46% of forest cover removed as of December, 1974.

Soils:

Associations:	Marlboro	Fickle
Infiltration (cm/h):	4 to 5	0.5

Surficial Deposits: Marlboro Till. Organic deposits (peat) near stream channel. Esker ridge on north side of watershed.

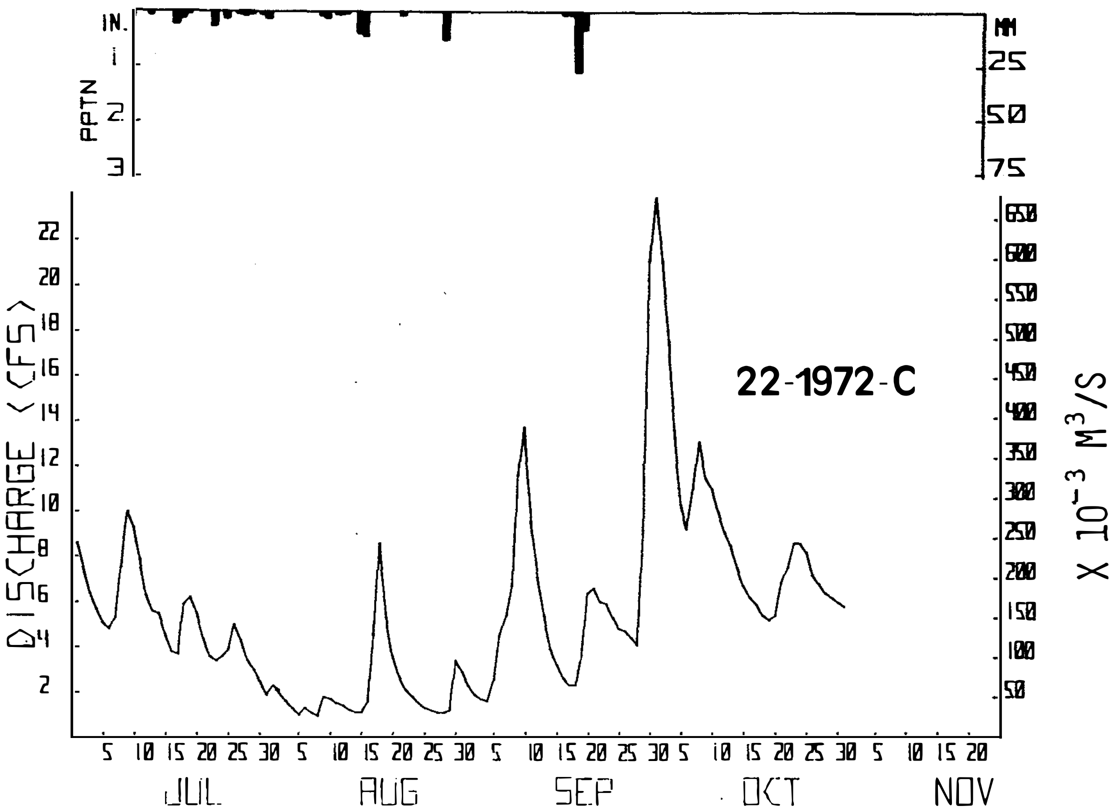
Bedrock: Mostly Brazeau Fm: sandstone, shale, conglomerate, minor coal seams. In extreme NE corner of watershed—Paleocene: sandstone, shale, minor conglomerate, and coal seams.

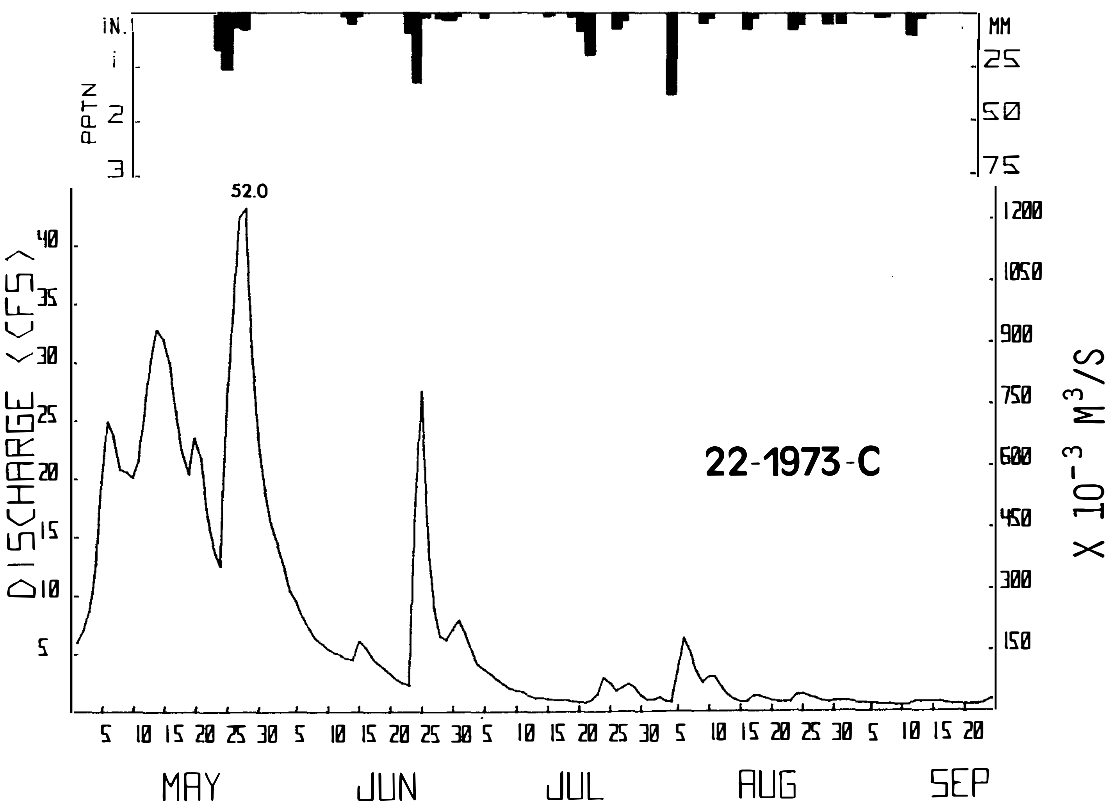
Stream Channel:

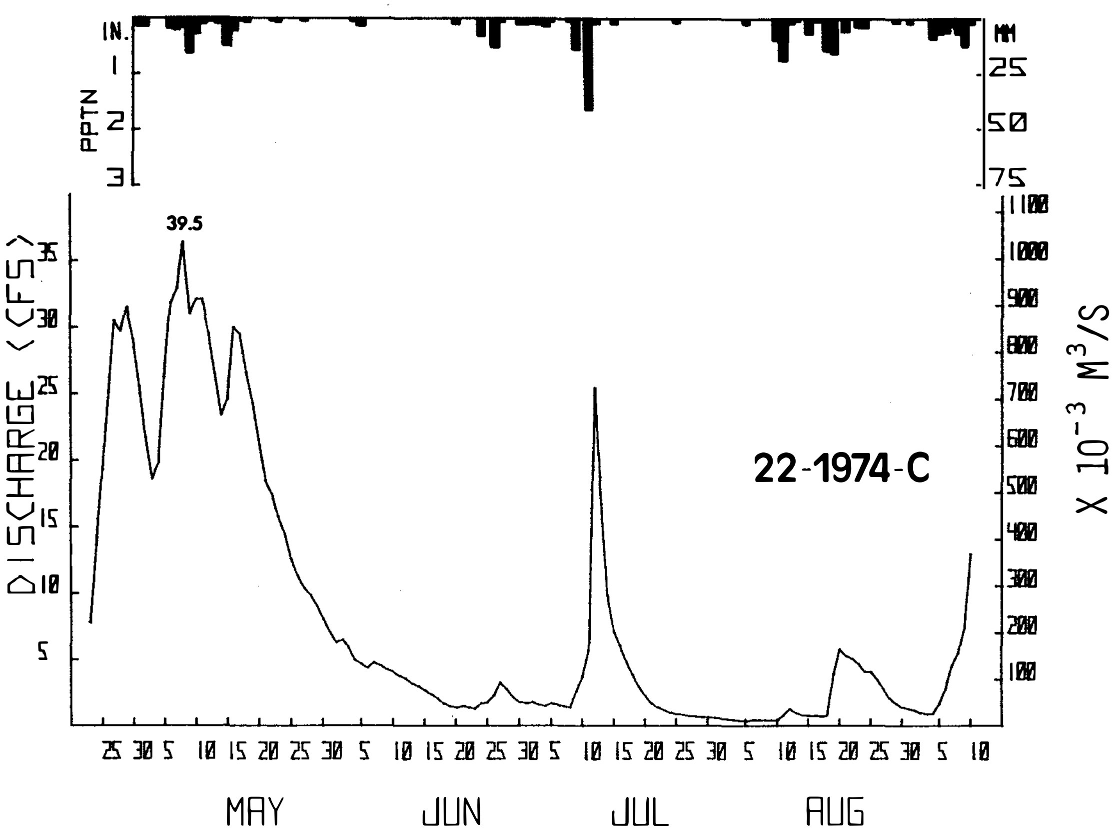
Gradient: 2%; *Order:* 3

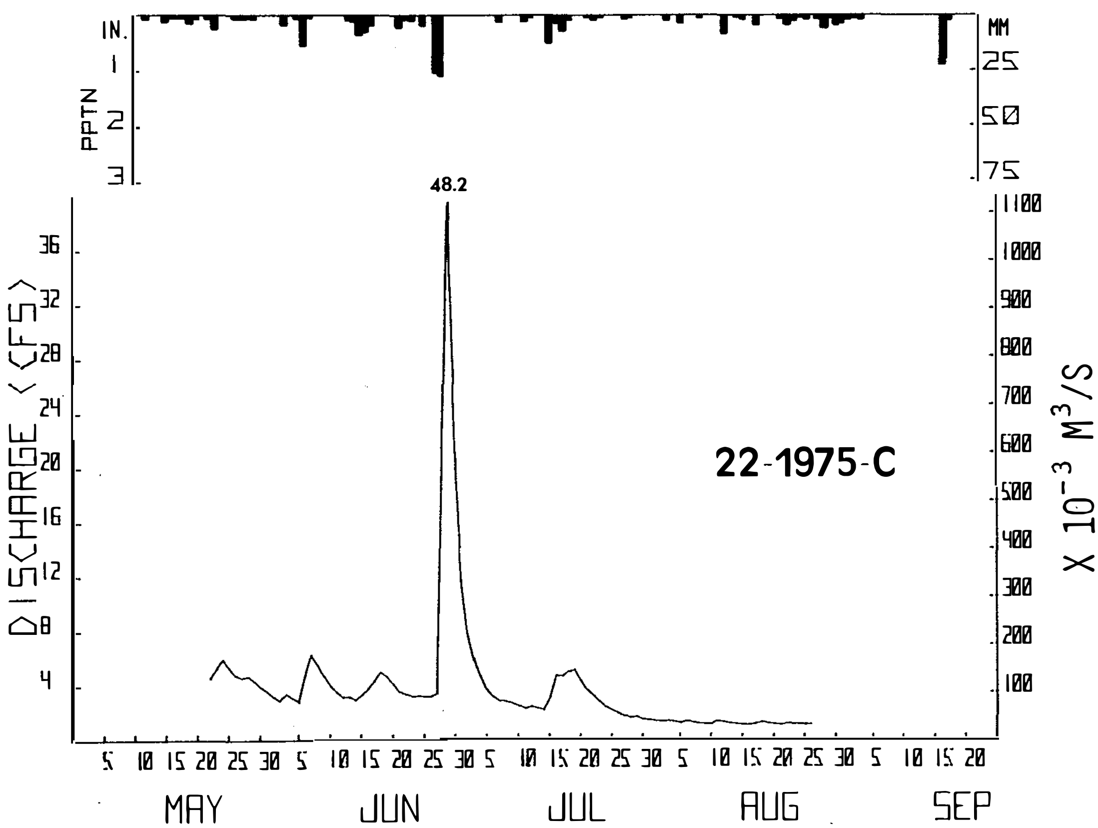
Perennial channel length: 6.8 km (4.2 mi)

Stream width-depth: 1.98 by 0.46 m (6.5 by 1.5 ft)


IN.
1
2
3
PPTN
MM
25
50
75
DISCHARGE (CFS)
22
20
18
16
14
12
10
8
6
4
2
650
600
550
500
450
400
350
300
250
200
150
100
50
X 10^{-3} M^3/S
22-1972-C
5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20
JUL
AUG
SEP
OCT
NOV


IN.
1
2
3
PPTN
MM
25
50
75
52.0
DISCHARGE (CFS)
40
35
30
25
20
15
10
5
1200
1050
900
750
600
450
300
150
X 10^{-3} M^3/S
22-1973-C
5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20
MAY
JUN
JUL
AUG
SEP


PPTN
IN.
1
2
3
MM
25
50
75
DISCHARGE (CFS)
5
10
15
20
25
30
35
39.5
X 10^-3 M^3/S
100
200
300
400
500
600
700
800
900
1000
1100
22-1974-C
25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10
MAY
JUN
JUL
AUG


PPTN
IN.
1
2
3
MM
25
50
75
DISCHARGE (CFS)
4
8
12
16
20
24
28
32
36
48.2
X 10^-3 M^3/S
100
200
300
400
500
600
700
800
900
1000
1100
22-1975-C
5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20
MAY
JUN
JUL
AUG
SEP

WATERSHED NO. 23

Drainage: Anderson Creek-1

Location: Section NW 13, Twp. 60, Range 24, W5M

Area: 10.6 km^2 (4.1 mi^2) **Aspect:** ESE

Elevation: Max. 1615 m (5300 ft); Min. 1280 m (4200 ft)

Physiography: Athabasca Tableland and Rocky Mountain Foothills.

Vegetation: Pl, Sw. 56% of forest cover removed as of December, 1974.

Soils:

	Marlboro	Fickle	Erith
Associations:	Marlboro	Fickle	Erith
Infiltration (cm/h):	4 to 5	0.5	0.5

Surficial Deposits: Marlboro Till and Robb Till. Organic deposits (peat) near stream channel.

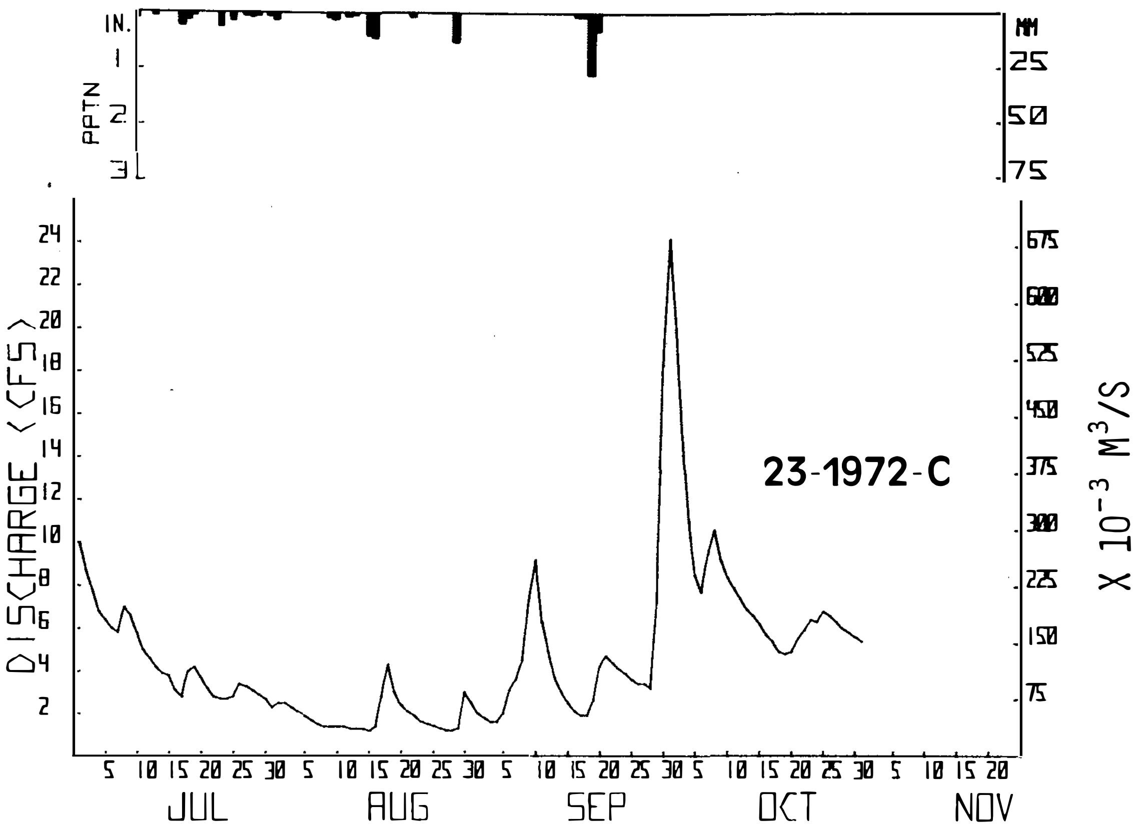
Bedrock: NE part of watershed--Brazeau fm: sandstone, shale, conglomerate. SW part of watershed--Paleocene. Pedley Fault forms the approximate boundary between the two formations.

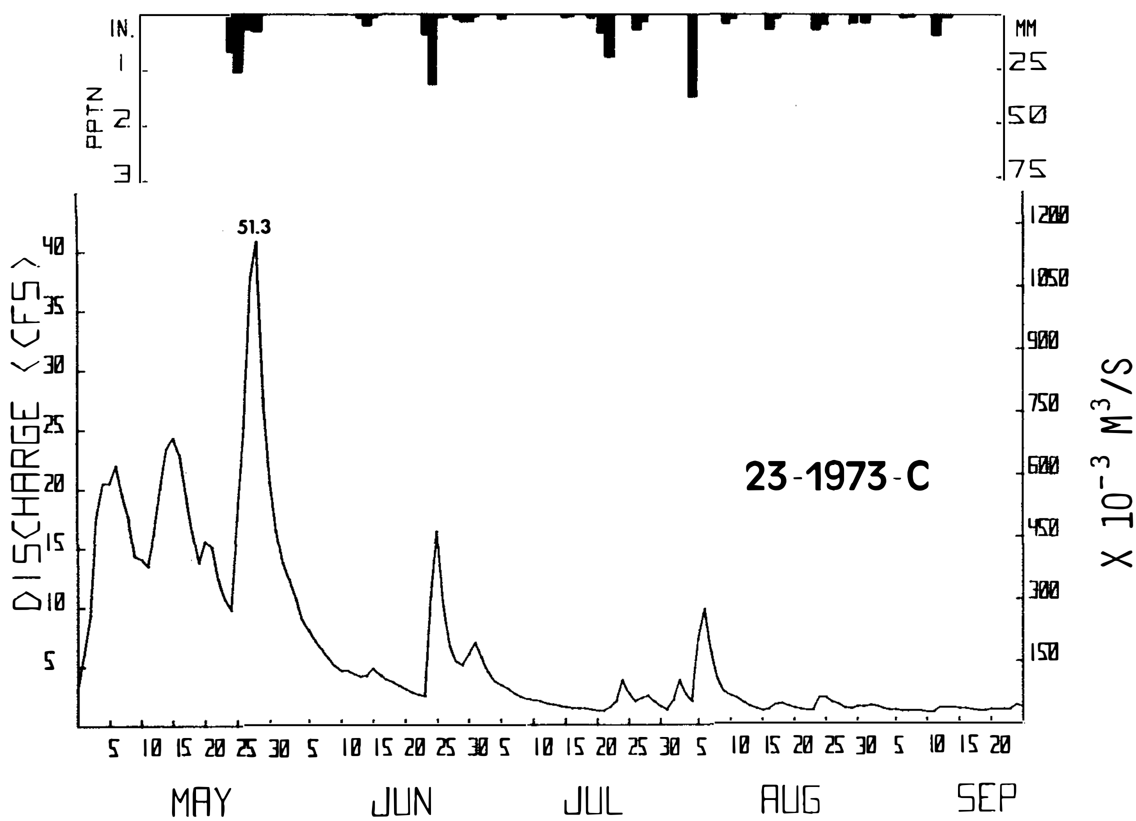
Stream Channel:

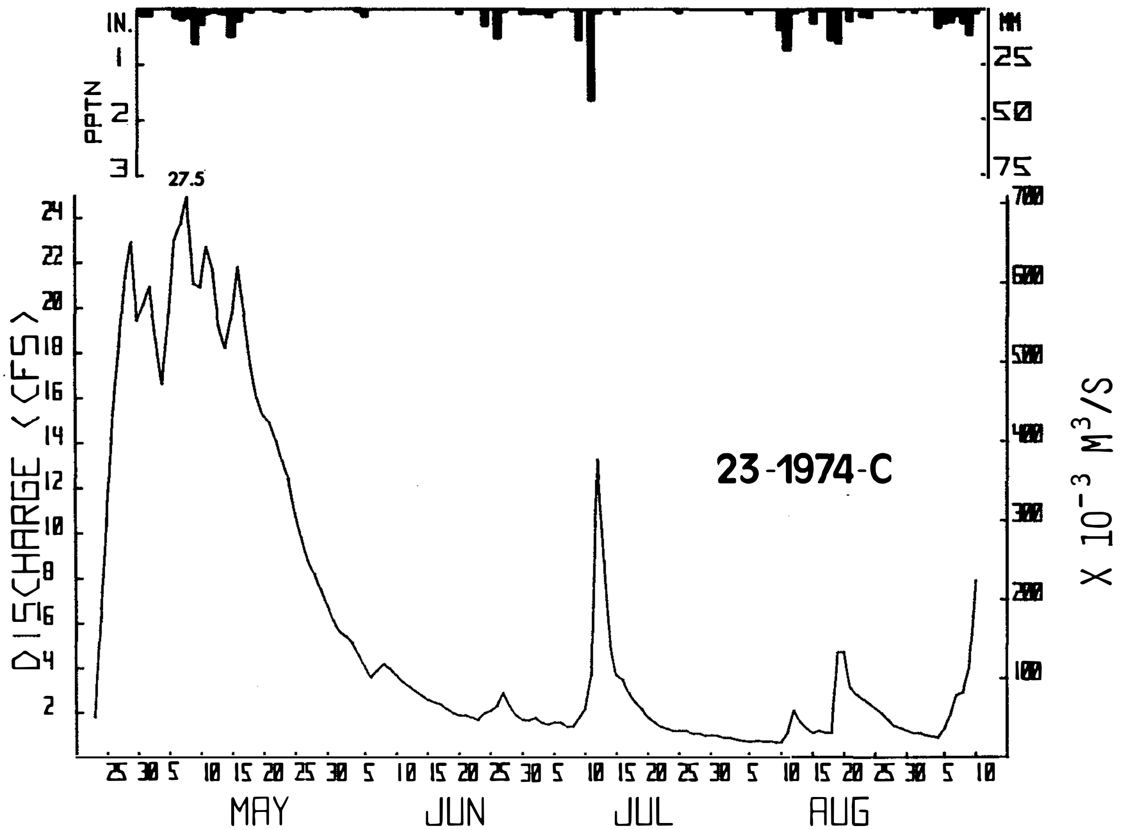
Gradient: 1%; *Order:* 3

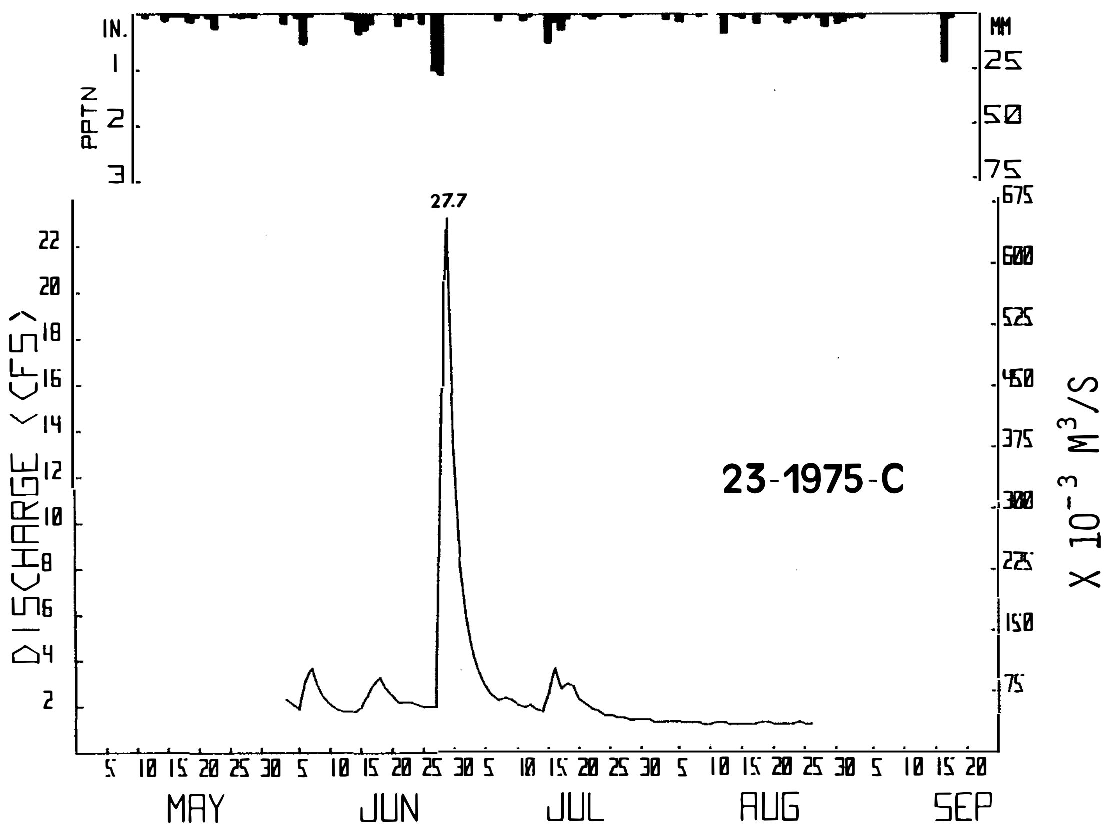
Perennial channel length: 6.6 km (4.1 mi)

Stream width-depth: 2.13 by 0.3 m (7.0 by 1.0 ft)


IN.
PPTN
MM
DISCHARGE (CFS)
X 10^{-3} M^3/S
23-1972-C
JUL
AUG
SEP
OCT
NOV


IN.
PPTN
MM
51.3
DISCHARGE (CFS)
X 10^{-3} M^3/S
23-1973-C
MAY
JUN
JUL
AUG
SEP


IN.
PPTN
MM
27.5
DISCHARGE (CFS)
X 10^{-3} M^3/S
23-1974-C
MAY
JUN
JUL
AUG


IN.
PPTN
MM
27.7
DISCHARGE (CFS)
X 10^{-3} M^3/S
23-1975-C
MAY
JUN
JUL
AUG
SEP

WATERSHED NO. 24

Drainage: Anderson Creek—2

Location: Section NE 09, Twp. 50, Range 23, W5M

Area: 19.7 km^2 (7.6 mi^2) **Aspect:** ENE

Elevation: Max. 1676 m (5500 ft); Min. 1189 m (3900 ft)

Physiography: Athabasca Tableland and Rocky Mountain Foothills.

Vegetation: Sw, Pl. 6% of forest cover removed as of December, 1974.

Soils:

Associations:	Robb	Erith	Jarvis
Infiltration (cm/h):	5 to 20	0.5	N/A

Surficial Deposits: Marlboro Till and Robb Till. Grooves and flutings. Stream channel—upper: outwash (sand & gravel); lower: lake sediments (clay, silt, sand).

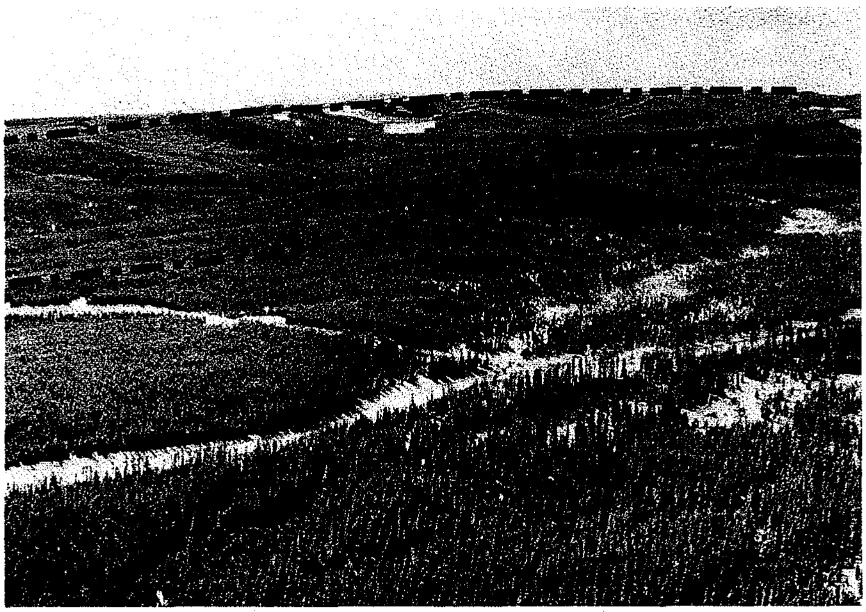
Bedrock: SW part of watershed—Paleocene: sandstone, shale. Entrance Syncline near SW boundary. NE part of watershed—Brazeau Fm: sandstone, shale. Pedley Fault separates Paleocene and Brazeau.

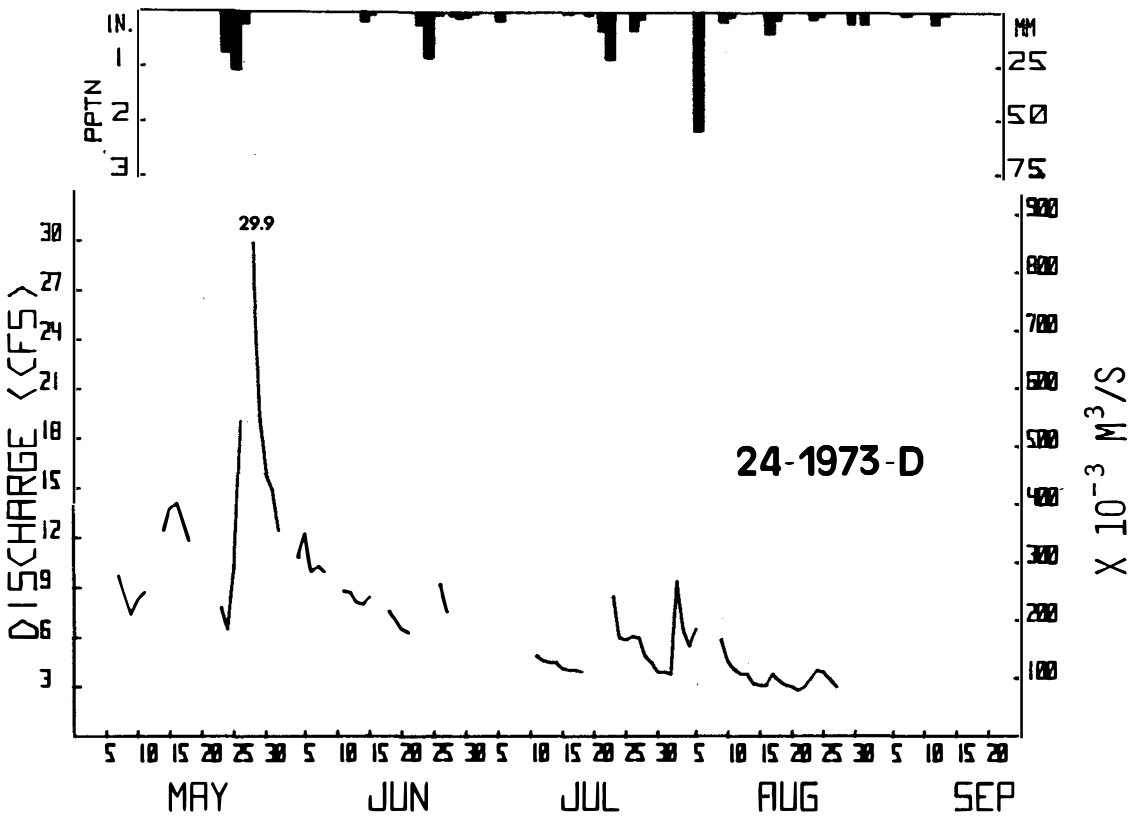
Stream Channel:

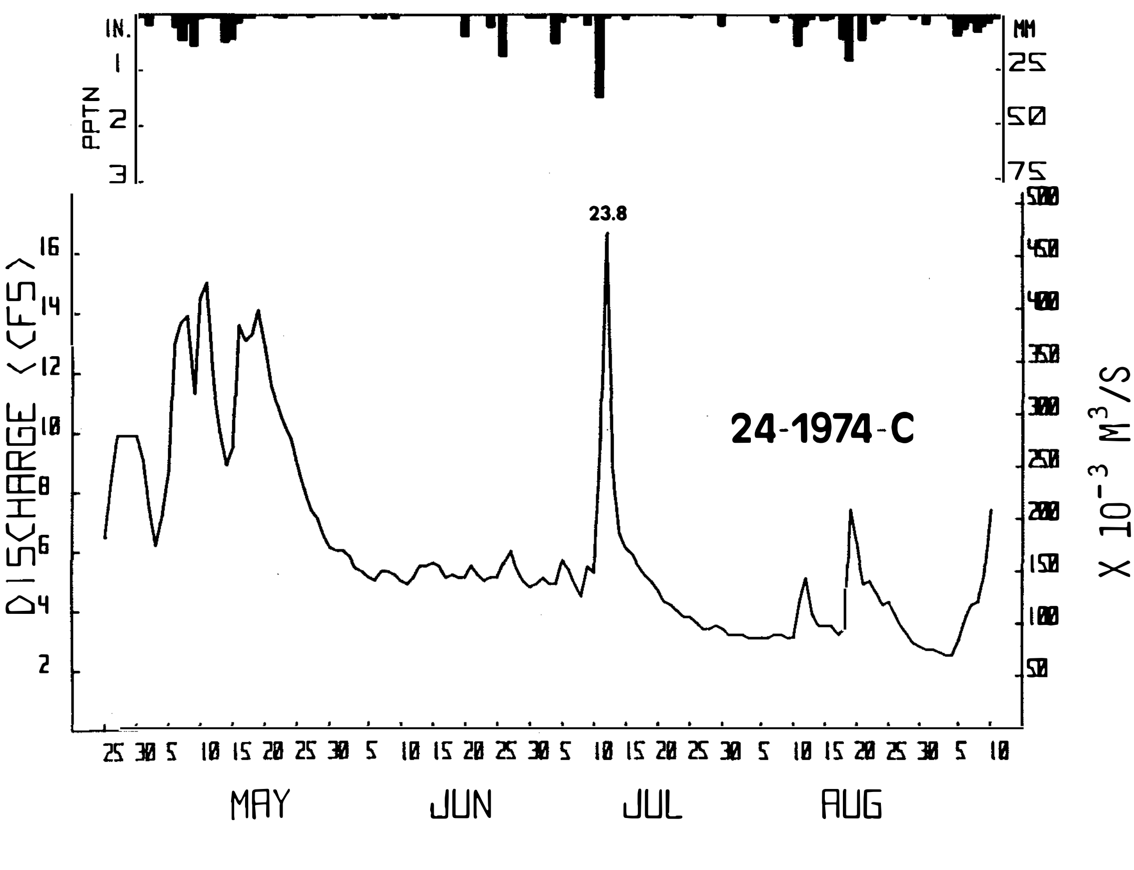
Gradient: 3%; *Order:* 3

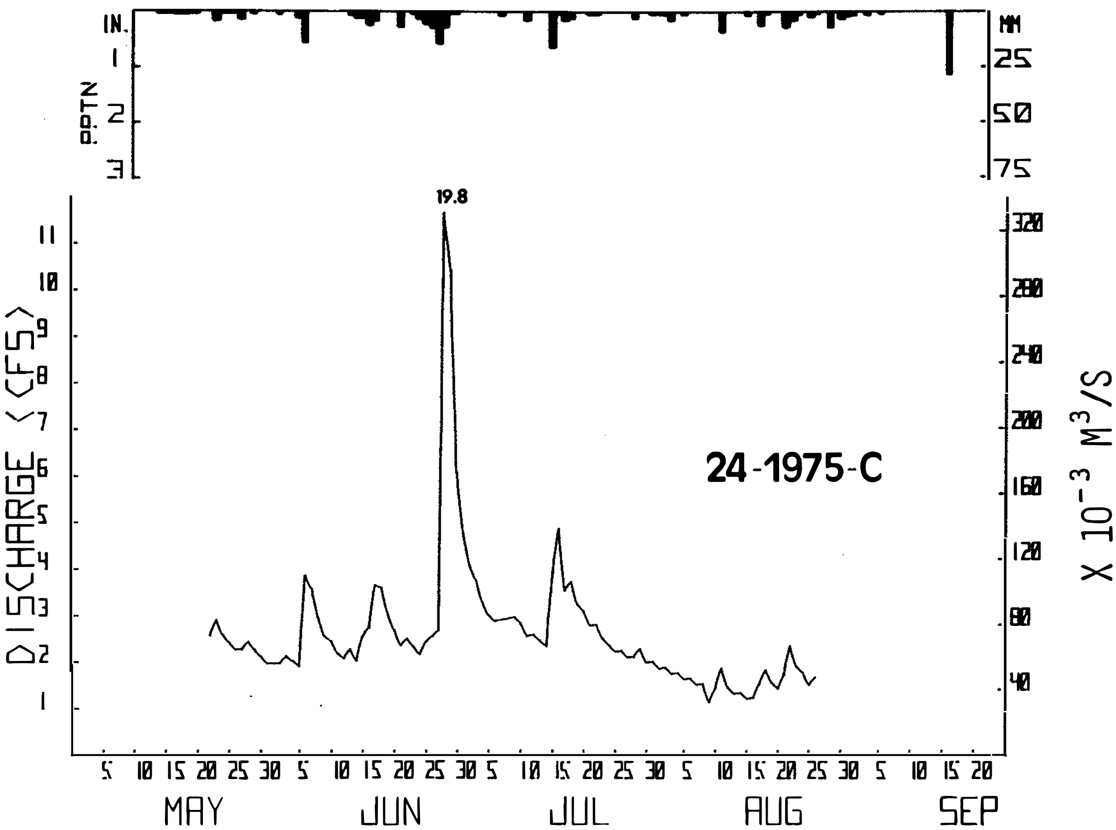
Perennial channel length: 12.7 km (7.9 mi)

Stream width-depth: 2.9 by 0.2 m (9.5 by 0.8 ft)




IN.
PPTN
MM
DISCHARGE (CFS)
X 10^{-3} M^3/S
29.9
24-1973-D
MAY
JUN
JUL
AUG
SEP


IN.
PPTN
MM
DISCHARGE (CFS)
X 10^{-3} M^3/S
23.8
24-1974-C
MAY
JUN
JUL
AUG


IN.
1
2
3
PPTN
MM
25
50
75
19.8
DISCHARGE (CFS)
1
2
3
4
5
6
7
8
9
10
11
320
280
240
200
160
120
80
40
X 10^-3 M^3/S
24-1975-C
5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20
MAY
JUN
JUL
AUG
SEP

WATERSHED NO. 25

Drainage: Unnamed Creek—2

Location: Section SW 15, Twp. 50, Range 23, W5M

Area: 8.8 km^2 (3.4 mi^2) **Aspect:** NE

Elevation: Max. 1463 m (4800 ft); Min. 1158 m (3800 ft)

Physiography: Athabasca Tableland and Rocky Mountain Foothills.

Vegetation: Sw, Pl. 22% of forest cover removed as of December, 1974. 11% was cut prior to 1972.

Soils:

Associations:	Robb	Fickle	Jarvis	RB
Infiltration (cm/h):	5 to 20	0.5	N/A	N/A

Surficial Deposits: Marlboro Till. Lake sediments (clay, silt, and sand) and alluvium near outlet into McLeod River.

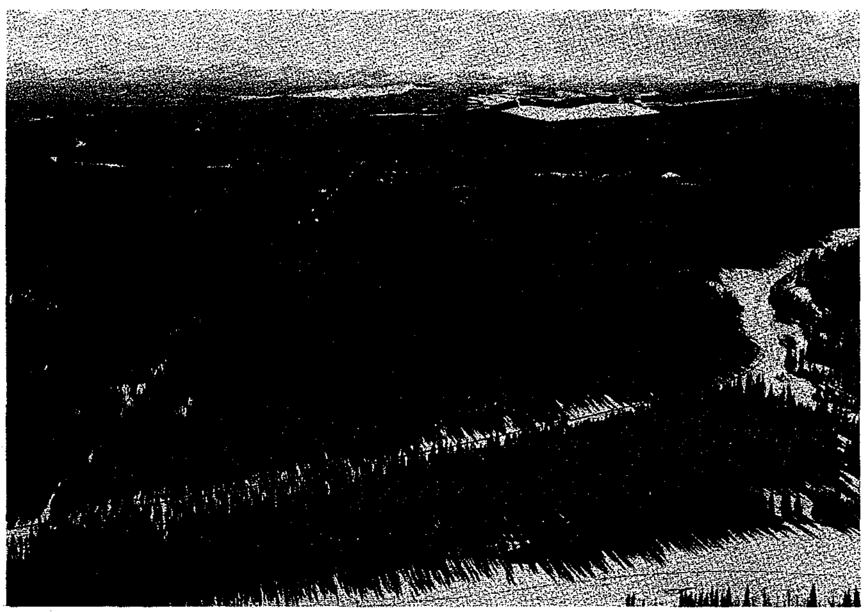
Bedrock: SW part of watershed—Paleocene: sandstone, shale, conglomerate. NE part of watershed—Brazeau Fm: sandstone, shale. Paleocene and Brazeau Fm separated by Pedley Fault.

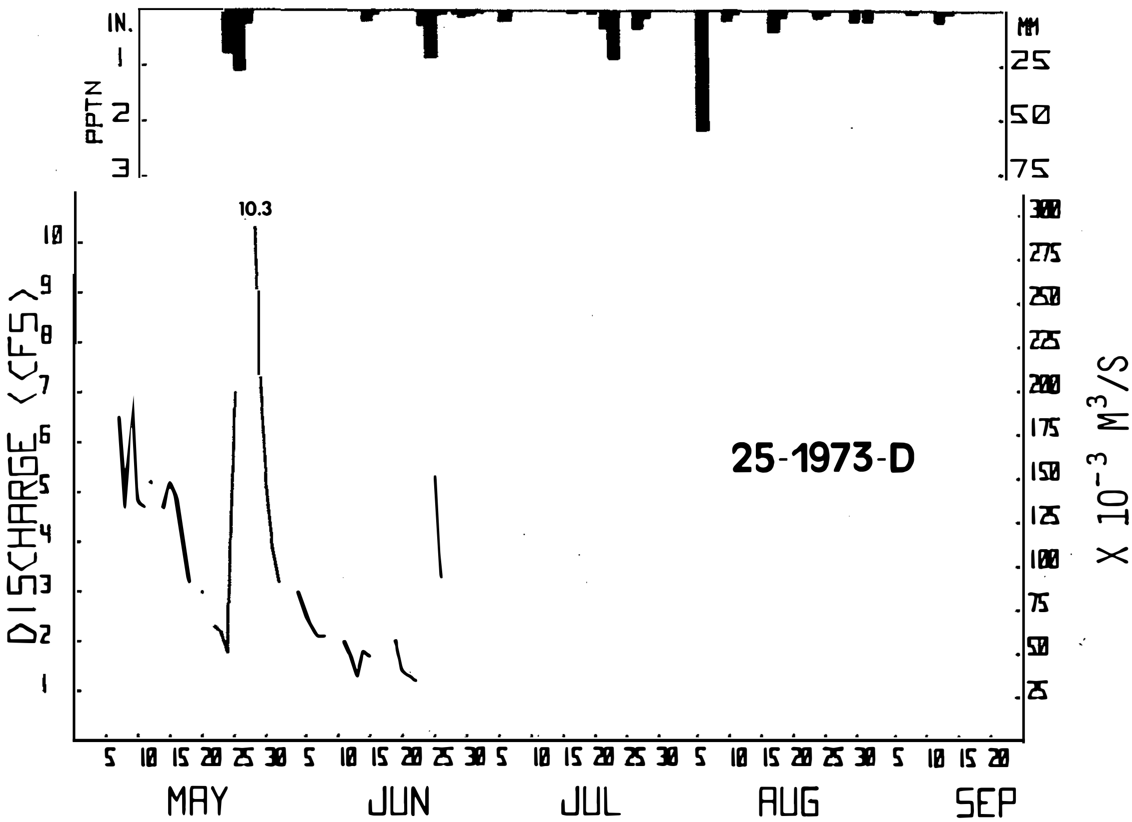
Stream Channel:

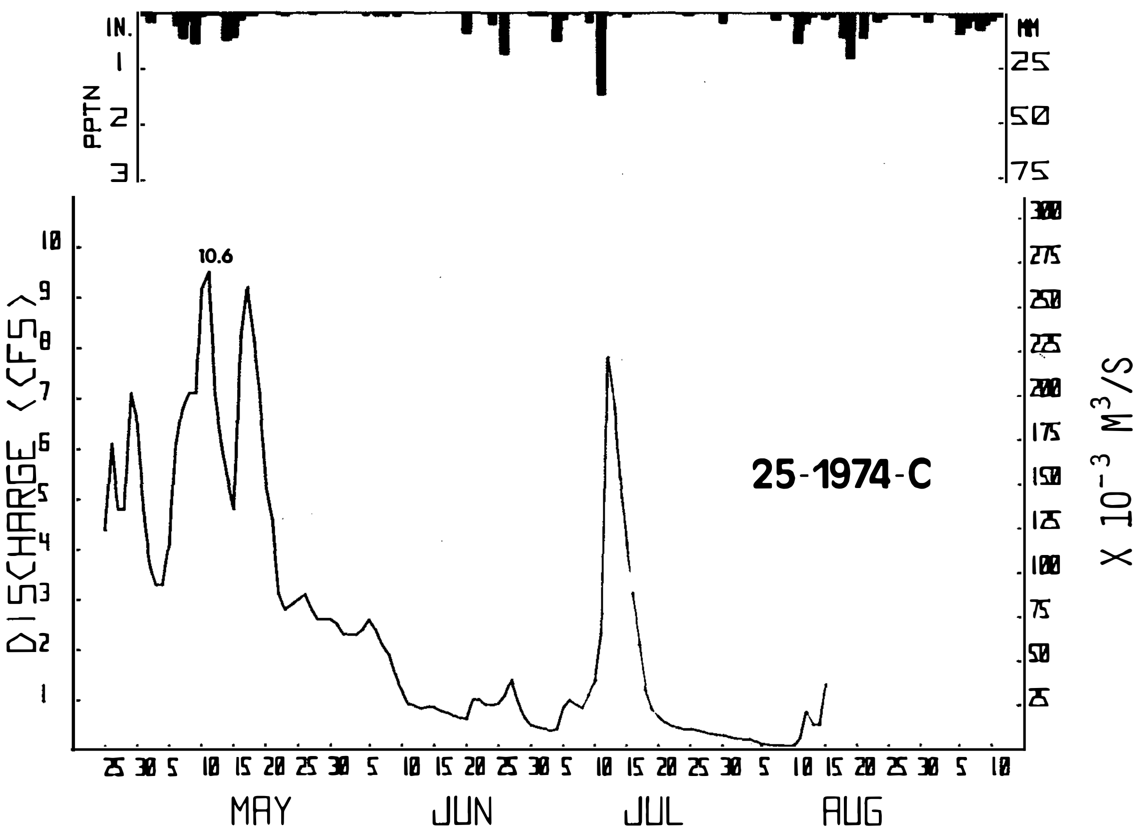
Gradient: 3%; *Order:* 2

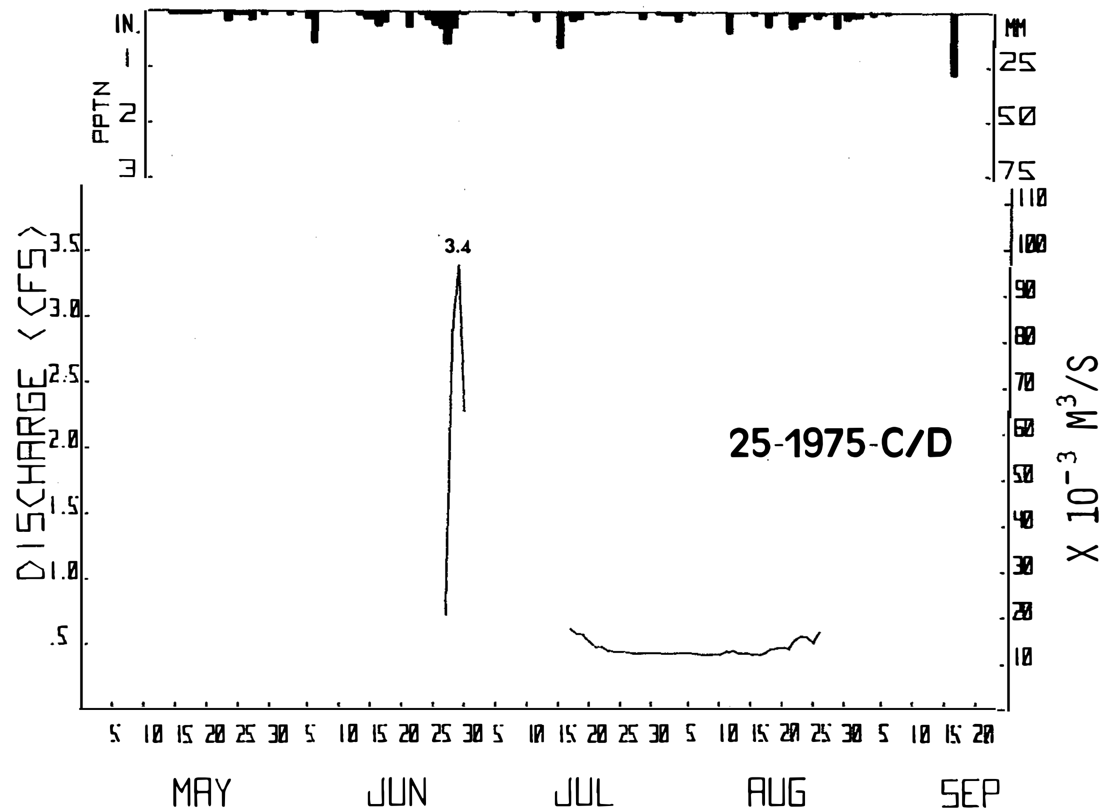
Perennial channel length: 6.1 km (3.8 mi)

Stream width-depth: 1.8 by 0.2 m (6.0 by 0.5 ft)




IN.
PPTN
MM
DISCHARGE (CFS)
X 10^-3 M^3/S
10.3
25-1973-D
MAY
JUN
JUL
AUG
SEP


IN.
PPTN
MM
DISCHARGE (CFS)
X 10^-3 M^3/S
10.6
25-1974-C
MAY
JUN
JUL
AUG


IN.
PPTN
MM
3.4
25-1975-C/D
DISCHARGE (CFS)
X 10^{-3} M^3/S
MAY
JUN
JUL
AUG
SEP

WATERSHED NO. 26

Drainage: Felton Creek—1

Location: Section SE 31, Twp. 49, Range 22, W5M

Area: 49.2 km^2 (19.0 mi^2) **Aspect:** W

Elevation: Max. 1387 m (4550 ft); Min. 1219 m (4000 ft)

Physiography: Athabasca Tableland—lower part of watershed. Rocky Mountain Foothills—upper part.

Vegetation: Pl, Sw, Sb. Grass meadows on lower part of watershed. 35% of forest cover removed as of 1973.

Soils:

Associations:	Robb	Fickle
Infiltration (cm/h):	5 to 20	0.5

Surficial Deposits: Marlboro Till.

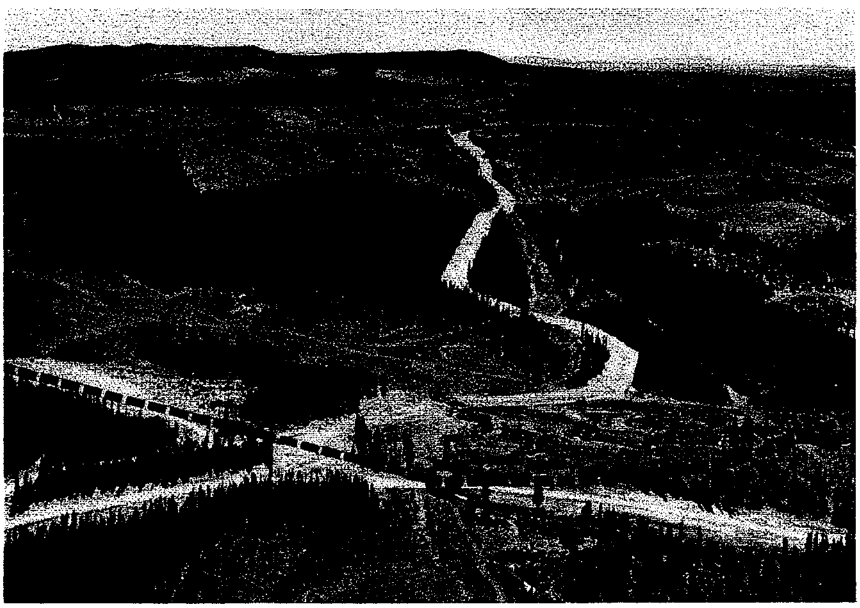
Bedrock: TERTIARY—Paleocene: sandstone, shale, minor conglomerate. LATE UPPER CRETACEOUS—Brazeau Fm: sandstone, shale, conglomerate, minor coal seams, and ash beds.

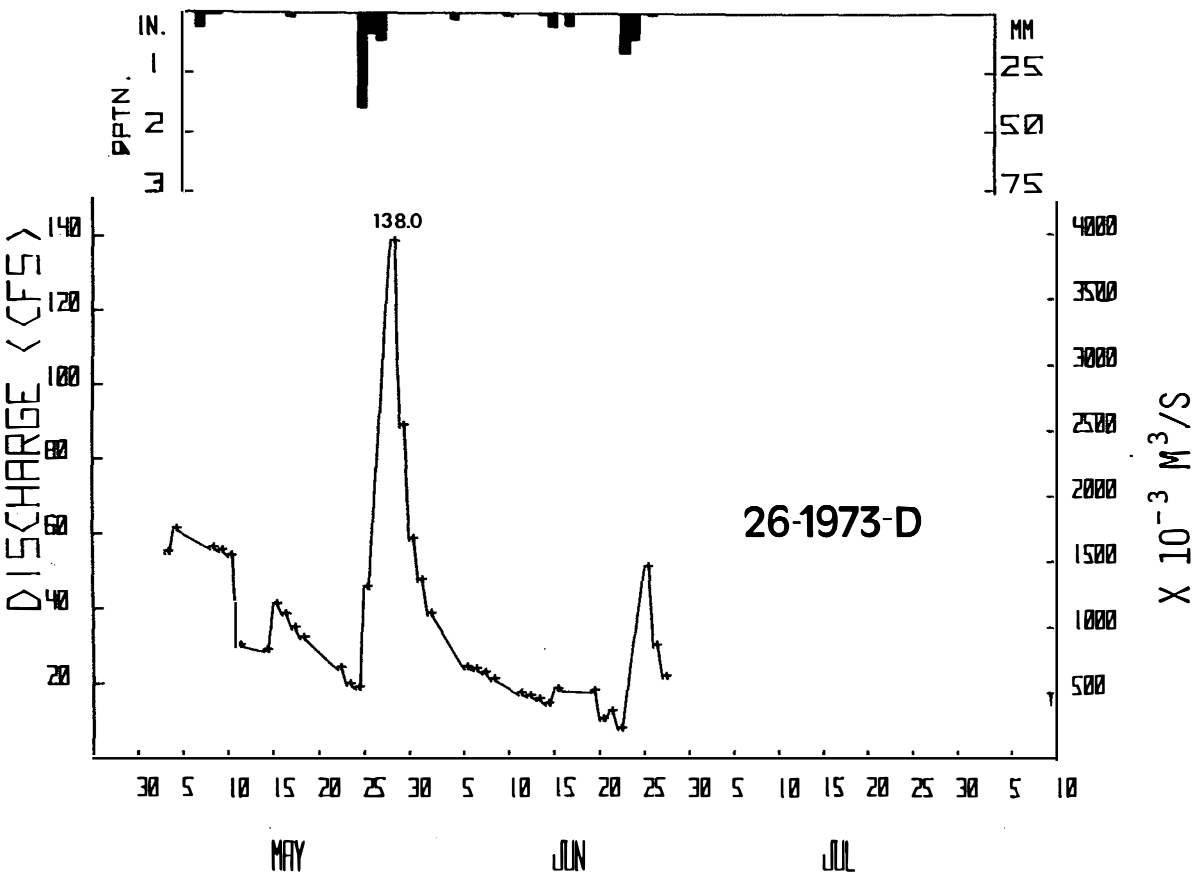
Stream Channel:

Gradient: 2%; *Order:* 3

Perennial channel length: 12.9 km (8.0 mi)

Stream width-depth: 3.4 by 0.3 m (11.0 by 1.0 ft)




IN.
PPTN.
1
2
3
MM
25
50
75
DISCHARGE (CFS)
140
120
100
80
60
40
20
138.0
26-1973-D
4000
3500
3000
2500
2000
1500
1000
500
X 10⁻³ M³/S
30
5
10
15
20
25
30
5
10
15
20
25
30
5
10
15
20
25
30
5
10
MAY
JUN
JUL

WATERSHED NO. 27

Drainage: Felton Creek—2

Location: Section NW 19, Twp. 49, Range 22, W5M

Area: 9.3 km^2 (3.6 mi^2) **Aspect:** E

Elevation: Max. 1387 m (4550 ft); Min. 1219 m (4000 ft)

Physiography: Rocky Mountain Foothills.

Vegetation: Pl, Sw, Sb. 33% of forest cover removed as of 1973.

Soils:

Associations:	Robb	Tri-Creek	Erith
Infiltration (cm/h):	5 to 20	>20	0.5

Surficial Deposits: Marlboro Till?

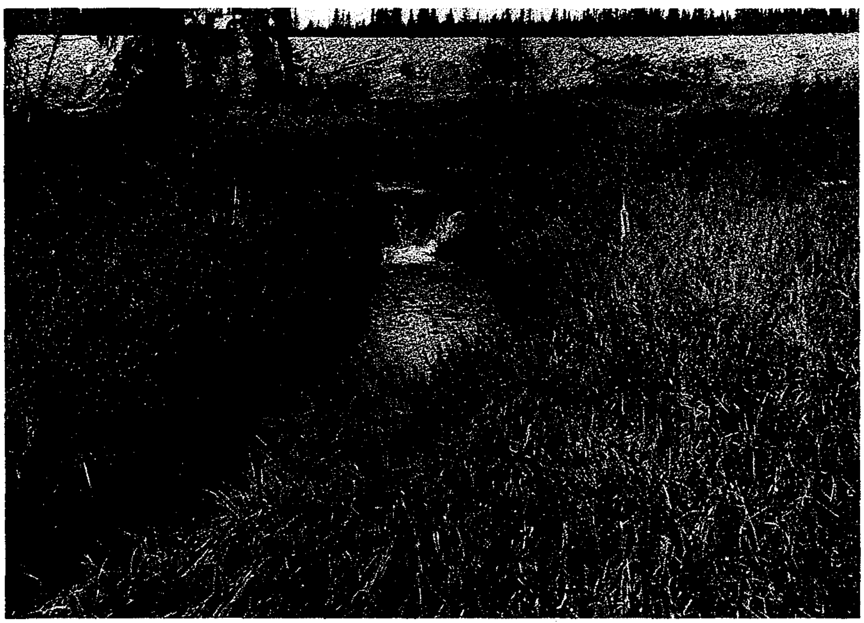
Bedrock: TERTIARY—Paleocene: sandstone, shale, minor conglomerate. LATE UPPER CRETACEOUS—Brazeau Fm: sandstone, shale, conglomerate, minor coal seams, and ash beds.

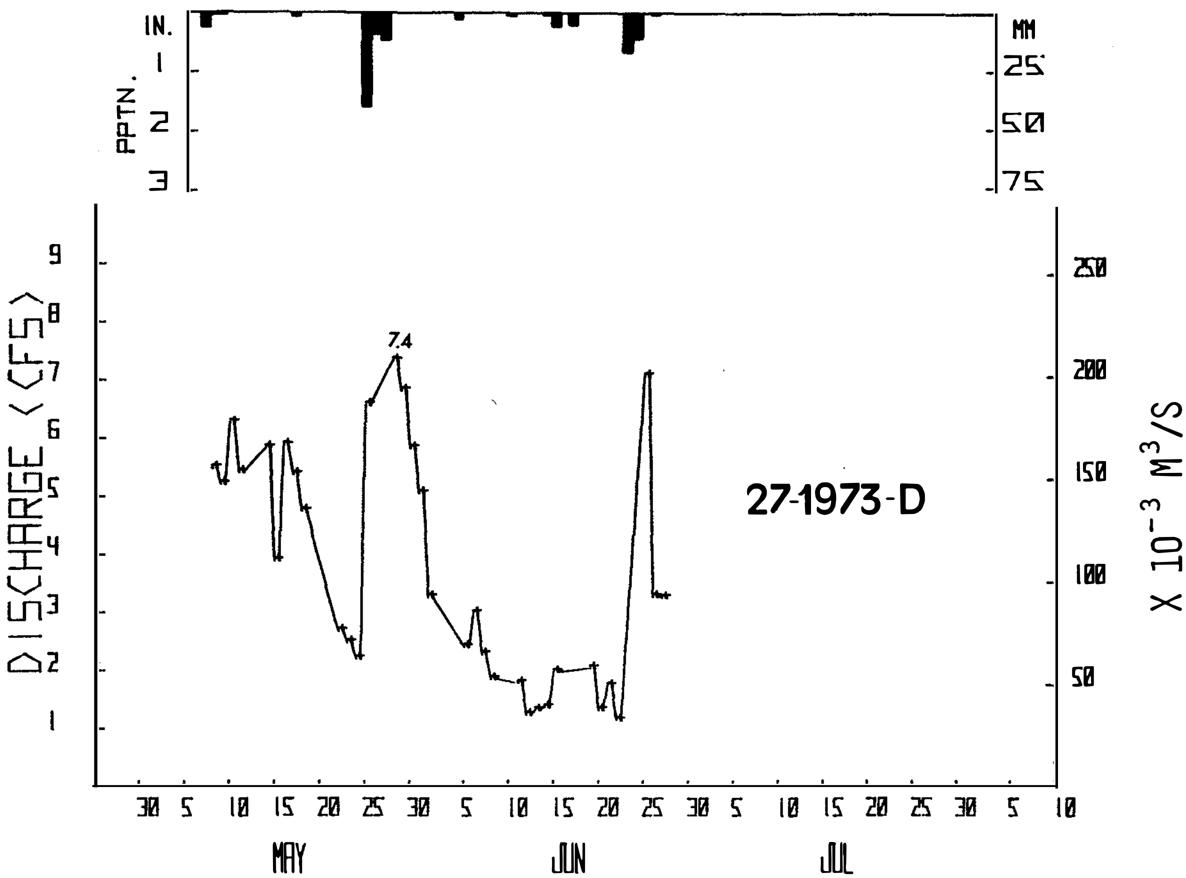
Stream Channel:

Gradient: 2%; *Order:* 2

Perennial channel length: 6.4 km (4.0 mi)

Stream width-depth: 1.2 by 1.2 m (4.0 by 4.0 ft)





IN.
PPTN.
1
2
3
MM
25
50
75
DISCHARGE (CFS)
1
2
3
4
5
6
7
8
9
7.4
27-1973-D
X 10^-3 M^3/S
50
100
150
200
250
30
5
10
15
20
25
30
5
10
15
20
25
30
5
10
15
20
25
30
5
10
MAY
JUN
JUL

WATERSHED NO. 28

Drainage: Felton Creek—3

Location: Section SE 17, Twp. 49, Range 22, W5M

Area: 5.7 km^2 (2.2 mi^2) **Aspect:** NE

Elevation: Max. 1387 m (4550 ft); Min. 1295 m (4250 ft)

Physiography: Rocky Mountain Foothills.

Vegetation: Pl. Sw, Sb. 32% of forest cover removed as of 1973.

Soils:

Associations:	Robb	Fickle
Infiltration (cm/h):	5 to 20	0.5

Surficial Deposits: Marlboro Till?

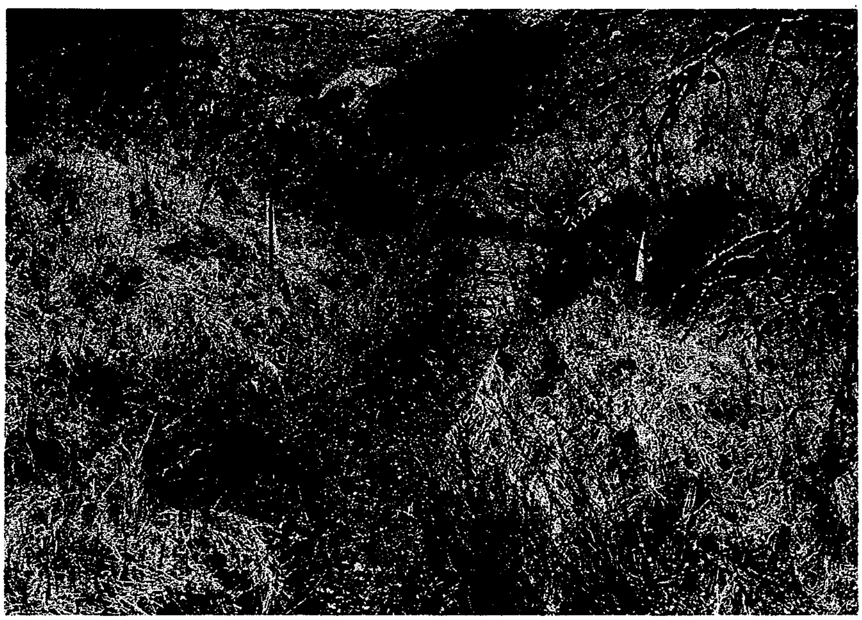
Bedrock: TERTIARY—Paleocene: sandstone, shale, minor conglomerate.
LATE UPPER CRETACEOUS—Brazeau Fm: sandstone, shale, conglomerate, minor coal seams and ash beds.

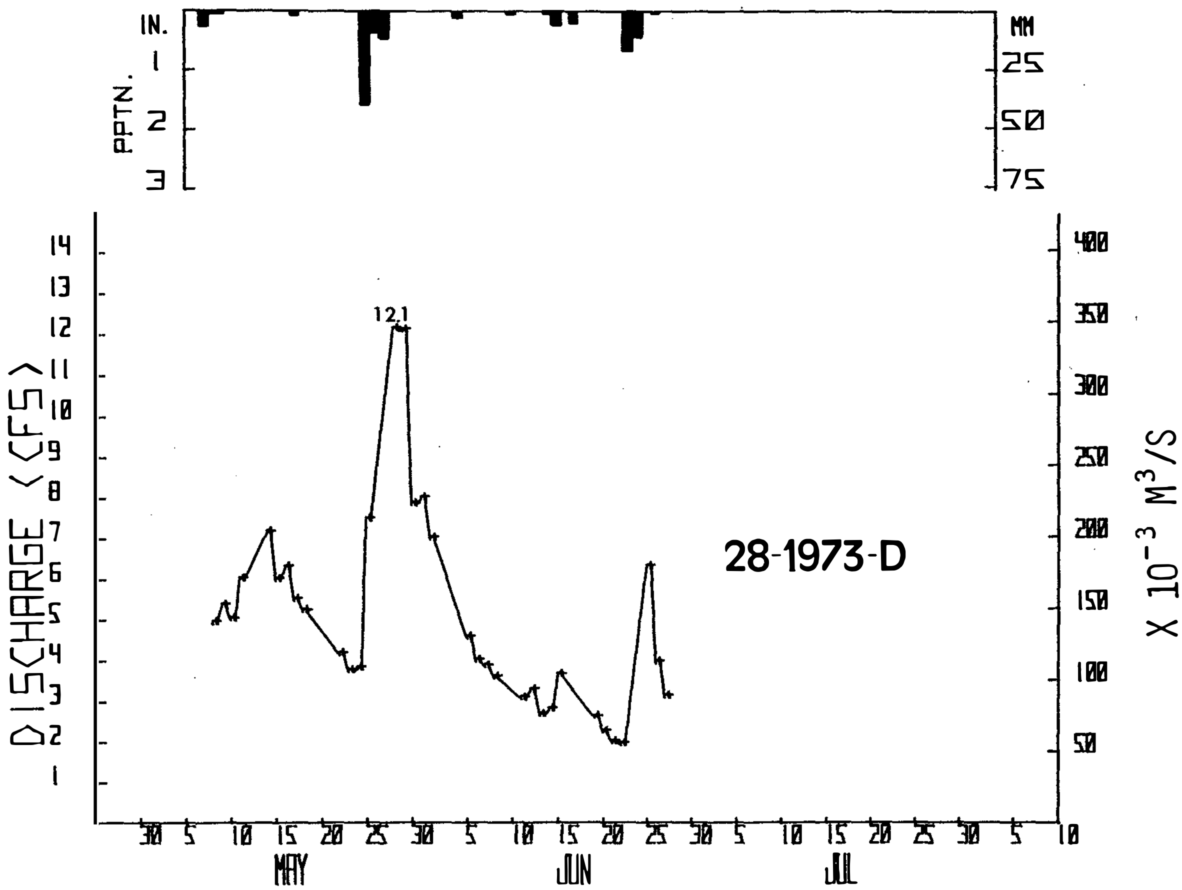
Stream Channel:

Gradient: 2%; *Order:* 1

Perennial channel length: 5.1 km (3.2 mi)

Stream width-depth: 0.9 by 0.5 m (3.0 by 1.5 ft)




IN.
PPTN.
1
2
3
MM
25
50
75
DISCHARGE (CFS)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
12.1
28-1973-D
400
350
300
250
200
150
100
50
X 10^{-3} M^3/S
30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10
MAY
JUN
JUL

WATERSHED NO. 29

Drainage: Wampus Creek

Location: Section NW 23, Twp. 48, Range 23, W5M

Area: 27.5 km^2 (10.6 mi^2) **Aspect:** N

Elevation: Max. 1676 m (5500 ft); Min. 1265 m (4150 ft)

Physiography: Rocky Mountain Foothills.

Vegetation: Pl, Sw, Sb.

Soils:

Associations:	Robb	AV	Tri-Creek	RB
Infiltration (cm/h):	5 to 20	N/A	>20	N/A

Surficial Deposits: Marlboro Till, local till, glaciolacustrine and glaciofluvial deposits, ice contact deposits.

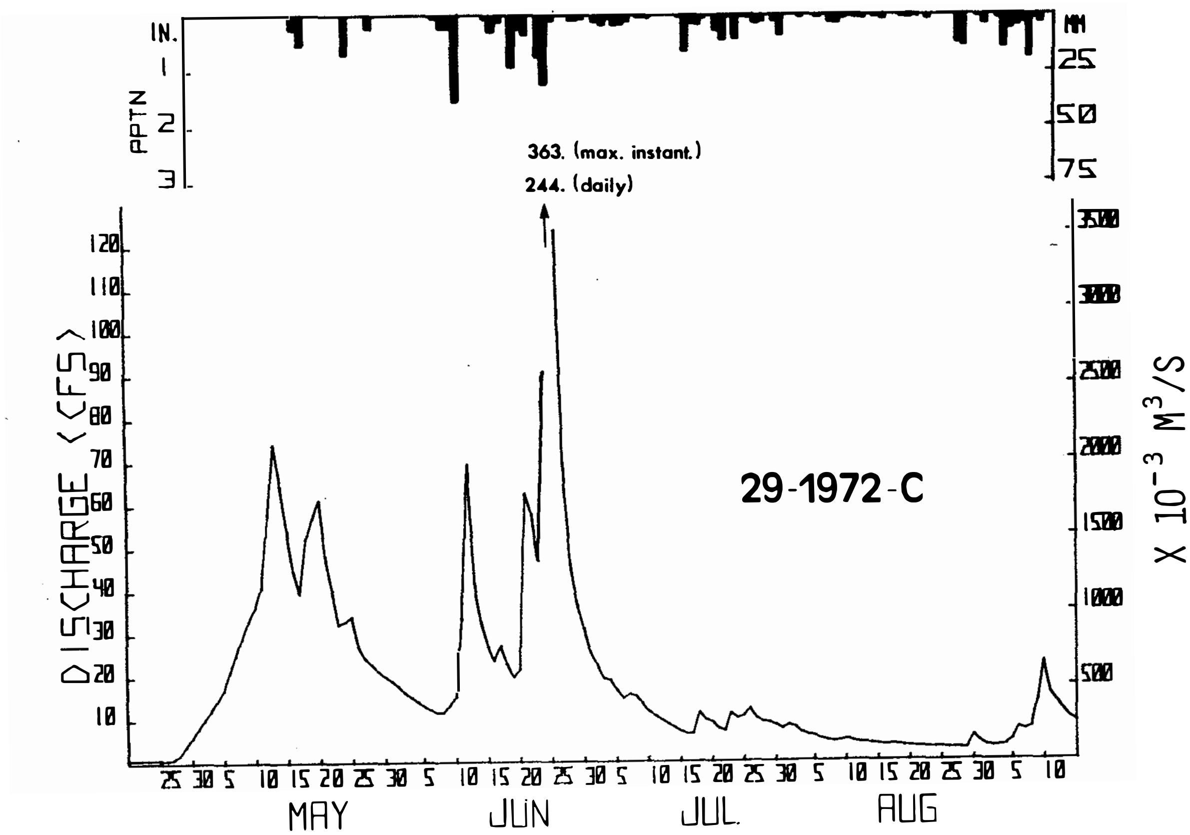
Bedrock: LATE UPPER CRETACEOUS—Brazeau Fm: sandstone, shale.
UPPER CRETACEOUS—Wapiabi Fm: shales, sandstones, siltstone.
Cardium Fm: sandstones, shales, siltstone. Blackstone Fm: shales.

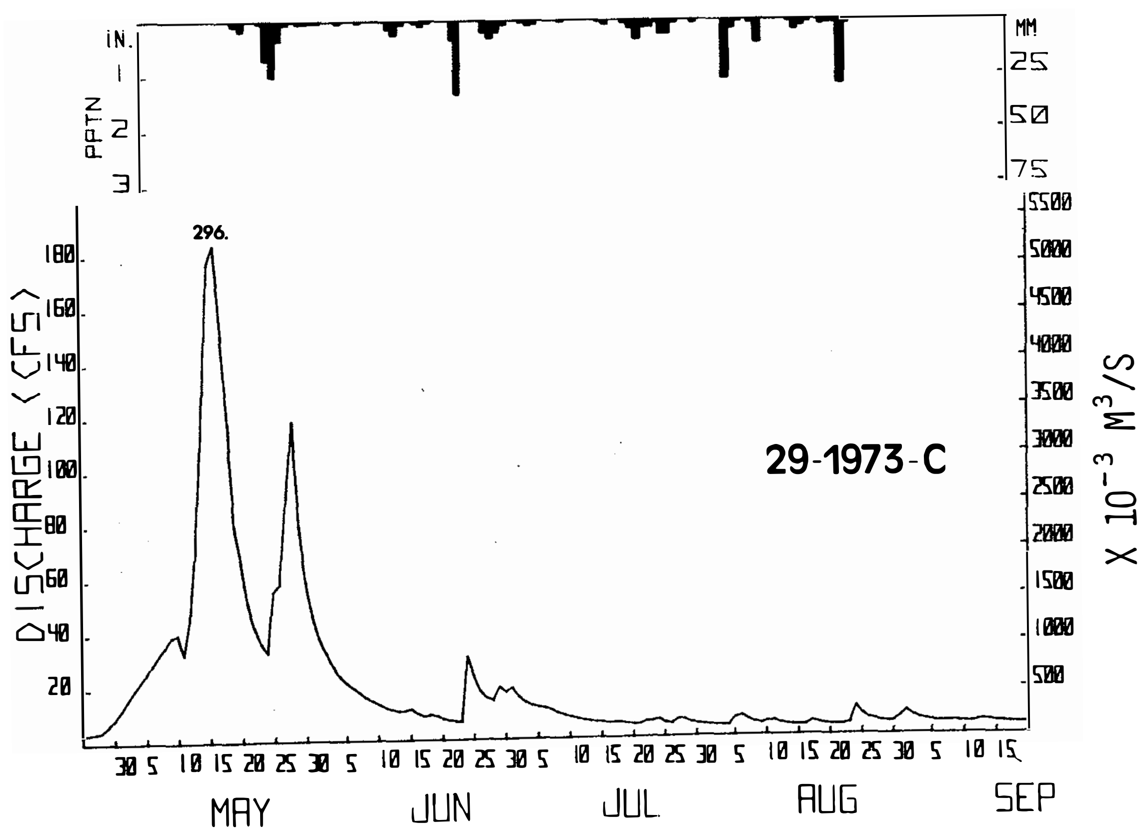
Stream Channel:

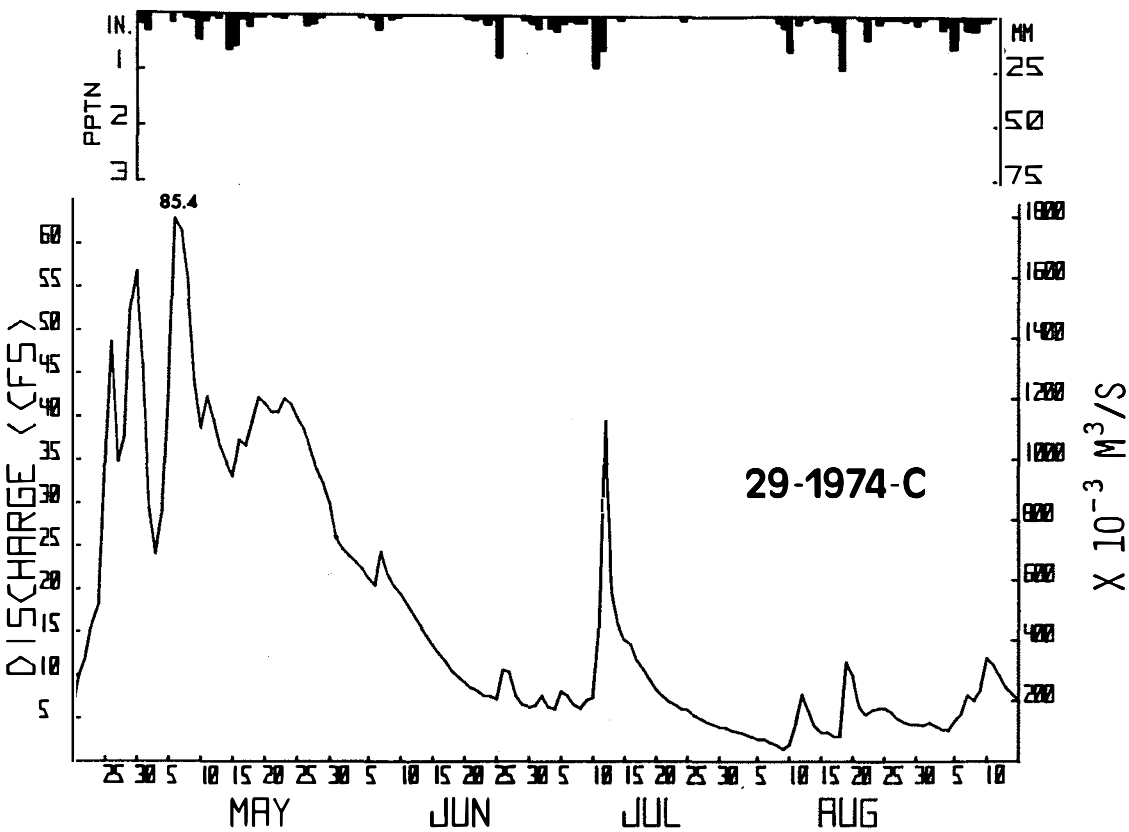
Gradient: 3%; *Order:* 4

Perennial channel length: 17.5 km (10.9 mi)

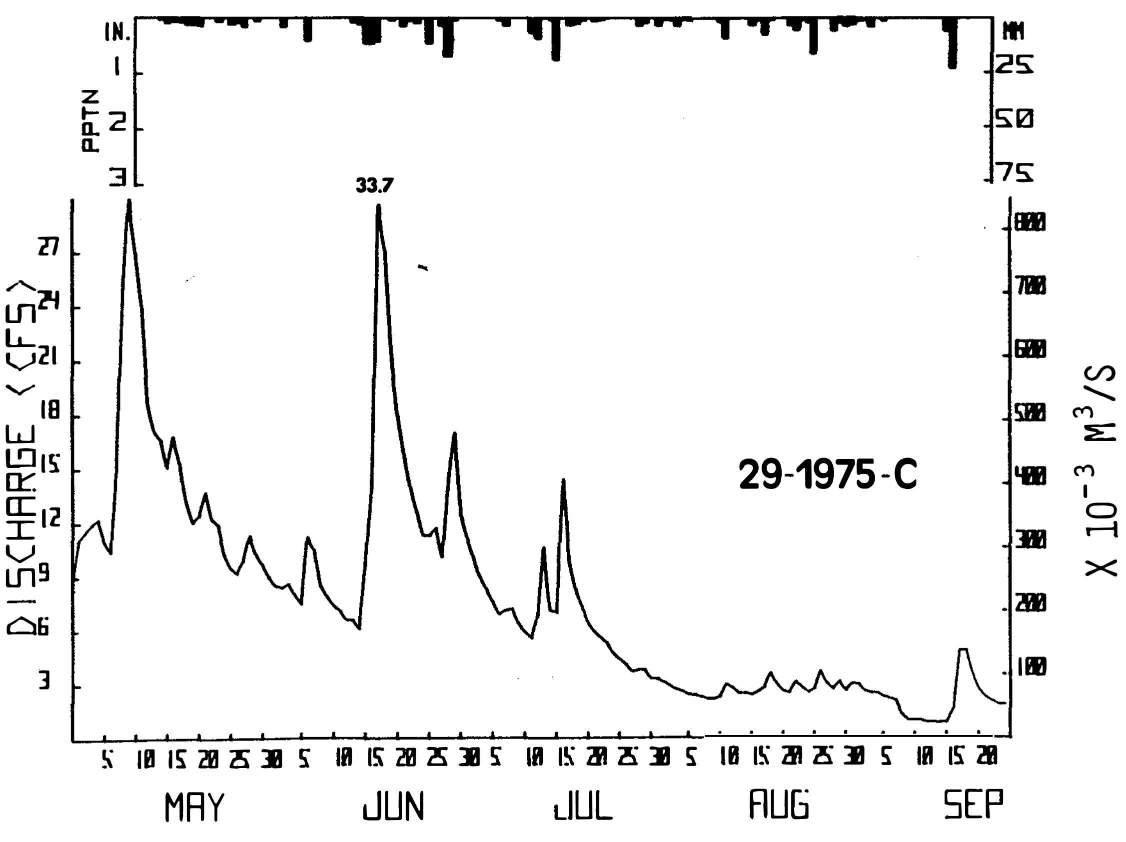
Stream width-depth: 5.5 by 0.3 m (18.0 by 0.9 ft)


IN.
PPTN
MM
363. (max. instant.)
244. (daily)
DISCHARGE (CFS)
X 10⁻³ M³/S
29-1972-C
MAY
JUN
JUL
AUG


IN.
PPTN
MM
296.
DISCHARGE (CFS)
X 10⁻³ M³/S
29-1973-C
MAY
JUN
JUL
AUG
SEP



IN.
MM
PPTN
85.4
DISCHARGE (CFS)
X 10^-3 M^3/S
29-1974-C
MAY
JUN
JUL
AUG



IN.
MM
PPTN
33.7
DISCHARGE (CFS)
X 10^-3 M^3/S
29-1975-C
MAY
JUN
JUL
AUG
SEP

WATERSHED NO. 30

Drainage: Deerlick Creek

Location: Section NE 23, Twp. 48, Range 23, W5M

Area: 13.7 km^2 (5.3 mi^2) **Aspect:** N

Elevation: Max. 1684 m (5525 ft); Min. 1265 m (4150 ft)

Physiography: Rocky Mountain Foothills.

Vegetation: Pl, Sw, Sb.

Soils:

Associations:	Robb	Tri-Creek	Erith
Infiltration (cm/h):	5 to 20	>20	0.5

Surficial Deposits: Marlboro Till, local till, glaciolacustrine and glaciofluvial deposits.

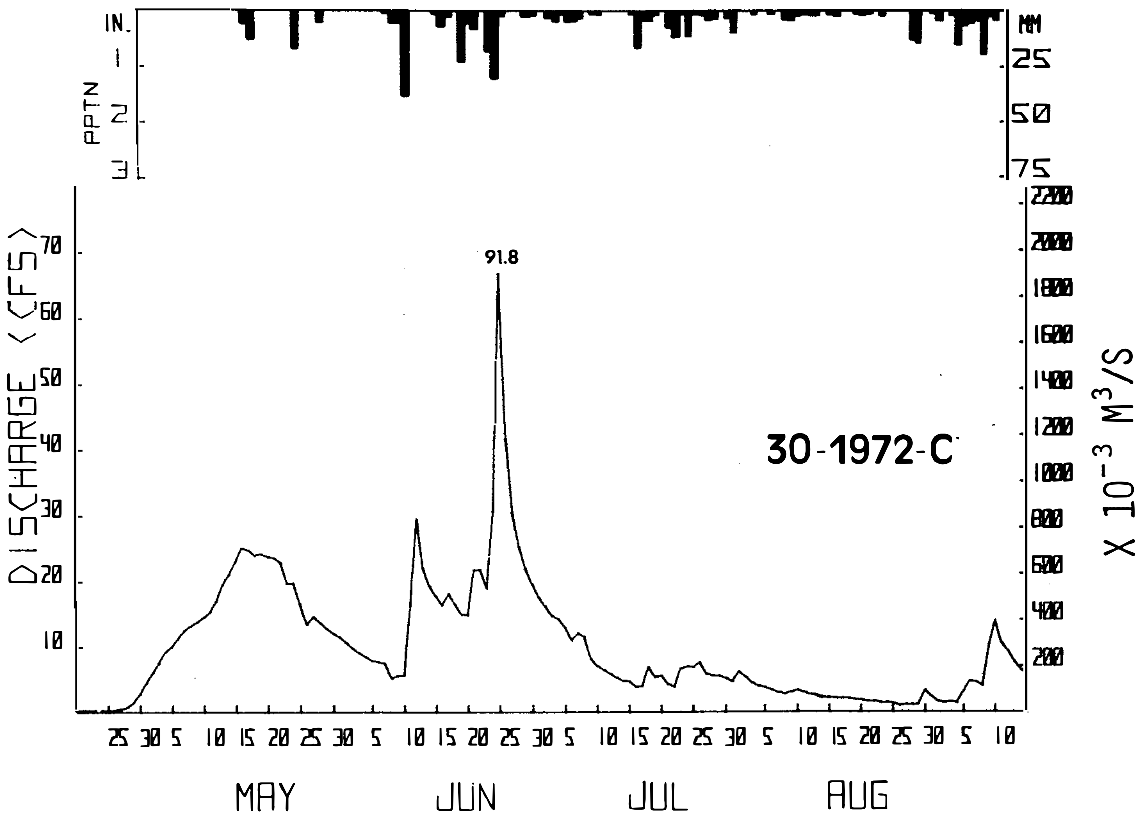
Bedrock: LATE UPPER CRETACEOUS—Brazeau Fm: sandstone, shale. UPPER CRETACEOUS—Wapiabi Fm: shales, sandstones, siltstone. Cardium Fm: sandstones, shales, siltstone. Blackstone Fm: shales.

Stream Channel:

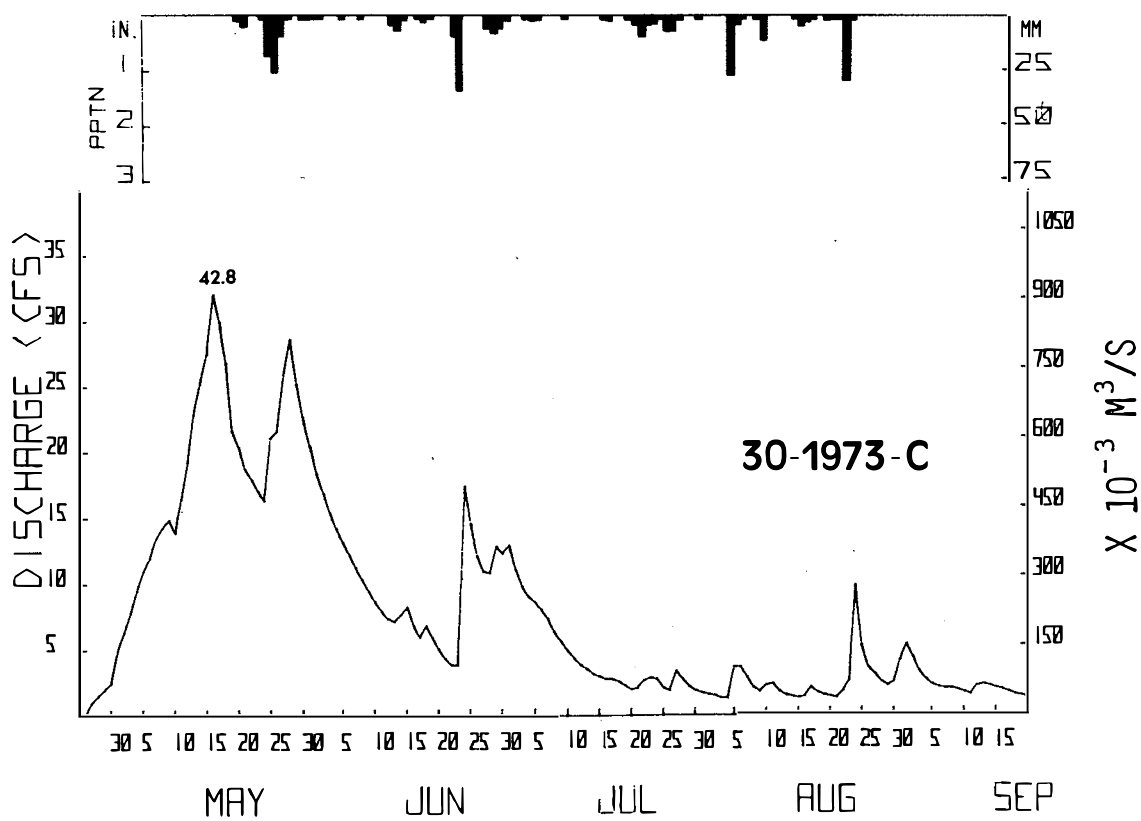
Gradient: 3%; *Order:* 4

Perennial channel length: 11.1 km (6.9 mi)

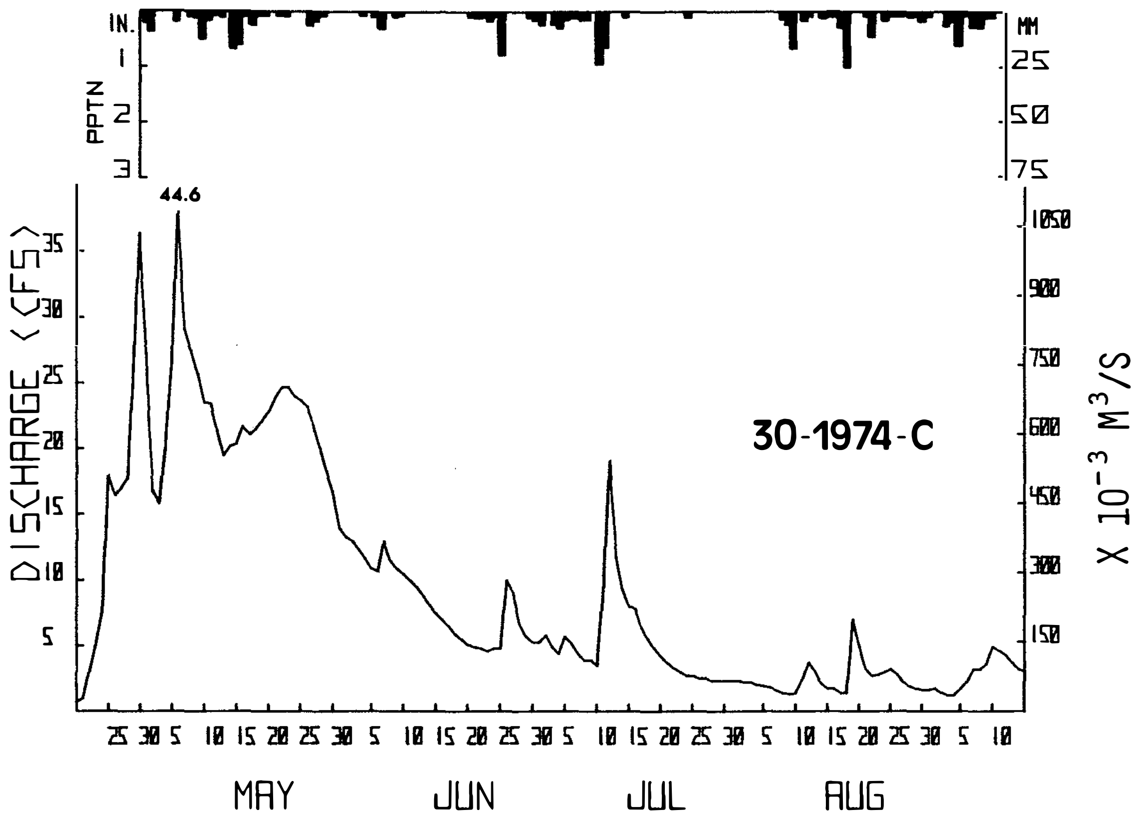
Stream width-depth: 3.7 by 0.2 m (12.0 by 0.7 ft)



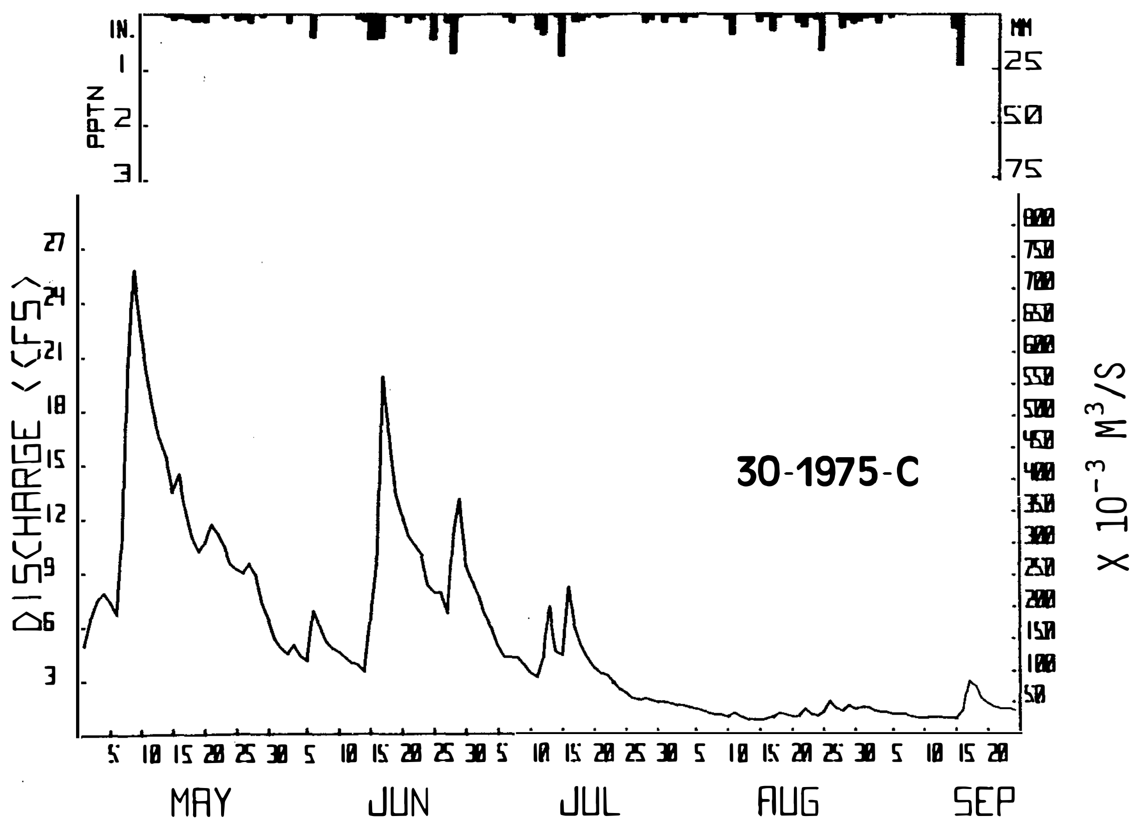
IN.
1
2
3
PPTN
MM
25
50
75
DISCHARGE <CFS>
10
20
30
40
50
60
70
91.8
30-1972-C
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
X 10^{-3} M^3/S
25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10
MAY
JUN
JUL
AUG



IN.
1
2
3
PPTN
MM
25
50
75
DISCHARGE <CFS>
5
10
15
20
25
30
35
42.8
30-1973-C
150
300
450
600
750
900
1050
X 10^{-3} M^3/S
30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15
MAY
JUN
JUL
AUG
SEP



IN.
PPTN
MM
44.6
DISCHARGE <CFS>
X 10^-3 M^3/S
30-1974-C
MAY
JUN
JUL
AUG



IN.
PPTN
MM
DISCHARGE <CFS>
X 10^-3 M^3/S
30-1975-C
MAY
JUN
JUL
AUG
SEP

WATERSHED NO. 31

Drainage: Eunice Creek

Location: Section SW 24, Twp. 48, Range 23, W5M

Area: 15.8 km^2 (6.1 mi^2) **Aspect:** N

Elevation: Max. 1676 m (5500 ft); Min. 1265 m (4150 ft)

Physiography: Rocky Mountain Foothills.

Vegetation: Pl, Sw, Sb.

Soils:

Associations:	Robb	Tri-Creek	Erith
Infiltration (cm/h):	5 to 20	>20	0.5

Surficial Deposits: Marlboro Till, local till, glaciolacustrine deposits, ice contact deposits.

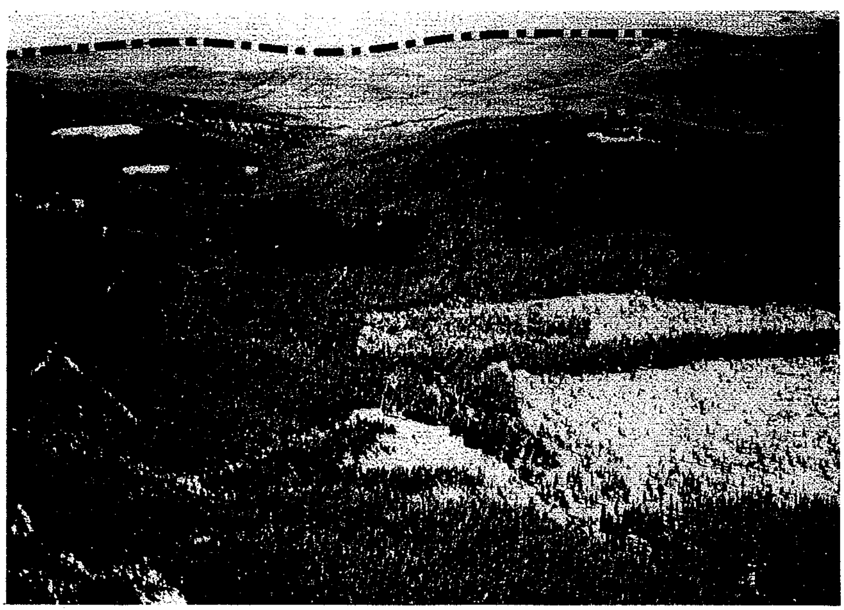
Bedrock: LATE UPPER CRETACEOUS—Brazeau Fm: sandstone, shale, conglomerate, minor coal seams and ash beds.

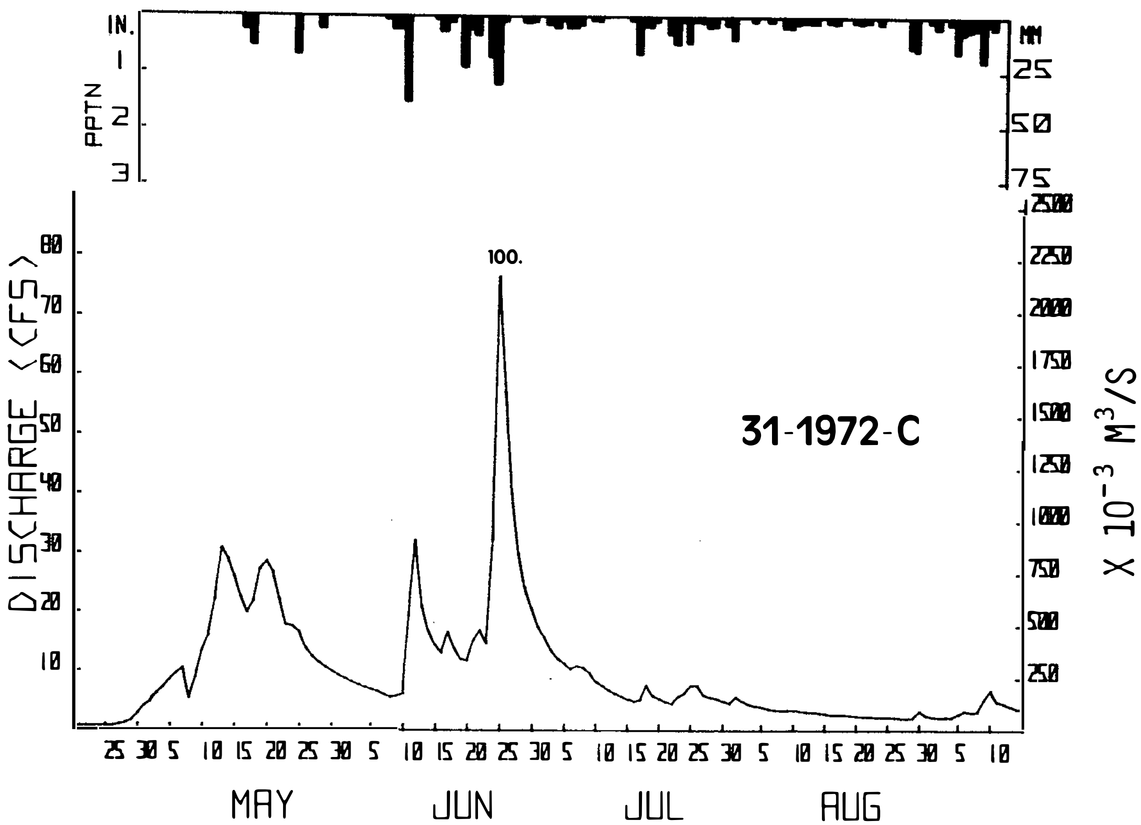
Stream Channel:

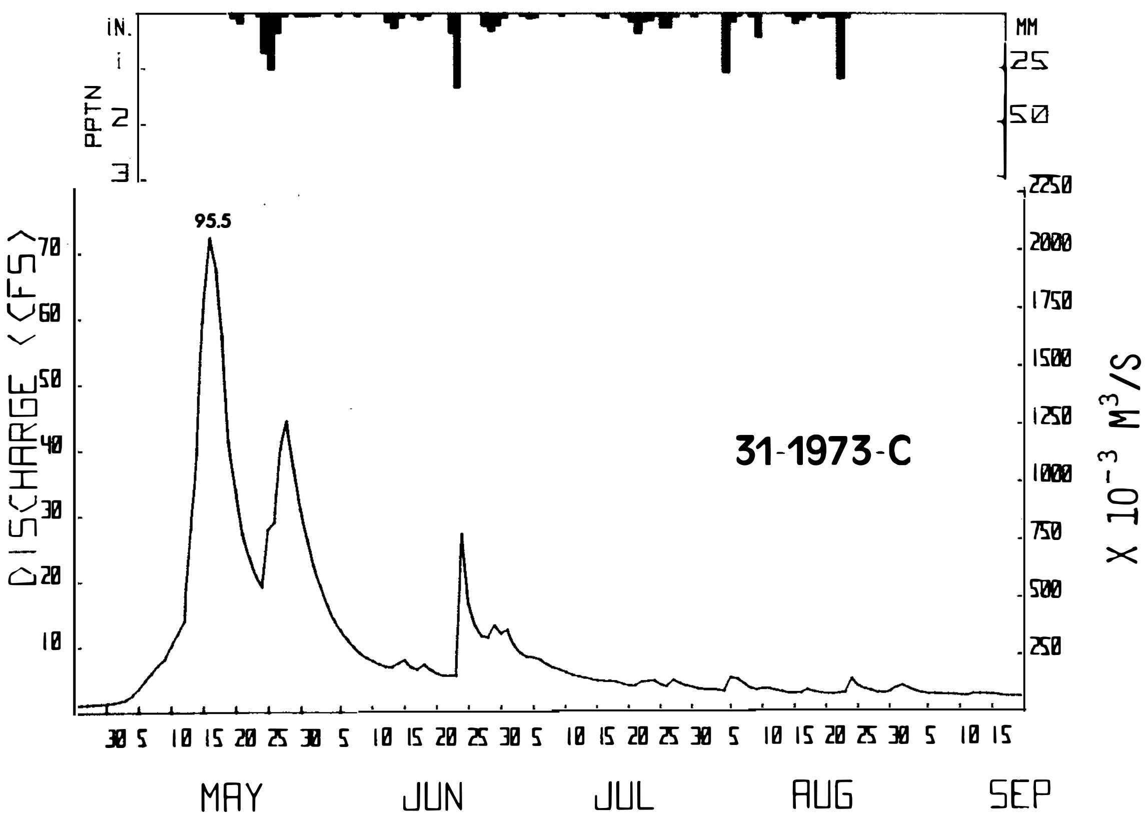
Gradient: 2%; *Order:* 4

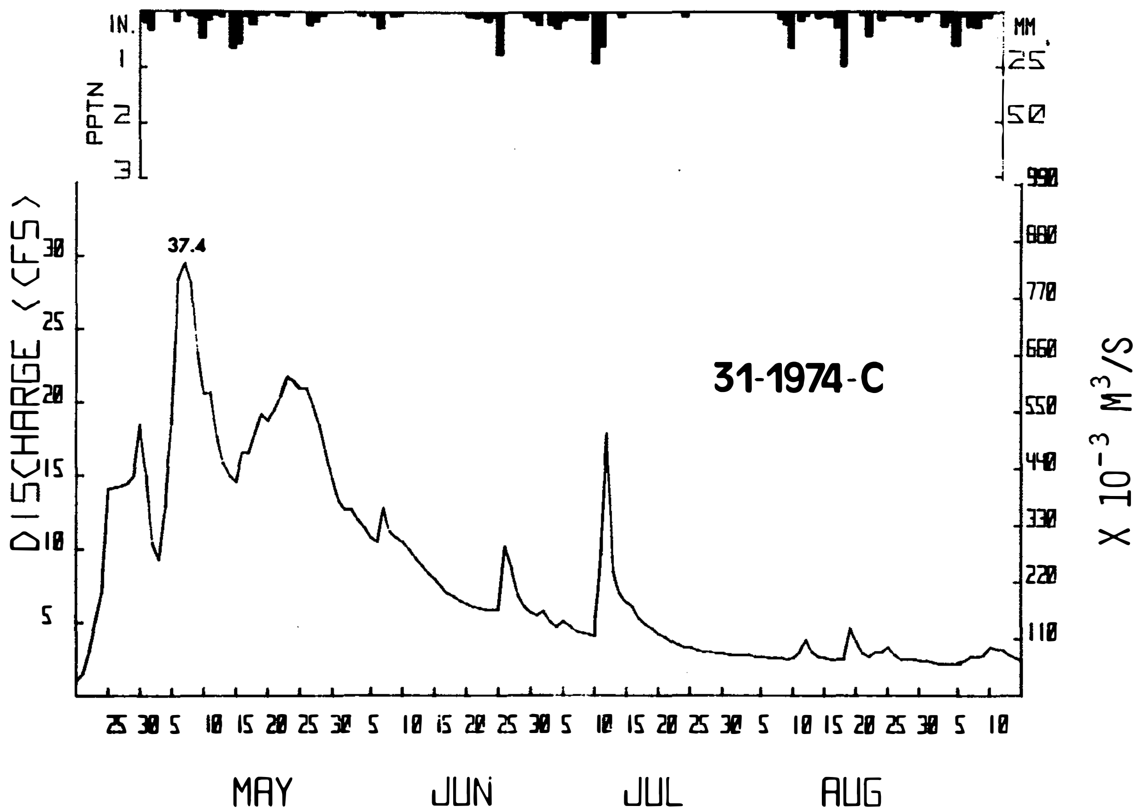
Perennial channel length: 15.3 km (9.5 mi)

Stream width-depth: 2.7 by 0.2 m (9.0 by 0.6 ft)

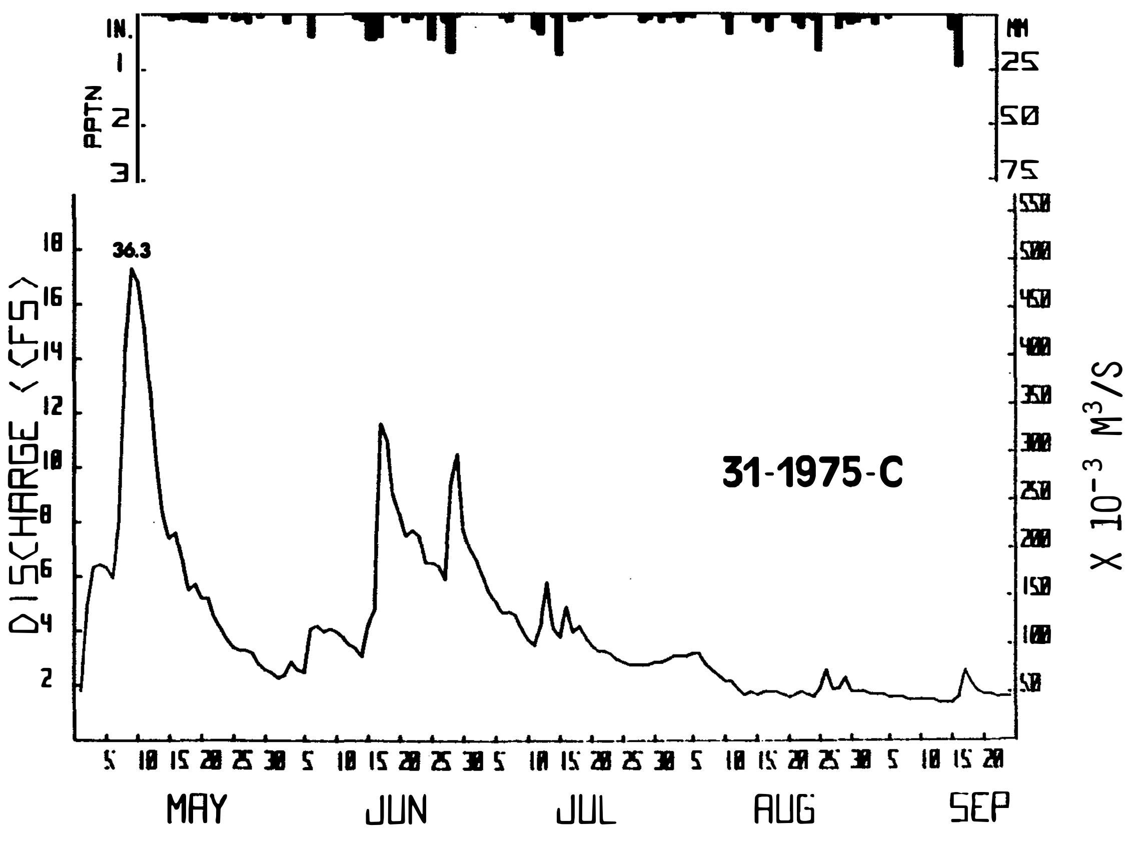



IN.
PPTN
MM
DISCHARGE (CFS)
X 10^-3 M^3/S
100.
31-1972-C
MAY
JUN
JUL
AUG


IN.
PPTN
MM
DISCHARGE (CFS)
X 10^-3 M^3/S
95.5
31-1973-C
MAY
JUN
JUL
AUG
SEP



31-1974-C
37.4
PPTN
IN.
MM
DISCHARGE (CFS)
X 10^{-3} M^3/S
MAY
JUN
JUL
AUG



31-1975-C
36.3
PPTN
IN.
MM
DISCHARGE (CFS)
X 10^{-3} M^3/S
MAY
JUN
JUL
AUG
SEP

WATERSHED NO. 32

Drainage: White Creek

Location: Section 22, Twp. 49, Range 21, W5M

Area: 10.1 km^2 (3.9 mi^2) **Aspect:** NW

Elevation: Max. 1463 m (4800 ft); Min. 1196 m (3925 ft)

Physiography: Pembina—McLeod Benchland.

Vegetation: Pl, Sw, Sb. 35% of forest cover removed as of 1973.

Soils:

Associations:	Robb	Erith
Infiltration (cm/h):	5 to 20	0.5

Surficial Deposits: Marlboro Till.

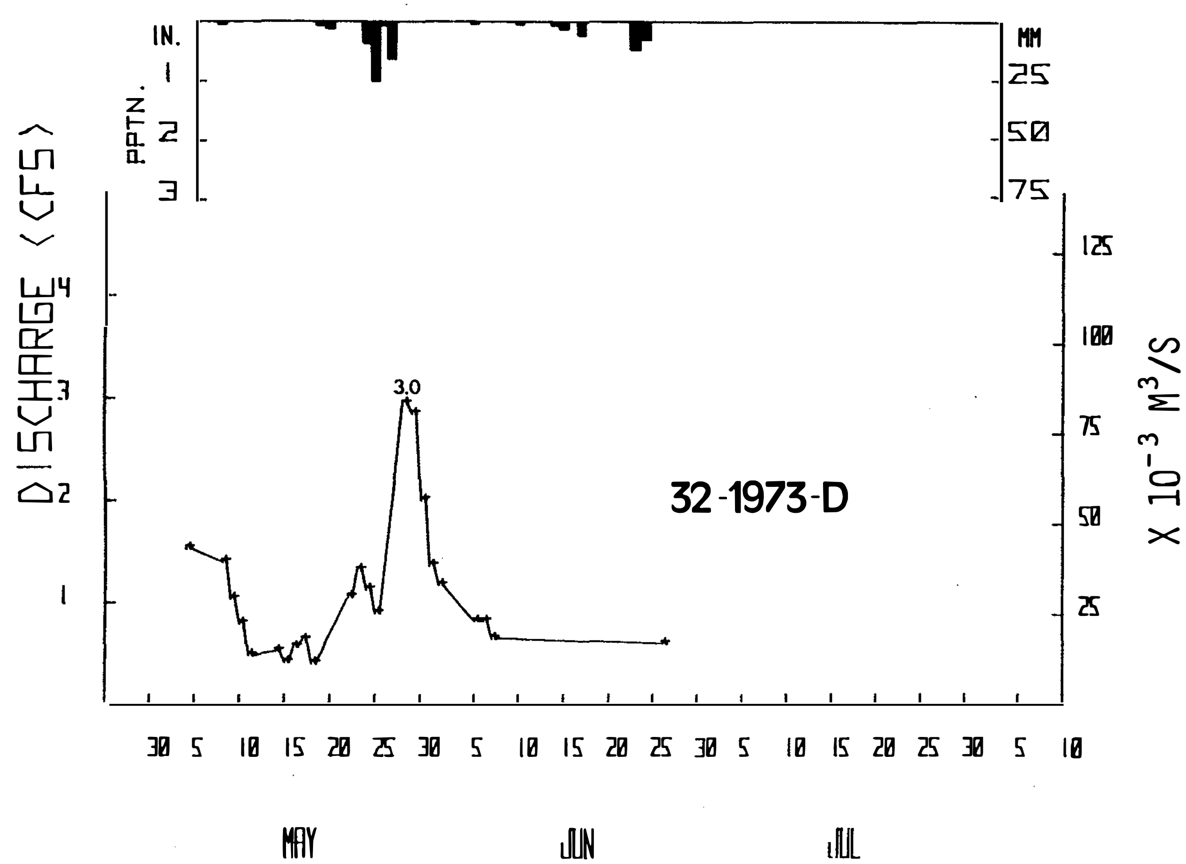
Bedrock: LATE UPPER CRETACEOUS—Brazeau Fm: sandstone, shale, conglomerate, minor coal seams, and ash beds.

Stream Channel:

Gradient: 6%; *Order:* 3

Perennial channel length: 3.9 km (2.4 mi)

Stream width-depth: 0.9 by 0.3 m (3.0 by 1.0 ft)


IN.
PPTN.
1
2
3
MM
25
50
75
DISCHARGE (CFS)
1
2
3
4
3.0
32-1973-D
125
100
75
50
25
X 10^{-3} M^3/S
30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10
MAY
JUN
JUL

WATERSHED NO. 33

Drainage: Prest Creek

Location: Section NW 06, Twp. 50, Range 22, W5M

Area: 1.0 km^2 (0.4 mi^2) **Aspect:** NE

Elevation: Max. 1219 m (4000 ft); Min. 1158 m (3800 ft)

Physiography: Pembina—McLeod Benchland.

Vegetation: Pl, Sw, Sb.

Soils:

Associations:	Marlboro	Fickle
Infiltration (cm/h):	4 to 5	0.5

Surficial Deposits: Marlboro Till.

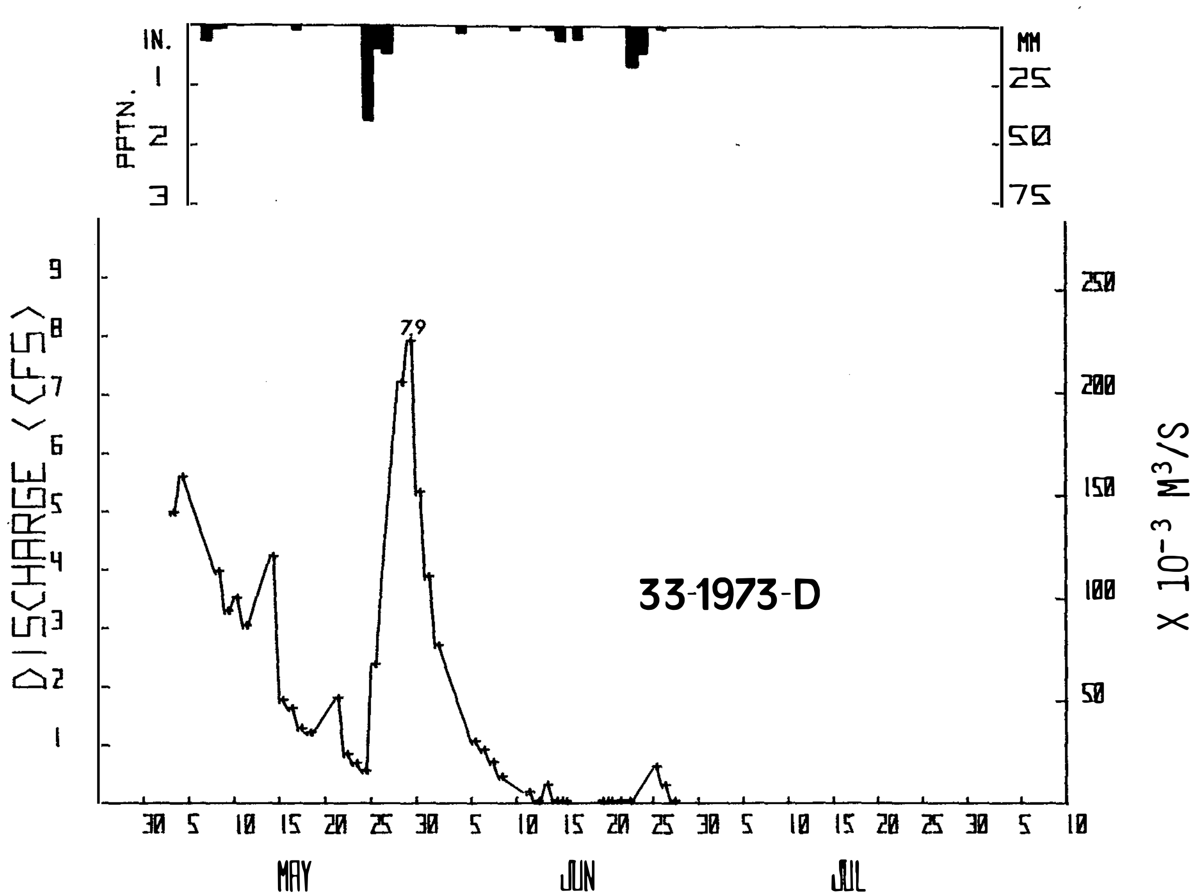
Bedrock: TERTIARY.
Paleocene: sandstone, shale, minor conglomerate, and coal seams.

Stream Channel:

Gradient: 4%; *Order:* 1

Perennial channel length: 0.3 km (0.2 mi)

Stream width-depth: 1.7 by 0.3 m (5.5 by 1.0 ft)


IN.
MM
PPTN.
1
2
3
25
50
75
DISCHARGE (CFS)
X 10^-3 M^3/S
7.9
33-1973-D
250
200
150
100
50
30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10
MAY
JUN
JUL

WATERSHED NO. 34

Drainage: Chance Creek

Location: Section 32, Twp. 48, Range 21, W5M

Area: 20.5 km^2 (7.9 mi^2) **Aspect:** E

Elevation: Max. 1432 m (4700 ft); Min. 1204 m (3950 ft)

Physiography: Rocky Mountain Foothills.

Vegetation: Pl, Sw, Sb.

Soils:

Associations:	Robb	Maskuta	Fickle
Infiltration (cm/h):	5 to 20	>20	0.5

Surficial Deposits: N/A

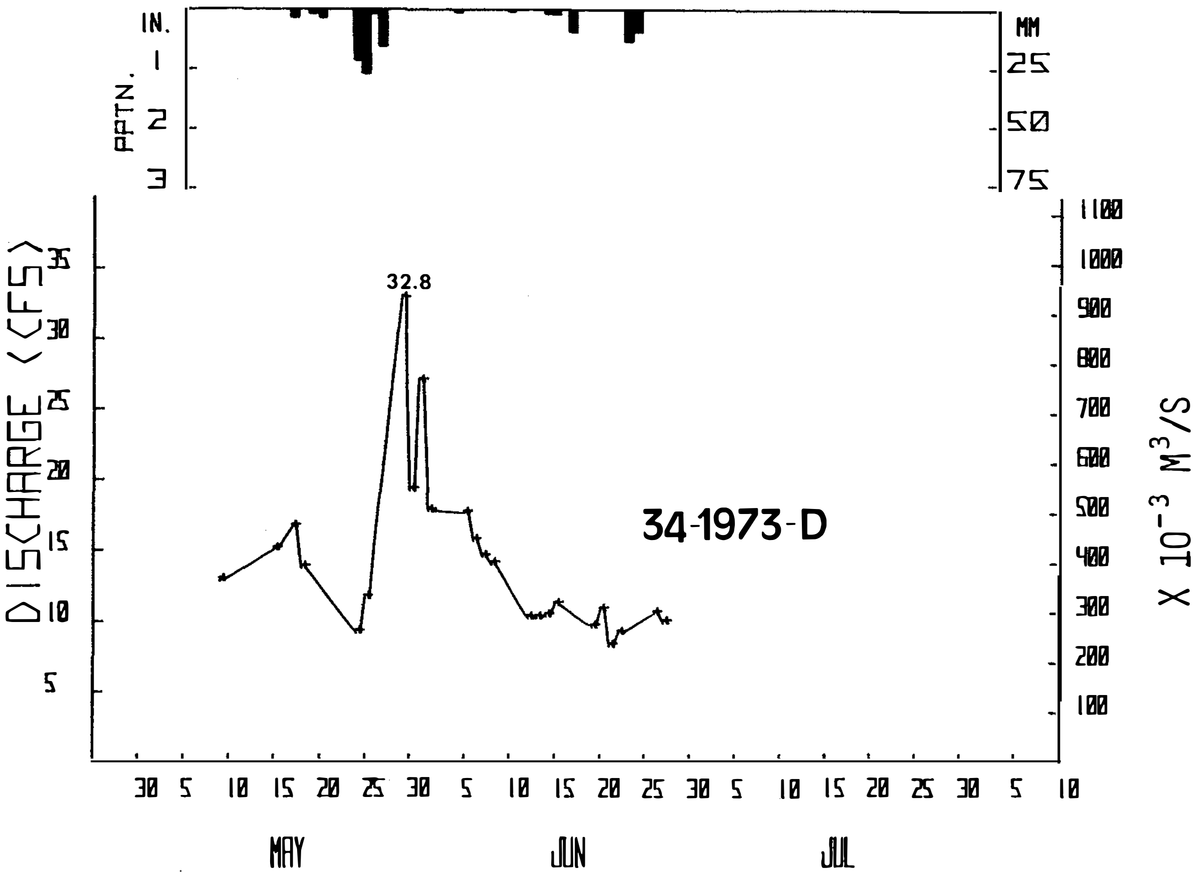
Bedrock: N/A

Stream Channel:

Gradient: 3%; *Order:* 3

Perennial channel length: 8.0 km (5.0 mi)

Stream width-depth: 3.0 by 0.5 m (10.0 by 1.5 ft)


IN.
MM
PPTN.
1
2
3
25
50
75
DISCHARGE (CFS)
X 10^-3 M^3/S
35
30
25
20
15
10
5
1100
1000
900
800
700
600
500
400
300
200
100
32.8
34-1973-D
30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10
MAY
JUN
JUL

WATERSHED NO. 35

Drainage: Bryan Creek

Location: Section 15, Twp. 49, Range 21, W5M

Area: 22.3 km^2 (8.6 mi^2) **Aspect:** E

Elevation: Max. 1433 m (4700 ft); Min. 1128 m (3700 ft)

Physiography: Pembina—McLeod Benchland.

Vegetation: Pl, Sw, Sb.

Soils:

Associations:	Robb	Erith
Infiltration (cm/h):	5 to 20	0.5

Surficial Deposits: Marlboro Till.

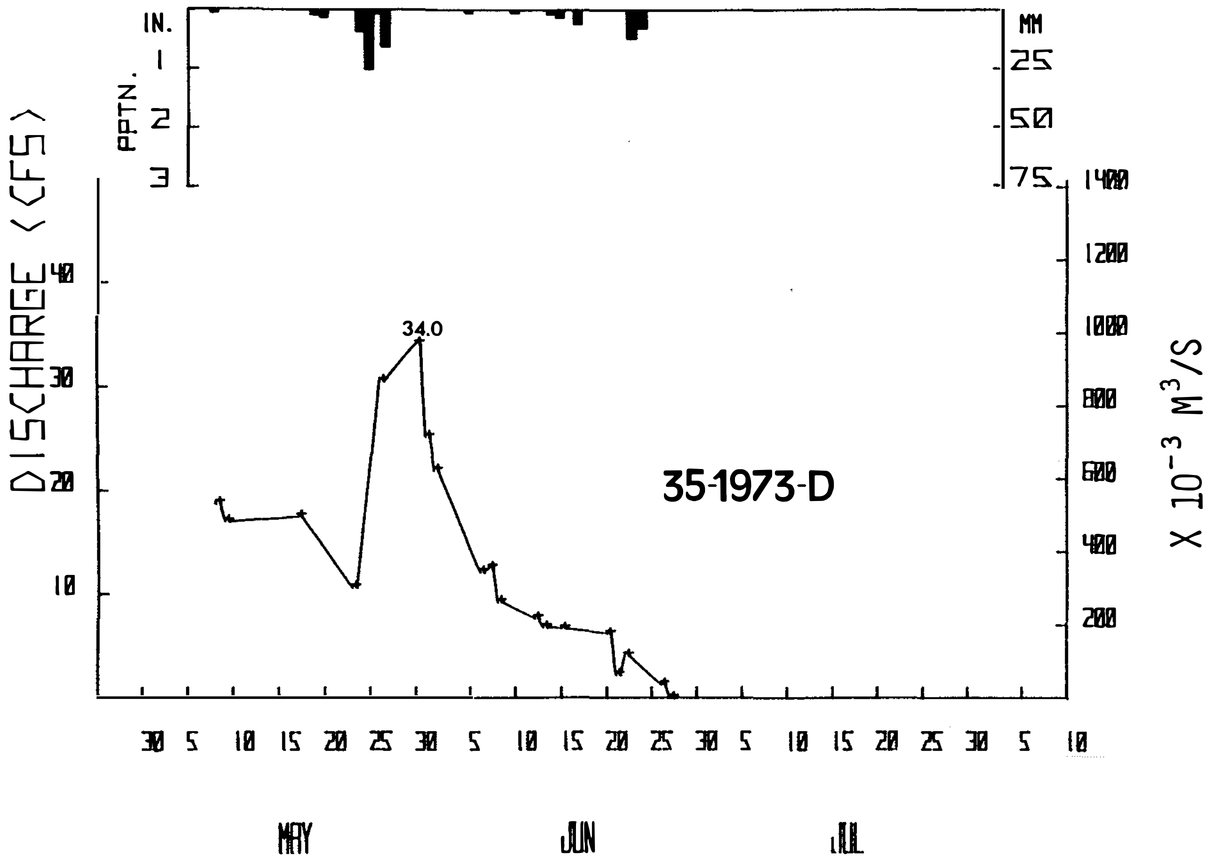
Bedrock: N/A

Stream Channel:

Gradient: 4%; *Order:* 4

Perennial channel length: 8.0 km (5.0 mi)

Stream width-depth: 2.6 by 0.6 m (8.5 by 2.0 ft)


IN.
PPTN.
1
2
3
MM
25
50
75
DISCHARGE (CFS)
40
30
20
10
34.0
35-1973-D
1400
1200
1000
800
600
400
200
X 10⁻³ M³/S
30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10
MAY
JUN
JUL

WATERSHED NO. 36

Drainage: Unnamed Creek—3

Location: Section 22, Twp. 55, Range 21, W5M

Area: 9.6 km^2 (3.7 mi^2) **Aspect:** W

Elevation: Max. 1524 m (5000 ft); Min. 1036 m (3400 ft)

Physiography: Athabasca Benchland.

Vegetation: Pl, Sw, Sb.

Soils:

Associations: Marlboro

Infiltration (cm/h): 4 to 5

Surficial Deposits: Marlboro Till. Glaciofluvial deposits.

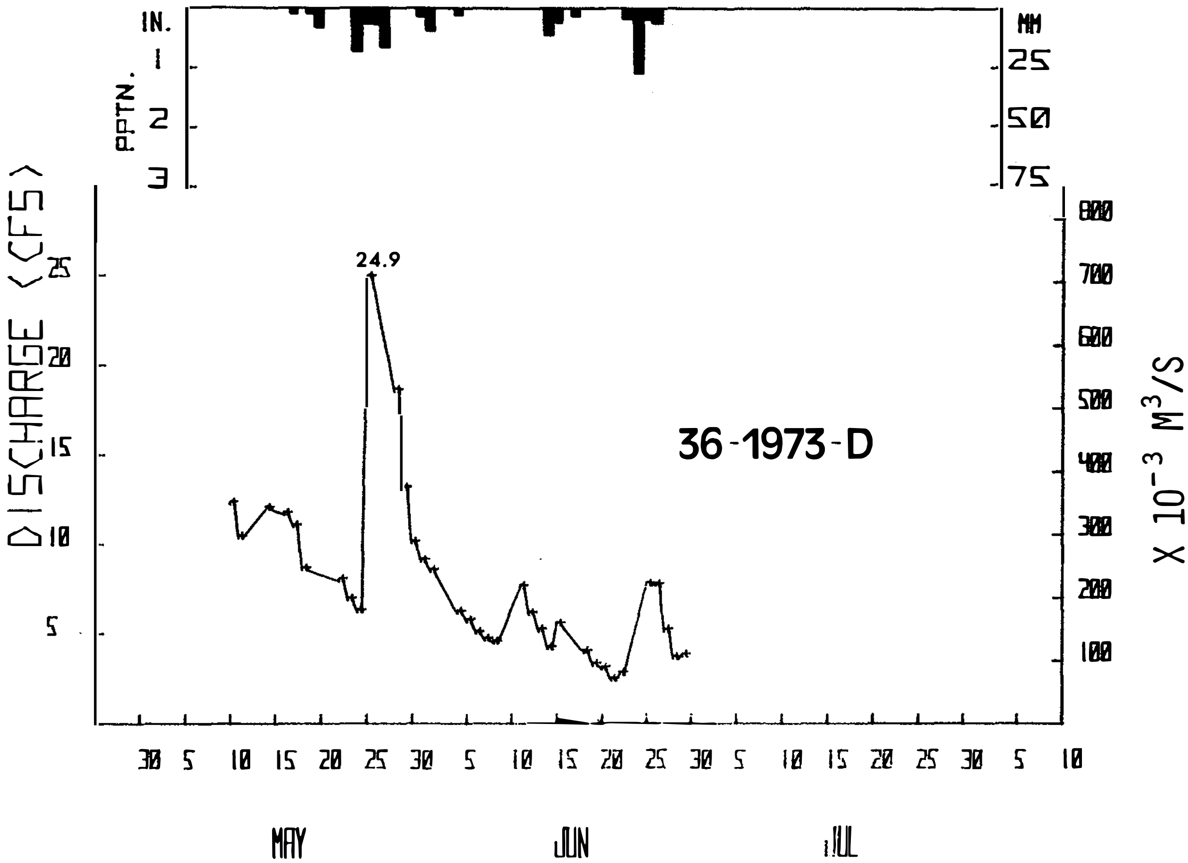
Bedrock: UPPER CRETACEOUS AND TERTIARY.
Paskapoo Fm: sandstone, shale, and coal.

Stream Channel:

Gradient: 4%; *Order:* 3

Perennial channel length: 10.5 km (6.5 mi)

Stream width-depth: 1.8 by 0.3 m (6.0 by 1.0 ft)


IN.
PPTN.
MM
DISCHARGE (CFS)
24.9
36-1973-D
X 10^-3 M^3/S
MAY
JUN
JUL

WATERSHED NO. 37

Drainage: Unnamed Creek—4

Location: Section 18, Twp. 55, Range 20, W5M

Area: 3.1 km^2 (1.2 mi^2) **Aspect:** S

Elevation: Max. 1402 m (4600 ft); Min. 1174 m (3850 ft)

Physiography: Edson Benchland.

Vegetation: Pl, Sw, Sb.

Soils:

Associations: Marlboro

Infiltration (cm/h): 4 to 5

Surficial Deposits: Mayberne Till.

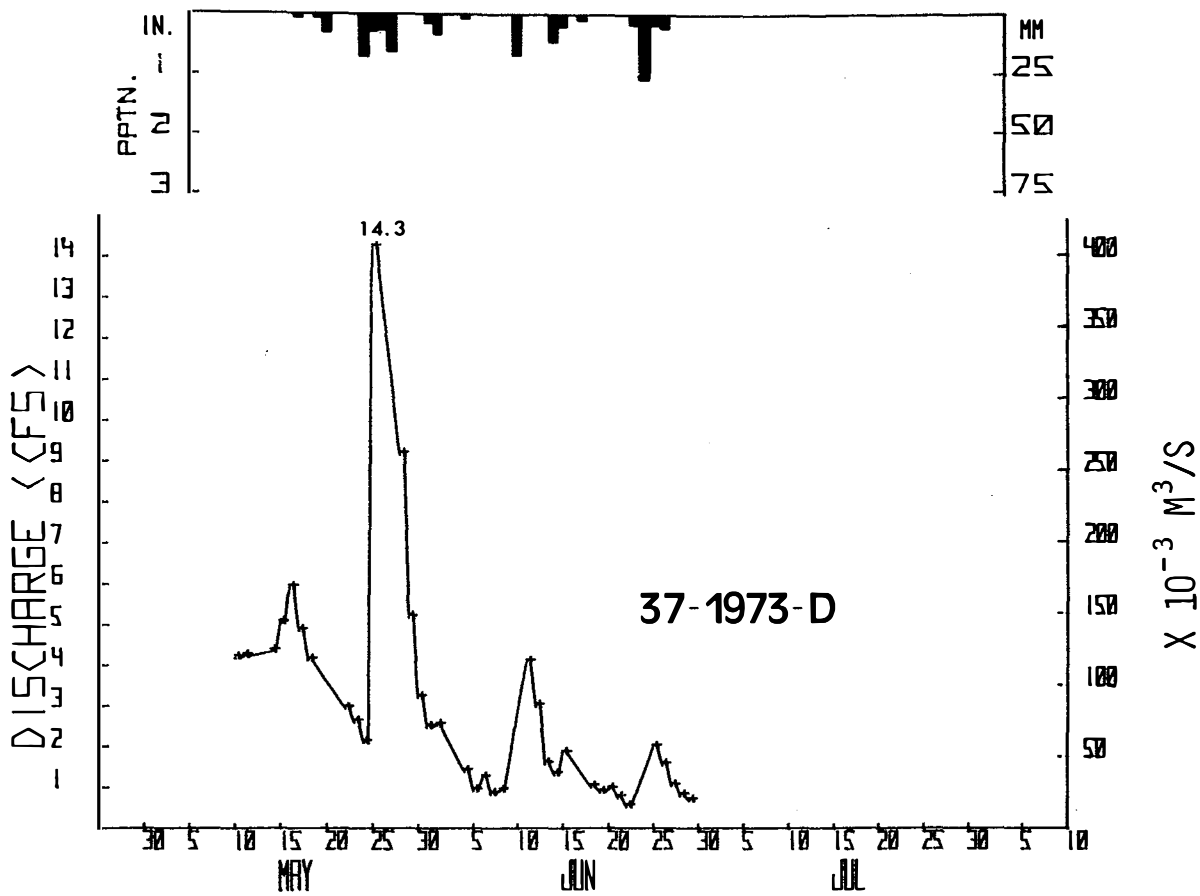
Bedrock: UPPER CRETACEOUS AND TERTIARY.
Paskapoo Fm: sandstone, shale, and coal.

Stream Channel:

Gradient: 6%; *Order:* 2

Perennial channel length: 1.9 km (1.2 mi)

Stream width-depth: 1.1 by 0.3 m (3.5 by 1.0 ft)


IN.
PPTN.
1
2
3
MM
25
50
75
14.3
DISCHARGE (CFS)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
50
100
150
200
250
300
350
400
X 10^-3 M^3/S
37-1973-D
30
5
10
15
20
25
30
5
10
15
20
25
30
5
10
15
20
25
30
5
10
MAY
JUN
JUL

WATERSHED NO. 38

Drainage: Unnamed Creek—5

Location: Section 18, Twp. 55, Range 20, W5M

Area: 3.4 km^2 (1.3 mi^2) **Aspect:** S

Elevation: Max. 1402 m (4600 ft); Min. 1234 m (4050 ft)

Physiography: Edson Benchland.

Vegetation: Pl, Sw, Sb.

Soils:

Associations: Marlboro

Infiltration (cm/h): 4 to 5

Surficial Deposits: Mayberne Till.

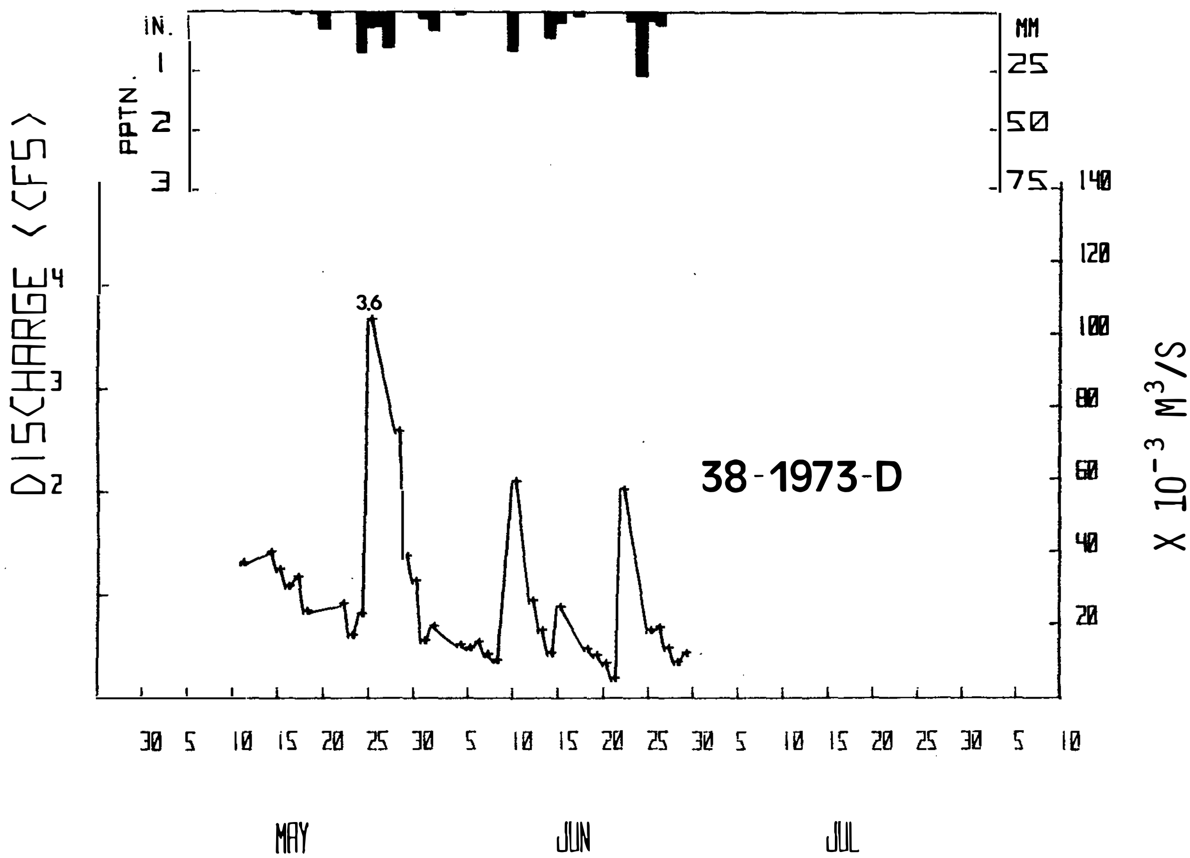
Bedrock: UPPER CRETACEOUS AND TERTIARY.
Paskapoo Fm: sandstone, shale, and coal.

Stream Channel:

Gradient: 2%; *Order:* 2

Perennial channel length: 0.8 km (0.5 mi)

Stream width-depth: 0.7 by 0.2 m (2.3 by 0.7 ft)


IN.
PPTN.
1
2
3
MM
25
50
75
DISCHARGE (CFS)
4
3
2
3.6
38-1973-D
140
120
100
80
60
40
20
X 10^-3 M^3/S
30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10
MAY
JUN
JUL

WATERSHED NO. 39

Drainage: Edson River—1

Location: Section 08, Twp. 55, Range 19, W5M

Area: 10.1 km^2 (3.9 mi^2) **Aspect:** S

Elevation: Max. 1219 m (4000 ft); Min. 1052 m (3450 ft)

Physiography: Edson Benchland.

Vegetation: Pl, Sw, Sb. 30% of forest cover removed as of 1973.

Soils:

Associations: Mayberne

Infiltration (cm/h): 3 to 4

Surficial Deposits: Mayberne Till.

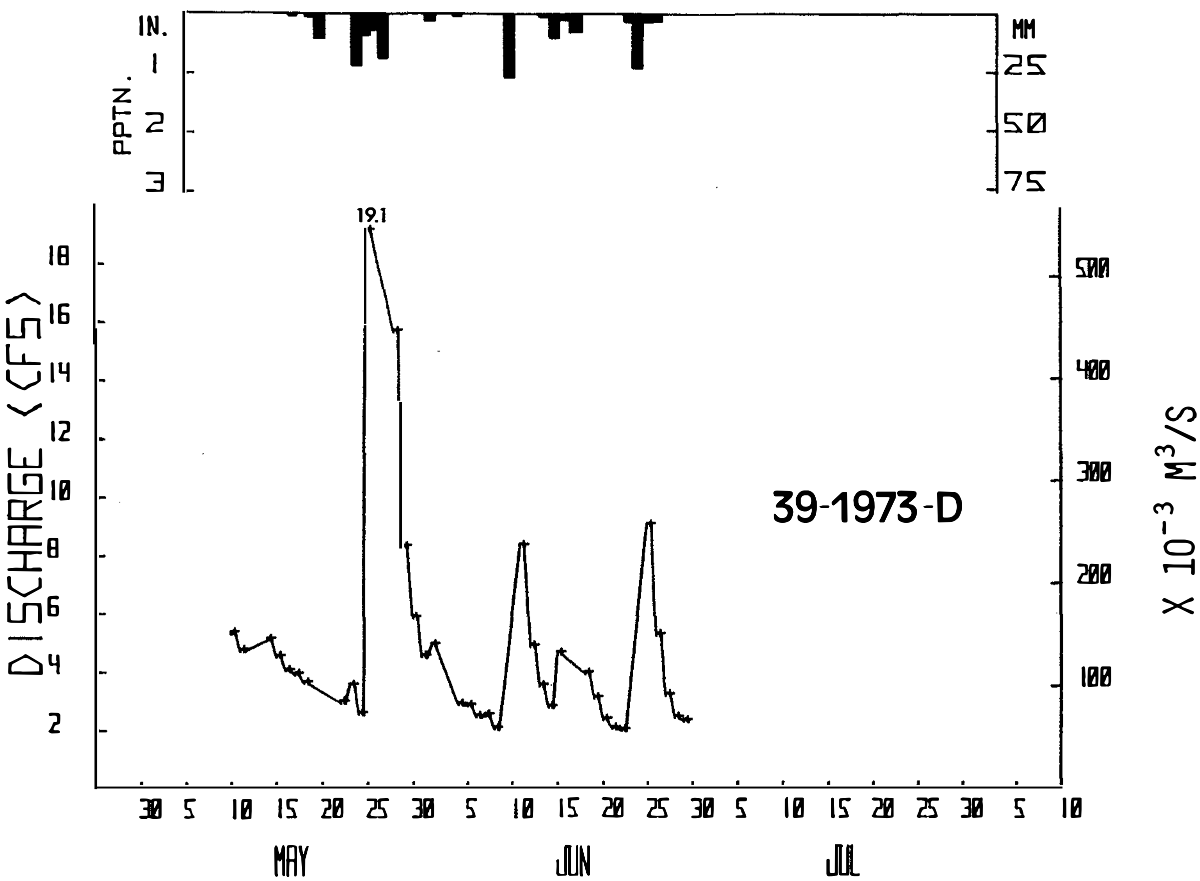
Bedrock: UPPER CRETACEOUS AND TERTIARY.
Paskapoo Fm: sandstone, shale, and coal.

Stream Channel:

Gradient: 2%; *Order:* 3

Perennial channel length: 2.1 km (1.3 mi)

Stream width-depth: 1.4 by 0.2 m (4.5 by 0.5 ft)


IN.
PPTN.
1
2
3
MM
25
50
75
19.1
DISCHARGE (CFS)
18
16
14
12
10
8
6
4
2
500
400
300
200
100
X 10^-3 M^3/S
39-1973-D
30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10
MAY
JUN
JUL

WATERSHED NO. 40

Drainage: Edson River—2

Location: Section 33, Twp. 56, Range 19, W5M

Area: 3.9 km^2 (1.5 mi^2) **Aspect:** S

Elevation: Max. 1326 m (4350 ft); Min. 1143 m (3750 ft)

Physiography: Edson Benchland.

Vegetation: Pl, Sw, Sb. 50% of forest cover removed as of 1973.

Soils:

Associations: Summit

Infiltration (cm/h): <3.0

Surficial Deposits: Mayberne Till.

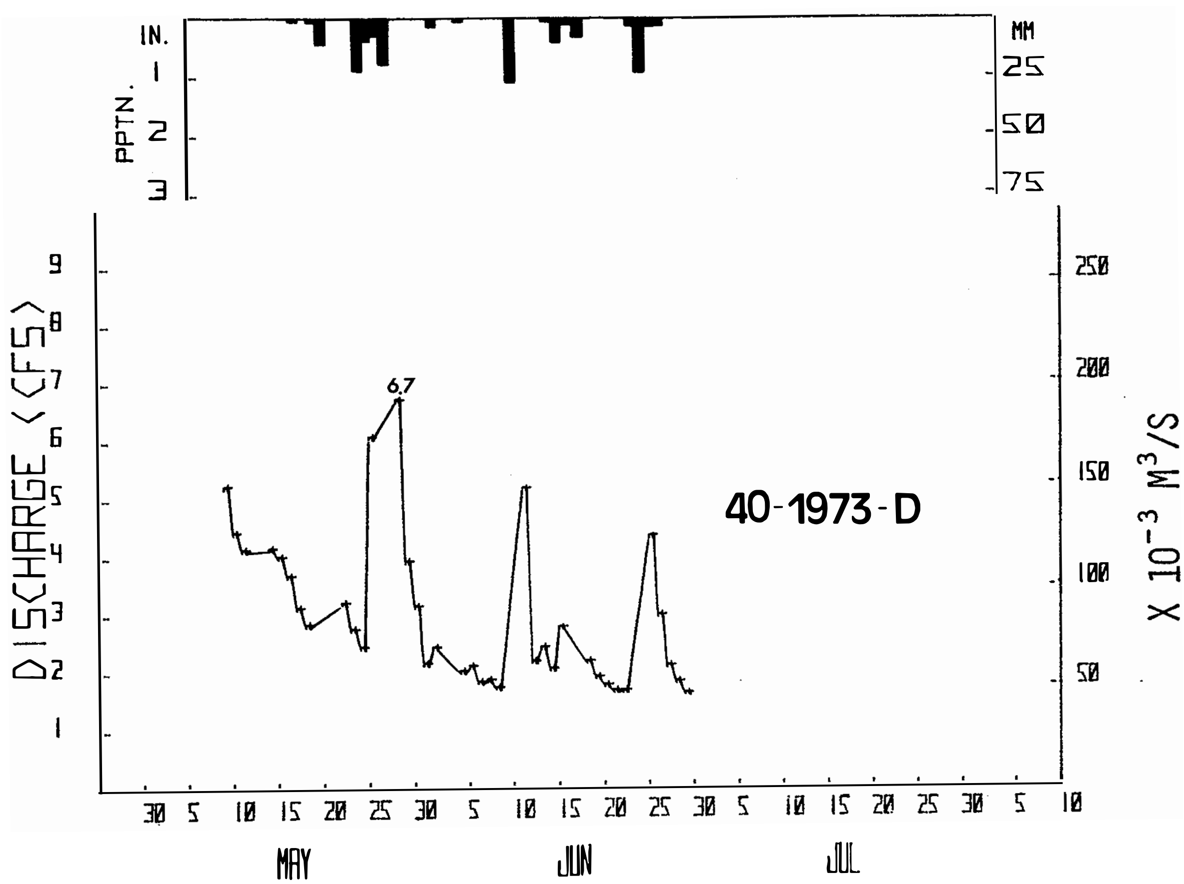
Bedrock: UPPER CRETACEOUS AND TERTIARY.
Paskapoo Fm: sandstone, shale, and coal.

Stream Channel:

Gradient: 6%; *Order:* 2

Perennial channel length: 1.3 km (0.8 mi)

Stream width-depth: 1.2 by 0.3 m (4.0 by 1.0 ft)


IN.
PPTN.
1
2
3
MM
25
50
75
DISCHARGE (CFS)
9
8
7
6
5
4
3
2
1
6.7
40-1973-D
250
200
150
100
50
X 10^-3 M^3/S
30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10
MAY
JUN
JUL

WATERSHED NO. 41

Drainage: Edson River—3

Location: Section 07, Twp. 56, Range 18, W5M

Area: 4.1 km^2 (1.6 mi^2) **Aspect:** S

Elevation: Max. 1219 m (4000 ft); Min. 1128 m (3700 ft)

Physiography: Edson Benchland.

Vegetation: Pl, Sw, Sb. 27% of forest cover removed as of 1973.

Soils:

Associations: Mayberne

Infiltration (cm/h): 3 to 4

Surficial Deposits: Mayberne Till.

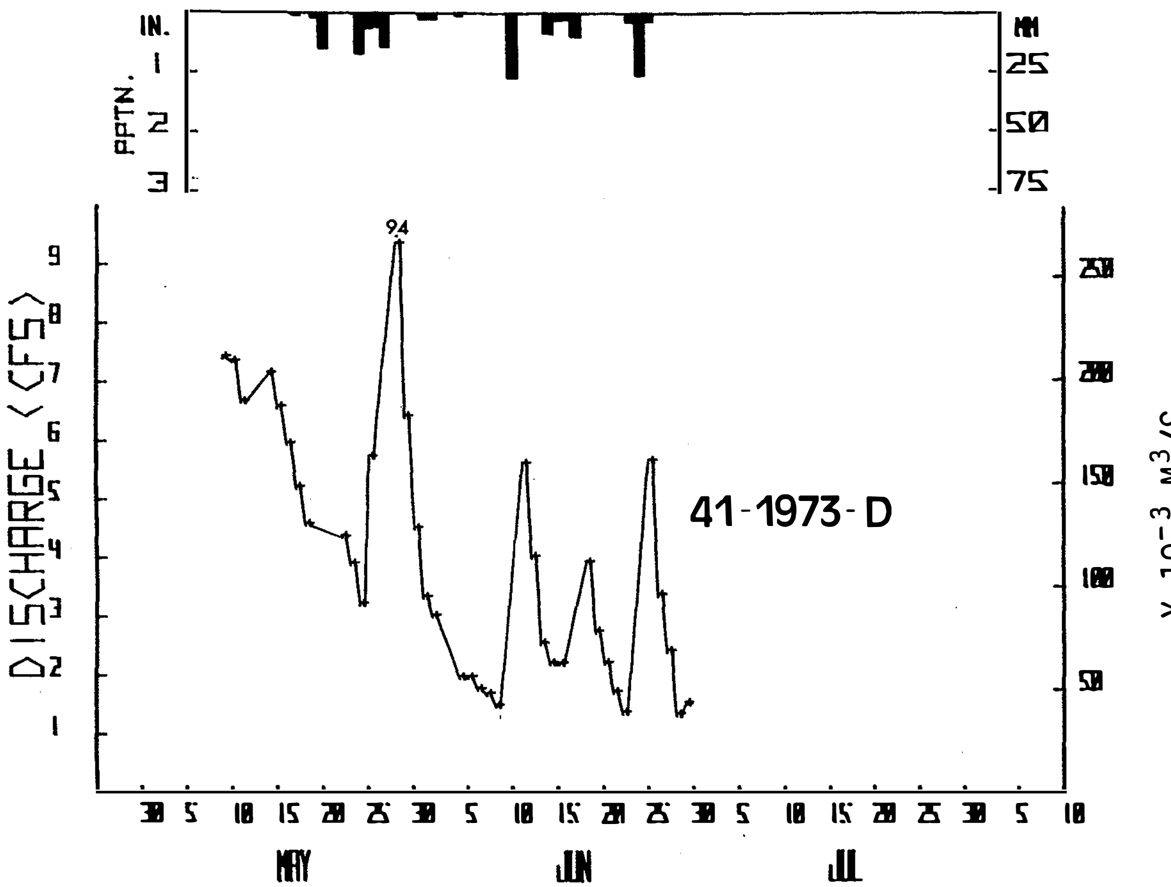
Bedrock: UPPER CRETACEOUS AND TERTIARY.
Paskapoo Fm: sandstone, shale, and coal.

Stream Channel:

Gradient: 1%; *Order:* 1

Perennial channel length: 0.3 km (0.2 mi)

Stream width-depth: 2.0 by 0.3 m (6.5 by 1.0 ft)


IN.
MM
PPTN.
1
2
3
25
50
75
9.4
DISCHARGE (CFS)
X 10^-3 M^3/S
41-1973-D
MAY
JUN
JUL

WATERSHED NO. 42

Drainage: Edson River—4

Location: Section NW 03, Twp. 56, Range 19, W5M

Area: 23.1 km^2 (8.9 mi^2) **Aspect:** SE

Elevation: Max. 1402 m (4600 ft); Min. 1113 m (3650 ft)

Physiography: Edson Benchland.

Vegetation: Pl, Sw. 28% of forest cover removed as of March, 1975.

Soils:

Associations:	Mayberne	Summit	Fickle
Infiltration (cm/h):	3 to 4	<3.0	0.5

Surficial Deposits: Mayberne Till.

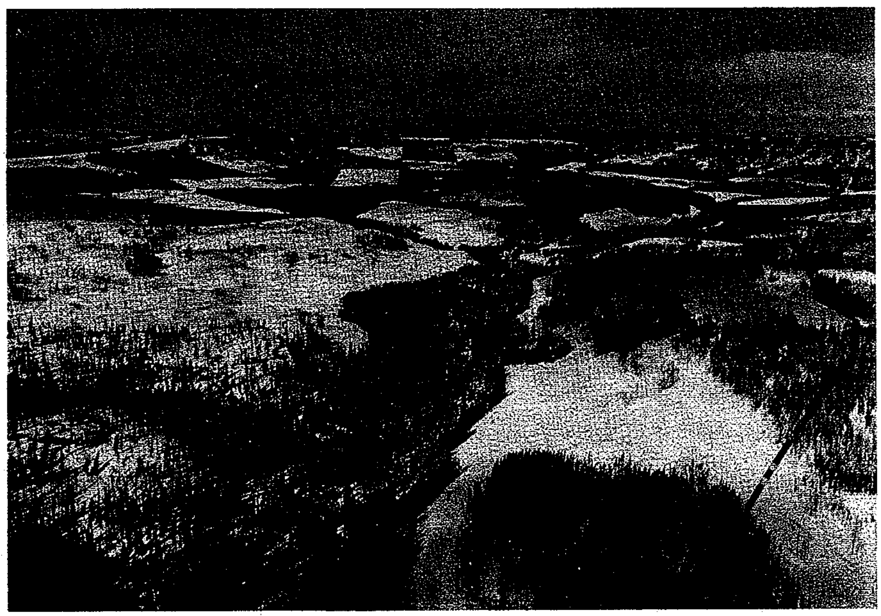
Bedrock: UPPER CRETACEOUS AND TERTIARY.
Paskapoo Fm: sandstone, shale, and coal.

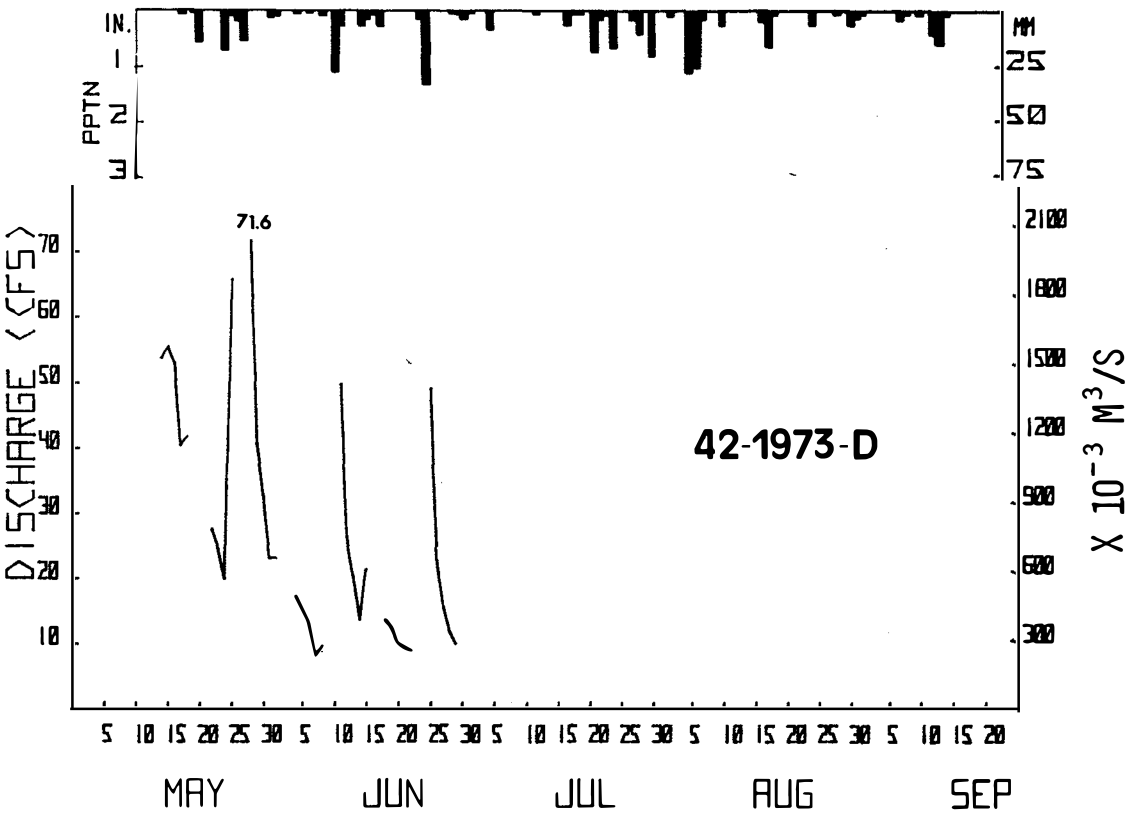
Stream Channel:

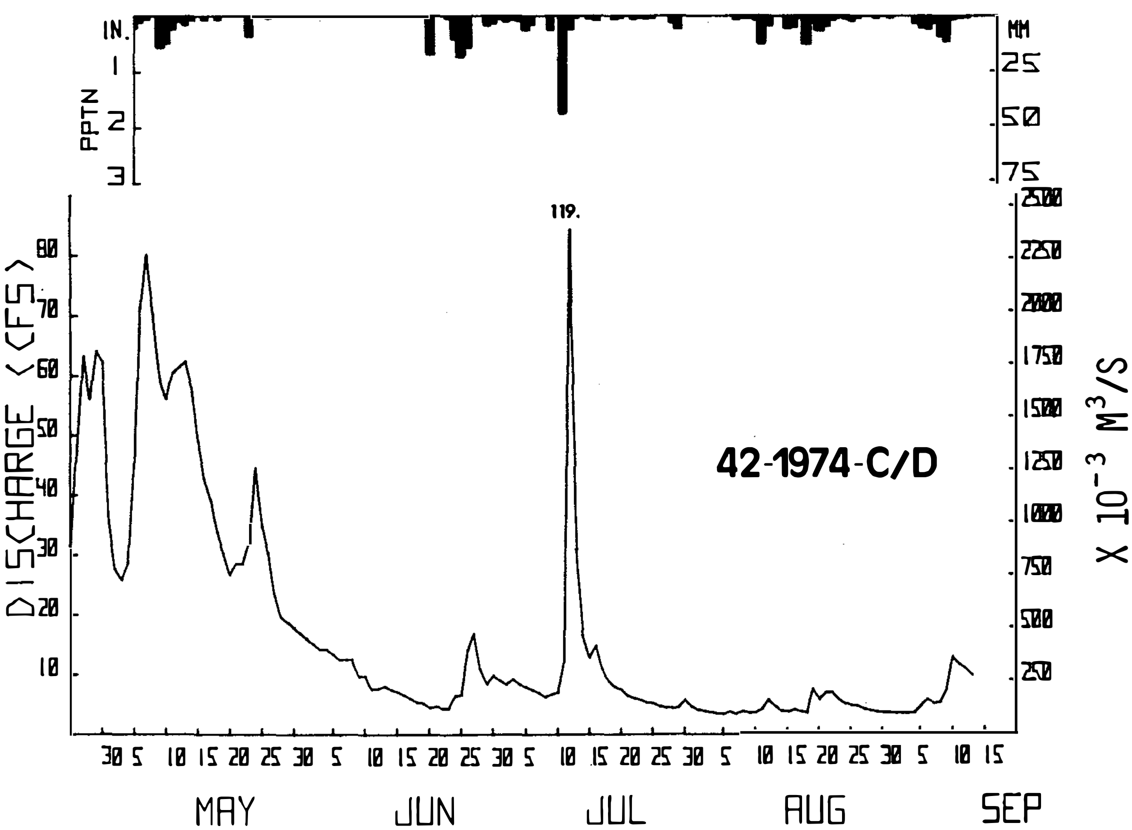
Gradient: 2%; *Order:* 5

Perennial channel length: 17.2 km (10.7 mi)

Stream width-depth: 4.4 by 0.2 m (14.5 by 0.8 ft)




IN.
PPTN
MM
DISCHARGE (CFS)
X 10^-3 M^3/S
71.6
42-1973-D
MAY
JUN
JUL
AUG
SEP


IN.
PPTN
MM
DISCHARGE (CFS)
X 10^-3 M^3/S
119.
42-1974-C/D
MAY
JUN
JUL
AUG
SEP

WATERSHED NO. 43

Drainage: Pine Creek—1

Location: Section SW 09, Twp. 57, Range 19, W5M

Area: 22.0 km^2 (8.5 mi^2) **Aspect:** N

Elevation: Max. 1372 m (4500 ft); Min. 1181 m (3875 ft)

Physiography: Mayberne Tableland.

Vegetation: Pl, Sw. 38% of forest cover removed as of December, 1974.

Soils:

Associations:	Summit	Mayberne	AV	Fickle
Infiltration (cm/h):	<3.0	3 to 4	N/A	0.5

Surficial Deposits: Mayberne Till.

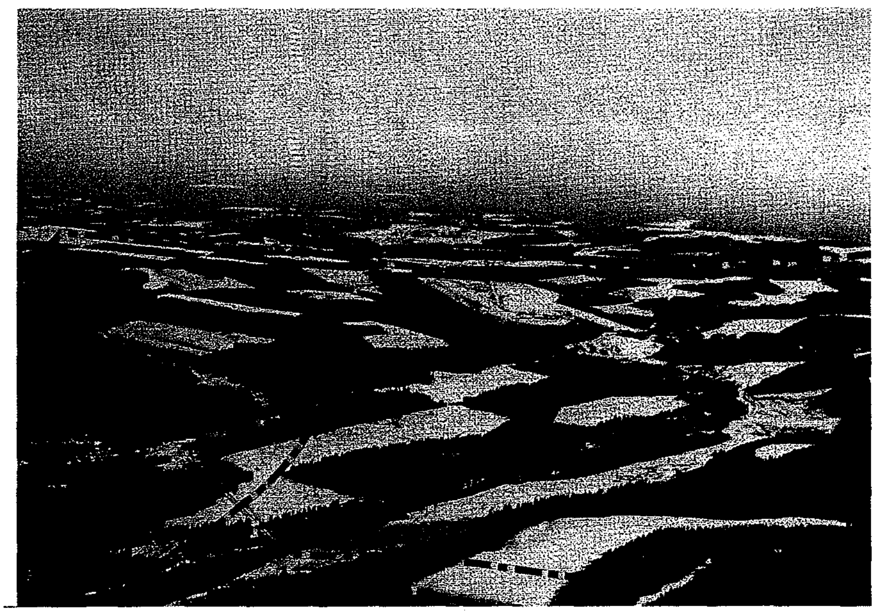
Bedrock: UPPER CRETACEOUS AND TERTIARY.
Paskapoo Fm: sandstone, shale, and coal.

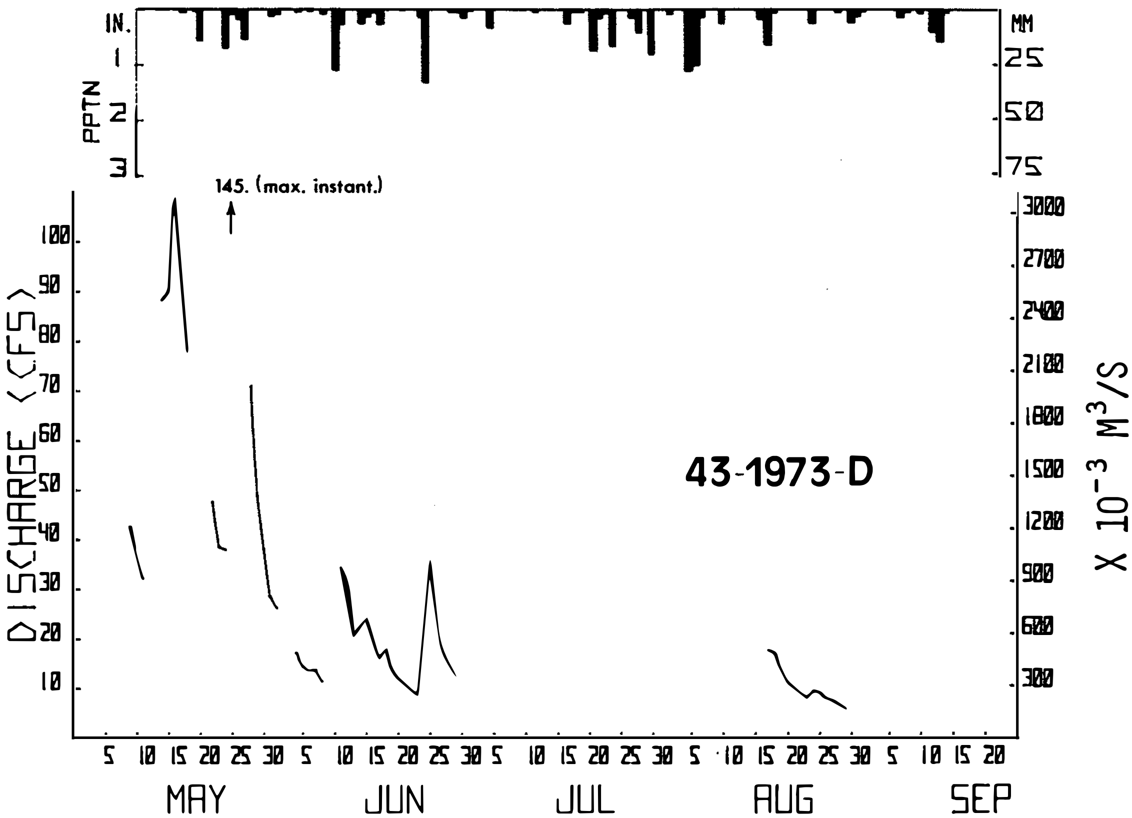
Stream Channel:

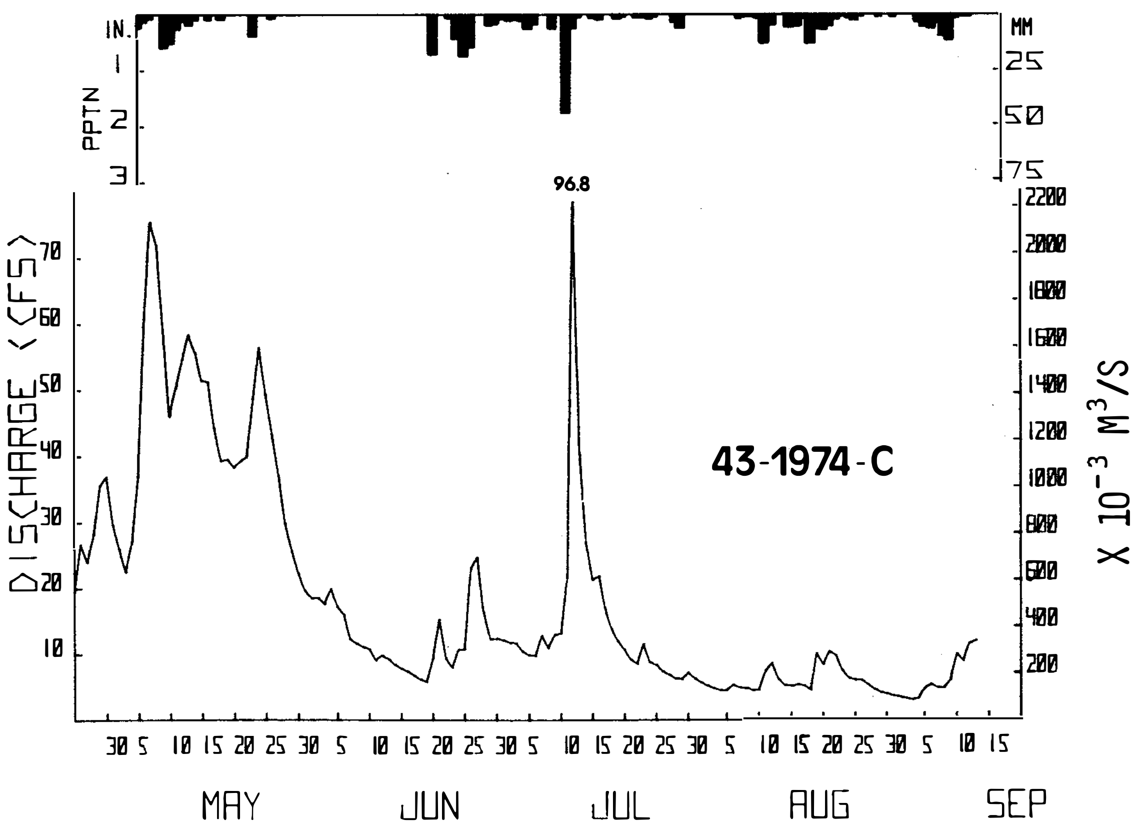
Gradient: 3%; *Order:* 3

Perennial channel length: 13.5 km (8.4 mi)

Stream width-depth: 5.5 by 0.2 m (18.0 by 0.8 ft)




IN.
MM
PPTN
145. (max. instant.)
DISCHARGE (CFS)
X 10^{-3} M^3/S
43-1973-D
MAY
JUN
JUL
AUG
SEP


IN.
MM
PPTN
96.8
DISCHARGE (CFS)
X 10^{-3} M^3/S
43-1974-C
MAY
JUN
JUL
AUG
SEP

WATERSHED NO. 44

Drainage: Pine Creek—2

Location: Section NW 11, Twp. 57, Range 19, W5M

Area: 23.8 km^2 (9.2 mi^2) **Aspect:** N

Elevation: Max. 1448 m (4750 ft); Min. 1143 m (3750 ft)

Physiography: Mayberne Tableland.

Vegetation: Pl, Sw. 8% of forest cover removed as of December, 1974.

Soils:

Associations:	Summit	AV	Mayberne	Erith
Infiltration (cm/h):	<3.0	N/A	3 to 4	0.5

Surficial Deposits: Mayberne Till. Organic deposits (peat) near stream channel.

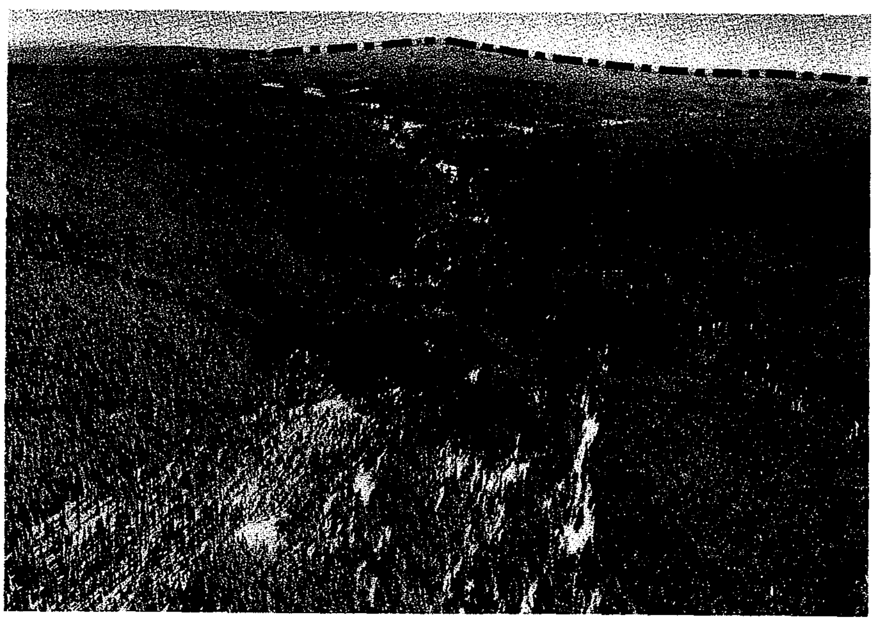
Bedrock: UPPER CRETACEOUS AND TERTIARY.
Paskapoo Fm: sandstone, shale, and coal.

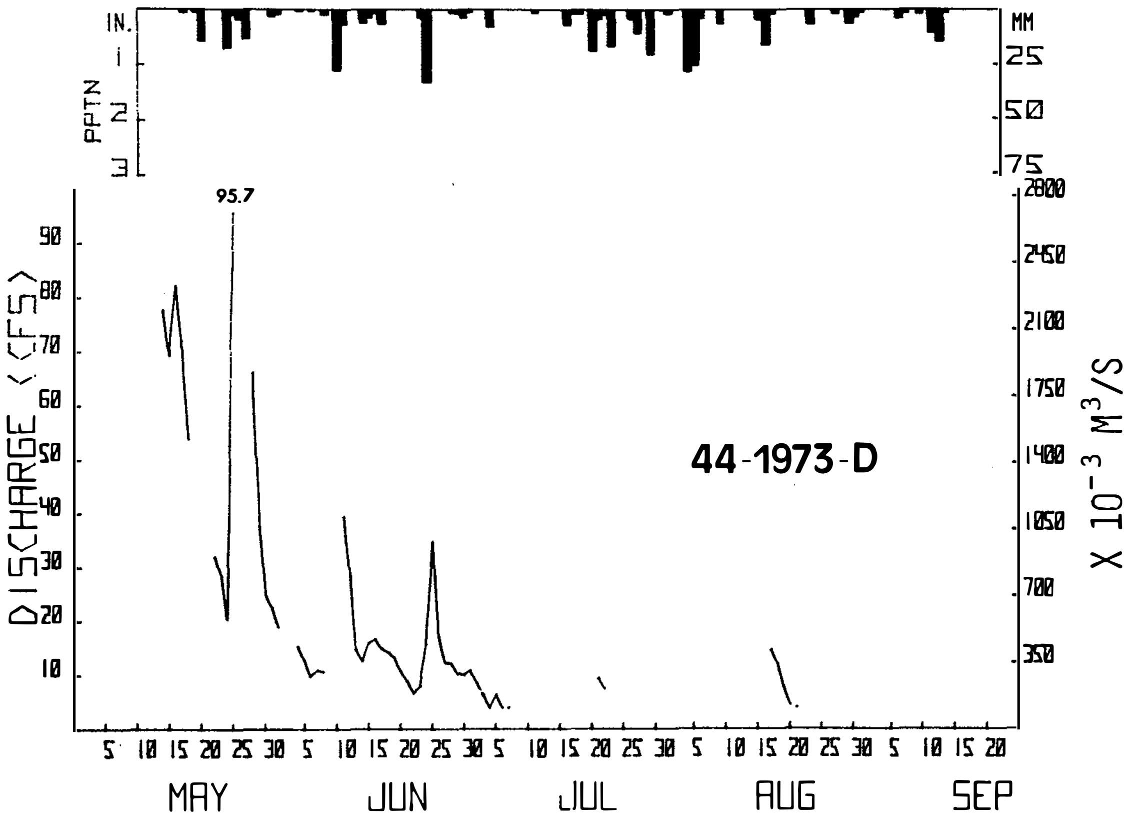
Stream Channel:

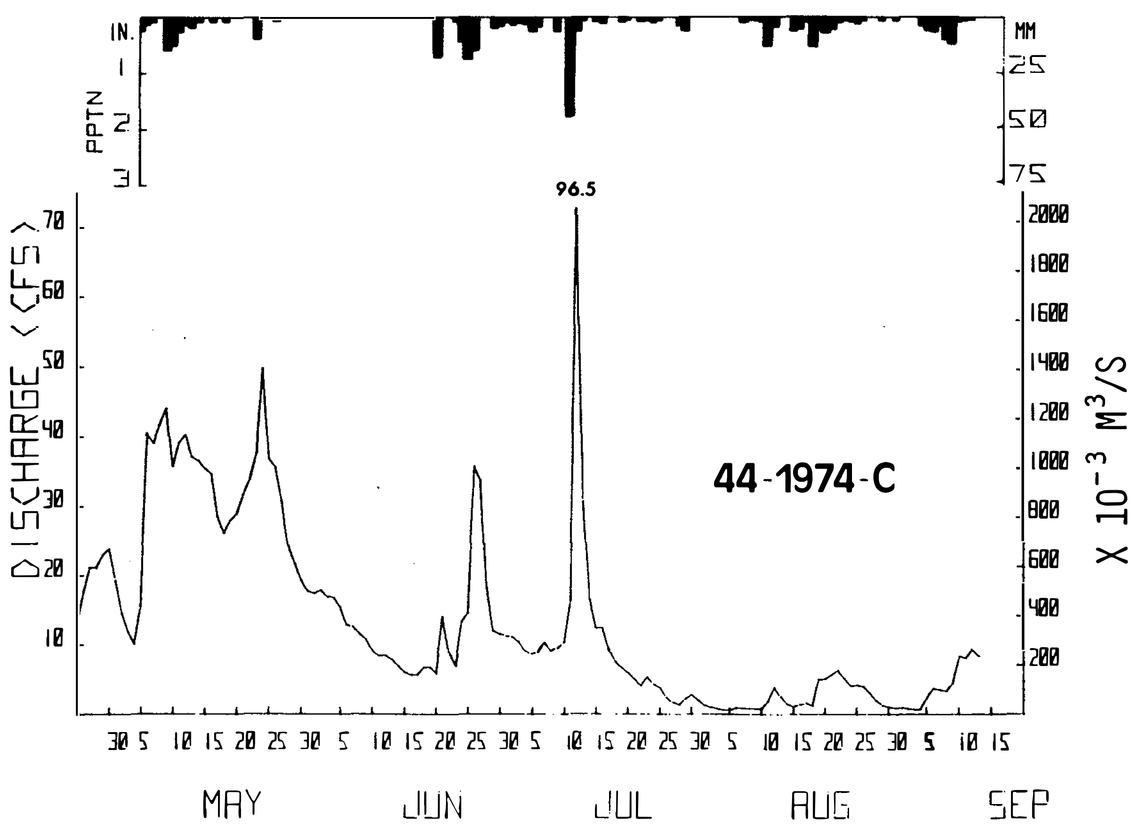
Gradient: 2%; *Order:* 4

Perennial channel length: 12.9 km (8.0 mi)

Stream width-depth: 6.6 by 0.2 m (21.5 by 0.5 ft)




IN.
1
2
3
PPTN
MM
25
50
75
95.7
DISCHARGE (CFS)
90
80
70
60
50
40
30
20
10
2800
2450
2100
1750
1400
1050
700
350
X 10^{-3} M^3/S
44-1973-D
5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20
MAY
JUN
JUL
AUG
SEP


IN.
1
2
3
PPTN
MM
25
50
75
96.5
DISCHARGE (CFS)
70
60
50
40
30
20
10
2000
1800
1600
1400
1200
1000
800
600
400
200
X 10^{-3} M^3/S
44-1974-C
30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15
MAY
JUN
JUL
AUG
SEP

WATERSHED NO. 45

Drainage: Edson River—5

Location: Section SE 13, Twp. 56, Range 19, W5M

Area: 7.0 km^2 (2.7 mi^2) **Aspect:** S

Elevation: Max. 1448 m (4750 ft); Min. 1143 m (3750 ft)

Physiography: Edson Benchland.

Vegetation: Pl, Sw. 37% of forest cover removed as of December, 1974.

Soils:

Associations:	Mayberne	Summit
Infiltration (cm/h):	3 to 4	<3.0

Surficial Deposits: Mayberne Till.

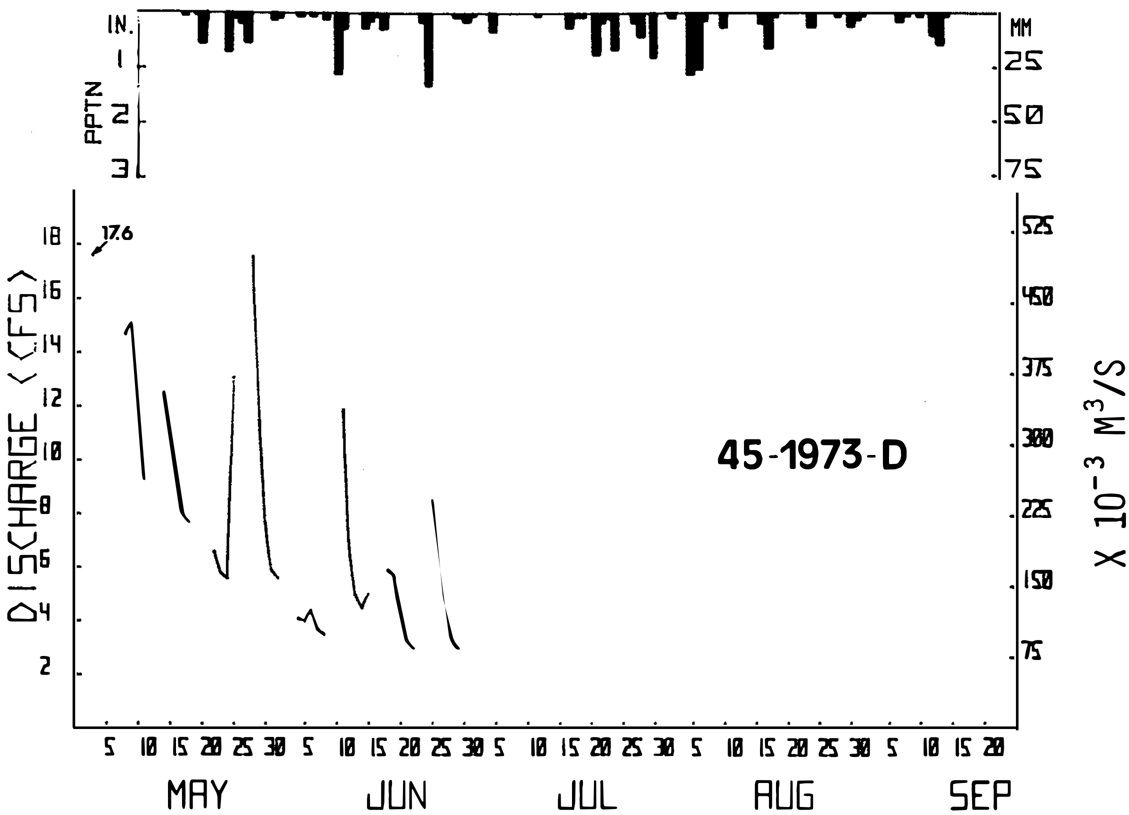
Bedrock: UPPER CRETACEOUS AND TERTIARY.
Paskapoo Fm: sandstone, shale, and coal.

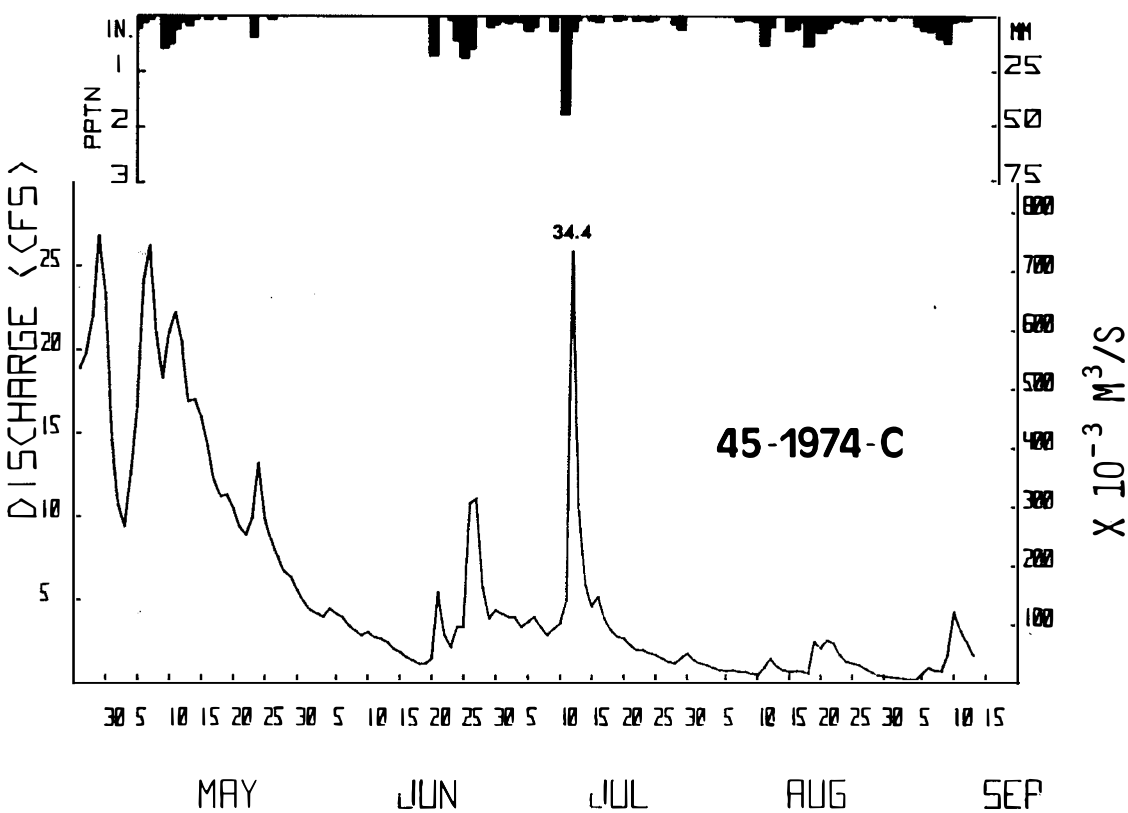
Stream Channel:

Gradient: 5%; *Order:* 3

Perennial channel length: 2.1 km (1.3 mi)

Stream width-depth: 1.8 by 0.4 m (6.0 by 1.3 ft)


IN.
PPTN
MM
DISCHARGE (CFS)
X 10^-3 M^3/S
17.6
45-1973-D
MAY
JUN
JUL
AUG
SEP


IN.
PPTN
MM
DISCHARGE (CFS)
X 10^-3 M^3/S
34.4
45-1974-C
MAY
JUN
JUL
AUG
SEP

WATERSHED NO. 46

Drainage: Edson River—6

Location: Section 14, Twp. 56, Range 19, W5M

Area: 3.9 km^2 (1.5 mi^2) **Aspect:** S

Elevation: Max. 1311 m (4300 ft); Min. 1158 m (3800 ft)

Physiography: Edson Benchland.

Vegetation: Pl, Sw, Sb. 46% of forest cover removed as of 1973.

Soils:

Associations:	Mayberne	Maskuta	Summit
Infiltration (cm/h):	3 to 4	>20.0	<3.0

Surficial Deposits: Mayberne Till.

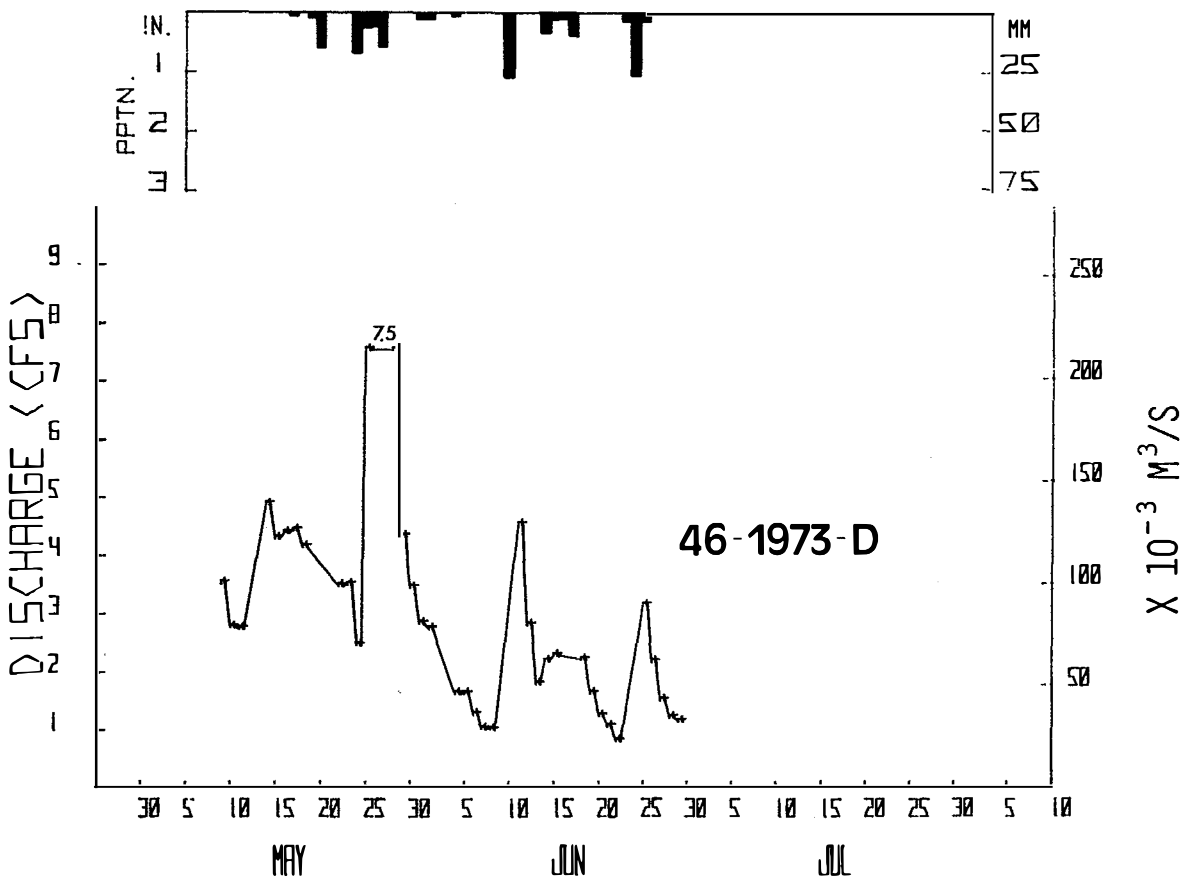
Bedrock: UPPER CRETACEOUS AND TERTIARY.
Paskapoo Fm: sandstone, shale, and coal.

Stream Channel:

Gradient: 3%; *Order:* 2

Perennial channel length: 1.6 km (1.0 mi)

Stream width-depth: 0.8 by 0.3 m (2.5 by 1.0 ft)


IN.
PPTN.
1
2
3
MM
25
50
75
DISCHARGE (CFS)
9
8
7
6
5
4
3
2
1
7.5
46-1973-D
250
200
150
100
50
X 10^-3 M^3/S
30 5 10 15 20 25 30 5 10 15 20 25 30 5 10 15 20 25 30 5 10
MAY
JUN
JUL

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