THE FISH AND FISHERIES OF THE ATHABASCA RIVER BASIN

Their Status and Environmental Requirements

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PREFACE

This report was prepared by consultants supervised by Bryan Kemper for Planning Division of Alberta Environment, and Dave Rimmer for Fish and Wildlife Division of Alberta Energy and Natural Resources. The Fisheries Overview series of reports have been commissioned to summarize known data to assist river basin planning studies and assist in the planning of new studies with the appropriate management agencies.

The opinions expressed in this report are based upon written and verbal information provided to the consultant and therefore do not necessarily represent those of Alberta Environment.

EXECUTIVE SUMMARY

The information presented here reviews what is currently known of fish ecology and production of the Athabasca Basin, and includes discussions of fish production, sport and commercial use of fish populations, and alternative opportunities for recreational fishing in the rivers of the Athabasca Basin. Fisheries management objectives for the basin rivers and data gaps in existing knowledge of fish and fisheries are also discussed. In addition, water quality criteria for the protection of fish and aquatic life have been referenced, and, where possible, stream flows which affect fish populations have been included.

The Athabasca Basin accounts for 23% of the land area of Alberta. For the purposes of this report, the basin has been divided into 10 sub-basins: four mainstem sub-basins, and six tributary sub-basins. These sub-basins are grouped under the following headings:

The Upper Sub-Basins
- Jasper National Park
- Berland
- McLeod

The Lower Sub-Basins
- Lac La Biche
- Clearwater

The Central Sub-Basins
- Pembina
- Lesser Slave

The Athabasca Sub-Basins
- Athabasca I
- Athabasca II
- Athabsca III

The mainstems of the principal rivers of the 10 sub-basins provide approximately 4,390 km of fish habitat which can be roughly divided as providing 1,500 km (34%) coldwater habitat (supporting mainly trout and whitefish), 2,250 km (51%) warmwater habitat (supporting mainly pike, walleye, and goldeye), and 640 km (15%) transition zone intermediate between the two.

Both commercial and recreational fisheries occur within the Athabasca Basin. The commercial fish catch represents a substantial proportion of the overall harvest and total market value of the Alberta commercial fishery. The recreational fishery occurs mainly in rivers and streams, though some lakes and reservoirs provide alternate opportunities. In 1980/81, approximately 9% (26,346) of Alberta's licensed anglers resided and fished within the Athabasca Basin. The opportunities provided to sport fishermen by the basin rivers have local, regional and in some cases, national significance.

The Athabasca River rises high in the Rocky Mountains, and terminates at the delta created by the Peace and Athabasca rivers at the western extreme of Lake Athabasca. Over its length, the Athabasca River grows from a torrential high-mountain stream to a silt-laden major river at its delta, and its basin encompasses virtually every temperate stream type. In its upstream reaches, the Athabasca River flows generally northeast, steadily increasing in volume as it receives flows from the Berland, McLeod, Pembina, Lesser Slave, Lac La Biche, and Calling rivers.

Further downstream, in the vicinity of a series of rapids, the river receives flows from the Pelican and Horse rivers. Near Fort McMurray, the Athabasca forms a confluence with the Clearwater River, and turns to flow north through the Athabasca Oil Sands region. Within the oil sands, the Athabasca River receives flows from many rivers and streams, including the Steepbank, Muskeg, Mackay, Ells, Firebag, and Richardson rivers. Reaching the Peace-Athabasca Delta near Embarras Portage, the Athabasca River subsequently forms part of the Mackenzie drainage, which empties into the Beaufort Sea.

Flowing through diverse and widely differing terrain, including remote alpine areas, populated urban settings, and the largest open-pit oil sands mining sites in the world, the Athabasca Basin is made up of a corresponding variety of waterbodies. Within the basin, each sub-basin has characteristic fish-producing capabilities, which are largely determined by the conditions which contribute to its environment. The primary features of each sub-basin and the characteristics of its lakes and rivers are summarized below:

The Upper Sub-Basins

The extreme headwaters of the Athabasca River lie within the Jasper Park Sub-Basin, which accounts for 7.4% (10,878 km^2) of the area of the Athabasca Basin. In this sub-basin, the productivity of the salmonid sport fishery is limited by the cold, short growing season. Low rates of discharge in the winter, limited nutrients, and the nature of glacial stream flows also characterize this typical cold, clearwater fish habitat zone. The low rate of biological productivity relative to angling demand is offset by fish stocking programs throughout many lakes in Jasper Park. Moderate to heavy angling pressure exists in favoured tributaries and along accessible portions of the Athabasca mainstem. Fish populations in the area are relatively unproductive and slow-growing. As a result, these populations may be particularly vulnerable to over-fishing, especially given the predicted, long term use of the park by recreationalists.

The Berland Sub-Basin makes up 3.9% (5,750 km^2) of the Athabasca Basin. While sparsely populated, this sub-basin has experienced significant forestry clear-cut operations, and oil and gas exploration and development. The Berland Sub-Basin has a high recreational demand and presents excellent well-known sport fishing habitat. The relatively clear, cold waters of the tributary rivers provide habitat for coldwater species, chiefly rainbow trout and eastern brook trout, although Dolly Varden, mountain whitefish and Arctic grayling are known to occur. Large populations of mountain whitefish are known to utilize the lower Berland River. The lakes of the sub-basin are well fished, especially Gregg and Jarvis, where northern pike and lake whitefish are taken. Most of the anglers using the region originate in Edmonton, and evidence of over-exploitation of remote populations of such species as Dolly Varden in wilderness areas, due to substantial angling pressure, is beginning to emerge.

The McLeod Sub-Basin constitutes 6.7% (9,850 km^2) of the Athabasca Basin, and embraces a wide spectrum of fish habitat,

habitat, including coldwater highland tributary streams which typically support coldwater species. The upper reaches of the Gregg River, for instance, support a sizeable rainbow trout population (Hawryluk 1973), as do the adjacent MacKenzie Creek (Hawryluk 1974), and the more distant Spinx Creek (Alberta Fish and Wildlife Division, internal report). In the more easterly Edson River, rainbow trout make up the primary part of the sport fishery (Hawryluk 1976). Habitat damage in portions of the McLeod Sub-Basin resulting from forestry and mining operations is, at times, pronounced. Although the lowland tributaries of the McLeod Sub-Basin have limited potential for fish habitat development, the upland tributaries could be maintained as significant sport fishery areas. Indeed, the area could be used for enhanced recreational experiments. The Tri-Creeks Watershed Study area provides an almost ideal base of long term data upon which such enhanced research and operational programs could be predicated.

The Central Sub-Basins

The Pembina Sub-Basin constitutes 9.7% (14,300 km^2) of the Athabasca Sub-Basin, and is characterized by a wide variety of fish habitat. High summer temperatures occur along most of the watershed, especially in the slow, exposed, lower reaches; however, these temperatures do not appear to exceed warmwater species tolerance. The quality of fish habitat, of potential value to resource managers, is limited by low seasonal flows in the headwaters, seasonal flooding in the lower reaches, and the impact of the most intensive industrial, urban, and agricultural development within the Athabasca

Basin. Documentation for specific tributaries indicates that the sportsfish potential of the Pembina Sub-Basin has declined in the past 40 years; however, stocking programs in lakes have tended to offset this decline. The mainstem reaches, particularly at the primary confluences (Paddle, Bigoray, and Lobstick rivers) are heavily angled, as is the confluence with the Athabasca River. Access throughout the sub-basin is excellent, and fishery programs, where implemented, have received significant attention from sport fishermen. In the upper reaches of the Pembina Sub-Basin, rainbow and brook trout are the most abundant sportsfish. In terms of angling effort, walleye represent the principal gamefish in the mainstem of the Pembina River, and most of the effort is directed to areas where concentrations are, or have been, known to occur. Walleye are most abundant in the lower reaches (Sangudo to Flatbush) of the Pembina.

The Lesser Slave Sub-Basin makes up 20,600 km^2 (14%) of the Athabasca Basin. The range from coldwater to warmwater fish habitat which occurs throughout the Lesser Slave Sub-Basin results in a diverse fish population which includes coldwater species inhabiting the upland tributaries, and warmwater species inhabiting the tributaries of the Lesser Slave Lake flatlands. Agricultural practices and incidents of severe flooding have probably degraded fisheries habitat throughout the Lesser Slave Sub-Basin, but no clearly documented research has summarized these effects. The river represents a transition zone--fish common to both warmwater and coldwater aquatic habitat are found here. Of the coldwater species, mountain whitefish are probably the most numerous, although brown trout are also present. Pike, walleye and perch make up the warmwater species. In many respects, the fish populations of the Lesser Slave River are intermediate between those of the much larger Athabasca River and Lesser Slave Lake. Lesser Slave Lake is a large, but rather shallow, central Alberta lake which has provided a commercial fishery for four fish species in the last half-century. That fishery is the oldest and most productive commercial fishery in the Athabasca Basin, and has focused primarily on whitefish, although lake cisco was the second most important commercial species until the 1960's. Factors limiting productivity of fishes there include siltation, erosion, and severe flooding in tributary rivers, summer fish kills in smaller lakes, and high summer temperatures in some of the slow-moving lowland tributary rivers.

The Lower Sub-Basins

The Lac La Biche Sub-Basin (8,800 km^2) represents 5.98% of the Athabasca Basin, and contains highly sought-after populations of walleye and pike. Indeed, there have been some reports of conflict between commercial and recreational fishing interests throughout the region. Lac La Biche is one of the most important commercial fisheries in the entire Athabasca Basin (74 licences issued in 1982/83), one which has been exploited for well over 40 years. Increasing commercial, domestic, and recreational fishing pressures in the sub-basin will undoubtedly lead to requirements for enhanced fish management and assessment programs. Lac La Biche contains 13 species of fish. It is not known whether conditions in the lake were suitable for lake trout in earlier years, but conditions are now, apparently, not suitable. Limitations on the commercial catch of some species in

Lac La Biche have been in effect since 1917 and the principal commercial fish species in the lake have been lake whitefish, lake trout, and cisco. The Lac La Biche River is reported as having a good population of pike, which is exploited by anglers. Angling pressure is heaviest in spring at the lower sections of the river where anglers are seeking walleye and pike. The Lac La Biche Sub-Basin has experienced increases in angling pressure, especially from the developing centres of Athabasca and Fort McMurray. The Sir Winston Churchill Provincial Park on Lac La Biche is heavily used by tourists for fishery access.

The Clearwater Sub-Basin makes up 9.5% of the Athabasca Basin, of which approximately 14,000 km^2 falls within Alberta. The Clearwater Sub-Basin is one of the most pristine aquatic habitats in the province. The Christina River, which constitutes the largest portion of the Clearwater Sub-Basin within Alberta, has experienced increasing angling pressures. Arctic grayling are highly sought after in the Christina River, with fishing pressure extending from its headwaters in the vicinity of Christina Lake, to its confluence with the Clearwater River near Fort McMurray. During the spring, the walleye inhabiting the Clearwater and lower Christina rivers receive moderate to heavy angling pressure, largely due to the influx of sport fishermen from the Fort McMurray area. Since access is limited throughout the Clearwater Sub-Basin, especially in the upper reaches of the Christina river, the sub-basin constitutes one of the last largely undisturbed sport fisheries in the entire Athabasca Basin. Nevertheless, significant declines in sportsfish populations have been observed there and in the Hangingstone River. Winefred Lake is one of the few trophy lakes falling within the Athabasca Basin and supports small commercial and recreational fisheries.

The Athabasca Sub-Basins

The three Athabasca Sub-Basins (I, II, and III) make up the remainder (42.7%) of the Basin and together drain an estimated area of more than 62,000 km^2 within Alberta. These three sub-basins are part of the Athabasca River mainstem, which serves as a major migratory route for important fish species in the region. Fish utilize the river to reach overwintering, spawning, or summer feeding-rearing habitat. For instance, as many as a million lake trout leave Lake Athabasca in summer to reach fall spawning habitat upstream of Fort McMurray. The longnose sucker exhibits a similar type of migratory behaviour in late winter or the spring. Suckers, Dolly Varden, burbot, Arctic grayling, and mountain whitefish also use the Athabasca mainstem as a primary migratory route into tributary basins. In essence, the mainstem river section of the Athabasca functions as a linking corridor for fishes distributed among the numerous sub-basins.

Athabasca Sub-Basin I, extending from the Jasper National park boundary to just east of Fort Assiniboine, contains a diverse, and highly utilized fish population. Typically coldwater fishes are found within the area, and angling for Arctic grayling and rainbow trout is provided in several mainstem, tributary (Windfall Creek, Marsh Head Creek, and Oldman Creek) and lake (Obed, Carson, and Emerald) settings. The region is heavily exploited by anglers from the Edmonton urban centre. Industrial and urban water usage along the

Athabasca mainstem has been a centre of controversy, especially as incidents of fish-tainting downstream from the major industrial users has been reported and investigated. Tributary streams and rivers of Athabasca Sub-Basin I, the sub-basin at the highest elevation, contain typically coldwater sportsfish. This sub-basin, ranging from highland Eastern Slopes terrain to Interior Plain, is a popular sport fishing region. Several lakes, Obed and Carson, for instance, are heavily stocked with rainbow trout, and to a lesser extent, eastern brook trout. A significant use of these recreational lakes is made by anglers living within a 200 km radius, the majority of which live in Edmonton.

Athabasca Sub-Basin II is the least understood fisheries area along the Athabasca mainstem. To the north, the House River once yielded Arctic grayling to anglers, but catches have declined in the last decade as a result of over-exploitation. The Calling River is heavily angled, mostly for Arctic grayling and walleye. Calling, Orloff, Rock Island, and Baptiste lakes are used extensively for sport fishing, especially by residents from the Edmonton region. Except for the river section extending from Grand Rapids north to Fort McMurray, the fish populations within the Athabasca Sub-Basin II have been little studied. The river is known as a major, and important, spawning area for a population of lake whitefish originating in Lake Athabasca, and for longnose suckers. The area north of Calling Lake is very poorly known and requires further fisheries research.

Athabasca Sub-Basin III, extending from Fort McMurray in the south, at the confluence of the Clearwater River, north to the

Peace-Athabasca Delta, constitutes some of the most diverse fisheries habitat in Alberta. Drawing from an enormous tributary network, the sub-basin picks up flows from large areas of Saskatchewan, chiefly through the Firebag and Richardson rivers. To the east, the MacKay, Dover, and Ells rivers drain the Namur-Gardiner Lakes region of the Birch Mountains. Growing population centres, such as Fort McMurray, have placed increasing demands on the recreational fisheries throughout the sub-basin and focus attention on the need for more access to suitable recreational outlets. The sub-basin contains some of the most intensively studied aquatic habitat in western Canada. Large industrial developments from oil sands mines and the resultant significant urban growth at Fort McMurray have caused rising recreational and sport fishing demands throughout the region.

The region contains a wide variety of fish habitat, ranging from spawning grounds for walleye in the silty mainstem, to cold brownwater habitat for Arctic grayling in the tributary rivers such as the Muskeg, MacKay, and Firebag. Primarily as a consequence of restricted access, the Namur and Gardiner trophy lakes represent a unique resource for a region which is sadly deficient in adequate recreational outlets. Those areas that are accessible from Fort McMurray, such as Gardiner Lake to the south, are heavily over-utilized. Among sportsfish, Arctic grayling, northern pike, yellow perch, and walleye are the most widely distributed in tributary streams. Lake whitefish, an important domestic fish, is widely distributed, but generally confined to confluences along the Athabasca. Trout-perch are probably the most abundant fish in Athabasca Sub-Basin III, followed by longnose and white suckers, goldeye, lake whitefish, walleye, and northern pike.

Fisheries management objectives for the Athabasca Basin to improve fish production, or to create new fisheries where possible, have been outlined for each sub-basin. Because of deficiencies in the data base in some cases, the implementation of specific fisheries management strategies is impossible. In order to correct these deficiencies, and so work toward regional fisheries management strategies, gaps in the existing data have been identified by sub-basin.

There are, however, several basic deficiencies in knowledge which apply, to greater or lesser extents, throughout the study area. These include:

- A lack of data on existing levels of fish production.
- A lack of data on many species occurrences and numbers and critical habitat areas.
- No thorough listing of factors known to limit fish production throughout the sub-basins.
- Incomplete studies and/or documentation of fish migrations, with respect to species and timing, in river systems throughout the basin.
- Insufficient studies of factors which influence major fish migrations.
- Lack of adequate data on the recreational use of the sport fishery throughout the basin, including important factors such as timing and location of activity and size of total catch.
- Inadequate documentation of supply and demand for the sport fishery based on each sub-basin.

- Inadequate documentation on the relationship between water quantity (discharge) and water quality (including domestic sewage, industrial and agricultural chemical inputs) as they influence levels of fish production.

In addition to the recommended water quality criteria and discussion on the impacts of water discharge, the following recommendations are made:

1. The Athabasca Basin presently provides recreational fishing for approximately 9% of Alberta's licensed anglers. This recreational demand has increased significantly in the recent past and there is every reason to expect that it will continue to increase.

   It is, therefore, recommended that the preservation and enhancement of fish production in the sub-basin tributaries and mainstem of the Athabasca River be recognized as a significant water use in the basin.

   There is a significant economic return to the Province from the recreational, commercial, and domestic fisheries in the Athabasca Basin. However, in many cases, few alternative fishing sites are easily available or accessible throughout the region due to, in many cases, a lack of fish-producing waters. It must be recognized that the Athabasca's fish and fish habitat are a finite and valuable resource in an expanding economic region of Canada.

2. Water and land use practices, in addition to direct fishery exploitation, are the major factors presently limiting fish production and habitat conservation in the Athabasca Basin.

   Criteria for land use and water management practices need to be established for operational and planned developments in the basin as a whole. Minimum discharge values for fisheries need to be assessed and recommended for several sub-watersheds in the basin, especially with a view to impacts from water level control structures (Paddle, East Prairie, and West Prairie rivers, and structures in the Lac La Biche Sub-Basin). Recommendations in each sub-basin should be reviewed and revised as new data become available.

3. It is recommended that the criteria for water quality for protection of fish and aquatic life, as outlined in Longmore and Stenton (1981), be adopted for all the sub-basins and the mainstem of the Athabasca River. Surveys should be conducted to confirm maintenance of those standards and, where fishes are at risk due to lapses from those standards, measures should be implemented to improve the water quality. This may necessitate a considerable expansion in current capabilities for monitoring and modeling water quality parameters within basins.

All criteria adopted for water quality should be reviewed or revised as new data are made available. Research and monitoring on the long-term effects of treated sewage discharged to waters of the Athabasca Basin need to be more fully addressed. Chlorination of subsequent treated waters should be fully assessed and monitored where they occur. The conservation and enhancement of habitat and water quality should be made a priority for those Athabasca Basin waters which flow through, or near, large urban centers.

As noted in the report by Longmore and Stenton (1981), special steps should be undertaken to assess the effects on aquatic life of the group of chemical compounds known as phenols, particularly with respect to their aquatic toxicity and their ability to impart taste to fish flesh. While some phenolic compounds occur naturally, any water uses which contribute new phenols to the Athabasca River Basin should be carefully monitored.

Further research is required on the effects of pesticides and herbicides used in agricultural applications adjacent to the Athabasca River, or added directly to the river water (such as the blackfly control program at Athabasca). Very little has been established regarding long-term residues in fishes in the region, or of the acute or sub-acute toxicities to aquatic organisms of chemical compounds used throughout the basin.

4. It is recommended that more basic, ecological data be collected on the fish and the fisheries of the Athabasca Basin. Surveys which embrace all the components of aquatic ecosystems (benthos, periphyton, and fishes) are urgently needed as long-term, continuing studies in order to formulate and assess ongoing management strategies. Without a sound base of ecological data strategies for enforcement, management and enhancement of fish populations can be, at best, only haphazard.

   Levels of fish production, the routes of fish migrations, and habitat capability need to be carefully assessed throughout the basin.

   The recreational, commercial, and particularly domestic use and catch need to be examined throughout the Athabasca Basin, especially as these levels of "demand" relate to fish production.

5. A supply and demand model for fisheries in all the

sub-basins of the Athabasca Basin needs to be developed, especially in areas where recreational, commercial, and domestic fisheries are situated. Data should be collected and appropriate management strategies implemented on a sub-basin basis. This would reflect the ecological realities of the fish populations in the regions and would allow for the development of management strategies suitable to each of the widely different sub-basins which make up the Athabasca Basin.

More data on the recreational, commercial, and domestic use of fisheries are required for each sub-basin. These data, once available, should be further assessed in the development of an Athabasca Region Fisheries Management Program.

6. Experimental methods should be employed to assess various fish production enhancement methods. The Tri-Creeks Watershed Study, for instance, should be expanded to include augmented, experimental studies on freshwater fish production. Long-term studies such as these could have a profound, positive influence on the development and management of the coldwater sport fishery so important to recreational interests throughout the region.

In line with this, more liaison and communication should occur between federal and provincial authorities in the long-term management and monitoring of the fisheries within, or immediately adjacent to, the Jasper National Park area.

RECOMMENDED FISHERIES ACTIVITIES

As part of any Athabasca Basin Water Management Plan, specific recommendations must be forthcoming for minimum water discharges, water quality criteria, and fish production. Several aspects of fish production and management, however, require further investigation before specific recommendations can be implemented throughout the basin.

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I INTRODUCTION

In 1979, Alberta Environment initiated a planning program to develop a framework and strategy for the management of waters throughout Alberta. The planning process was divided into four stages:

Phase I Design of the planning process.

Phase II Overview of the basins, including a compilation of water uses, needs, and policies based on existing information, identification of data gaps and the formulation of preliminary water management policy recommendations.

Phase III Further data collection and refinement of policy recommendations.

Phase IV Policy implementation and monitoring of the system of water allocation and use.

In March 1981, the Alberta Fish and Wildlife Division, Fisheries Branch, published their contribution to Phase II of the process: "The Fish and Fisheries of the South Saskatchewan River Basin" by L.A. Longmore and C.E. Stenton. That report recommended water quality criteria and minimum water quantities required to sustain or enhance fish production in the rivers of the South Saskatchewan Basin. Subsequent to the release of that report, three River Basin reports were commissioned for each of the Athabasca, Peace, and North Saskatchewan River basins.

Here, we report on the second largest, in areal extent, of those basins--the Athabasca Basin. Water quality criteria and, where possible, minimum water quantities required for the maintenance of fish production in the basin are described. Fish species and production, limitations to fish production, sport and commercial fisheries demands, and aquatic habitats are described in a format similar to that of Longmore and Stenton (1981). Fisheries management objectives and data gaps for the fish and/or fisheries in each sub-basin of each river are also listed.

In order to protect or enhance the fish production and fisheries in the several sub-basins forming the Athabasca River drainage, adequate water quality and quantity must be maintained. Fish production is just one of many aspects of increasingly competitive water use in the Athabasca Basin. Existing fish populations support an extensive sport fishery and, in some cases, commercial fisheries. In addition, the region has a significant tourist and recreational demand, so that aesthetic considerations for water quality maintenance and conservation must be included as part of any water management planning.

Provincial authority to protect and manage fish and fish habitat derives from the Fisheries Act of Canada, the Alberta Fishery Regulations, and the Alberta Fishery Propagation Order issued pursuant to this Act. In agreement with the Government of Canada, the Government of Alberta, through the Alberta Fish and Wildlife Division of Alberta Energy and Natural Resources, administers the Fisheries Act of Canada and its Regulations. The Alberta Department of the Environment is responsible for water resources management in Alberta, chiefly through its Water Resources Management Service (multi-purpose water needs) and the Environment Protection Service (pollution control).

Legislative acts related to water quantity management in Alberta include the Water Resources Act, the Drainage Districts Act, the Groundwater Control Act, and the Irrigation Districts Act. Legislative Acts relating to water quality management in Alberta include the Department of Environment Act, the Clean Water Act, the Agricultural Chemicals Act, and the Waste Management Act.

The province's water resources are managed on a river basin system, with planning organized around the six major river basins in Alberta. The Alberta Department of Energy and Natural Resources is responsible for the Fish and Wildlife Division and the Alberta Forest Service, with associated connotations for water resource management. Recreation and Parks is responsible for provincial parks and other aspects of water-based recreation. The Irrigation Division of Alberta Agriculture has responsibilities for irrigation services and planning. Private irrigation is licenced through Alberta Environment, which is also responsible for the construction and operation of major irrigation works.

OBJECTIVES OF THIS REPORT

There are six primary objectives for this report, which deals with existing data on fisheries production and management in the tributary rivers and lakes forming the Athabasca Basin (Jasper Park, Berland, McLeod, Pembina, Lesser Slave, La Biche, Clearwater, and Athabasca sub-basins):

- To identify fish populations, productivities, characteristics, and habitat requirements in each of the major river systems.
- To assess present water quality in the basin, using the water quality criteria used in the Longmore and Stenton (1981) reports.
- To describe the levels of demand from recreational and commercial fisheries in the Athabasca Basin.
- To describe sport fishing opportunities available to residents of the Athabasca Basin, other than those afforded by the mainstem of the river.
- To identify significant gaps in the available data regarding fish population sizes and distributions, characteristics of productivity, habitat requirements, and the level and nature of demand on the fishery resource of the Athabasca River Basin.
- To incorporate fisheries management objectives and policies for the basin, as developed by Fish and Wildlife Division staff.

METHODOLOGY AND SOURCES OF DATA

In order to meet the stated objectives for the report, productivity, habitat, and recreational significance of the fish populations in each of the major sub-basins of the Athabasca Basin were reviewed. Study areas, extending approximately 150 km from each side of the mainstem of the river, were identified. In some cases, greater distances were included, to take into consideration special habitat areas or fish populations.

Longmore and Stenton (1981) considered that, since most anglers seldom travel more than 150 km on routine fishing trips, the study corridor used would encompass all angling opportunities available to resident anglers, including alternate opportunities afforded by lakes or other river systems. At the same time, major population centres, with their attendant concentrations of anglers, were included within the study areas. In this review, however, due to the uniqueness of many of the sub-basins which make up the Athabasca Basin and the relative importance which each may contribute to commercial or recreational fishing, areas considerably removed from the mainstem are included. In many cases, locations well beyond the 150 km limit set by Longmore and Stenton (1981) are considered.

Background review data on the Athabasca Basin and its associated sub-basins were obtained from the published literature and from many unpublished or manuscript government reports. More detailed, specific information, such as morphometric data on streams and rivers within the basin, was obtained from Kellerhals et al. (1972) and from unpublished data provided by Alberta Environment.

Data on fish habitat and populations were obtained from both the published literature and from unpublished reports. In addition, detailed interviews were conducted with personnel in the Alberta Fish and Wildlife Division in Regional or Headquarters offices. Consultants' reports and other unpublished reports were also used (refer to general bibliography) in the review of data for the region. Statistics for commercial fishing and recreational or sport fishing were obtained from annual harvest records maintained by appropriate provincial government departments. Water quality parameters and criteria were provided by personnel in Alberta Environment (Pollution Control Division and Water Quality Control Branch) and Alberta Fish and Wildlife, and were largely transposed from those cited in Longmore and Stenton (1981).

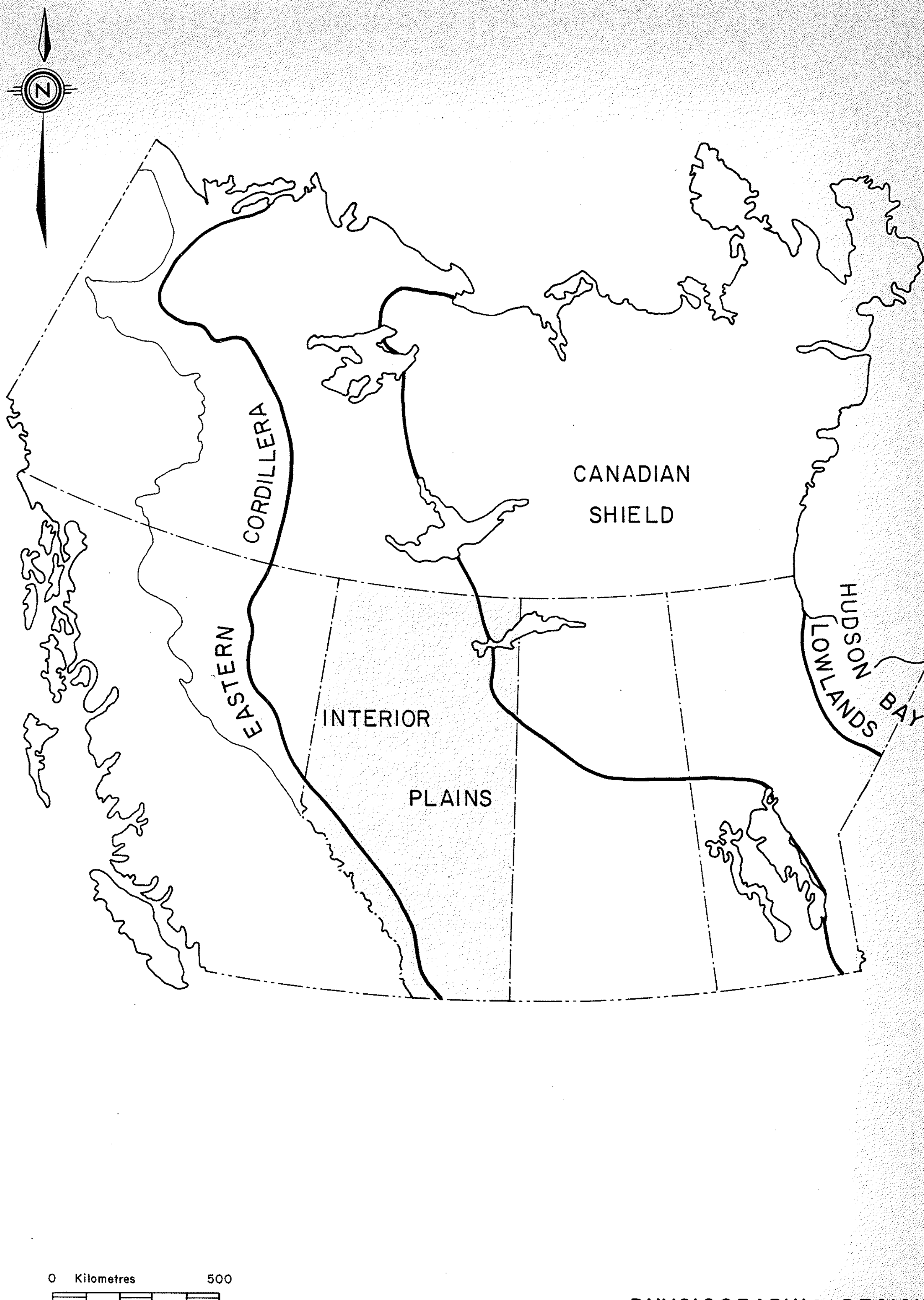
Working maps of the sub-basins were provided by the Technical Services Division, Hydrology Branch of Alberta Environment. Final preparation of the report was done by Alberta Environment in conjunction with staff of the Cartographic Services of Alberta Energy and Natural Resources.

II OVERVIEW

The Athabasca Basin, which is one of the most important drainages in Western Canada, falls within the physiographic region known as the Interior Plains (Figure 2-1). Although the high ridges of the Eastern Cordilleran mountain ranges produce an extensive "rain shadow" to the east, a significant amount of precipitation occurs in those mountains. Draining to the east, the runoff produces a high annual yield of water to rivers which flow through the foothills and eventually out onto the Interior Plains. Rivers arising from glaciers, such as the Athabasca, are characteristically turbid as a result of the finely ground, suspended materials derived from glacial flow. Many tributary rivers in the mountain regions are clear, cold, and of excellent quality.

Traversing a significant part of the Alberta portion of the Interior Plains, the Athabasca River encounters a wide diversity of soil types, vegetation groups, and urban or industrial developments. The Athabasca Basin embraces all the major types of fish habitat which occur in Alberta, from clear, cold mountain brooks through to wide, warm, silty meanders. Accordingly, a wide variety of recreational and commercial fish populations occur there, each of which imparts distinctive characteristics as a valuable renewable resource in the sub-basins.

In its course from glacial highland to marshy delta, the Athabasca River touches many areas of Alberta's agricultural, urban, industrial, and recreational life. The Jasper Park Sub-Basin is a significant recreational region, as are the Berland and McLeod sub-basins. The latter two also support oil and gas and forestry industries. The Pembina and Athabasca I sub-basins are an important part of Alberta's agricultural base. The Lac La Biche and Lesser Slave sub-basins are important recreational and commercial fishing regions,



Source : Canada West Foundation (1982)

PHYSIOGRAPHIC REGIONS OF WESTERN CANADA

FIGURE 2-1

and the northeastern portion of the Athabasca flows through the world's foremost heavy oil and oil sands mining area. Trophy lakes in the basin, such as Gardiner, Namur, and Winefred provide unique opportunities for recreational development.

The mountain areas of the basin are characterized by post-glacial gravels which give way to the progressively darker soils of the foothills and plains. Further north, extensive organic soils, typically composed of muskeg and characterized by discontinuous permafrost, are found. Vegetation groups vary widely throughout the basin, showing a gradual transition as the alpine and coniferous vegetation of the south yields to the more diverse vegetation of the north. The northern portion of the Athabasca Basin supports parkland and boreal forest characterized by a mix of grassland, woodland, and muskeg bog.

In general, much of the available streamflow of the Interior Plains arises in the Cordilleran Mountain ranges, since the flow contributed by the plains is limited by low precipitation and high transpiration/evaporation rates. The water quality of rivers arising within, or flowing through, the Interior Plains region can be quite variable. As the rate of erosion in this region is generally high, its waters usually exhibit relatively high values for dissolved or suspended solids. Work done by Kellerhalls et al. (1972) illustrate the changeable conditions exhibited by the Athabasca River as it progresses from its headwaters to its delta (Table 2-1). Riverbed material changes dramatically along the watercourse, beginning with a D_{90} value of 42 near its source, peaking at 170 near Hinton, and falling dramatically to 0.22 near its mouth at Lake Athabasca.

Values for mean annual precipitation in Western Canada are shown in Figure 2-2. Except for the Cordilleran Mountain ranges, which contain the Athabasca headwaters, most of the area is relatively dry.

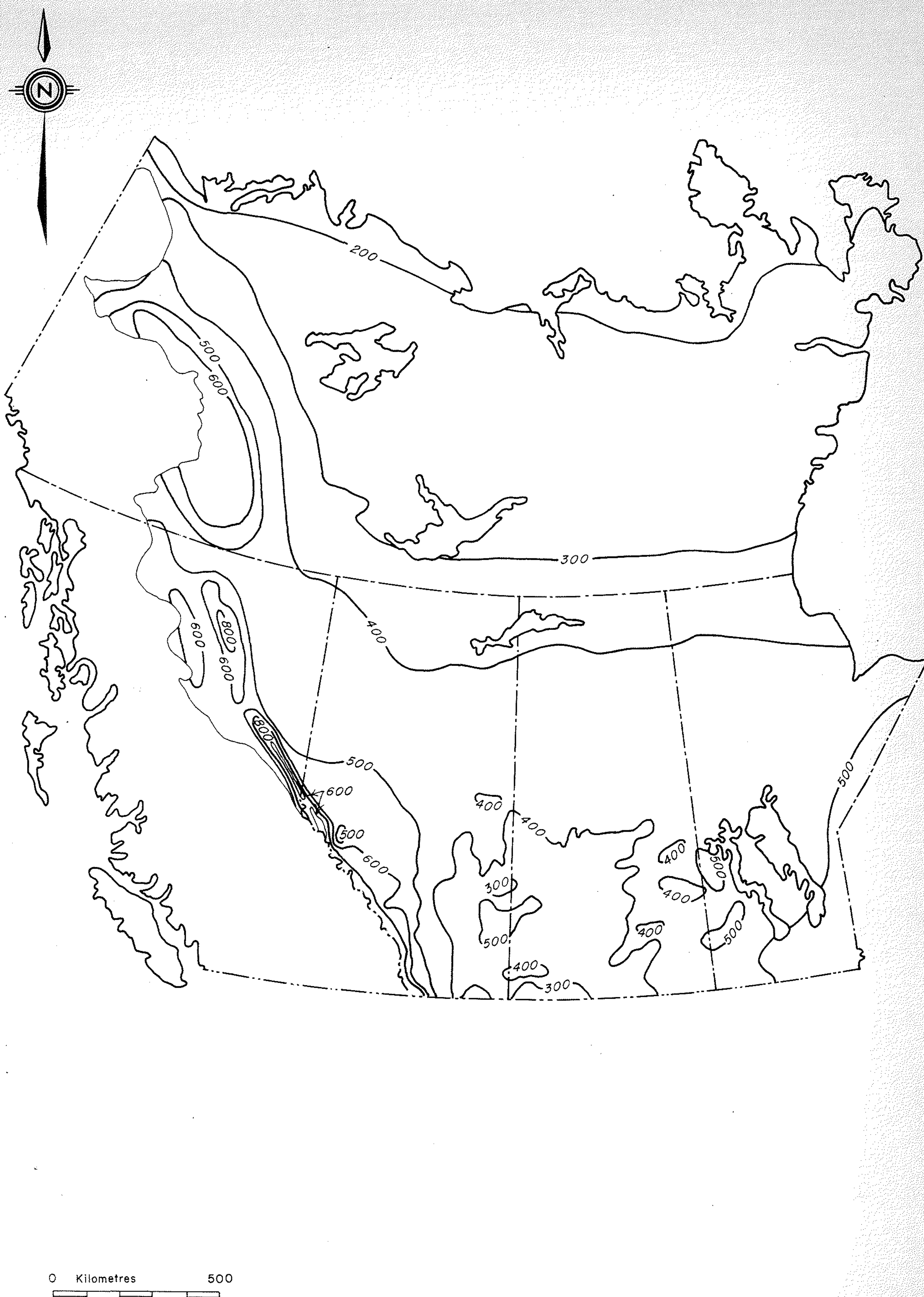
TABLE 2-1

ATHABASCA RIVER BED MATERIAL SAMPLES

Athabasca River			Total Sample			Fraction >8 mm	
Approximate Location	Distance From Mouth (mi)	(km)	D_{90} (mm)	D_{50} (mm)	<8 mm (%)	D_{90} (mm)	D_{50} (mm)
Lake Athabasca	3	4.8	0.22	0.15	100	na	na
Athabasca Delta	9	14.5	0.24	0.16	100	na	na
South of Embarras Portage	68	109	0.45	0.25	100	na	na
South of Firebag River Mouth	120	193	0.25	0.17	100	na	na
Athabasca	425	684	128	31	30	160	52
Downstream from Smith	479	770	0.55	0.35	100	na	na
Smith	491	790	48	18	40	57	35
Freeman River (Ft. Assiniboine)	576	927	80	28	23	90	39
Whitecourt	634	1,020	100	62	1	105	64
Hinton	748	1,204	170	57	22	195	76
Indian River Mouth (Jasper Lake)	808	1,300	125	36	20	145	50
Above Sunwapta River Mouth	854	1,374	42	9	47	50	22

Notes:
1. Samples collected from Athabasca River channels (gravel or sandbars) appearing representative of the surrounding reach. Where the size composition of the bar was non-uniform, the sample was taken from the coarsest material. Sample numbers correspond to distance from the mouth of the river.
2. na means not applicable
3. D90 refers to 90% by weight of the sample is smaller than the given size.
4. D50 refers to 50% by weight of the sample is smaller than the given size.

Source: Adapted from Kellerhals et al. (1972)



MEAN ANNUAL PRECIPITATION

FIGURE 2-2

Source: Canada West Foundation (1982)

Annual precipitation values range from 200 to 500 mm. The high mountain areas receive relatively more precipitation and, since many recording stations are located in valleys, values may be higher than those reported.

Although spring and summer precipitation yield a substantial portion of the total annual moisture, much of it goes to replace soil and groundwater losses which occur during the hot summer months. Hence, comparatively little summer precipitation moves into local streams, emphasizing the relative importance of Cordilleran snowmelt to the annual runoff which recharges the Athabasca headwaters. Snowmelt from the Eastern Slopes also provides the greater part of the runoff which eventually reaches the plains.

The glaciers of the Cordillera have an important influence, not simply because of their enormous water content, but also because of their influence on stream flow. Streams rising in glaciated areas have a greater seasonal consistency, and fewer anomalies in discharge, than those originating on the plains. The North Saskatchewan and Athabasca rivers are two examples of this. In hot summer months, meltwater from glaciers and their associated snow pack may contribute as much as 25% of the total flow to these two rivers.

Historically, there exists a close relationship between the inhabitants of the Athabasca Basin and its waterways, and prehistoric peoples were probably just as closely bound to the lakes and rivers of the basin as subsequent native groups. Right up to, and including, the present historic epoch, the Athabasca River simultaneously represented a source for food, water, and transportation. More recently, its added value as an "assimilator" of municipal and industrial wastes has received attention. While its historical use as a transportation corridor continues today throughout the Athabasca Basin, the growing populations of the major urban centres in Alberta have increasingly influenced the tributary streams and mainstems of the river.

Cities, and their attendant industries, require water for domestic and industrial uses, including subsidiary aspects of urban life, such as park/lawn maintenance and firefighting. These needs, when combined with agricultural demands and the heavy industrial uses characteristic of the oil sands region, suggest an ever-increasing potential for water quality deterioration with associated impacts on fish populations in the basin.

The growing cities in the Athabasca Basin not only require water for their sustenance, they may significantly affect the water which they use, process, and ultimately dispose of downstream. The figures projected for growth of Alberta in the next 15 years, suggest that problems resulting from indirect (water use) and direct (fishing) exploitation of the water resources of the Athabasca Basin will continue to increase (Table 2-2). These "allocative conflicts", arising from a fixed resource base which must meet constantly increasing demands both in consumptive and conservative activities, will certainly continue to impact on the fishery resource.

Indications of these trends are found in growth figures for the province. The mid-1983 population of Alberta was 2,350,100, which represented a five-year change of +20.4%. In the same year, the province, largely due to natural resource industries, had an estimated gross domestic product in excess of $49 billion, giving it one of the highest personal incomes per capita (1982 - $14,025) in Confederation. These figures contrast sharply with estimates of approximate land and freshwater areas within the three prairie provinces. On a percentage basis, Alberta has by far the smallest (2.54%) freshwater area, compared with that of Manitoba (15.62%) or Saskatchewan (12.68%) (Table 2-3).

Comparative figures for municipal water usage in the principal basins of Alberta are summarized in Table 2-4, which

TABLE 2-2

PROJECTED POPULATION GROWTH IN WESTERN AND NORTHERN CANADA

	Population (Thousands)					
	1980[1]	1980[2]	1985	1990	1995	2000
Manitoba	1,028	1,054	1,098	1,141	1,179	1,211
Saskatchewan	969	972	1,026	1,066	1,100	1,128
Alberta	2,079	2,092	2,450	2,826	3,171	3,481
British Columbia	2,637	2,613	2,860	3,154	3,433	3,686
Yukon	21	24	28	32	36	39
Northwest Territories	43	48	56	64	71	77
Canada	23,914	24,135	25,724	27,352	28,794	29,997

Notes: 1. Actual
2. As projected in 1976
3. Projections were based on the 1976 population census and assume a net international migration of 75,000 per year and a continued westward shift in economic activity.

Source: Canada West Foundation (1982)

TABLE 2-3

APPROXIMATE LAND AND FRESH WATER AREAS, BY PROVINCE

Province or Territory	Land (km2)	Freshwater (km2)	Total (km2)	Freshwater (%)
Manitoba	548,495	101,592	650,087	15.62
Saskatchewan	570,269	82,631	651,900	12.68
Alberta	644,389	16,796	661,185	2.54
British Columbia	930,528	18,068	948,596	1.91
Yukon Territory	478,034	4,481	482,515	0.93
Northwest Territories				
Franklin	1,403,134	19,425	1,422,559	1.37
Keewatin	565,809	25,123	590,932	4.25
MacKenzie	1,277,447	88,746	1,366,193	6.50

Source: Adapted from Canada West Foundation (1982)

TABLE 2-4

MUNICIPAL WATER USE, BY BASIN

Basin	Treated Water Supply From (Percentage)				Total Flow(m3/s)	Treated Wastewater Disposal To (Percentage)			Total Flow(m3/s)
	Lake	River	Well	Other		Lake	River	Other	
Oldman	-	98.8	1.0	0.2	1.53	5.3	89.7	5.0	0.78
Bow	1.0	96.0	1.5	1.5	4.75	-	98.4	1.6	4.02
Red Deer	2.3	62.3	31.5	3.9	0.43	1.1	95.2	3.7	0.33
North Saskatchewan	2.8	87.4	8.8	1.0	3.54	1.9	98.0	0.1	3.30
South Saskatchewan	0.5	95.1	4.3	0.1	0.99	-	92.5	7.5	0.70
Athabasca	10.4	80.5	9.1	-	0.36	2.5	97.5	-	0.13
Peace	38.6	53.1	8.3	-	0.19	3.7	96.3	-	0.14

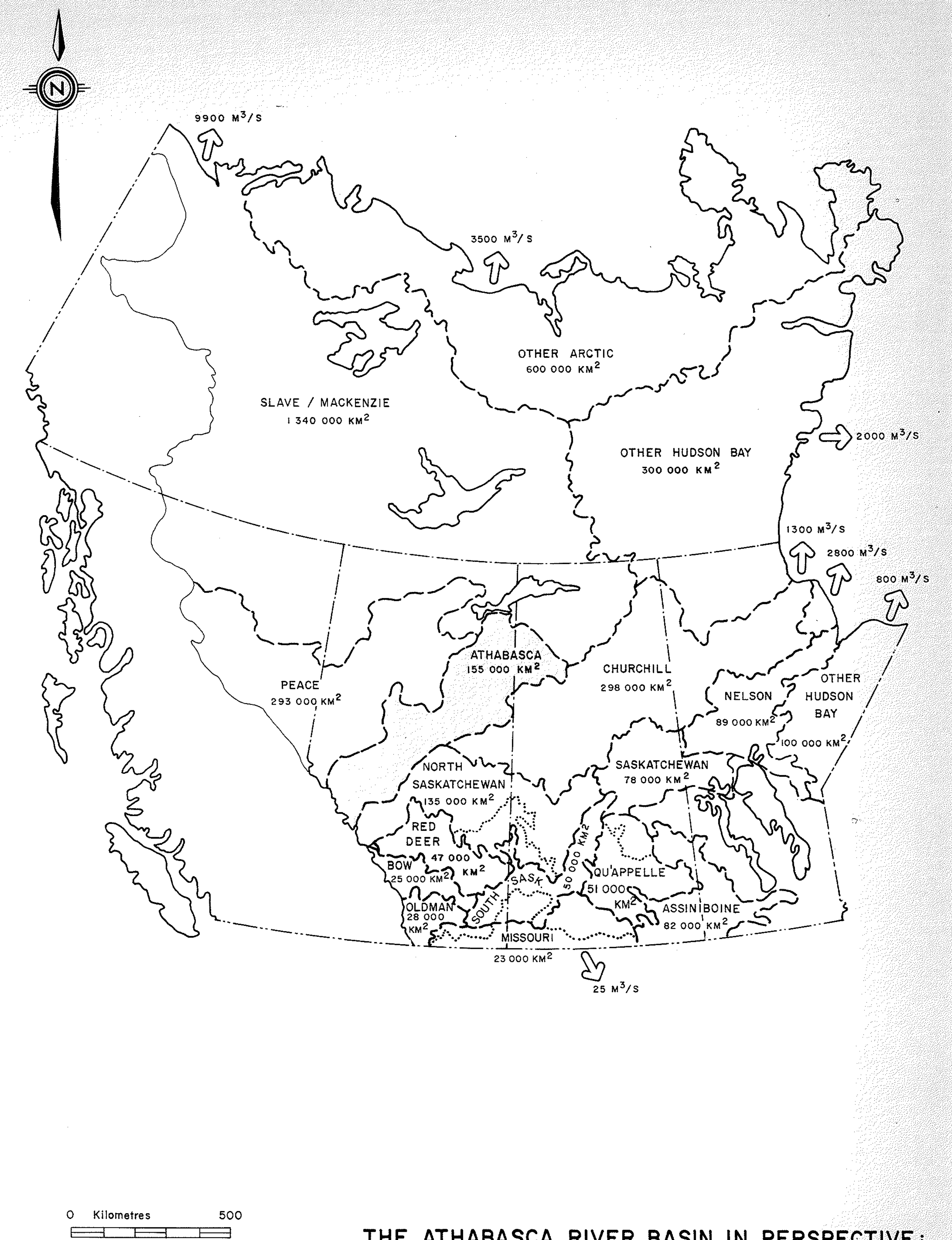
Source: Canada West Foundation (1982)

indicates that most (97.5%) of the treated wastewaters produced in the area are eventually discharged into rivers in the basin.

The Athabasca Basin forms part of the Mackenzie Basin, which ultimately empties to the Arctic Ocean through the Mackenzie Delta. The Athabasca is one of the largest drainage basins of Western Canada, and represents a sizeable portion of the contribution by the province of Alberta to the Mackenzie drainage (Figure 2-3). The major river system of Western Canada is the Slave River/Mackenzie River Complex, with its large tributaries--the Athabasca, Peace, and Liard rivers. Overall, the Athabasca/Slave/Mackenzie River Complex reaches about 3,800 km in length. Comparative mean annual flows indicate the relative contribution and significance of the Athabasca Basin to that Arctic drainage (Table 2-5).

A closer examination of the Athabasca Basin reveals its surprising regional diversity. Arising high in the Columbia Ice Fields in Jasper National Park, the Athabasca River flows north through the park and then turns to the northeast. It flows through the major forestry centre at Hinton, and then through the important oil and gas region near Whitecourt. Successively receiving flows from the Berland, McLeod, Pembina, and Lesser Slave rivers, it turns south toward the agricultural region surrounding the town of Athabasca. Once again resuming its northward course, the river receives flow from the largely undisturbed, boreal Clearwater Sub-Basin at Fort McMurray, and then enters the Athabasca oil sands region. The Athabasca River ends its journey at the large delta on Lake Athabasca.

The foregoing discussion illustrates the dynamic nature of natural and man-made influences which occur in the Athabasca Basin, and which ultimately affect the fish species that inhabit this sizeable portion of Alberta (Figure 2-4). Sport, commercial, and domestic fishing are important activities in the Athabasca Basin, the maintenance of which are dependent on water quality and quantity parameters.



THE ATHABASCA RIVER BASIN IN PERSPECTIVE: MAJOR BASINS OF WESTERN CANADA

Source: Canada West Foundation (1982)

FIGURE 2-3

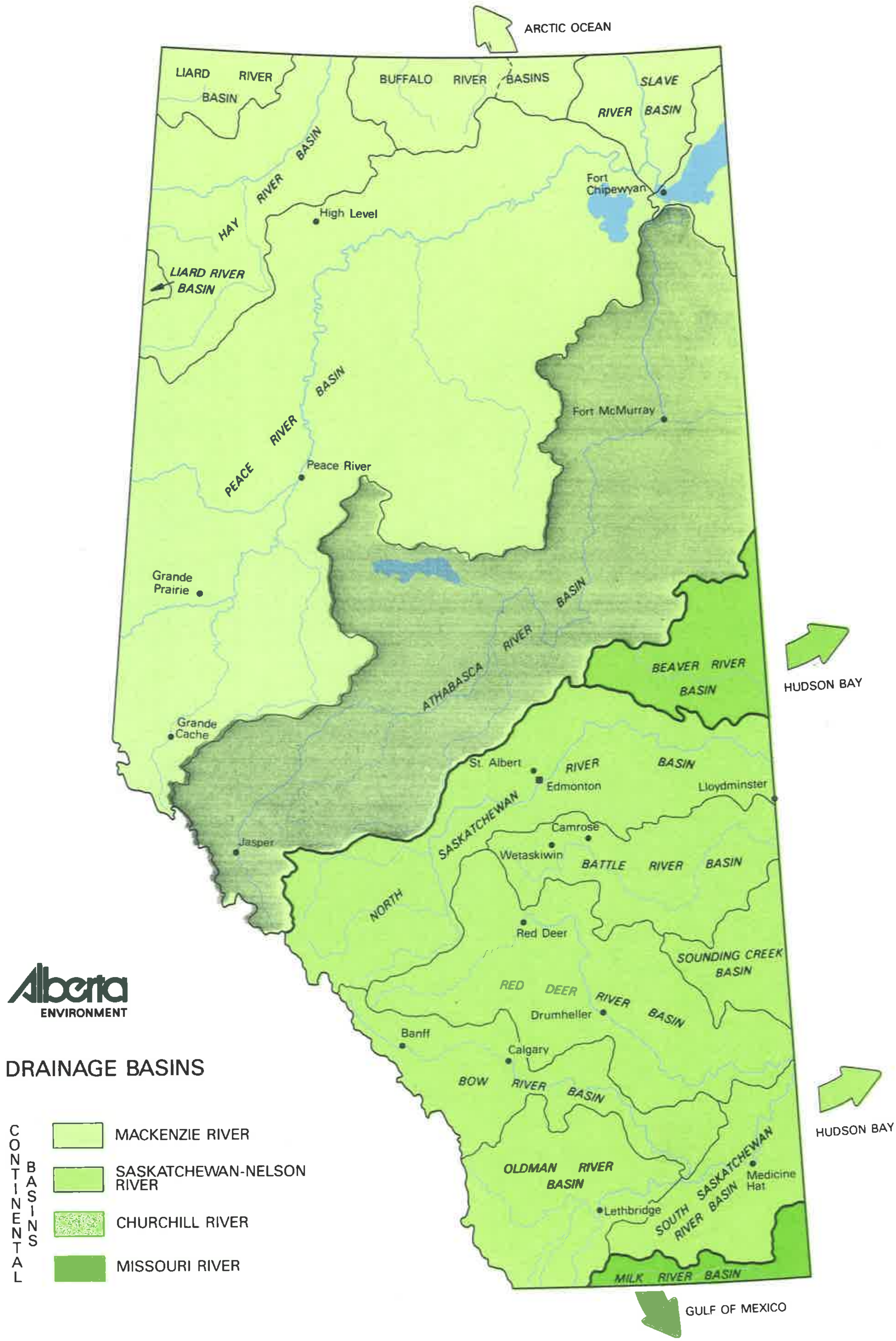
TABLE 2-5

RECORDED MEAN ANNUAL FLOWS OF SELECTED RIVERS

River	Location	Flow (m3/s)
MacKenzie	Above Arctic Red River	9630
Slave	Fitzgerald	3520
Peace	Peace Point	2070
Athabasca	Embarras Airport	785
North Saskatchewan	Prince Albert	245
Oldman	Near mouth	110
Bow	Below Carseland Dam	110
Red Deer	Near Empress	70

Note: Periods of record vary.

Source: Canada West Foundation (1982)



Water Resources Management Services — Revised 01/83/5m

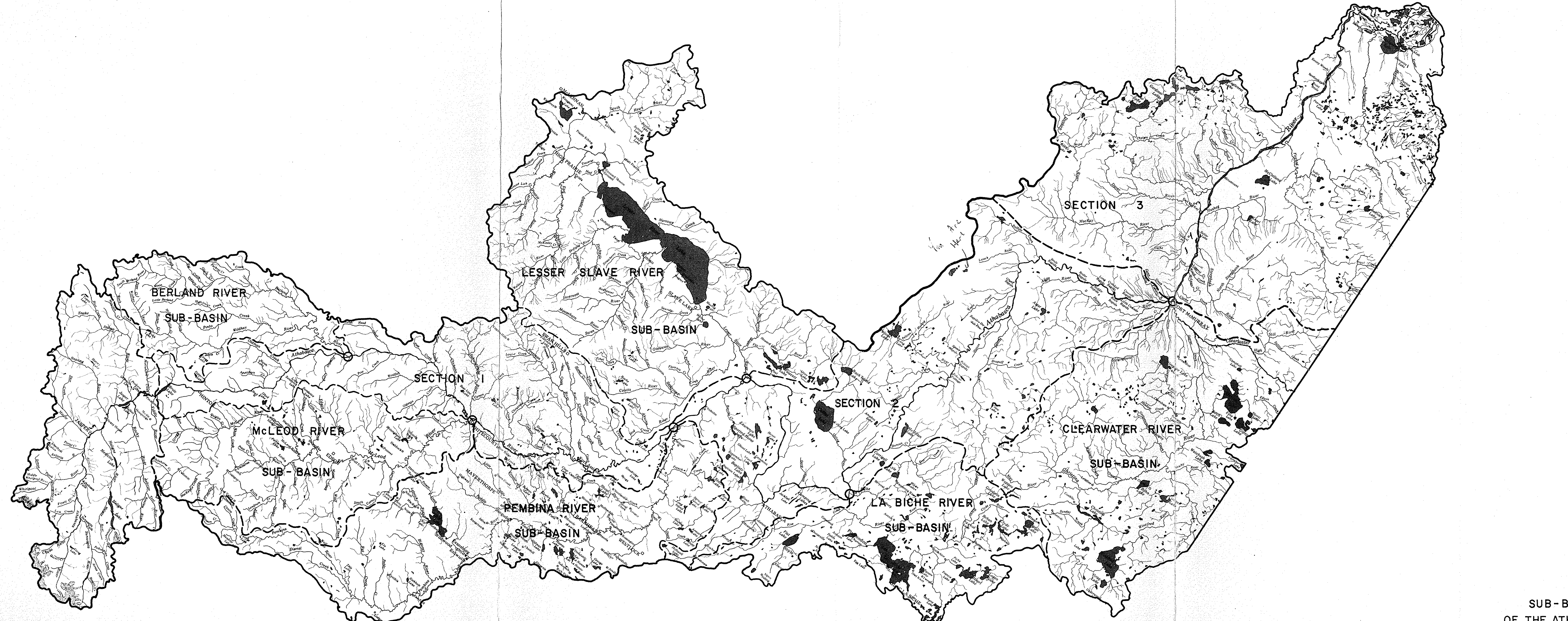
PROVINCIAL LOCATION OF ATHABASCA RIVER BASIN

FIGURE 2-4

Draining a total area of 155,000 km^2, (147,000 km^2 of which falls within Alberta) or approximately 22% of the province of Alberta (661,100 km ^{2}), the Athabasca Basin is made up of 10 sub-basins: Jasper Park Sub-Basin (10,878 km^2), Berland Sub-Basin (5,750 km^2), McLeod Sub-Basin (9,850 km^2), Pembina Sub-Basin (14,300 km^2), Lesser Slave Sub-Basin (20,600 km^2), Lac La Biche Sub-Basin (8,800 km^2), Clearwater Sub-Basin (14,000 km^2 estimated Alberta portion), and the Athabasca River which, for purposes of this report, is considered to be made up of three sub-basins (>62,822 km^2 estimated Alberta portion) (Figure 2-5). Flow statistics, which illustrate the increase in flow of the Athabasca River as it receives successive input from its major tributary rivers, are noted in Table 2-6.

Several factors affect the productivity of fishes in the Athabasca Basin, the most important of which are natural influences and those impacts related to man-made industrial or domestic activities.

The Athabasca Basin encompasses a very wide spectrum of fishery habitat, ranging from that of a clear, cold, stream in its upper tributaries to that of a slow-flowing, silt-laden river in its reaches near the delta. The clear, cold upper tributaries present many sport fishing opportunities. Some locations, especially those within Jasper National Park, are of national significance, and many others throughout the basin are of local, regional or, in some cases, provincial significance. Because they afford unique aesthetic and recreational opportunities, the protection and enhancement of these waters is obviously of special importance to all Albertans. In addition to the important considerations related to fish production, water from this basin is also required for competitive uses such as urban and industrial consumption and agricultural applications.



SUB-BASINS AND SECTIONS
OF THE ATHABASCA RIVER BASIN
FIGURE 2-5

TABLE 2-6

FLOW STATISTICS (M^3/S) FOR SELECTED POINTS - ATHABASCA RIVER BASIN

River	Hydrometric Station (Period of record)	Mean Annual	Lowest Annual	Highest Annual	Lowest Monthly	Highest Monthly	Minimum 5 Yr Mean	Maximum 5 Yr Mean
Athabasca	Hinton [1] (1962 to 1979)	176	141 (1970)	213 (1965)	16.9 (Mar/63)	752 (June/72)		
	Athabasca [1] (1914 to 1979)[4]	436	299 (1919)	740 (1954)	49.2 (Feb/23)	2,500 (May/48)		
	Athabasca [3] (1912 to 1973)	417	277 (1939)	740 (1954)	49.2 (Feb/23)	2,500 (May/48)	329 (1937 to 41)	491 (1962 to 66)
	Embarras Airport [1] (1971 to 1979)[4]	783	749 (1972)	813 (1973)	134 (Feb/72)	2,790 (July/71)		
McLeod	Whitecourt [1] (1968 to 1979)[5]	69.2	33.2 (1975)	111 (1971)	2.3 (Feb/69)	304 (July/71)		
Pembina	Jarvie [1] (1957 to 1979)[4]	38.6	15.2 (1968)	85.1 (1965)	0.7 (Feb/68)	321 (July/65)		
Clearwater	Fort McMurray [1] (1931 to 1979)[4]	137	92.4 (1968)	215 (1960)	33.4 (Feb/68)	488 (May/74)		

Notes:
1. Recorded flows (Natural)
2. Recorded flows (Regulated)
3. Computed flows (Natural)
4. Discontinuous record
5. For period March to October inclusive

Source: Canada West Foundation (1982)

Given the continued growth and industrialization in Alberta, government agencies vested with responsibility for the enhancement and protection of the fisheries resource will be increasingly faced with competing water resource users. While there is an obvious need to attempt to accommodate all types of major water users in the province, there are, just as obviously, limits to the capability of a finite resource. The protection and maintenance of water quality, fish habitat and fish populations in all the sub-basins, and in the mainstem of the Athabasca Basin, therefore, becomes of critical importance if we are to preserve this important renewable natural resource.

Along the Athabasca mainstem, six sub-basins provide important sportsfish habitat: the Berland, McLeod, Pembina, Lesser Slave, Lac La Biche, and Clearwater. Some, notably the Jasper National Park headwaters, provide sport fishing opportunities which are internationally recognized. Among angling licences sold in Alberta in 1980/81, 8.95% were sold in the Athabasca Basin and 0.04% were sold in the Jasper Park region. The extent to which this resource industry is growing in Alberta is highlighted by Longmore and Stenton (1981), who noted that sales of Alberta angling licences increased by 95% in the period from 1971 to 1981. In the Athabasca Basin, resident angling licence sales rose from 11,977 in 1972/73 to 26,346 in 1980/81, an increase of more than 100% in less than a decade.

In other sub-basins (chiefly Lesser Slave and Lac La Biche), commercial fish harvests constitute an important part of the total Alberta fishery. Lac La Biche and Lesser Slave Lake, for instance, recorded commercial landings of 411,688 kg ($166,079) and 484,272 kg ($223,204) respectively, in 1982/83 (Appendix C).

Given the present known levels of recreational and commercial fishing demand on the Athabasca Basin, and the several types of impact which are forecast to steadily increase, it is apparent that maintenance or improvement of the fisheries habitat in this basin will be a significant priority. Obviously, production of fish is directly dependent on the availability and quality of appropriate fish habitat. Therefore, in each sub-basin, minimum instream flows and water quality will have to be maintained. Both these topics are dealt with herein, especially with a view to maintaining or, preferably, improving those minimum values.

Resource management objectives for the fishery in each sub-basin, including specific strategies, are described below. Each has been developed from published and unpublished data available through biologists of Alberta Fish and Wildlife and the scientific literature.

The fisheries management objective for the McLeod Sub-Basin and the Berland Sub-Basin is to maintain native fish populations at maximum population levels through natural reproduction, water and habitat quality maintenance, and habitat and fish population enhancement for recreational fishing.

The fisheries management objective for Athabasca Sub-Basin I, and the Pembina and Lesser Slave Sub-Basins is to maintain native fish population at maximum levels of production through natural reproduction, water and habitat quality maintenance, habitat and fish population enhancement, for recreational fishing. The Lesser Slave Sub-Basin will also be managed for commercial and domestic fishing.

The fisheries management objective for Athabasca Sub-Basin II (Calling, Horse, and Hangingstone rivers) and for the Lac La Biche Sub-Basin, is to maintain the native fish populations at maximum population levels through natural reproduction, water and habitat quality maintenance, habitat and fish population enhancement for recreational, commercial, and domestic fishing. Enhancement of walleye populations in the Lac La Biche Sub-Basin will be a major objective over the next five years.

The fisheries management objective for Athabasca Sub-Basin III (MacKay, Dover, Ells, Steepbank, Muskeg, and Firebag rivers) and for the Clearwater Sub-Basin, is to maintain the native fish populations at maximum population levels through natural reproduction, water and habitat quality maintenance, habitat and fish population enhancement for recreational, commercial, and domestic fisheries.

In order to employ and further develop the above-noted fishery management objectives, there is a defined, critical need for more scientific data on the ecology, habitat, and productivity of fish populations of the Athabasca Basin. The types of studies and general data required fall under several broad headings:

1. Documentation of existing habitat.
   Present fish habitat in all sub-basins of the Athabasca require further elaboration and study, particularly in relation to habitat changes caused by activities in agricultural, urban, industrial, recreational, or flow-regulation sectors.

2. Documentation of existing stocks.
   Standing crops of all the important species of fishes, and their levels of productivity, need to be carefully documented in relation to existing limiting factors such as pollution from all sources--agricultural, urban, industrial, eutrophication, and fluctuations in water levels. In particular, identification of other factors which may be limiting significant fish populations (but which may be poorly understood, or, even, undetected) should be studied in each sub-basin.

3. Documentation of fish movements.

   Documentation is required for fish migrations of each important species in Alberta, in each sub-basin.

   Fish migration routes, known and suspected, should be carefully described with special emphasis on critical habitat areas for, and timing of, the movements.

   Critical habitat areas should be clearly described in each sub-basin for each important fish species. The significance of each tributary river or stream for those fish populations should be assessed in terms of spawning, migratory, or seasonal habitat.

4. Access to data.

   The data noted above, once obtained, should be summarized and presented in a widely accessible document which is simultaneously understandable to the lay reader and useful to management biologists. Each basin should be dealt with individually, and sensitive times and habitat areas should be clearly identified. The format should be such that the summary volume is of use to engineers, biologists, developers, and recreationalists alike.

III THE FISHERY RESOURCE OF THE ATHABASCA RIVER BASIN

THE FISH POPULATION

The history of the development of fish populations of the Athabasca Basin started 15,000 years before present (B.P.) with the beginning of the gradual recession and disappearance of the Kewatin and, to a lesser extent, the Cordilleran, ice sheets from the land mass that was to become Alberta. The last trace of the Ice Age retreated from the northeastern corner of the province about 10,000 years B.P. The watercourses, one of which became the Athabasca Basin, were then in the early stages of formation, but later served as the means of re-introducing fish species to the region (Paetz and Nelson 1970).

Prior to the introduction of fish species by man, it is thought that four major dispersal routes were followed by fishes re-entering post-glacial Alberta. The fish species now occupying the central and northern parts of the province utilized three of these routes, including one through Lake Agassiz in the east, one from unglaciated portions of the Yukon, and one from the interior of British Columbia via the Peace and Fraser-Athabasca drainage systems. Paetz and Nelson (1970) note that rainbow trout, for instance, abundant in the waters of the upper basins of the Athabasca, probably originated in the headwaters of the Fraser system. The presence of Arctic grayling in the Athabasca drainage and its absence in the Saskatchewan River System also implies a dispersal route from the north or northwest for that species.

Since the departure of the Pleistocene ice, the fish fauna of Alberta has become relatively impoverished compared to the neighbouring provinces or regions such as the Ohio-Mississippi drainage. The Continental Divide presents a significant barrier to many species, and the cold waters arising in the high mountain regions are unsuitable for many species of fish found in the south. In all, 51 species of freshwater fish are known to occur in Alberta, four of which have been introduced by man. None has its entire range restricted to the province, and most range widely throughout the drainage basins in which they occur (Paetz and Nelson 1970, Scott and Crossman 1973).

The Athabasca Basin makes up part of the much larger Arctic drainage which terminates at the Mackenzie Delta. Fifty-five species of fish are known to occur within the Arctic Drainage Basin (Table 3-1), of which 32 occur in the Athabasca. Species from seven families of fishes provide sport and commercial fishing opportunities in the Athabasca Basin.

The occurrence of the fish species throughout the six major river systems which make up the the Athabasca Basin is determined by geographical and ecological factors such as habitat availability, adequate food supplies, and temperature or oxygen tolerances. The distributions of fishes and the important habitat areas of the Jasper Park, Berland, McLeod, Pembina, Lesser Slave, Lac La Biche, Clearwater, and Athabasca sub-basins are detailed in subsequent sections of this report. Summaries of fish distributions and habitat for the Athabasca Basin are given in Appendix A.

Within the Athabasca Basin, fish species can be broadly grouped into two primary types: those tolerant of cold waters and those which require relatively warmer water temperatures. Salmonid fishes, the most abundant type, are typical of the coldwater species which occur in the high mountain or cold upper tributaries of the drainage. In that family, 32 species are native to Canada, nine occur in Alberta.

Salmonid fishes inhabiting the Athabasca Basin include Arctic grayling (*Thymallus arcticus*), cisco (*Coregonus artedii*), lake whitefish (*Coregonus clupeaformis*), Dolly Varden (*Salvelinus*

TABLE 3-1

MAJOR FISH SPECIES OF THE ATHABASCA RIVER BASIN

Taxon	Common Name	Scientific Name	Primary Water and Habitat Type	Sport Fish	Commercial Fish	Stocked or Introduced
SALMONIDAE	Salmon Family					
Thymallinae	Arctic grayling(1,4,5)	_Thymallus arcticus_	Cold clean rivers and lakes	Yes	No	No[7]
Coregoninae	Cisco	_Coregonus artedii_	Cold deep lakes highly oxygenated	Yes	Yes[2]	No
	Mountain whitefish	_Prosopium williamsoni_	Cold streams and shallow lakes	Yes	No	No
	Lake whitefish(3)	_Coregonus clupeaformis_	Cold well-oxygenated lakes	Yes	Yes[3]	Yes
Salmoninae	Lake trout(4,5)	_Salvelinus namaycush_	Cold deep lakes	Yes	Yes	Yes
	Brook trout(5)	_Salvelinus fontinalis_	Cool streams and ponds and clear, shallow lakes	Yes	No	Yes
	Dolly Varden	_Salvelinus malma_	Cold headwater streams	Yes	No	Yes
	Kokanee(5)	_Oncorhynchus nerka_	Cool lakes (spawn in creeks)	Yes	No	Yes
	Brown trout(5)	_Salmo trutta_	Cool streams, ponds and lakes	Yes	Yes	Yes[6]
	Cutthroat trout(5)	_Salmo clarki_	Cool clear lakes and streams	Yes	No	Yes
	Rainbow trout(4,5)	_Salmo gairdneri_	Cool rivers and ponds (from Swan Hills to Athabasca headwaters)	Yes	Yes	Yes[6]
ESOCIDAE	Pike Family					
	Northern Pike(4,5)	_Esox lucius_	Warm, shallow, slow weedy, clear lakes and streams	Yes	Yes	No[7]
HIODONTIDAE	Mooneye Family					
	Goldeye(3,5)	_Hiodon Alsoides_	Warm, turbid lakes and rivers	Yes	Yes	No
PERCIDAE	Perch Family					
	Iowa darter	_Etheostoma exile_	Warm lakes and clear, slow streams	No	No	No
	Yellow perch(5)	_Perca favescens_	Warm lakes and ponds; slow streams	Yes	Yes	No
	Walleye(5)	_Stizostedion vitreum vitreum_	Warm lakes and rivers	Yes	Yes	No
CATOSTOMIDAE	Sucker Family					
	Longnose sucker	_Catostomus catostomus_	Warm rivers and deep lakes	No	No	No
	White sucker	_Catostomus commersoni_	Warm rivers and shallow, deep lakes	No	No	No

TABLE 3-1 CONCLUDED

Taxon	Common Name	Scientific Name	Primary Water and Habitat Type	Sport Fish	Commercial Fish	Stocked or Introduced
COTTIDAE	Sculpin Family					
	Slimy sculpin	Cottus cognatus	Cool streams and lakes	No	No	No
	Spoonhead sculpin	Cottus ricei	Warm, muddy rivers and lakes	No	No	No
GASTEROSTEIDAE	Stickleback Family					
	Brook stickleback	Culaea inconstans	Warm, small, clear streams; bogs and lakes	No	No	No
	Ninespine stickleback	Pungitius pungitius	Warm streams and lakes	No	No	No
PERCOPSIDAE	Trout-Perch Family					
	Trout-perch	Percopsis omiscomaycus	Warm, deep, lakes and slow rivers	No	No	No
GADIDAE	Codfish Family					
	Burbot	Lota lota	Cold parts of lakes; large and small streams	Occasional	No	No
CYPRINIDAE	Minnow Family					
	Longnose dace	Rhinichthys cataractae	Warm lakes; rivers and small creeks	No	No	No
	Flathead chub	Platygobio gracilis	Warm, large, muddy rivers	No	No	No
	Lake (northern) chub	Couesius plumbeus	Warm lakes; rivers and small creeks	No	No	No
	Pearl dace	Semotilus margarita	Warm lake margins and slow streams	No	No	No
	Northern redbelly dace	Chrosomus eos	Warm lakes and streams	No	No	No
	Finescale dace	Chrosomus neogaeus	Warm lakes and slow creeks	No	No	No
	Fathead minnow	Pimephales promelas	Warm, muddy creeks; ponds and lakes	No	No	No
	Emerald shiner	Notropis atherinoides	Warm, large, rivers and lakes	No	No	No
	Spottail shiner	Notropis hudsonius	Warm lakes and streams	No	No	No

Notes:
1. Denotes species highly susceptible to pollution or disturbance of habitat
2. Source of commercial mink food (Lac La Biche/Lesser Slave region)
3. Noteably valuable commercial fish species in Alberta
4. Denotes trophy fish capability
5. Valued sport fish
6. Only classed as "commercial" when used in game fish farms
7. Occasionally stocked

malma), mountain whitefish (*Prosopium williamsoni*), and trout, such as lake trout (*Salvelinus namaycush*), and rainbow trout (*Salmo gairdneri*). These species are distinctive in their preference for cooler waters (or, conversely, in their inability to tolerate warm water temperatures), although the tolerance levels and distributions of individual species may vary. Many species of salmonids, however, show a considerable ability to adapt to other environmental variables. Dolly Varden, for instance, display a remarkable flexibility in changing their diet, when necessary, to suit their environment.

Since salmonids require relatively high levels of dissolved oxygen, they generally frequent clear, cold streams where the water is highly aerated by white-water flows. Such streams are typical of the mountain and Eastern Slope regions of Alberta, although rainbow trout, for instance, are able to tolerate stream temperatures up to 22°C, and Dolly Varden frequent lakes and streams from sea level to high mountains. The latter are generally known only from the upper tributaries of the Athabasca drainage, chiefly in the Jasper, Berland, and McLeod sub-basins.

Salmonids make up the majority of fish species which are important in the commercial and sport fishery in the Athabasca Basin. Trout spawn in redds ("nests") excavated in the clean gravel generally found in riffle areas of streams. These areas tend to be well supplied with oxygen and free of silt, which could suffocate the developing embryos. Young trout, and those which are freshly hatched, require high concentrations of dissolved oxygen.

Whitefish, on the other hand, are rather more tolerant of changes in the concentration of dissolved oxygen or variations in water temperature. Lake whitefish, for instance, are widely distributed throughout the Athabasca drainage, as are, to a lesser extent, mountain whitefish. The lake whitefish are an exceptionally valuable commercial fish species in Alberta, generally frequenting cool, well oxygenated regions of lakes and feeding primarily on bottom organisms. Lake whitefish seldom enter rivers, but mountain whitefish are generally abundant in both streams and the shallow waters of lakes. They occur most frequently in the portion of the Athabasca Basin upstream of the Lesser Slave River confluence. The Alberta record for this species (2.4 kg) was set in the Athabasca River in 1976.

In many salmonids, there is a strongly-developed homing tendency which often results in sizeable spawning migrations up rivers or into lake outlet areas. For many species, the preservation of their spawning habitat and, equally important, ensured access to spawning areas, is crucial to the survival of local, or even regional, populations. Disruptive events, such as stream siltation or blockages at road crossings and culverts can, if they occur at crucial times in the life histories of certain species, have devastating effects on populations. Within the Athabasca Basin, major migrations of salmonid species are known to occur in the Berland, McLeod, Clearwater, and Athabasca III sub-basins.

Most salmonid species are highly prized both as game fish and as a commercial catch. Grayling, for instance, are harvested by angling in the upper reaches of the Athabasca, as are Dolly Varden, brook trout, and rainbow trout. The latter two are highly esteemed game fishes caught by artificial fly, spin casting, or live bait. Increasingly, provincial hatcheries have started rearing programs to increase or maintain the stocks of brook trout, and Alberta hatcheries are no exception to this.

The second major classification of fishes which occur within the Athabasca Basin are the warmwater species, so called because they are generally more able to tolerate higher water temperatures than the salmonids and, in most cases, somewhat lower dissolved oxygen levels. Four primary species of warmwater game fish are found in the Athabasca Basin: northern pike (<u>Esox lucius</u>), walleye (Stizostedion vitreum vitreum), yellow perch (Perca flavescens), and goldeye (Hiodon alosoides) (Table 3-1). These species characteristically inhabit the relatively warm, slow waters found within the Athabasca Basin. Some, notably goldeye, undertake spectacular lengthy seasonal migrations through the silty mainstem reaches of the Athabasca.

Voraciously predatory, northern pike inhabit shallow, weedy clear waters, although they are most frequently found in lake/marsh habitat or in slow, warm streams. Adult pike have been discovered with ducklings and young muskrats in their stomach, and attacks on adult loons have been reported. Their feeding habits make northern pike a most popular game fish, as they will strike a wide variety of lures and, in some areas, trophy-sized specimens have been recorded weighing in at up to 13.6 kg, notably from lakes such as Athabasca and Winefred. The Alberta record for this species (17 kg) was set in the Milk River Ridge Reservoir in 1974.

Walleye and goldeye prefer warm, silty waters, and they are often found in this type of habitat in the middle to lower reaches of the Athabasca system. Yellow perch are found in warm lake waters of the Athabasca Basin, or in slower moving waters of the tributary streams.

Fish stocking programs have been carried out in Alberta for almost 40 years, and such programs have extended the ranges of several species in the Athabasca Basin. In 1982, over 5.79 million sportsfish were stocked into the lakes and rivers of Alberta. In that year, slightly more than 702,000 fish were stocked in the Athabasca Basin, which represented 12.1% of all fish stocked in the province that year. No walleye fry were stocked, but 642,247 trout accounted for 91.5% of the fish stocked in the basin. Alberta agencies now have a major walleye hatchery and rearing program under active development. This program should contribute to the maintenance or expansion of populations of this sought-after fish in selected habitat areas throughout Alberta, including the Athabasca Basin.

Stocking programs for game fishes represent only one strategy practised to enhance the Alberta freshwater fishery. Habitat enhancement and protection programs, coupled with sport and commercial fishing regulations, represent substantive aspects of fishery management programs for the province. A summary list (Table 3-1) shows the range of fish species found within the Athabasca Basin, and also indicates those artificially stocked.

DEMAND FOR SPORT FISHING RECREATION

The demand for recreational fishing in the Athabasca Basin has steadily increased and is projected to continue to increase in the foreseeable future (Table 3-2). In two five-year periods, from 1971 to 1976 and from 1976 to 1981, the Alberta provincial percentage increase for angling licence sales was 47.3% and 41.2%, respectively. In the decade from 1970 to 1981, total sales more than doubled from 148,337 to 308,444 (Table 3-2). Some areas, such as the Jasper Park region and the area near Fort McMurray, have been subjected to sudden, dramatic increases in demand resulting from sudden population growth in urban centres. The Upper Basins, for instance, have not only experienced recreational demands from regional cities such as Edmonton and Calgary, but also from national or international centres. Fort McMurray, on the other hand, grew rapidly in the 1960's and 1970's in response to oil sands developments in the region. Sudden increases in recreational demands accompanied the significant influx of new people to the region. Between 1972 and 1981, total angling sales more than doubled within Athabasca Sub-Basin II, chiefly due to the influence of Fort McMurray (Table 3-2).

The sales of resident and non-resident angling licences give some indication of the annual demand for sport fishing recreational activity within the Athabasca Basin. In 1980/81, resident anglers made up 8.95% of the angling population of Alberta. Table 3-3 shows the sales of resident angling licences by sub-basin in the Athabasca drainage, and their percentage of the total provincial sales for the years for which data are available (1972 to 1981). Appendix B gives more detailed breakdowns by community for each of the sub-basins summarized in Table 3-3. Exact comparisons are difficult to make since data are usually collected by Improvement District and not by watersheds (sub-basin). However, comparisons were attempted by using a "best fit" method of estimation for each sub-basin, wherever possible.

TABLE 3-2

TOTAL NUMBER OF ALBERTA ANGLING LICENCES
SOLD BETWEEN 1967/68 AND 1980/81

Year	Total Angling Licences Sold	% Change
Annual Increases:		
1967-68	136,693	-
1968-69	140,874	+3.0
1969-70	152,978	+8.6
1970-71	148,337	-3.0
1971-72	159,484	+7.5
1972-73	175,253	+9.9
1973-74	184,745	+5.4
1974-75	211,591	+14.5
1975-76	218,460	+3.2
1976-77	257,636	+17.9
1977-78	269,041	+4.4
1978-79	276,774	+2.9
1979-80	289,664	+4.7
1980-81	308,444	+6.5
5-Year Increases:		
1970-71	148,337	-
1975-76	218,460	+47.3
1980-81	308,444	+41.2

Source: Longmore et al. (1982)

TABLE 3-3

SUMMARY TABLE OF RESIDENT ANGLERS

(PERCENT OF ALBERTA TOTAL)

		1972/73		1977/78		1980/81	
Waterbody		(n)	(%)	(n)	(%)	(n)	(%)
I	Upper Basins						
	Jasper	31	0.018	107	0.04	105	0.04
	Berland	--	--	--	--	--	--
	McLeod	1,815	1.06	2,813	1.09	4,522	1.54
	Subtotals	1,846	1.08	2,920	1.13	4,627	1.57
II	Central Basins						
	Pembina	3,312	1.94	4,516	1.75	5,948	2.02
	Lesser Slave	1,871	1.10	2,717	1.06	3,550	1.21
	Subtotals	5,183	3.04	7,233	2.81	9,498	3.23
III	Lower Basins						
	Lac La Biche	956	0.56	1,455	0.57	2,093	0.71
	Clearwater	14	0.01	24	0.01	29	0.01
	Subtotals	970	0.57	1,479	0.57	2,122	0.72
IV	Athabasca Basins						
	Athabasca I	1,636	0.96	2,733	1.06	3,308	1.12
	Athabasca II	2,339	1.37	5,854	2.24	6,762	2.30
	Athabasca III	3	0.002	294	0.11	29	0.01
	Subtotals	3,978	2.33	8,881	3.45	10,099	3.43
Athabasca Basin Total		11,977	7.02	20,513	7.96	26,346	8.95
Total Alberta Anglers		170,714		257,405		294,358	

Source: Data File, Fisheries Section, Alberta Fish and Wildlife Division, Edmonton

Longmore and Stenton (1981) cited data which indicated that licenced anglers represented only 69% of all anglers. For instance, an estimated 31% of the total angling population is either under 16 years or over 65 years of age. Since no licences are required for anglers in these groups, no firm data are available for them. As a result, all angling data obtained from licence sales in the province must be considered to reflect minimum levels of demand (Table 3-2, 3-3, and Appendix B).

In Alberta, provincial angling licence sales provide a dramatic reflection of the influx of people to the region caused by the resource "boom" cycle which occurred in the 1970's. While provincial angling licence sales showed an increase of only 6.8% in the decade from 1960 to 1970, there was an astounding 95% increase in the nine years between 1970 and 1979 (Longmore and Stenton 1981) (Table 3-2). Although earlier projections (550,000 annual licence sales by the year 2000) may be somewhat optimistic in view of the slowdown of economic activity which occurred in the early 1980's, the data emphasize just how quickly demand for recreational resources may develop in relation to economic activity and population growth in urban centres.

Long term trends in recreational demand, based solely on data derived from sales of angling licences, are difficult to assess for the Athabasca Basin. This is because the basin embraces such widely different habitat types, and, therefore, fish distributions. The Lac La Biche Sub-Basin is, for instance, considerably different, in terms of geography, recreational demands, and access, from either the McLeod or Jasper Park sub-basins; and the sub-basins around Fort McMurray may be subject to wide fluctuations in recreational demand, depending on the rate and volume of future oil sands developments in the region. Nevertheless, while it may be difficult to make generalized predictions for the Athabasca Basin as a whole, it is possible to group the sub-basins and make broad inferences based on past experience.

Longmore and Stenton (1981) analysed Alberta angling licence sales from 1960 to 1981 and included predictions to the year 2000. Their projection was based on trends in licence sales and population numbers prior to 1977 and may, therefore, be somewhat higher than is justified by current trends. Nevertheless, the trend analysis shows a steadily increasing demand for sport fishing licences in the province. Given current assumptions, some sub-basins, such as Jasper Park, Berland, and Pembina would be expected to experience extreme recreational demands by the year 2000. Indeed, if trends which began in 1972 are maintained throughout the 1980's, one could expect that by 1991 more than 25,000 resident anglers may reside within the Athabasca Basin. From 1972 to 1981, the strongest real growth in the numbers of resident anglers occurred in the McLeod, Lac La Biche, and Athabasca II sub-basins. Resident anglers in the latter sub-basin were largely derived from Fort McMurray (Table 3-3 and Appendix B). This growth may indicate that tributaries in those regions will continue to receive a progressively increasing angler demand.

The experience of Alberta Fish and Wildlife Division personnel indicates that anglers in the province generally exploit the aquatic resources available within a 150 km radius of their residences (Longmore and Stenton 1981). While occasional long trips are made outside of this radius, these trips are generally confined to summer holiday periods, and are considered to be the exception.

Although the density of provincially registered anglers is somewhat less in the Athabasca Basin than that known for other, more populated basins (such as the South Saskatchewan, with one-third of all Alberta's anglers), the available data indicate that considerable demand within the basin arises from outside. Edmonton, for instance, is a prime focus for anglers who travel into the Athabasca Basin. As a result, resident angling licence sales may be seriously misleading, particularly for sub-basins such as Jasper Park, Berland, McLeod, and Lac La Biche. Movement may occur within the Athabasca Basin, as well, the best example of which is the observation of local Fisheries Officers of the movement of anglers out of the Athabasca Sub-Basin II (Fort McMurray) into the Clearwater, Lac La Biche, and Lesser Slave sub-basins.

In short, interbasin and intrabasin movements of anglers make predictions of angler demand exceedingly difficult, and places increasing importance on the need for accurate, regular, creel surveys in areas of high demand or, at least, the deployment of trained field officers to monitor the demand. These, in turn, should be followed by detailed fish habitat and population studies in order to permit accurate predictions of the recovery or maintenance of sportsfish populations.

Comparative values for resident angling activity in each major region within, and bordering upon, the Athabasca Basin are shown in Table 3-4, and the numbers of resident-caught fish are noted in Table 3-5. Similar comparisons for non-resident anglers are shown in Table 3-6 and 3-7. Table 3-7 illustrates the relative impact of non-resident versus resident anglers and, therefore, the difficulty of estimating local demand for angling based strictly on licence sales. While in the northeast region, 89.3% of the fish caught were taken by anglers from within the region, this was true of only 14.4% of fish caught in the Eastern Slopes region in 1980. In each case, however, the majority of fish caught were taken by resident anglers (Table 3-7). Provincial totals of landed sportsfish indicate that (in order of decreasing value) perch, pike, trout, walleye, and mountain and lake whitefish represented the majority of fish caught (Table 3-5).

Longmore and Stenton (1981) calculated the extent of resource usage resulting from angler recreation. Based on an average

TABLE 3-4

ANGLING ACTIVITY IN EACH REGION
BY RESIDENTS OF EACH REGION IN 1980

Angler Residence	Man-days of Angling									
	Peace River	Jasper	Eastern Slopes	Banff	Athabasca	Northeast	Central	Southern	Total	%
Peace River	223,336	1,620	19,296	1,802	7,278	10,191	7,576	3,783	274,882	6.2
Jasper	----	162	2,753	----	----	----	----	----	2,915	0.1
Eastern Slopes	26,670	22,786	191,247	5,828	1,767	17,486	10,717	41,719	318,220	7.1
Athabasca	----	----	3,236	----	57,060	5,785	1,142	1,903	69,126	1.6
Northeast	106,970	44,446	234,358	12,079	100,695	1,276,746	59,493	9,172	1,843,959	41.4
Central	17,797	17,797	400,902	105,213	2,676	123,557	664,659	100,029	1,412,630	31.7
Southern	1,488	2,238	51,773	7,066	2,607	10,784	30,078	423,086	529,120	11.9
Total Man-Days of Angling	376,261	89,049	903,565	131,988	172,083	1,444,549	753,665	579,692	4,450,852	
(%)	(8.4)	(2.0)	(20.3)	(3.0)	(3.9)	(32.5)	(16.9)	(13.0)		100.0

Source: Longmore et al. (1982)

TABLE 3-5

NUMBER OF RESIDENT FISH CAUGHT IN ADMINISTRATIVE REGIONS IN ATHABASCA DRAINAGE IN 1980

Region	Pike	Perch	Walleye	Trout	Goldeye	Lake Whitefish	Mountain Whitefish	Arctic Grayling	Other	Total	% Of Alberta Total
Jasper	41,775	12,079	3,940	49,047	203	15,847	15,958	7,912	----	146,761	1.4
Eastern Slopes	316,089	414,569	37,547	709,776	12,178	57,680	244,557	60,879	----	1,853,275	17.7
North East	1,346,575	1,821,450	480,576	193,051	60,551	257,546	14,217	10,196	----	4,184,162	40.1
Peace	337,772	168,686	185,283	83,630	915	12,929	40,294	32,167	----	861,676	8.3
Total	2,042,211	2,416,784	707,346	1,035,504	73,847	344,002	315,026	111,154	----	7,045,874	
Provincial Total	2,761,025	2,965,458	878,498	2,216,040	185,928	463,586	796,593	152,598	21,855	10,441,581	

Note: Due to misinterpretation by respondents, most of the fish reported to have been caught in Jasper National Park must have been caught elsewhere; only trout, mountain whitefish and a few Arctic grayling inhabit park waters.

Source: Longmore et al. (1982)

TABLE 3-6

NUMBER OF NON-RESIDENT FISH CAUGHT IN ADMINISTRATIVE REGIONS IN ATHABASCA DRAINAGE IN 1980

Region	Pike	Perch	Walleye	Trout	Goldeye	Lake Whitefish	Mountain Whitefish	Arctic Grayling	Other	Total	% Of Alberta Total
Jasper	19	----	----	400	----	----	----	----	----	419	0.3
Eastern Slopes	1,207	1,990	1,913	7,991	68	973	148	1,566	----	15,856	12.1
North East	23,243	17,896	3,838	1,324	570	516	118	1,317	----	48,822	37.3
Peace	7,821	2,130	3,749	3,704	1,301	195	340	1,110	----	20,350	15.6
Total	32,290	22,016	9,500	13,419	1,939	1,684	606	3,993	----	85,447	
Provincial Total	46,974	29,620	12,919	26,479	2,565	2,295	2,013	5,397	2,652	130,914	

Note: Due to misinterpretation by respondents, most of the fish reported to have been caught in Jasper National Park must have been caught elsewhere; only trout, mountain whitefish and a few Arctic grayling inhabit park waters.

Source: Longmore et al. (1982)

TABLE 3-7

NUMBER OF FISH CAUGHT AND RETAINED IN EACH REGION

BY RESIDENT AND NON-RESIDENT ANGLERS IN 1980

Region	Fish Caught By Non-Resident Anglers	Fish Caught By Resident Anglers	Total Fish Caught	Fish Caught By Regional Resident Anglers	Fish Caught By Regional Anglers As % Of Total Fish Caught In Region
Peace River	20,350	861,676	882,026	370,382	42.0
Eastern Slopes	15,856	1,853,275	1,869,131	268,864	14.4
Athabasca	14,563	732,521	747,084	129,163	17.3
Northeast	48,822	4,184,162	4,232,984	3,779,210	89.3
Central	17,598	1,203,706	1,221,304	982,307	80.4
Southern	9,606	1,097,866	1,107,472	662,862	59.9
Banff	1,048	153,424	154,472	-----	-
Jasper	419	146,761	147,180	657	0.4
Total	128,262	10,233,391	10,361,653	6,193,445	59.8

Notes: 1. Totals do not include fish caught for which no region was specified.
2. Due to misinterpretation by respondents, most of the fish reported to have been caught in Jasper National Park must have been caught elsewhere; only trout, mountain whitefish and a few Arctic grayling inhabit park waters.

Source: Longmore et al. (1982)

9.6 days angling per year by the average Alberta angler, the man-days of angling recreation for the South Saskatchewan River Basin was estimated as being in excess of one million man-days of effort for each of the years from 1978 to 1980. Based on similar assumptions, the comparative figures for the Athabasca Basin during 1980/81 would be 26,346 times 9.6 angler days for a total of 252,922 man-days, or 693 man-years. These figures are probably conservative, since creel surveys indicate that as many as 50% of "resident" anglers originate from the Edmonton area.

The leverage which the growing recreational demand is capable of exerting on the fixed aquatic resource of Alberta becomes even more apparent when one considers that only 2.5% (16,796 km^2) of the total surface area of Alberta (661,185 km^2) is covered by fresh water (Table 2-3). Obviously, habitat suitable for recreational species of fishes would be, again, only a small fraction of the total freshwater habitat area. In general, seasonal limitations, such as restricted winter access, would further limit exploitive demand to the open-water seasons.

When one considers that recreational demand is but one of several factors (water use conflicts, municipal and industrial pollution, and urban developments are but a few examples) which impinge on the freshwater fish resources in the Athabasca Basin, the relative fragility of the resource becomes apparent. At the very least, if the steadily-increasing demand for recreational fishing is to be met, the preservation and conservation of existing fish habitat must be a priority. At the same time, augmentation of this habitat through improvement schemes will undoubtedly become of increasing importance.

Methods to regulate and manage the sportsfish resources will have to be increasingly refined. For instance, regulated catch limits are only effective if they reduce or redistribute the harvest of sportsfish. For such limits to be truly effective, anglers must either voluntarily comply with set limits or be required to do so through strict enforcement. Most sub-basins in the Athabasca Basin contain four primary sportsfish species including rainbow trout, mountain whitefish, Arctic grayling, and Dolly Varden. Since, on many rivers, anglers may possess a legal daily limit of 20 fish, a family or party of three anglers could legally possess over 100 sportsfish after only a few days' effort (Hunt 1981). Since these limits would seldom be achieved, existing catch limits are, in many areas within the basin, rather ineffective at reducing or redistributing recreational catches. Further, they do not tend to encourage a redirection of angling effort toward other, more abundant, species.

If a stable recreational resource is to be maintained within the basin, more effective limits, tied to the demonstrated productivity of aquatic systems, will have to be developed and implemented within existing and future sportsfish areas.

COMMERCIAL FISHING

The most valuable commercially caught fish species in the Athabasca Basin are goldeye (Hiodon alsoides), lake cisco (Coregonus artedii), northern pike (Esox lucius), walleye (Stizostedion vitreum vitreum), and lake whitefish (Coregonus clupeaformis) (Appendix C). The commercial goldeye fishery is centred in the western part of Lake Athabasca. This fishery declined after 1963, and is considered outside the terms of this report. Walleye are commercially fished, chiefly in the Lesser Slave and Lac La Biche sub-basins, as are lake whitefish and lake cisco. These two sub-basins constitute some of the most important commercial freshwater fisheries in western Canada.

The commercial harvest of fish in the Athabasca Basin is an important source of income for many residents of the Athabasca Basin, constituting a "cash crop" income to many individuals in the region. The numbers of licenced commercial fishermen in each sub-basin are shown in Appendix C. Quotas established for commercially harvested lakes and rivers in the region determine the size of the allowable commercial catch per annum. The quotas, in turn, are determined by the fish productivity of the waterbody and its ability to maintain a sustainable yield over time.

Appendix C indicates that for 1982 (the last year for which continuous data are available at the time of writing), a total of 794,057 kg of fish valued at $426,655 were commercially harvested within the Athabasca Basin. The landed values amounted to $56,167 (13.16%) for cisco, $243,264 (57.02%) for lake whitefish, $61,984 (14.53%) for walleye, and $57,154 (13.40%) for northern pike. The figures emphasize the importance of the Lesser Slave and Lac La Biche sub-basins to the Athabasca commercial fishery. The Lesser Slave Sub-Basin accounts for 347,534 kg ($231,393), and the Lac La Biche Sub-Basin for 427,414 kg ($175,971), for a combined total of 774,948 kg ($407,364). The latter figures represent 97.6% of the Athabasca Basin landed commercial weight, and 95.5% of the cash value in 1982.

Between 1974/75 and 1979/80, the commercial freshwater fishery of the Athabasca Basin accounted for a year-to-year average of 15.82% of the annual landed value for Alberta (Table 3-8). It is significant that landed values from the Athabasca Basin more than doubled as a percentage of the Alberta total between the periods 1976 to 1977 and 1977 to 1980.

The present commercial fisheries quotas established within the Athabasca Basin are a reflection of the sustainable productivity of each waterbody and of the commercial demand for fish product. Methods to enhance or maintain the existing harvest levels include improved fish population assessment and quota assignments, along with possible hatchery programs to supplement populations. Expansion of the commercial fishery could be possible in the Lesser Slave and Lac La Biche sub-basins, should lakes in those regions prove both accessible and capable of producing sustainable yields.

TABLE 3-8

MARKET VALUE OF COMMERCIAL FISHERIES

HARVEST FROM ATHABASCA RIVER BASIN

1974/75 TO 1979/80

Year	Market Value	Market Value As Percent Of Provincial Harvest
1974/75	231,666	13.21
1975/76	209,138	12.31
1976/77	208,412	9.58
1977/78	247,051	11.35
1978/79	307,651	13.03
1979/80	554,456	19.63
Five Year Average	351,675	15.82

FISHERIES MANAGEMENT OBJECTIVES

The provincial fisheries management goals and objectives can be summarized as follows:

1. Goal **To manage the aquatic resources in the province to ensure that viable fish populations are maintained for the benefit and enjoyment of Albertans.**

   Objectives:

   To determine the current and projected demands and supply of fish resources and develop means to manipulate supply in relationship to demand. Manipulating supply of fish will include the maintenance of natural productivity of waters, stocking of fish species in waters barren of fish life or into waters where natural reproduction is limited, or by enhancing natural productivity to increase production.

   To determine the requirements of fish species in order to maintain an adequate supply. This will include the maintenance of water quality, the ensurance of adequate water flows, the protection of spawning areas and migration routes, and the enhancement of waters to improve production capabilities.

   To identify rare and endangered fish species and ensure that viable populations of these species are maintained.

2. Goal **To develop and maintain a habitat base consistent with fisheries resource supply requirements.**

   Objectives:

   To identify and monitor the habitat base necessary to maintain the required resource supply and develop habitat maintenance or enhancement measures. This will include water quality, adequate stream flows and lake levels, the protection of critical spawning and over-wintering areas, and migration routes.

To develop new habitat or enhance existing habitat in areas where fish stocks are limited.

3. Goal **To provide fishing opportunities for domestic use.**

Objective:
To identify and monitor the current and projected demands for fish by Indian, Metis and other domestic users.

4. Goal **To optimize the amount and variety of fishing opportunities for the recreational enjoyment of Albertans.**

Objectives:
To determine and achieve optimal levels of catch-per-unit-effort for recreational fishermen according to species, geographic location and standards of quality.

To provide a maximum diversity of native game fish species, and supplement native species with exotic species and hybrids where warranted.

5. Goal **To facilitate the development of economically viable industries based on the commercial use of fish.**

Objective:
To establish a system for resource allocation for the maintenance of economically viable commercial fisheries in the form of commercial net fisheries, tourist lodges, and fish farms.

DATA GAPS

An analysis of past production and growth characteristics for the fish populations in each commercial fishing location should be made with a view to identifying major limiting factors for the several important commercial fish species in each sub-basin within the Athabasca Basin.

Data on the commercial fishery should be assessed under a published, annual review for each sub-basin. Landed values should be adjusted to compensate for effects of inflation in assessments done every five years. These data would allow for comparative analyses in basins throughout Alberta.

IV AQUATIC HABITAT REQUIREMENTS FOR FISH PRODUCTION

While the development of water quality criteria provides a useful guide for managers of fisheries, the application of any such standards must be viewed with caution to take into consideration biological variability and adaptability. For some important environmental parameters such as temperature, fish often exhibit a considerable variation in response, even within species. In controlled environments, for intance, there is a parabolic relationship between the growth of yearling brook trout and temperature, the optimum occurring at around 13°C (Baldwin 1956). Fingerling brook trout, however, seem to prefer 17°C in temperature gradient experiments (Peterson et al. 1979). This demonstrates the care with which such standards should be applied and also the variability which can occur in biological systems. Nevertheless, such standards are useful in assessing instances where gross pollution has occurred and in setting objectives for enforcement or enhancement of habitat standards.

Longmore and Stenton (1981) extensively reviewed the scientific literature for standards and criteria necessary for the protection of freshwater fish in the South Saskatchewan River Basin. These standards are directly applicable to the waters and aquatic species of the Athabasca Basin and, therefore, the conclusions of that earlier work are incorporated herein. The reader is referred to Longmore and Stenton (1981, pp 30 to 36) for a fuller, tabular presentation of parameters, concentrations, and references regarding this subject.

It is important to note that Longmore and Stenton (1981) assessed only a limited selection of parameters, with the potential for affecting aquatic life. These included heavy metals, dissolved gases, temperature, suspended solids, and pH. Most notably, the authors state that criterion for phosphorus was based on its toxicity to fish and aquatic life, and did not address secondary effects, such as eutrophication, at similar levels. Similarly, no attempt was made to establish criteria for the several organic-based insecticides used in Alberta. This latter consideration may be of importance in the Athabasca Basin (as Longmore and Stenton point out is the case in the South Saskatchewan) due to the presence of such potentially toxic compounds in the watersheds. The presence of these compounds can occur as the result of agricultural activities or insect control measures. In an effort to control Simulium arcticum, for example, a pest of cattle in the Athabasca region, a blackfly abatement program required the addition of relatively large amounts of insecticide to the waters of Athabasca River.

This report concurs with the recommendation made by Longmore and Stenton (1981) that "Criteria for these pesticides be established in the future because of their presence in the watersheds..." In future, the development of such criteria may become necessary where potential resource conflicts arise--between agricultural or recreational interests and the possible development of future commercial or recreational fisheries, for example.

The fishes most sensitive to changes in habitat and water quality are the salmonids, particularly Arctic grayling, but also trout and whitefish. Salmonids are limited by their sensitivity to changes in temperature and dissolved oxygen, and, during the spawning season, to the effects of siltation on eggs. As a result, these species are generally found in clear, cold, clean water. Appropriately, Longmore and Stenton (1981) chose salmonids to represent a sensitive "indicator" fish, able to withstand less disruption to habitat or water quality than many other species.

Criteria for physical or chemical parameters which are protective of salmonids are obviously protective of the less sensitive species as well. The water quality criteria adopted for the South Saskatchewan River Basin are used here as the basis for determining the acceptability to fish of various waters in the Athabasca Basin (Table 4-1). While the criteria so employed may be amended or changed outright as a result of subsequent research, they form a standard measure by which comparative evaluations may be done for watersheds throughout the province. Deficiencies in our knowledge of either water quality monitoring or the effects of water quality on fish are discussed under specific sub-basin headings below.

Existing ranges for water quality parameters within the Athabasca Basin provide a useful comparison with the criteria developed by Longmore and Stenton (1981). The most complete compilation of water quality data in the basin is provided in Environment Canada (1981), a study prepared for the MacKenzie River Basin Committee. Generalizations on water quality in a basin which exceeds 150,000 km^2 in area are inherently limited in application, but may provide a useful basis for comparison with adjacent water basins.

In the Athabasca, the population densities of fish are relatively low, so that sewage effluents to mainstem or tributary reaches are generally only of local concern for fisheries managers (Table 4-2). Specific incidents related to oil spills or related chemical introductions have caused pollution, but these incidents are the exception over the operating life of the oil and gas and pulp industry in Alberta. Subtle, long term changes, however, from mining, forestry, and oil and gas operations, including increased siltation and runoff resulting from extensive erosion, are often the most significant impact on water quality and fish populations. Land

TABLE 4-1

WATER QUALITY CRITERIA FOR THE PROTECTION OF FISH

AND THE AQUATIC ENVIRONMENT

Parameter	Concentration	Context
Alkalinity		Concentration should not exceed 25% of natural background levels.
Ammonia	0.02 mg/L	As un-ionized ammonia.
Arsenic	0.05 mg/L	
Barium	1.0 mg/L	
Beryllium	1.1 mg/L	
Boron	10.0 mg/L	
Cadmium	0.001 mg/L	
Chlorine (residual)	0.002 mg/L	
Chromium	0.05 mg/L	
Copper	0.04 mg/L	
Cyanide	0.005 mg/L	
Dissolved Gases		Concentration of any gas (except oxygen) should not exceed 110% of saturation value for a specific temperature and atmospheric pressure. Concentrations of dissolved oxygen exceeding 110% saturation value should not persist beyond 6 hours.
Iron	0.3 mg/L	
Lead	0.01 mg/L	

TABLE 4-1 CONCLUDED

Parameter	Concentration	Context
Manganese	1.0 mg/L	
Mercury	0.0001 mg/L	
Nickel	0.25 mg/L	
Nitrate	30 mg/L	
Nitrite	0.6 mg/L	
Oxygen (dissolved)	5 mg/L	The minimum constant concentration for all fish.
	8 mg/L	The minimum concentration where salmonid eggs and larvae are present.
pH (units)	6.5 to 8.5	The pH should not change by more than 0.5 units from the natural seasonal maximum or minimum.
Phenols	0.001 mg/L	
Phosphorous (Total PO_4)	0.1 mg/L	
Selenium	0.01 mg/L	
Silver	0.0001 mg/L	
Sulphide (Hydrogen Sulphide)	0.002 mg/L	
Suspended Solids	10 mg/L	Over natural background level.
Temperature		Any increase should not be more than 3°C over ambient water temperature.
	22°C	For salmonid fish.
	25°C	For other fish species
Zinc	0.1 mg/L	

Source: Longmore and Stenton (1981)

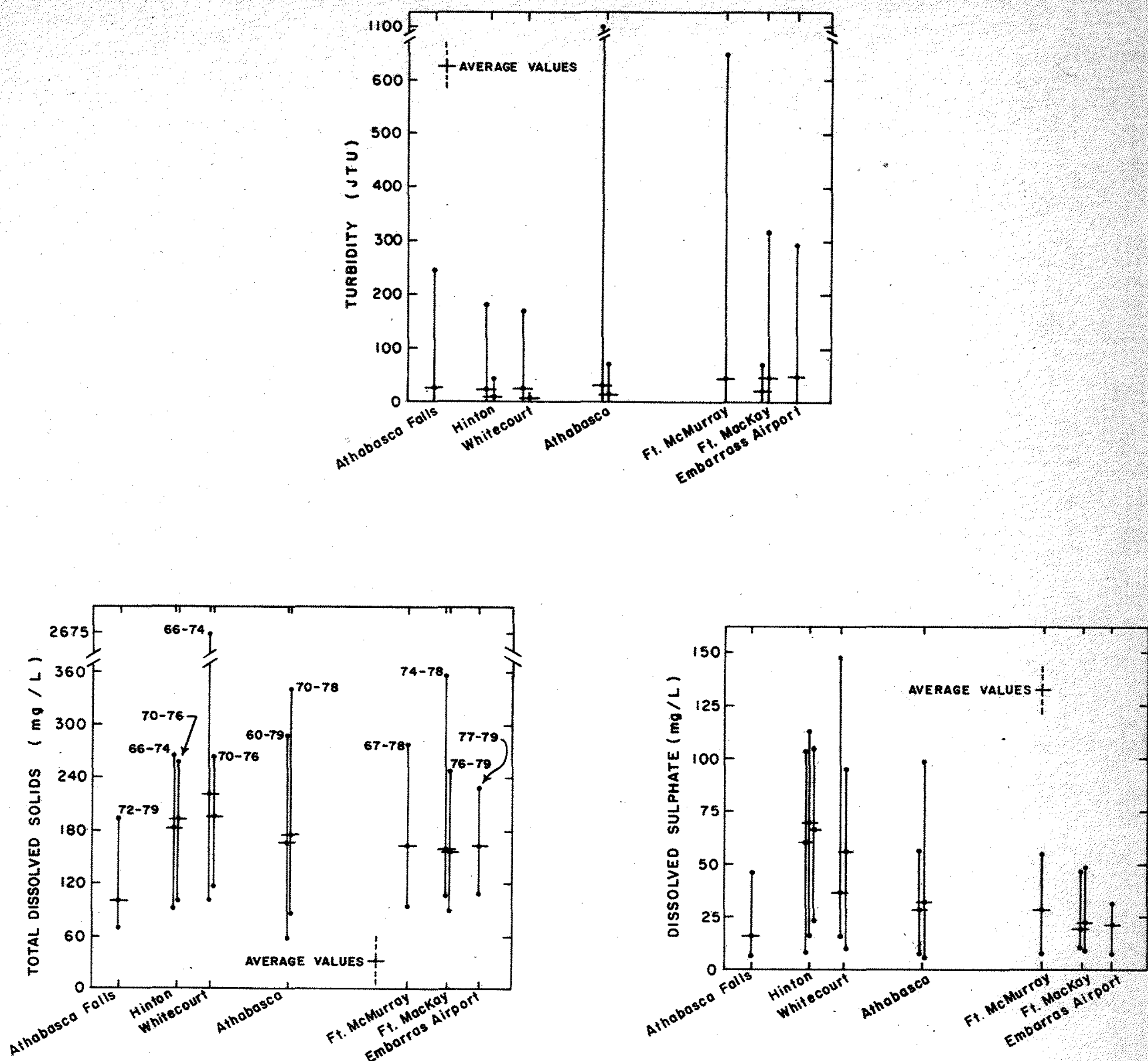
TABLE 4-2

CONTINUOUS SEWAGE DISCHARGE - SUMMARY OF FINAL EFFLUENT QUALITY, TREATMENT EFFICIENCY AND LOADINGS, ASSOCIATED WITH FOUR REPRESENTATIVE COMMUNITIES, IN 1982 - ATHABASCA RIVER BASIN

Parameter	Alberta Environment Design Criteria	Unit	Edson (Low)	Edson (High)	Whitecourt (Low)	Whitecourt (High)	Slave Lake (Low)	Slave Lake (High)	Fort McMurray (Low)	Fort McMurray (High)
pH	5.5-10.5	units	7.4	9.1(5)	6.2	7.7(30)	6.8	7.6(5)	6.6	8.1(5)
NFR	15-30 mg/L	Conc(mg/L): Mean	6.0	59.4(5)	3.4	17.0(30)	11.6	56.5(4)	13.0	31.0(5)
		Mass(kg/d): Mean	34.8	259.4	15.0	41.0	0.1	61.7	201.0	478.0
% NFR Removal	85-95	Mean	64.3	98.5	92.0	96.0	66.8	94.7	78.0	96.0
BOD	15-30 mg/L	Conc(mg/L): Mean	8.4	27.0(5)	2.9	9.3(30)	8.4	29.1(4)	12.0	39.0(5)
% BOD Removal	85-95	Mean	78.4	94.7	93.0	97.0	73.9	91.8	71.0	89.5
Ammonia-N	10-20 mg/L	Conc(mg/L)	5.4	29.9(1)	-	-	9.2	25.2(1)	20.0	60.0(1)
		Mass(kg/d)	15.3	263.5			0.2	26.7	309.0	926.0
Phosphorous (as PO_4)	15-30 mg/L	Conc(mg/L)	8.6	31.2(1)	-	-	15.2	23.6(1)	2.0	10.0(1)
		Mass(kg/d)	23.7	274.9			0.2	26.5	31.0	154.0
Dissolved Oxygen	3-5 mg/L	Conc(mg/L): Mean	4.7	10.1(15)	3.4	5.5(30)	1.4	7.6(5)	4.1	11.0(5)
Effluent Flow		m^3/d: Mean	2,241.1	7,498.0	2,113.0	3,071.0	10.0	30,887.0		15,430.0(e)

Notes:
1. (e) indicates estimate
2. Figures in brackets following highest mean monthly values indicate sample days per month. Note that values may vary slightly from month to month.
3. Values for Edson, Whitecourt, Slave Lake, and Fort McMurray are the lowest and highest mean monthly values derived from daily measurements taken in 1982 during the respective months, ie. the high mean monthly value is not the highest single measurement but the value for the month with the highest average of daily measurement.

Source: Sewage Treatment Plant monthly reports, cited in Athabasca River Basin, Water Use Assessment Report, Alberta Environment use activities in the upper to central reaches of the Athabasca Basin have caused considerable erosion (Canada West Foundation 1982). Values for total dissolved solids, turbidity, and dissolved sulphate are shown in Figure 4-1. High values for these parameters appear to be occurring in the central part of the Athabasca Basin.



(Adapted From Canada West Foundation, 1982 and Environment Canada, 1981)

RANGES OF CHEMICAL CONSTITUENT
VALUES IN THE ATHABASCA RIVER

FIGURE 4-1

V THE UPPER SUB-BASINS (JASPER PARK, BERLAND AND MCLEOD)

OVERVIEW

For the purposes of this report, the Athabasca River Basin has been divided into four primary zones: the Upper Sub-Basins (Jasper Park, Berland, and McLeod), the Central Sub-Basins (Pembina and Lesser Slave), the Lower Sub-Basins (Lac La Biche and Clearwater and three Athabasca River Sub-Basins (I, II, and III). Although somewhat arbitrary, this division roughly corresponds to the primary zones of fish habitat and to areas of fish harvest practices in the recreational, commercial, and domestic fisheries of the region.

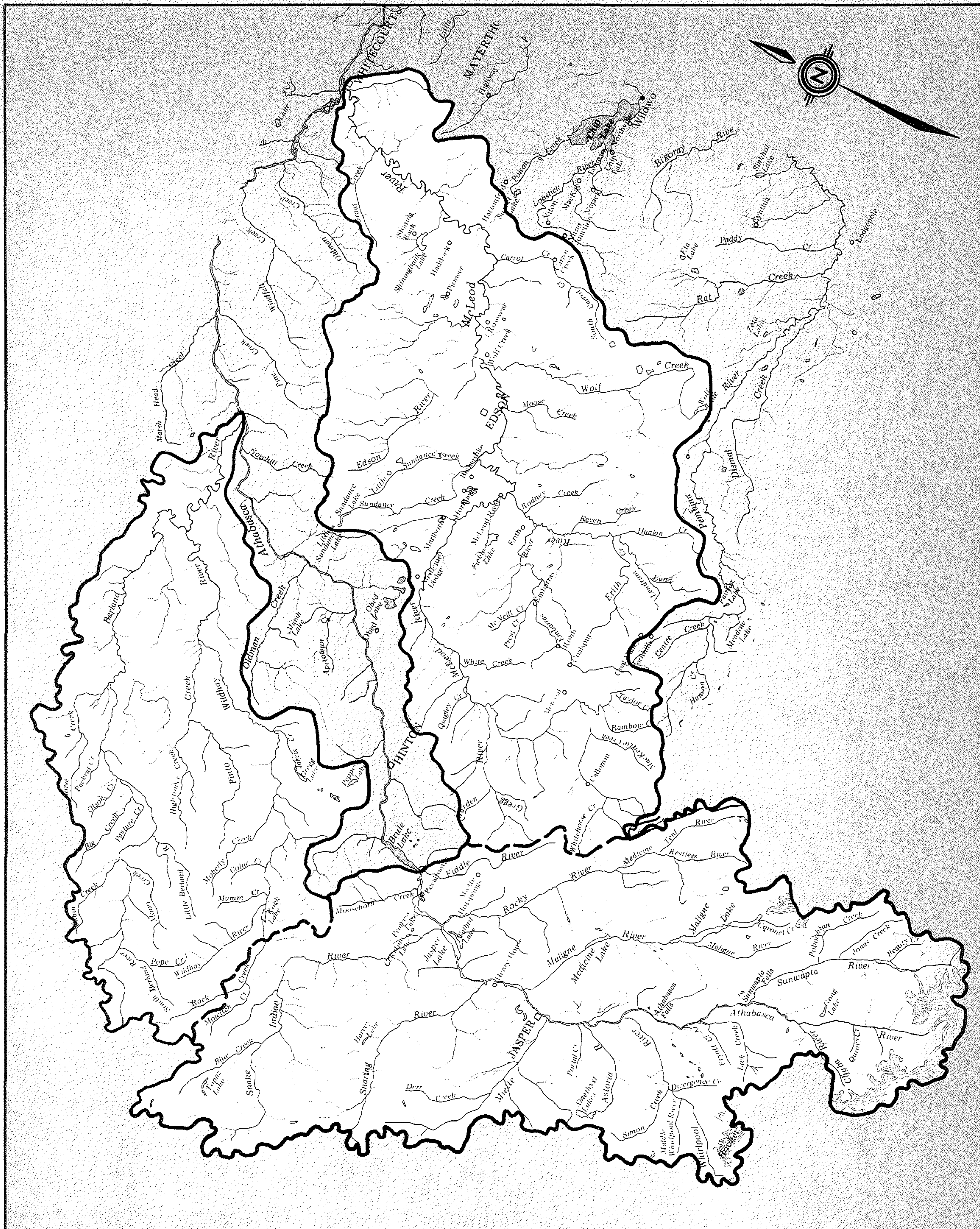
The numerous small watersheds situated along the Eastern Slopes of Alberta's Rocky Mountains are important both as sources of water for the major river systems, and as fisheries habitat. Forested with spruce and pine in the highland regions, the swift, cold, clear streams flow through rolling foothills, an area of near-surface coal deposits and oil and gas fields.

Rich in fish, wildlife, and aesthetic resources, the region is subjected to increasing recreational demands, at the same time maintaining the industrial and urban demands placed upon it. During the past 20 years, these once-remote sub-basins have received increasing attention from industry and recreationalists alike, and regional urban centers have grown in response to both. The manufacture of Kraft pulp and lumber products, the extraction of non-renewable resources in the form of petroleum products and strip-mined coal, and the construction of pipelines have increasingly affected habitats important to fish. New access to fish habitat afforded by forestry roads, seismic lines, and the ever-developing highway system has resulted in enormously increased pressure on the fisheries resource.

The Jasper Park Sub-Basin constitutes the extreme headwater region for the drainage. Arising high in the Columbia Ice Fields in the southern portion of Jasper Park, the Athabasca River flows northward and over the Athabasca Falls, past the town of Jasper, and then turns toward the northeast. The river leaves the park and flows into Brule Lake, located on the mainstem of the Athabasca.

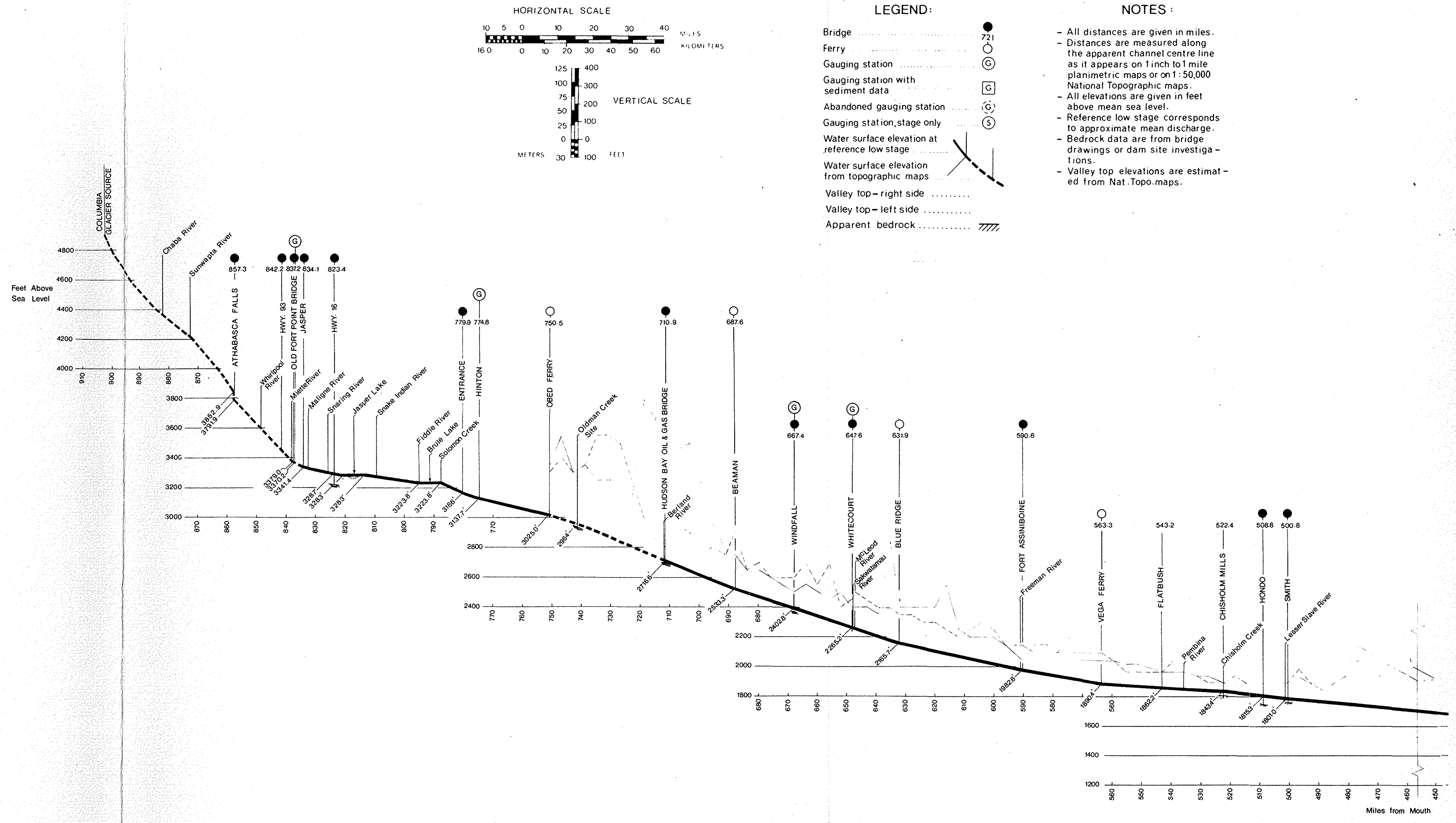
The Continental Divide forms the western boundary of the Jasper Park Sub-Basin. The eastern and southern boundaries are formed by the Berland, Athabasca, McLeod, and North Saskatchewan River basins. The Berland and McLeod sub-basins lie immediately to the east of the Jasper Park Sub-Basin, and are bordered to the north and south by the Peace River watershed and the Pembina Sub-Basin, respectively. The Berland River joins the Athabasca River approximately half-way between Hinton and Whitecourt, and the McLeod River enters the mainstem at Whitecourt (Figure 5-1).

The overall length of the Athabasca River mainstem, from the glaciers to the Peace-Athabasca Delta, is about 1,375 km. Approximately 10% of this length (about 134.6 km) occurs between the glaciers and the eastern boundary of Jasper Park, where the river turns northeastward toward Hinton (Figure 2-5). The Jasper Park Sub-Basin drains an area of 10,878 km^2, and is the largest in size of the three upper sub-basins. The McLeod Sub-Basin drains an area of 9,850 km^2, and the smaller Berland Sub-Basin an area of 5,750 km^2 (Figures 5-1 and 5-2). These three sub-basins make up some of the most important recreational zones in Canada, the Jasper Park region having received international attention since the turn of the century. Scenes of Maligne Lake, which lies within that sub-basin, are widely distributed across Canada by commercial enterprises and are recognized by a wide spectrum of the Canadian populace. For instance, Lawren S. Harris, one of the Group of Seven painters, made famous the view of Maligne Lake in Jasper Park in his painting done there in 1924.



THE UPPER SUB-BASINS
(Jasper Park, Berland & McLeod Sub-Basin)

FIGURE 5-1



SOURCE — Research Council of Alberta, 1972
Hydraulic and Geomorphic Characteristics
of Rivers in Alberta

PROFILE OF THE UPPER PORTIONS OF THE ATHABASCA RIVER

FIGURE 5-2

Below the eastern limit of the McLeod Sub-Basin, at Whitecourt, there is a gradual transition from coldwater to warmwater aquatic habitat in the tributary sub-basins of the Athabasca Basin and, in some areas, the fish population consists of both coldwater and warmwater species. The demarcation line is not sharp; however, it generally occurs for tributary sub-basins above and below a broad zone near Whitecourt, where the Berland River joins the Athabasca. As a result, there is a broad mix of fish habitat within the three sub-basins, ranging from very cold waters with high turbidity near the glacial sources through to the braided, alluvial tills of the mainstem Athabasca. Brook trout and lake trout generally frequent the high mountain streams of the three sub-basins; whereas rainbow trout are more widely distributed throughout the tributaries.

Much of the area covered by these sub-basins falls within the Edson Fish and Wildlife Region (Hunt 1977, 1979). The Jasper Park Sub-Basin falls entirely within the jurisdictional mandate of Parks Canada and, as such, is dealt with as a separate area.

The Eastern Slopes of central Alberta have a widely variable topography with vegetative cover ranging from forested conifers to open parkland. The streams, lakes, and rivers reflect this variability, and afford prime recreational opportunities of which fisheries are a valuable component. Industries in the region include agriculture, forestry (lumber, pulp and paper), petroleum exploration and development (oil and gas), coal mining (strip and underground), and commercial fisheries.

Hunt (1979) points out that to include only licensed fishermen in estimates of numbers of anglers in the region would greatly underestimate the angling pressure on the region, particularly since it is so heavily utilized by Edmontonians. Further, even if those figures were reliable, they would probably be increased by as much as one third if all those under age 16 and over 65 were included.

Summer creel surveys at Carson Lake and Pierre Greys Lakes indicated that anglers from Edmonton accounted for 76 and 45%, respectively, of total angler-days spent on those lakes.

Within the region, natural fish populations occur in 27 lakes, and another 20 lakes are stocked with trout. Naturally reproducing populations chiefly include northern pike, yellow perch, and lake whitefish. Reproducing lake trout populations occur in Rock Lake (Hunt 1979). Many of the streams and rivers in this mountainous, Eastern Slopes drainage contain native populations of Dolly Varden, Arctic grayling, rainbow trout and mountain whitefish. In several drainages, brook trout and brown trout occur as introduced species. The lowland tributaries of the Athabasca, Pembina, and McLeod rivers are known to harbour walleye and some northern pike. Typically, the streams in the region have naturally limited biological productivity due to several key factors:

- Long, cold winters
- Cool summer temperatures
- Severe, seasonal, fluctuations in stream flows
- High gradients

Nevertheless, the high aesthetic quality of the fishery, especially to nearby urban residents, makes the region a special area for habitat protection and fish conservation or enhancement programs. Despite this relative importance, less than one third of the streams and none of the major rivers, have received detailed, ecological assessments (Hunt 1979). This paucity of data has been aggravated throughout the region by the rapid rate of industrial development (logging and oil and gas) but, more important, by the much greater access which associated road construction has afforded to anglers.

Hunt (1979) estimated the total trout angling effort in the region to be possibly in excess of 400,000 angler-days: licensed local anglers (15,010) plus unlicensed anglers (33.3%) times the mean number of estimated days fished for anglers (9.6) equals 200,000 angler days. Since studies have shown that local angling pressure is equalled by people from Edmonton, the figure of 400,000 angler days seems plausible (Table 5-1).

Within the region, only seven lakes (Meekwap, Crooked, Smoke, Iosegun, Shiningbank, Fickle, and Chip) are thought to have commercial fisheries potential. Of these, Fickle, Shiningbank, and Crooked lakes were removed from the schedule of lakes for commercial fishing in 1970, 1965, and 1981, respectively, due to the collapse of the fishery (chiefly whitefish), and competitive angling pressures.

Maintenance of the existing diversity of chiefly coldwater fish species, required to accommodate growing recreational use, will be directly influenced by water quality, water discharge, and habitat preservation in the three upper sub-basins. Additional data are needed in order to develop more detailed management strategies for these sub-basins. A detailed review of habitat assessment and fish production/growth surveys for the McLeod and Berland sub-basins is contained in Hunt (1977b), who identified the following areas where more information is required:

- Seasonal distributions of fish species, especially in the extreme upland reaches of the tributary streams
- Existing standing crops and production of the fish species in each tributary basin
- More detailed studies of recreational use of lakes and tributary streams within each sub-basin.

TABLE 5-1

SUMMARY OF THE NUMBER OF ANGLERS, ACCESSIBLE STREAMS, NUMBER OF STREAMS WITH FISHERIES AND FISHERIES POTENTIAL IN THE MUNICIPAL DISTRICTS WITHIN THE BOUNDARIES OF THE EDSON FISHERIES REGION, MAY, 1979

	Licence Sales					Number of Stream Fisheries			Streams with Fisheries Potential		
District	1972-3	1977-8	% Change	Accessible Streams	Inaccessible Streams	Natural	Stocked	Unknown	Fisheries Potential	Unknown Potential	No Potential
I.D. 14(244)	2,504	4,003	+60	114	130	80	6	158	31	212	1
I.D. 15(12)	894	1,445	+62	9	3	8	1	3	8	1	3
I.D. 16(75)	1,898	2,570	+35	28	47	18	0	57	10	64	1
County 28(3)	937	1,469	+57	3	0	3	0	0	3	0	0
County 31(6)	2,964	5,523	+86	6	0	2	0	4	2	2	2
Totals (340)	9,197	15,010	+63	160	180	111	7	222	54	279	7

Source: Adapted from Hunt (1979)

THE JASPER PARK SUB-BASIN

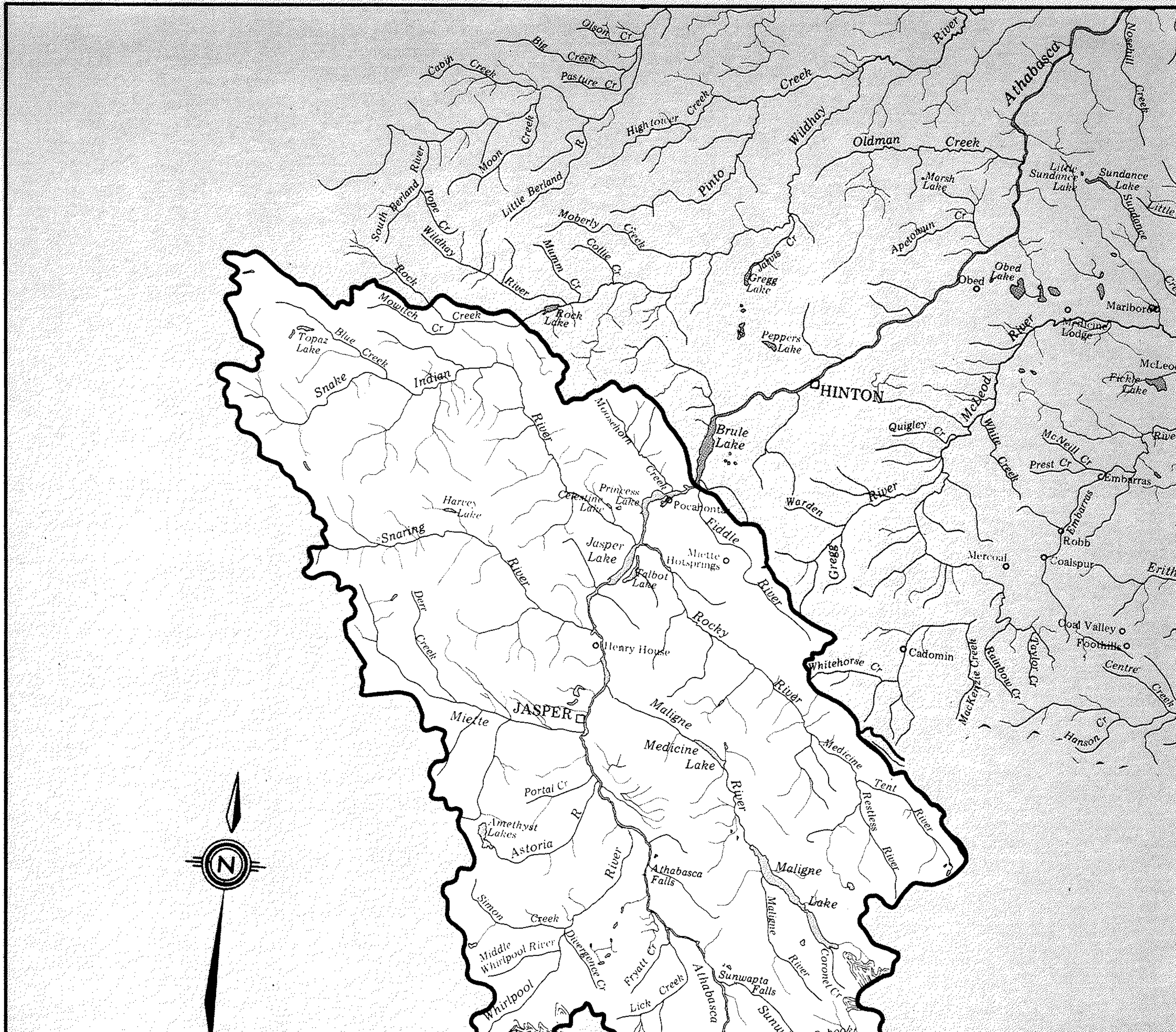
The River Environment

Jasper National Park, which is 10,878 km^2 in area, was established in the eastern Rocky Mountains in 1907. The park encompasses a wide variety of alpine to sub-alpine habitat including the Columbia Icefields, glacier-fed lakes, mineral hot springs, and large wilderness areas. The park is accessible by the CN Rail Line and the Northern Trans-Canada Highway. Jasper townsite is open year-round and, in 1983, consisted of 4,200 permanent residents. In fiscal year 1982/83, over 787,000 vehicles carrying over 2,056,000 passengers passed through the park (Parks Canada, unpublished data).

Within the park, which lies between 52° 08' and 53° 29' north latitude, are over 800 lakes and ponds, lying between 1,000 to 2,500 m in altitude (Figure 5-3). In 1976/77, the Canadian Wildlife Service undertook an extensive series of limnological investigations in the park, and produced extensive annotated bibliographies on previous aquatic research there (Anderson and Donald 1977, 1978a, 1978b, 1978c; Donald and Anderson 1978).

The high-mountain source of the Athabasca River above Jasper is typical of clear, cold glacial streams (Figure 5-2 and Table 5-2), as is the riverbed material which is composed of glacial fines. At lower elevations, the fines are replaced by larger bed material, composed chiefly of pebbles and the small, glacial alluvial substrates typical of braided alluvial streams.

The Athabasca River has an extremely steep gradient, and falls 318.3 m within 71.6 km of its source. At the Athabasca Falls, it drops 18.5 m over about 0.16 km. Overall, the gradient of the river averages 4.46 m/km. This average is exceeded only at the Athabasca Falls and in the reach between the lower falls and Jasper where the



JASPER PARK SUB-BASIN

FIGURE 5-3

TABLE 5-2

ATHABASCA RIVER BED MATERIAL SAMPLES

Athabasca River			Total Sample			Fraction >8 mm	
Approximate Location	Distance From Mouth (mi)	Distance From Mouth (km)	D_{90} (mm)	D_{50} (mm)	<8 mm (%)	D_{90} (mm)	D_{50} (mm)
Upstream of Sunwapta River Mouth	854	1,374	42	9	47	50	22
Indian River Mouth, Jasper Lake	808	1,300	125	36	20	145	50
Hinton, Alberta	748	1,204	170	57	22	195	76
Whitecourt, Alberta	634	1,020	100	62	1	105	64

Note: Bed samples Athabasca River channels which appeared representative of surrounding reaches. D90 (D50) means that 90% (50%) by weight of the sample is smaller than the given size.

Source: Adapted from Kellerhals et al. (1972)

gradient is 3.9 m/km (Figure 5-2). The first 10% of the total length of the Athabasca River lies within Jasper Park, and is among the most spectacular of the headwaters of any major drainage basin in Canada.

Arising at the foot of Mount Columbia in the Columbia Icefields, the Athabasca River is joined first by the Chaba River, which arises in the Chaba Icefields to the west, and then by the Sunwapta River, which arises from the Athabasca and Dome Glaciers near Sunwapta Pass. In its upper reaches, the Sunwapta River is bisected by the Winston Churchill Range of mountains.

The bordering Maligne River arises high in the Queen Elizabeth Mountain Range near Maligne Mountain, 3,193 m above sea level. The drainage comprises 881 km^2 and contains many alpine to sub-alpine lakes. Maligne Lake is the largest glacier-fed lake in the mountain National Parks. Situated at an elevation of 1,675 m, it has an area of 2,066 ha, and a maximum depth of 96 m.

After the Athabasca River has received inflows from the Chaba and Sunwapta sub-basins, it changes from a series of braided glacial brooks to a substantive river. The size of the Athabasca Falls, located at the foot of Mount Kerkeslin (2,984 m above sea level), reflects the increasing size of the river over its first 50 km of headwater flow. About 60 km from its source, the Athabasca River receives substantial flows from the Maligne River and the river's exceedingly steep course begins to level off (Figure 5-2). The gravel, riffle-pool substrates in the vicinity of Jasper are both indicative of the reduced slope, and typical of the river bottom seen in this region of the basin.

The Miette River and the Astoria River, which drains the Amethyst Lakes, join the mainstem above Jasper. Below that point, the Maligne, Snaring, Rocky, Indian and Fiddle rivers successively enter the Athabasca River until it exits the park, and flows into Brule Lake.

The cold, short summer season found at high altitudes, low levels of dissolved mineral and organic nutrients, and extreme fluctuations in the glacially-derived flow, cause the upper reaches of the Athabasca drainage to be a biologically unproductive area. Due to the extreme slopes, however, the dissolved oxygen concentrations are high, and the water, though often high in glacial fines, is unpolluted.

In the upland tributaries of the Athabasca River, the low levels of dissolved nutrients, coldwater temperatures (summer maxima rarely exceed 18 °C), intermittent torrential scouring, and the presence of glacial fines in the water combine to limit benthic invertebrate production. In spite of the limited production of fish food, the accessible reaches of these streams constitute optimum habitat for salmonid game fishes (Donald et al. 1977). Habitat suitable for overwintering fish species is restricted by the effects of anchor ice and fluctuating stream flows, especially during the low-flow winter months. The latter is a prime determinant in the total fish production in these highland streams.

Although limnological studies have been done of the low-altitude lakes in Jasper Park (Bajkov 1927, 1929; Bere 1929; Neave 1929; Rawson 1940, 1942, 1953; Reed 1959; Wallis 1929), there have been relatively few investigations of the high-altitude (sub-alpine to alpine) lakes (Anderson 1969). The latter, however, are exceedingly isolated and, unless stocked, would not contain fish.

The Fish Population

In spite of the factors limiting productivity, the upland tributaries of the Athabasca River provide excellent habitat for several salmonid species. Arctic grayling are recorded from the Miette and Snaring rivers, and cutthroat trout are found in both the Miette and at the extreme reaches of the Sunwapta. Rainbow and brook trout occur in both the Athabasca mainstem and the tributaries near the Maligne River, as do Dolly Varden. Below Jasper, mountain whitefish and lake whitefish are generally found in predominantly mainstem flows. The Athabasca Falls limit further upstream migration of fish species which, in that region of extreme gradients, is probably not of significance for fish productivity. Goldeye, predominantly distributed in the lowland tributaries of the Athabasca River, have been recorded near Jasper. Longnose and white suckers have also been recorded along the Athabasca mainstem and in tributary streams (eg. Miette and Astoria). Northern pike exhibit similar distributions (Paetz and Nelson 1970).

Mountain whitefish, which are the most abundant sportsfish in streams of the Jasper Park Sub-Basin, migrate on a seasonal basis, between their feeding, spawning, and overwintering habitat. Spawning is thought to occur in suitable stream locations throughout the park. The Canadian Wildlife Service (Ward 1974) undertook a detailed review of fish stocking and distributions in the park and mapped known distributions in detail.

Sport Fishing Opportunities

The Jasper Park Sub-Basin provides important sport fishing opportunities on a regional, provincial, and national basis. Centred as it is in a National Park, there are obvious attractions for tourists, and therefore heavy demands on the fishery resources. Perhaps more important still, the aesthetic qualities of the high mountain streams carry a special responsibility for their protection and maintenance. Jasper, in Jasper National Park, which is within 370 km of Edmonton and 335 km of Calgary, receives increasing numbers of tourists from major centres such as Vancouver, many of whom have come from countries as distant as Japan.

In the recent past, increased tourist and recreational pressure has resulted in a number of studies, all of which have been aimed at quantifying user demand for camping, fishing, hiking, and other facilities. Since 1969, a number of specific areas, including Jasper townsite, the Maligne Lake area, and Mount Edith Cavell, have been studied (Anonymous 1977, 1978; Drapell 1969; Kuchar 1972; Parks Canada 1973). In more recent publications, park use statistics have been extensively summarized for the years 1982 to 1983 (Parks Canada 1983). The data indicate a continued trend of heavy park use by a wide range of recreationalists.

Angling pressure on the tributary rivers in this sub-basin is high. Although Jasper Lake is considered to be a poor fishing area, the mainstem of the Athabasca River supports angling at those sites which have access, especially those located near summer camping areas. Rivers especially favoured by anglers include the Athabasca River, Sunwapta River, Snaring River, Miette River, and the Maligne River below Maligne Canyon. The areas around Beaver, Buck, and Maligne lakes are also well-utilized. An updated annotated list of closed and open fishing areas has been published in the form of the National Parks Regulations (Parks Canada 1983).

Jacques Lake and Beaver Lake are easily accessible to those who camp or day-hike. Fish stocking programs in both lakes have been followed by extensive biological surveys (Donald and Anderson 1978, Miller and Dayman 1977, Strachan et al. 1978), which have indicated the catch and rates of growth for rainbow trout, Dolly Varden, and brook trout. Such fish stocking programs in Jasper have a long history, starting as far back as 1917 when Pyramid Lake was stocked. Maligne Lake and Amethyst Lake were stocked with rainbow and eastern brook trout from 1928 to 1975 and 1931 to 1975, respectively.

Christine Lake has been stocked with cutthroat, brook and rainbow trout on various occasions since 1934. Although present stocking programs are much reduced over those carried out in earlier years (as many as 45,000 fingerlings have been stocked into some lakes on occasion), a total of 39,000 rainbow trout fingerlings were stocked into 15 lakes in the park in 1983, the majority of the fish going to Edith (13,900), Pyramid (5,000), Celestine (5,000) and Dragon (3,600) lakes.

In stocked lakes, angling pressure is very high, as is the pressure to expand and increase stocking programs. The present thrust of management programs is to maintain fish populations in the lakes. During 1980, Donald et al. (1982) evaluated the existing stocking program, and recommended strategies for future programs.

Availability of Alternative Sport Fishing Opportunities

Within the Jasper Park Sub-Basin, the mainstem and major tributaries of the Athabasca River provide the majority of sport fishing opportunities in the region. Immediately to the north of the Jasper Park Sub-Basin are the upper reaches of the Smokey River which is part of the Peace River drainage. Access here is limited, the headwaters falling almost entirely within the boundary of the Willmore Wilderness Park, just south of Grande Cache. Immediately south of the Jasper Park Sub-Basin, the Banff Park encompasses the headwaters of the North Saskatchewan River. Here, as in Jasper Park, access is good, and the river is well utilized by tourists and anglers alike. On the western border of the park, across the Continental Divide, the Mount Robson Provincial Park in British Columbia provides good access (through a continuation of the Yellowhead Highway 16 route) to the drainage surrounding Moose Lake.

Many anglers use the Forestry Reserve areas outside the park (Berland and McLeod sub-basins) as alternate fishing areas, but the allocation of "migrant" anglers to these alternate locations is unquantified.

Water Quality

The salmonid populations in this section of the Athabasca Basin are highly dependent on the maintenance of two water quality parameters: water temperature (cold--temperature should not exceed 22 °C) and dissolved oxygen (high--a minimum of 8 mg/L is needed to maintain juveniles and eggs). Activities which could lead to sedimentation of the waterways or siltation of the streambeds should be curbed in riverine areas where spawning habitat exists. Erosion problems are rare within the park boundaries.

Anderson (1969) summarized water quality data for alpine and sub-alpine lakes in the park. The high-level lakes showed remarkably pristine values. For instance, salinity values (<3 mg/L) approached the lowest ever recorded for natural waters. Water temperatures in the high altitude lakes rarely exceed 10 °C, and some may not exceed 4 °C if they receive large amounts of meltwater. Oxygen saturations generally approach 100%, though turbidity from glacial fines limits light penetration. pH ranges from 7.3 to 8.3 and hardness from 0.8 to 137 mg/L (soft to moderately hard).

Water Quantity

Water flows through the Jasper Park Sub-Basin of the Athabasca drainage are currently able to maintain the existing fish population. Flows in this sub-basin range from 3.64 to 610 m^3/sec with a long-term mean flow of 89.3 m^3/sec. These extreme ranges (from January low-flows to July melt runoff) typify the high mountain range watershed environment of the Jasper park region (Kellerhals et al. 1972). At a station near Jasper, on the Athabasca mainstem, mean dates recorded for freeze-up and spring breakup, based on 17 years' data, were November 5 and April 7, respectively (Kellerhals et al. 1972)

Environmental Problems

1. Arising from Natural Causes

Donald et al. (1980) found that substantial growth of brook trout can occur at high elevations in lakes which have low seasonal temperature ranges, if amphipods are abundant. Lakes with a mean water temperature below 12.3 °C, and an ice-free season as short as 110 days, have been found to support exceptional brook trout growth in the presence of substantive amphipod populations. Although specific conductance was shown to be an indicator of the productivity of lakes, Donald et al. (1980) also demonstrated the importance of lake elevation to fish production. Correlations between brook trout growth, water temperature, and lake elevation were highly significant.

2. Arising from Water Management Practices

Channelization of streams has occurred at both highway and railway crossings within Jasper Park, though none of these modifications is known to have caused problems. Recently, the twinning of the CNR rail line has become an issue (Anonymous 1980), the impact of which is discussed in that report.

3. Arising from Other Sources

The trend toward increasing tourist and recreational activities within the Jasper Park Sub-Basin will undoubtedly continue to exert substantial pressure on fish resources and fish habitat. Several reports have been published on the sewage and waterworks in Jasper Park (Anonymous 1970), and the bacteriological and nutrient characteristics of the park's surface waters have been studied (Gummer and Block 1978). The latter report contains numerous analyses of water quality in the lakes, streams, and rivers of the park. The authors found that, in selected areas of the Sunwapta, Athabasca, and Fiddle River drainages, significant degradation of surface waters had occurred from existing developments. The effluent from the Jasper townsite lagoons was found to have less impact on the Athabasca River than much smaller effluent sources from developments nearby.

Some small lakes have been affected by man-made operations in the park. For instance, Lane et al. (1978) documented the impact of Jasper Park Lodge operations on Mildred Lake, where nutrient-induced eutrophication has led to very low levels of dissolved oxygen in the lake. Expansion of the urban center at Jasper and its attendant increase in water consumption and disposal has the potential to have an impact on fish habitat.

Of equal, or possibly more significance, might be the long-term incremental impacts on habitat associated with the development of access roads and campsites within the park. River crossings in the highland tributary streams, if not properly installed, could lead to erosion and siltation problems. Blocked crossings could create artificial barriers to fish movements, isolating migrating populations or removing vital spawning channels. It is therefore important that any new construction activity involving fish habitat areas be considered as to time of year and long-term impacts, such as erosion or stream channel alterations. Subsequent to the construction phase in important habitat areas, monitoring should be done to ensure maintenance of existing fish populations.

Data Gaps

Up-to-date creel census data are lacking for streams and rivers throughout the park. Prime sportsfish migration and spawning areas in rivers are poorly known, and population estimates are lacking for both lakes and rivers. Species composition and fish distribution data are lacking for many areas currently experiencing heavy angling pressure. The reader is referred to the report of Donald and Anderson (1979) for a summary of creel census data from 1933 to 1977 for the Maligne River watershed.

Fisheries Management Strategies

These were not provided for this section of the review as Federal Departments, outside the Provincial agencies sponsoring the study, were not part of the review process.

Summary

The productivity of the salmonid sport fishery in the Jasper Park Sub-Basin is limited by the cold, short growing season. Low rates of discharge in the winter, limited nutrients, and the nature of glacial stream flows also characterize this typical cold, clearwater fish habitat zone. The low rate of biological productivity relative to angling demand is offset by fish stocking programs throughout many lakes in the park.

Moderate to heavy angling pressure exists in favoured tributaries and along accessible portions of the Athabasca mainstem. Fish populations in the area are naturally relatively unproductive and slow-growing. As a result, these populations may be particularly vulnerable to over-fishing, especially given the predicted, long-term use of the park by recreationalists.

Although water quality in the Jasper Park Sub-Basin is generally acceptable, continued pressures for recreational access and urban development, most of which are oriented to the tourist industry, could pose a significant long-term hazard to the maintenance of fish habitat. In particular, road crossings within sensitive habitat reaches could affect fish populations by providing new access to anglers, and by creating the potential for siltation of spawning beds. Where necessary, close attention should be paid to the construction of adequate culverts, which must be large enough to accommodate seasonal stream flows, and installed so that risks of siltation, channel erosion, or blockages are minimized.

A thorough study of fish species composition, population structure, spawning areas, and critical stream habitat has not been completed for the Jasper Park Sub-Basin. The total long-term impact from sport fishing in the region has not been comprehensively assessed, particularly in tributary streams favoured by anglers.

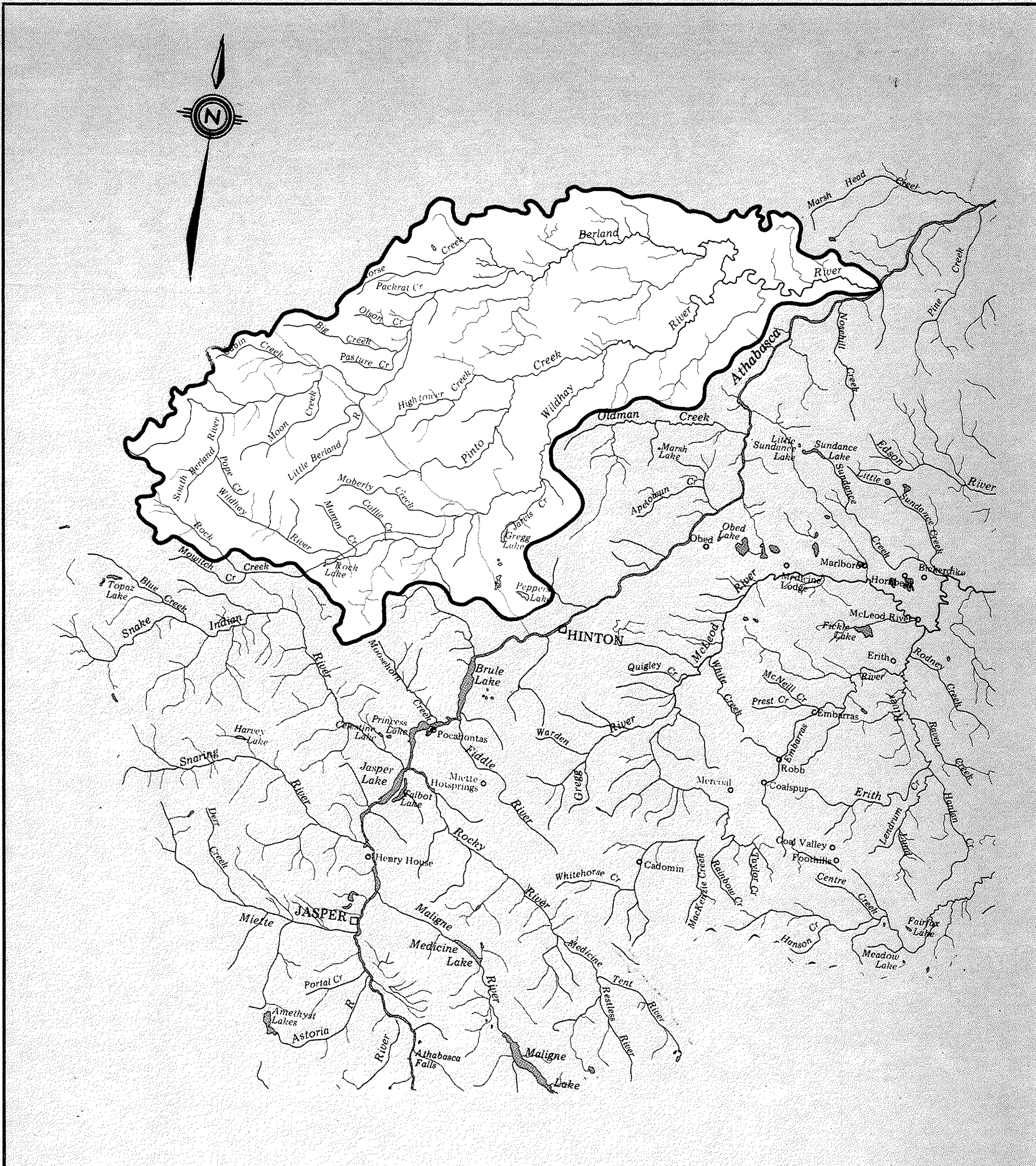
THE BERLAND SUB-BASIN

The River Environment

Bordering the northeastern boundary of the Jasper Park Sub-Basin, the Berland Sub-Basin drains an area of 5,750 km^2. The main channel of the Berland River is approximately 165 km long. It originates in the Persimmon, Hoff, and Berland Mountain Ranges in the eastern portion of the Willmore Wilderness Park at an elevation of 2,270 m, and enters the Athabasca mainstem approximately half-way between Hinton and Whitecourt at an elevation of 842 m. The headwaters of the sub-basin are divided between the Berland and Wildhay rivers, which come together approximately 29 km above the Berland River confluence with the Athabasca mainstem (Figure 5-4). The lower reaches of the Berland River have been extensively developed by oil and gas interests, with many oil and gas pipelines and seismic lines crossing that portion of the basin.

The Berland River varies from about 12 to 35 m in width, and has clear water, which flows rapidly until reaching the lower reaches. The banks are chiefly gravel, and are bordered by mature forest over most of the river's length. The upland tributaries of the Wildhay River (Rock, Mumm, Collie, and Moberly creeks) are characterized by fast-moving, clear waters flowing over rocky streambeds. These high-gradient streams contrast with the lower Berland River, which is clear, but has slow-moving water running over clean gravel riffles interspersed with deep pools.

The Berland Sub-Basin takes in 21 major tributaries and includes highly diversified terrain ranging from rugged mountains and steep, timbered foothills to broad, gently rolling timberlands and low-lying muskeg areas. The streams are similarly diverse, ranging from swift, cold mountain streams in the west to slow, brownwater muskeg streams in the east (Cunningham 1960). Rainbow trout, Dolly



BERLAND RIVER SUB-BASIN

FIGURE 5-4

Varden, and mountain whitefish predominate in the colder, swift waters while Arctic grayling typically occur in the slower, brown waters. Northern pike, minnows, and suckers occur in many areas of the Berland Sub-Basin, which provides habitat suitable to those species.

The Wildhay River drains 2,745 m^2, and flows east toward the Berland River, entering the latter at an elevation of 908 m. In the Wildhay watershed, Gregg Lake is situated within the north end of the relatively small William A. Switzer Provincial Park, which is located just northwest of Hinton. The lake is drained by Jarvis Creek to the Wildhay River, and is accessible by road from Hinton. The Hanlon and Muskeg rivers, to the northwest, occur in an area which is crossed by Highway 40 and a rail link connecting Hinton and Grande Cache. The upper reaches of the Wildhay River are fast-flowing (0.8 m/sec), and have an average width of 15 m. The lower sections of the river are somewhat wider (20 m) with frequent pools ranging from 1.5 to 2.0 m in depth. The river is characterized by gravel bars, and by open banks vegetated by willow and grass.

The smaller streams of the upper Berland drainage (Moon, Pasture, Big, Olson, Cabin and Packrat creeks) are characterized by gravel bottoms and are surrounded by open forested lands. Cabin Creek ranges from 3 to 6 m in width and has a streambed made up of small to medium-sized gravel, which, if used, would appear to be excellent spawning substrate for trout.

Hightower and Pinto creeks, draining 695 km^2 of the Wildhay watershed, complete the basin in its central reach. In the forested areas of these tributaries, pine and spruce dominate the vegetation; in the open reaches, small grass and willow meadows predominate. In these streams, gravel riffles alternate with pools, containing gravel and silt (Hawryluk 1980). At the confluence with Hightower Creek, Pinto Creek runs through a narrow valley with steep, sandstone banks. Slumping of large boulders from the sandstone banks has created excellent cover which, alternating with deep pools, is ideal for fish production and maintenance (Hawryluk 1980).

Summer water temperatures in the region average approximately 5 to 8 °C, though maximum temperatures may reach 18 °C. Although the rates of flow, compared with many steeper gradient streams of the Jasper Park Sub-Basin, are somewhat slower, the colder water temperatures and naturally low nutrient levels limit fish productivity in these streams.

The Fish Population

The Berland Sub-Basin lies across a transition zone from coldwater to warmwater streams, creating a range of habitat that is reflected by the fish populations found in the region. Since few permanent residents live there, the sub-basin is virtually wilderness, except in locations where developments have altered the terrain.

The Berland River is classified as Class 2 fish habitat under the ARDA rating system. In some places, the river offers good overwintering areas, riffles for possible spawning and food production, and excellent sport fishing for Dolly Varden, mountain whitefish, rainbow trout, and Arctic grayling (Hawryluk 1980). Though large populations of mountain whitefish on upstream spawning migrations have been documented in the lower Berland River during late August and early September, specific spawning areas have not been identified. Anglers report large numbers of mountain whitefish in tributaries to the Berland (eg. Donald's Flats) in late September and early October, which is suggestive of a movement of at least one population into the lower tributaries.

The Wildhay River, the main channel of which flows for about 180 km, has been surveyed at several locations on a number of occasions (Paetz and Hartman 1957, Cunningham 1960, Hawryluk 1980). This river provides good sport fishing for Dolly Varden, mountain whitefish, and rainbow trout; and Arctic grayling and brook trout commonly occur throughout the Wildhay drainage. The lowland tributaries of the Wildhay have also been noted to contain pool areas suitable for mountain whitefish, though no spawning sites have been documented. A fall whitefish run has been reported for the Wildhay River near Jarvis Creek, and many individuals of this species have also been reported in the upper Berland River (R. Hawryluk, pers. comm., Alberta Fish and Wildlife Division, Edson).

Pinto Creek, a tributary of the Wildhay River, supports Dolly Varden, mountain whitefish, rainbow trout and Arctic grayling (Hawryluk 1980). Brook trout are also thought to inhabit the stream; however, no records are available. Brown trout have been stocked in both Pinto and Jarvis creeks, but apparently have not established themselves in either stream (Alberta Fish and Wildlife Division, internal records).

Cabin Creek, surveyed in 1960 by Cunningham (1960) and more recently by Hawryluk (1980) is reported to have yielded rainbow trout and Dolly Varden to anglers. A tributary to Cabin Creek, Henderson Creek, is also reported by anglers to contain rainbow trout, mountain whitefish, and, it is believed, Dolly Varden. A 1971 survey (Lane 1971) indicated that the fish population of Cabin Creek consisted of a few rainbow and eastern brook trout. In 1974 (Watters 1974), a preliminary survey showed that the rainbow trout was the predominant game fish in Collie Creek (Wildhay drainage) and that the water quality of the stream was high. Northern pike have also been documented from the upper tributaries of the Berland River (Paetz and Nelson 1970). An early survey (Paetz 1956) indicated that the principal fish resident in Moberly Creek was rainbow trout, with Dolly Varden and eastern brook trout also present. Walleye have been stocked in Gregg Lake (Watters 1971); however, the program was recommended discontinued in 1974 (Watters 1974) as studies from 1969 to 1973 indicated it was not successful.

Appropriately perhaps, Rainbow Lake is known to contain a native population of rainbow trout. Two unnamed lakes within the Wildhay Sub-Area (LSD 4 of Sec. 8, Twp. 56, Rge. 24, W5 and LSD 8 of Sec. 36, Twp. 55, Rge. 24, W5) formed in muskeg depressions, may have potential as put and take lakes (Hawryluk 1980).

Sport Fishing Opportunities

Although Hunt (1979b) described the fish production in the Eastern Slopes region of Alberta as limited, the demand for high-quality sport fishing is high throughout the Berland Sub-Basin (Hawryluk 1980). The eastern side of the sub-basin typically exhibits relatively high-gradient foothill streams, which have sparse populations of naturally-occurring sportsfish. Stream stocking is restricted to a few beaver ponds, which undergo heavy angling pressure, and to some lakes, such as Pierre Greys and Crystal lakes (Hawryluk 1980).

The present recreational use of the fishery of the Berland Sub-Basin is not well documented. It is known, however, that the area provides good sport fishing and campground facilities are often filled during summer months. Hawryluk (1980) reported a creel survey conducted from June to September 1978 which showed that the middle, upper, and lower lakes had been fished by 2,200, 1,055 and 370 anglers, respectively. These figures, although somewhat dated, are indicative of the angling pressures today. In spite of the distances involved, 45% of the anglers in the area originated in Edmonton. Rock Lake had an Edmonton angler use rate of 75% (Mentz 1980). These figures are indicative of the popularity and range of sportsfish attraction of the Berland Sub-Basin.

Rock Lake has a Forestry Service campground, and this well-used facility provides access for anglers to the self-sustaining populations of lake trout, pike, mountain whitefish and Dolly Varden which inhabit it (Lane 1969). In addition to the limnological and fishery management study done by Lane in 1969 on Rock Lake, Mentz's (1980) creel survey indicated the importance of the lake as a recreational fishery for lake trout and mountain whitefish. The William A. Switzer Provincial Park, which lies within 20 km of Hinton (via Highway 40), provides access to Jarvis, Gregg, Cache, Graveyard and Blue lakes. The first two are the most heavily fished, chiefly for northern pike and lake whitefish. Walleye introduced to Gregg Lake between 1969 and 1973 have failed to become established (C. Hunt, pers. comm., Alberta Fish and Wildlife Division, Edson). Cache, Graveyard, Gregg and Jarvis lakes all have good access and park campgrounds.

Jarvis Lake was reported to sustain moderate populations of northern pike, yellow perch, and white suckers (Snyder 1972a, 1972b). Petite Lake has been stocked with rainbow trout since 1979, and Dunn Lake was stocked with brook trout. Cutthroat trout, which were stocked in the early 1960's, were placed in Upper Moosehorn Lake, and are still reported for Rock Creek. A sustained population is thought to inhabit Mowitch Creek (R. Hawryluk, pers. comm.).

The fall whitefish run in the lower Berland River is heavily fished by approximately 50 to 100 anglers/day during the course of the run. Rainbow trout and mountain whitefish found in the Wildhay River also provide sport fishing opportunities in the region. Utilization of these streams by anglers is thought to be heavy. Rainbow Lake, with its native rainbow trout population, is accessible only by foot or all-terrain vehicle, but is reported to be frequently visited by anglers (Hawryluk 1980). Commercial outfitters are known to be exploiting Dolly Varden populations in the upper Wildhay and Berland rivers and in Rock Creek, although angling success has recently tapered off. This may be indicative of heavy angling pressure in these rivers in the recent past.

Availability of Alternative Sport Fishing Opportunities

South of the Athabasca River mainstem, which borders the southern edge of the Berland drainage, the McLeod Sub-Basin presents an extensive headwater stream system which includes the Gregg, Erith and Embarras rivers. Immediately to the west, the Indian River drainage of the Jasper Park Sub-Basin borders the Berland; to the north, the Little Smokey River headwaters (which form part of the Peace River drainage) make up the northern alternative fishing areas. Also to the north, the Muskeg River and its tributaries are noted for their sportsfish populations of Dolly Varden and brook trout. Access to this area is good via the Grande Cache Highway 40.

While it is reported that many commercial outfitters are taking anglers into the Willmore Wilderness area to fish for Dolly Varden (R. Hawryluk, pers. comm., Alberta Fish and Wildlife Division, Edson) success has apparently decreased in recent years, a decline which may be indicative of excessive fishing pressure.

Water Quality

Within the Berland Sub-Basin, siltation resulting from extensive seismic and forestry operations has been identified . The Berland Forest Management Area has estimated that the area is capable of supporting a net annual cut of 317,800 cunits/year of coniferous trees. Siltation and runoff patterns will change as the sub-basin is altered through forestry operations, including both the creation of new access and vegetation removal. Sedimentation, where it occurs, is usually closely associated with stream crossings (ie. pipeline, road, and seismic crossings), particularly in the case of temporary crossings. The latter may also, on occasion, cause blockage of fish channels, particularly during freshets and high flow periods.

No water quality data are available for the Berland Sub-Basin from the water quality station network in the Athabasca Basin.

Water Quantity

There are no known stream diversions or water removal schemes within the Berland Sub-Basin. During 1980, severe flooding after intense rainstorms was thought to have altered rainbow trout habitat and, perhaps, populations (C. Hunt, pers. comm., Alberta Fish and Wildlife Division, Edson). Higher peak runoff often occurs in watersheds subjected to extensive forestry operations; however, there is no demonstrated correlation of such effects in the Berland Sub-Basin.

No flow data are published for the Berland Sub-Basin as a whole, however, Kellerhals et al. (1972) noted that, over a 12-year period, the Wildhay River had a mean flow of 7.92 m^3/sec (0.81 to 108.4 m^3/sec). The large maximum value, which was recorded in July of 1965, indicates a capability for severe flooding in the Eastern Slopes region, and a possibility for the potential impacts on fish habitat which can occur in such instances.

Environmental Problems

1. Arising from Natural Causes

Bank undercutting has been observed at the lower sections of Cabin Creek (Hawryluk 1980), and siltation was noted in Hendrickson Creek (a tributary to Cabin Creek) in most of the stream's pools. Heavy rains and serious flooding within the Berland Sub-Basin in 1980 are thought likely to have reduced populations and habitat for rainbow trout (C. Hunt, pers. comm., Alberta Fish and Wildlife Division, Edson).

2. Arising from Water Management Practices

No dams or major diversions are known.

3. Arising from Other Sources

The Berland Sub-Basin combines the somewhat unique features of being a remote, sparsely inhabited region which has been subjected, nevertheless, to significant renewable (forestry pulp operations) and non-renewable (oil and gas exploration and development) resource exploitation.

Early reports (Cunningham 1960) indicated that the fish habitat of Moberly and Pinto creeks appeared to have sustained damage from siltation. It was suggested that this damage was related to erosion resulting from clear cutting of trees used in the pulp operation. By comparison, Jarvis Creek (flowing out of Gregg Lake) was undisturbed in 1972, when a preliminary survey indicated the presence of a high number of clean water organisms.

The Berland Forest Management Area developed an allowable cut of more than 300,000 cunits/year of coniferous trees. The lowland areas of the sub-basin are rated as having moderate to excellent capabilities for oil and gas, and seismic exploration and well drilling have taken place throughout the area. Siltation has been observed along Highway 40 in places where the grade is unstable, and many erosion gullies are visible along that section of the basin. Stream crossings on the upper tributaries are also eroding. Throughout the sub-basin, temporary access roads, especially in the vicinity of stream crossings, have caused siltation problems, although most of these areas have been stabilized. The resources railroad also presents several areas where siltation, unstable fills, and culverts block fish passage. In general, many culverts prevent fish passage in the region.

Although it was not possible to quantify the amount of enforcement activity in the sub-basin, the level of activity in the Edson Regional Office is indicative of the level of development activity generally in the region. Hunt (1977a) noted that there are "approximately a dozen oil and gas fields" in the Edson region, and those fields necessitated developments in seismic exploration, roads, well sites, pipelines, power lines, and gas plants. In the first ten months of 1977, over 400 applications were received from the oil and gas industry alone, and 75 inspections were made. Though all this activity would not have been limited to the Berland Sub-Basin, it is indicative of the high level of development in the region.

Data Gaps

The Berland Sub-Basin, a relatively unexploited, wilderness area twenty years ago, has seen extensive development from forestry and oil and gas development. Nevertheless, there exist no detailed, or even general, studies on the effects of forestry on the waters and aquatic species in the sub-basin.

As a first step in elucidating fish populations and known habitat distributions, a fish species distribution map of the area should be compiled, published, and updated. There are far too few data, given the intensity of sport fishing exploitation in the area, on the relative abundance of the various important fish species and their spawning or overwintering habitat areas. Detailed stream surveys are presently lacking. These should include important factors such as fish species composition, population estimates, migration routes, spawning habitat and ranges, and overwintering areas.

Where critical stream habitat areas are defined, strategies for dealing with long-term recreational exploitation and short-term industrial impacts should be implemented to protect and maintain sportsfish populations. Much better creel census data and catch statistics are needed throughout the region, especially with respect to relative exploitation pressures on existing remote tributary sportsfish species. Careful planning of future road access networks should be done in conjunction with fisheries resource inventories both to ensure habitat protection from temporary and permanent stream crossings, and to regulate access by anglers to sensitive habitat areas.

Further studies are urgently required to clearly show the effects of the growing angling pressure on Arctic grayling and Dolly Varden populations. The latter are especially vulnerable to exploitation pressures due to their relatively late maturation. As remote areas of stream habitat are discovered and opened up, streams harboring extant populations may quickly be over-exploited and, indeed, may vanish before basic fishery inventory studies even identify them. The reader is referred to a detailed discussion on required fishery management programs for the Berland Sub-Basin in Hawryluk (1980).

Fisheries Management Strategies

The fisheries management objective for the Berland Sub-Basin is to maintain native fish populations at maximum population levels through natural reproduction, water and habitat quality maintenance and habitat and fish population enhancement for recreational fishing.

Summary

The Berland Sub-Basin, while sparsely populated, has experienced significant forestry clear-cut operations, and oil and gas exploration and development. The sub-basin has a high recreational demand and presents excellent well-known sport fishing habitat.

The relatively clear, cold waters of the tributary rivers provide habitat for coldwater species, chiefly rainbow trout and eastern brook trout, although Dolly Varden, mountain whitefish and Arctic grayling are known to occur. Large populations of mountain whitefish are known to utilize the lower Berland River. The lakes of the sub-basin (Gregg and Jarvis lakes, the smaller Wildhorse, Kinky, Cache, Graveyard, and Blue lakes) are well fished, especially Gregg and Jarvis, where northern pike and lake whitefish are taken.

Most of the anglers using the region originate in Edmonton, and evidence of over-exploitation of remote populations of such species as Dolly Varden in wilderness areas, due to substantial angling pressure, is beginning to emerge.

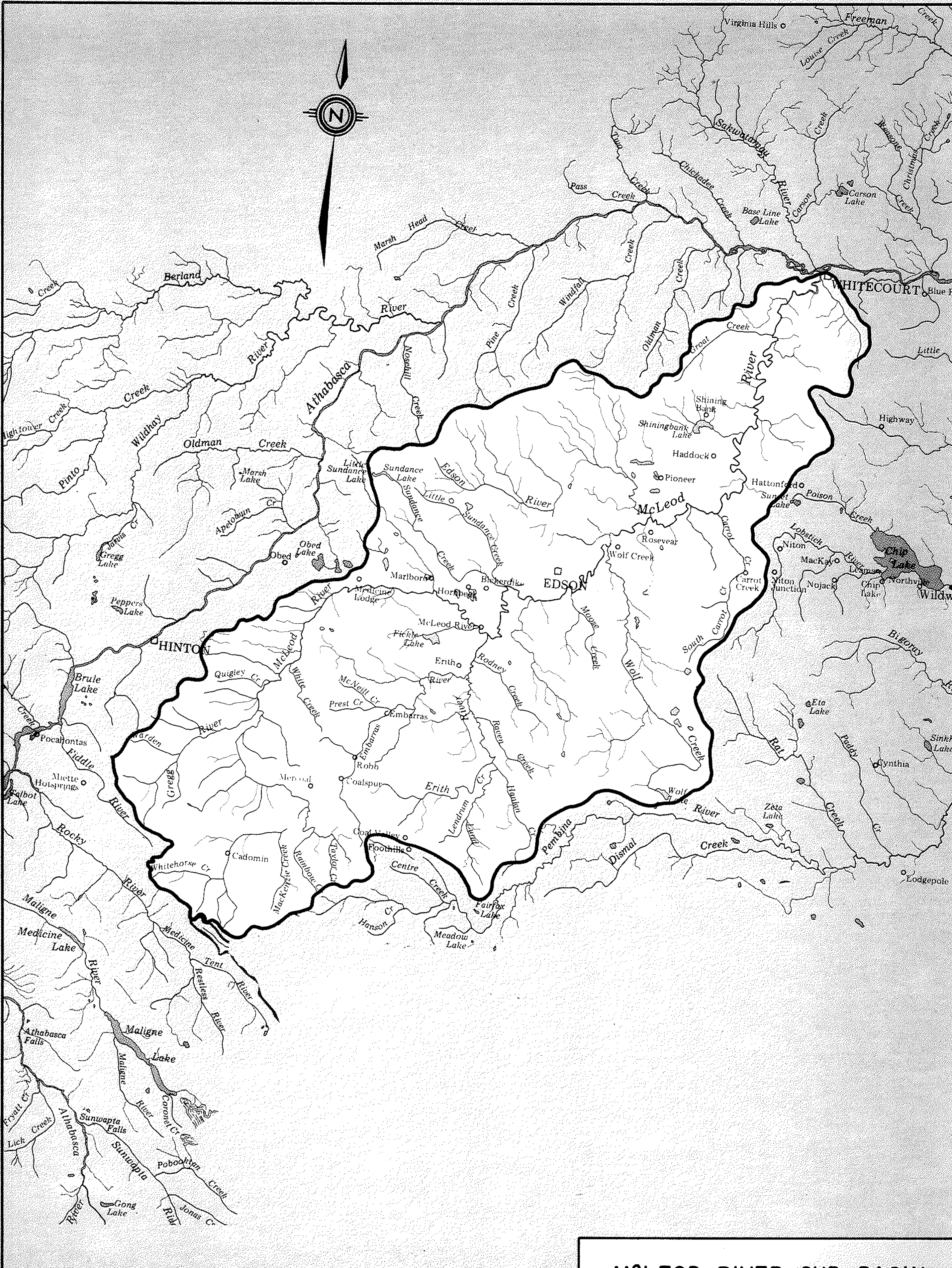
THE MCLEOD SUB-BASIN

The River Environment

The McLeod Sub-Basin, which is almost completely surrounded by the sub-basins of Jasper Park to the west, Athabasca to the north and east, and Pembina to the south, drains an area of 9,850 km^2 (Figure 5-5). The rivers of the sub-basin pass through two physiographic zones: the foothills and the interior plain. This separation causes two distinct runoff patterns in the sub-basin, since peak flows occur in May on the plains, and in July in the mountain foothills. Mineable coal deposits were early noted on the McLeod River near Hargwen, a discovery which later led to strip mining operations in the sub-basin.

In its upper reaches, the McLeod River is divided into two branches, the McLeod River and the Erith River. The McLeod River rises at an elevation of 1,800 m in the Nikanassin Mountain Range on the eastern boundary of Jasper Park. The Erith River rises toward the east, in the foothills region near Coalspur. The two rivers merge near the community of McLeod River, and flow northeast, as the McLeod River, to Whitecourt, where the McLeod forms a confluence with the Athabasca River at an elevation of 600 m. The basin of the McLeod River is bisected by Highway 16 (Yellowhead) which runs west from Edmonton to Edson and Hinton.

The upper tributaries of the McLeod River, which include the Gregg River and Whitehorse and MacKenzie creeks, are flanked by the Embarrass and Erith rivers to the southeast. The latter two merge near Erith, and subsequently join the McLeod mainstem near the community of McLeod River. The Sundance River, which drains Sundance Lake, joins the mainstem above Edson. Below Edson, the Edson River and Wolf Creek enter the McLeod.



McLEOD RIVER SUB-BASIN

FIGURE 5-5

The upland tributaries of the McLeod River are characterized by high gradients and clear, fast-flowing, cold water. Gravel substrates and riffles interspersed with pools typify the upper reaches of these streams. Further downstream, near the mouth of the McLeod River, the tributaries form meandering reaches, where the water flows in wide riffles over gravel substrates. The lower rates of flow in the lowland tributaries contribute both to increased water temperatures, compared with the high mountain values, and to enhanced biological productivity. In these streams, summer water temperatures range from an average value of 5.0 to 7.7°C to a maximum of 18°C. Leachate from the foothills landform, which constitutes most of the McLeod Sub-Basin, further provides for enhanced productivity. Based on 47 years' data, the mean dates for freeze-up and spring breakup in the McLeod Sub-Basin are November 4 and April 25, respectively (Kellerhals et al. 1972).

The Fish Population

The McLeod Sub-Basin embraces a wide spectrum of fish habitat, including coldwater highland tributary streams which typically support coldwater species. The upper reaches of the Gregg River, for instance, support a sizeable rainbow trout population (Hawryluk 1973), as do the adjacent MacKenzie Creek (Hawryluk 1974), and the more distant Spinx Creek (Alberta Fish and Wildlife Division, internal report). In the more easterly Edson River, rainbow trout make up the primary part of the sport fishery (Hawryluk 1976).

Early reports (Miller 1943, 1947) rated the fish production potential of the McLeod River as poor because of the relatively heavy silt load contributed by the lowland tributaries during spring runoff. The benthic productivity of the upland tributaries was also assessed as poor, and was judged to have led to the minimal success experienced in early stocking trials with trout. In subsequent work, Paetz (1953) concluded that much of the McLeod River was unsuitable as rainbow trout habitat.

Mercoal Creek is known to have some unstable banks and in many places, a lack of suitable spawning habitat. Nevertheless, brook trout have established themselves in this stream and it is rated as having good sportsfish potential. Access via the Coal Branch Road is good, and Dolly Varden, rainbow trout, and mountain whitefish have been reported there.

Sundance Lake contains a marginal population of northern pike and white suckers (Snyder 1971). Two tributaries, Little and Big Sundance creeks, are known for Arctic grayling and brook trout. Longnose suckers have been reported in the upper tributaries of the Embarrass drainage, as have northern pike and walleye. Arctic grayling occur in both the mainstem and the upper reaches of the McLeod River; rainbow trout and mountain whitefish are known to occur in the upland tributaries of the McLeod, Embarras, and Erith drainages. Mountain whitefish, which ascend the river at least as far as Mercoal in the late summer, provide fair angling.

Brook trout have been recorded in the upper reaches of the McLeod River near Whitehorse and MacKenzie creeks. Spoonhead sculpin occur throughout the length of the river, and brook sticklebacks have been recorded in its lower reaches near the Athabasca confluence. In the upper reaches of the McLeod River, burbot have been reported in the vicinity of Gregg River and Whitehorse Creek.

The lowland tributaries of the McLeod River are known to support northern pike, walleye, and mountain whitefish (R. Hawryluk, pers. comm., Alberta Fish and Wildlife Division, Edson) and a substantial, but unquantified, whitefish run is known to occur in the fall between mid-August and mid-October. In 1977, a major run of spawning mountain whitefish was observed in Lower Wampus Creek in the Tri-Creeks Watershed Study Area.

Arctic grayling spawn in early spring, with the adults moving into the tributaries to spawn, and then returning to the larger, lower-gradient main streams. Dolly Varden and mountain whitefish spawn in the fall in tributary streams over gravel or rocky substrates. Eggs hatch in March or April and, for the former species at least, young may remain in tributaries for up to three to four years. Rainbow trout spawn in riffles in June. The fry hatch within four to seven weeks, and remain in the streams, where they usually seek sheltered areas. In many tributaries of the McLeod River there is a disproportionate scarcity of older fish within rainbow trout populations, probably due to high angling pressure on slow-growing populations.

The Gregg River was surveyed in 1973 (Hawryluk 1973). The upper tributaries of this river lie in the lease area of Cardinal River Coals Ltd., and strip mining has altered the topography of that area. The study indicated that the upper reaches of the stream support approximately 250 rainbow trout per 1.61 km of stream, but that very few Dolly Varden and brook trout occur. As expected for such cold waters, growth rates were quite slow, with three-year fish averaging 13.2 cm in length and 32.4 g in weight. Heavy siltation has been reported in this river (Alberta Fish and Wildlife Division, internal reports), and this may have affected existing fish populations.

Preliminary surveys of the trout populations in the Tri-Creek Watershed (located approximately 40 km southeast of Hinton in the McLeod Sub-Basin) were done in 1965 and 1966. The three streams in the Tri-Creeks Watershed Study Area (Wampus, Deerlick, and Eunice creeks) all flow north, and empty directly into the McLeod River. Together, the three streams drain a total area of approximately 60 km^2. Dissolved oxygen concentrations in these streams are high.

Mean seasonal water temperatures are cool (5.1 to 7.7°C), and maximum water temperatures range from 12 to 18°C in July/August to 0°C in winter. Mean total dissolved solids range from 90 to 142 mg/L. These streams are typical of many pristine foothill streams which occur in the McLeod Sub-Basin, as well as throughout adjacent sub-basins.

The Tri-Creeks Watershed Study Area was established to gauge the effects of clear cutting and associated activities on aquatic fauna and water quality in the Tri-Creek Watershed streams, as it was thought these activities could affect sportsfish populations, particularly those of rainbow trout. Sportsfish angling has been prohibited in the three streams since 1965, and surveys have been regularly conducted by Fish and Wildlife personnel since 1971. Results of the research on the project are contained in a number of reports (Jablonski 1978a, 1978b, 1980; Stirling 1978, 1980; Stevens 1978; Bergstrom 1980) and represent an invaluable, continuous record of typical foothills streams subjected to renewable resource exploitation.

The predominant fish species in the Tri-Creeks Watershed is the rainbow trout. Mountain whitefish are seasonally abundant in the lower reaches of the Tri-Creeks streams, and a population of Dolly Varden inhabits the lower reaches of Eunice Creek. Movements of limited numbers of rainbow trout from the McLeod River into these tributary streams have been observed during the spawning season, as have localized instream movements of resident populations. Mature Dolly Varden return to the streams to spawn in early August and have been observed until mid-September, when the spawned-out fish drift back to the McLeod River. Immature fish return to the tributaries after wintering in the McLeod River. Foraging groups of mountain whitefish move up into the tributaries in spring and summer, and juvenile whitefish movement into the tributaries has been observed in late summer.

In the lower reaches of Eunice Creek, Withler (1980) noted that siltation of the gravel spawning beds had led to the disappearance of rainbow trout, though Dolly Varden were still common. In the absence of the highly territorial rainbow trout, the Dolly Varden reached higher densities than elsewhere in the watershed where trout predominate (Sterling 1978).

As would be expected for cold-water tributary streams, growth of trout is slow, with a maximum fork length of 200 to 250 mm in eight to nine years (Sterling 1978). Hunt (1981) presents an extensive discussion of age/growth correlations for fish species in exploited and non-exploited populations in the area.

In 1982, an extensive Phase II reconnaissance survey throughout the McLeod Sub-Basin was carried out by Fish and Wildlife Division personnel. Several tributaries near Hinton yielded information on existing fish species. Nice Creek (a tributary to Antler Creek) is reached by the Tri-Creeks Road. The stream has habitat suitable for spawning trout, and good bank stability (Seidel 1983). Earlier surveys by Mentz (1977), in which rainbow trout and mountain whitefish were captured, were reconfirmed, and the short (7 km) stream was judged to be moderately fished.

Nearby Wigwam Creek (on the Gregg River) had been extensively logged in the lower reaches and was subject to extensive erosion, chiefly at stream crossings, but nevertheless had excellent spawning and habitat potential. Rainbow trout were captured during the survey (Seidel 1982a). Burbot, mountain whitefish, and rainbow trout were found in McCardle Creek which was judged to have poor fish habitat. McPherson Creek was described as having good fish habitat (Seidel 1982b, 1982c).

Rainbow trout were reported for Erickson and Prospect creeks; rainbow and brook trout were found in Watson Creek (Seidel 1982d, 1982e, 1982f). Streams on the Embarras River section of the McLeod Sub-Basin, including Basil, Hay, and Lost creeks near the town of Robb, (Seidel 1982g, 1982h, 1982i) had moderate to good fish habitat. Rainbow trout was the primary sportsfish in Hay and Lost creeks; Basil Creek yielded burbot, pearl dace, longnose suckers, and white suckers. The Edson River drainage, which was extensively logged in the mid-1970's, has a sportsfish population composed chiefly of rainbow trout, though some mountain whitefish have been recorded (Hawryluk 1976b).

Extensive comparative data on fish and invertebrates throughout the McLeod and adjacent sub-basins are found in Anonymous (1980). The authors noted the susceptibility of Arctic grayling and Dolly Varden to both disturbance and angling pressure. They also noted that rainbow trout in the region reach sexual maturity at age three to four years, though length at maturity varies; and that mountain whitefish mature at age three years for males and four years for females, at lengths ranging from 190 to 230 mm.

Sport Fishing Opportunities

The major regional centre of Edson (Figure 5-5) lies near the middle of the McLeod Sub-Basin. The upper tributaries of the sub-basin supply localized fishing opportunities for sportsfishermen. Access is provided by a number of routes. Highway 16 (Yellowhead) bisects the McLeod River Basin, and Highway 47 follows the Embarras River toward its source. Much of the upper McLeod Basin is flanked immediately to the west by Highway 40, which eventually crosses the Athabasca River mainstem near Hinton, and both Gregg River and Warden Creek in the uplands. In combination, these highways provide virtually 360° of access to the streams of the McLeod Sub-Basin.

Fishing is reported throughout the sub-basin (R. Hawryluk, pers. comm., Alberta Fish and Wildlife Division, Edson). Little Sundance Creek is subject to heavy angling pressure, as it is a well-known, continuous producer of rainbow trout, brook trout, and Arctic grayling. The nearby Edson River is also known for good angling opportunities for rainbow trout. The upper reaches of the extensive Erith River system harbour Arctic grayling, and angling pressure ranges from moderate to heavy in that part of the sub-basin.

Hunt (1981) used the results of a survey of 30 streams in the Erith, Embarras, McLeod, and Pembina watersheds, in areas which had been subjected to industrial and angling pressure, to determine the species composition of the fish utilizing streams in these areas. The result of the analysis was as follows:

Rainbow trout	63%
Mountain whitefish	16%
Brook trout	15%
Arctic grayling	5%
Dolly Varden	1%

Hunt (1981) reported that, while the migratory habits of mountain whitefish and Arctic grayling may have biased the results shown, the low numbers of these two species in the survey "probably reflect their vulnerability to heavy angling pressure". It should be noted, however, that in this region, Arctic grayling thought to be close to the southern limit of their continuous distribution, although the Alberta record Arctic grayling is reported to have been caught in the Embarass River.

Shiningbank Lake undergoes sustained high angling pressure, and the Improvement District campground is well-utilized during peak fishing months. The lake has naturally occurring populations of walleye, northern pike, perch, lake whitefish, and minnows (R. Hawryluk 1975). Shiningbank Lake was commercially fished from 1947 to

1965; however, by 1975, the whitefish population had not recovered sufficiently to warrant a commercial season.

Fickle Lake, which has a Forestry Service campground, is also well used. The lake is a well-known source of lake whitefish, and also supports natural populations of walleye, perch, and northern pike. This lake was studied extensively throughout the 1960's (Alberta Fish and Wildlife Division, internal records) with respect to its whitefish population and the perch which had been stocked in it (1964). Commercially fished from 1942 to 1971 (Hawryluk 1976a), the lake is subject to considerable angling pressure.

Fickle and Shiningbank lakes, which have heavy angling pressure (Hunt 1977a), were removed from the schedule of lakes for commercial fishing in 1970 and 1965, respectively, after fish populations (chiefly lake whitefish) seriously declined.

Bear Lake has good access, is equipped with an Improvement District campground, and is angled for northern pike and perch. Long Lake has good road access, and is angled for northern pike. Lambert's Pond on the outskirts of Edson, has been regularly stocked with rainbow trout in 1952, 1960, 1961, and regularly since 1977. From 1977 to 1983, it was stocked annually, receiving 2,000 fish in 1982. Lambert's Pond functions primarily as a "children's pond", but also receives wide use from a broad segment of the local populace.

Mary Gregg Lake, which was first stocked with eastern brook trout in 1949, has been intermittently stocked since 1974. Miller's Lake was initially stocked with rainbow trout in 1952, and has received annual additions since 1978. The lake also supports a population of yellow perch. More recently, from 1981 to 1983, Peanut Lake has been stocked annually with rainbow trout, receiving 1,000 18 cm trout in 1982.

Availability of Alternative Sport Fishing Opportunities

The McLeod Sub-Basin is bordered to the north by the Athabasca and Berland sub-basins, with their attendant sportsfish capabilities. Within Jasper Park Sub-Basin to the west, and the Pembina Sub-Basin to the east and southeast, ample recreational and sport fishing opportunities occur. Access from the primary population centre of Edson is excellent throughout the region via Highways 16 (Yellowhead), 47, and 32. Extensive forestry operations and seismic lines, provide forestry road access to areas outside the McLeod Sub-Basin. Primary alternative locations are Obed Lake (rainbow trout), Eccles Pond (rainbow trout), Emerson Lake (brook trout), and Pedley Reservoir (rainbow trout).

Water Quality

The McLeod Sub-Basin exhibits two distinct fish habitat types: clear, cold fast-flowing waters in the upper tributary reaches of the foothills; and muddy substrates, warmer waters, and slower flows in streams nearer the Athabasca River confluence.

The upland tributaries are characterized by good bank cover and high dissolved oxygen levels (11 mg/L). Most of these streams are low in sediment, although heavy siltation has been reported in the Gregg River, which has been affected in some reaches by coal mining operations. The water quality of many unaltered foothills streams in the area is best reflected by data from the Tri-Creeks Watershed Study (Jablonski 1980).

Water quality data are available for the lowland McLeod Sub-Basin from a sampling station (AG2120) near Whitecourt for the years 1965 to 1976. Over that period, total dissolved solids ranged from 161 to 273 mg/L, and pH from 7.4 to 8.5. Total alkalinity (as $CaCO_3$) ranged from 129 to 350 mg/L, and turbidity values from 1 to

37 JTU. Anonymous (1980) reported alkalinity values in these waters that ranged from 40 to 209 mg/L.

Water Quantity

No major diversions are known or planned for the McLeod Sub-Basin, though minor diversions for rail or road access have been carried out. The first 80 m of Hay Creek have been altered by railway construction, and forestry and mining roads occur throughout the sub-basin. In the vicinity of the Gregg River, coal strip-mining operations have substantially altered both the topography and drainage patterns of the area. In 1980 and 1982, heavy rains throughout the sub-basin led to flooding around the Robb, Coal Branch, Cadomin, and Tri-Creeks Watershed areas. Floods were sufficiently severe to cause disruption of spawning habitat utilized by trout.

Nine years' data summarized by Kellerhals (1972) demonstrate the variability in flow within the McLeod Sub-Basin. At a station upstream of the Embarras River, maximum-minimum recorded flows in the McLeod River ranged from 1.0 to 896 m^3/sec, with a mean value of 20.2 m^3/sec. About one half the total seasonal streamflow in the sub-basin is derived from a combination of snowmelt and mixed rain and snow falling in May (Anonymous 1980).

Environmental Problems

1. Arising from Natural Causes

The siltation characteristics of the lowland tributaries of the McLeod Sub-Basin, which have mud banks and river bottoms, limit productivity in those streams. In general, the habitat is unsuitable for sportsfish (Paetz 1953). Mercoal Creek, in particular, has unstable banks and a lack of suitable spawning habitat.

2. Arising from Water Management Practices

None known.

3. Arising from Other Sources

Other sources of impact in the McLeod Sub-Basin are associated with forestry, mining, industrial development, and domestic sewage disposal. Environmental concerns associated with these activities are discussed below. Forestry is the major industry in the McLeod Sub-Basin, and the area is known to have experienced impacts associated with forestry activity. Erosion, coupled with increasingly severe runoff in forested areas, has led to bank instability, channel alteration, flooding, and streambed siltation.

Detailed studies have been carried out on the effects of road crossings on streams within forested areas in the Edson-Hinton region (Rothwell 1979). It has been noted elsewhere (Anderson et al. 1976) that as much as 90% of the erosion and produced sediment arises from the construction of roads, particularly those which cross streams. At stream crossings, water collecting on road surfaces and in ditches can flow into streams, carrying heavy loads of sediment with it. Peak erosion and sediment introductions occur during snowmelt or intense rainstorms. These effects are heightened in areas where the surrounding soil has been disturbed, or where road gradients are extremely steep. Rothwell (1979) presented data from 40 stream crossings, most of them within the McLeod Sub-Basin, in the Hinton area. These data indicated an average sediment production of 29 kg/day during periods of fair weather, rising to an average of more than 10 times that value during a storm that produced 6.25 cm of rainfall. Peak values of sediment production ranged as high as 14,500 kg/day.

Hawryluk (1976b) documented the impact of sedimentation in the Edson River on rainbow trout populations. Many of the problems resulting from siltation were attributed to the numerous stream crossings for logging roads constructed within the watershed. Luscar Creek was found to be affected by coal dust and iron particle pollution from a nearby coal mining interest (Lane 1972), especially during periods of heavy runoff as a result of snowmelt or rainstorms.

The Forest Management Area in the McLeod Sub-Basin is supported by extensive networks of roads, including both haul roads and access roads. These roads have been described as having erosion problems, on average, every 13 km (Schultz 1973, Rothwell 1979). Many of these problems occur at road stream crossings. Erosion frequently occurred along the main haul roads, particularly those with extensive soil exposure, steep slopes, and erodable soils (Packer 1967). Rothwell (1979) noted that sediment production is greatest during and following road construction, decreasing within three to five years if revegetation is successful. That author also documented some cases of extreme sediment deposition at road crossings equipped with culverts, one of which resulted in sediments 30 cm deep being deposited for a distance of 1,000 m in the streambed below the crossing. He noted that a brush mulch treatment applied at road-stream crossings was more effective in controlling such erosion and sediment than direct seeding to bare soil. The treatment, however, is only a temporary measure used to provide protection from significant erosion for one to two years, until a good vegetation cover is established (Rothwell 1979).

Coal operations at Cadomin (Cardinal River Coals) and Mercoal have significantly altered topographic features in some areas, chiefly in the upper Gregg River tributary region where heavy siltation has been reported. Forest Product operations require haul road access for the transport of timber through the sub-basin, and oil and gas exploration, pipelines, and associated developments further contribute to impacts.

This continuous industrial activity has opened up large areas of previously inaccessible fish habitat, allowing increased angling pressure on streams throughout the region (Hunt 1977). The effects of road access construction were demonstrated by the Tri-Creeks Study (Jablonski 1980). Following construction of an access road in 1974, the mean seasonal concentration of suspended sediments increased from a mean (10 year baseline) concentration of 8.2 mg/L in Deerlick Creek to six times that value in 1976.

The Coalspur region of Alberta has recently been the subject of several detailed literature reviews and field studies sponsored by mining interests (Withler 1980, McCart et al. 1982, Grant and McCart 1982). These areas overlap the McLeod Sub-Basin, and the reports contain summaries of the fish and benthic invertebrates found there. Previous reports have also reviewed the available data on aquatic and terrestrial resources in the region. These data are far too numerous to be summarized from these reports for inclusion in the present overview; however, the reports contain, or confirm, data noted herein on fish habitat type and distributions.

Sedimentation and blocked fish passage remain the primary concerns for protection and maintenance of fish habitat. Blocked and eroded culverts have the potential to destroy entire spawning populations of migratory species (Arctic grayling, mountain whitefish) which are sought after by sport fishermen in the sub-basin (Hunt 1977).

The long-term influence of domestic sewage outflows to the McLeod Sub-Basin has not been studied or documented, but the enhanced nutrient flows (chiefly from the Edson outflow into the McLeod River) undoubtedly contribute to increased primary productivity for portions of the watershed.

Data Gaps

Populations of fishes in selected key tributaries (eg. Sundance Creek) need to be surveyed more accurately, and key spawning and overwintering habitat need to be carefully documented within the McLeod River Sub-Basin. The pressures from angling need to be thoroughly studied throughout the basin, so existing quotas and management practices can be assessed. The reader is referred to the excellent discussion in Hunt (1981) on the applicability of current angling regulations to the coldwater streams of the Eastern Slopes region.

Monitoring of the sewage outflows from major population centers on the McLeod River (chiefly Edson) needs to be implemented, particularly as these outflows may ultimately affect resident or migratory fish populations. Stream inventories should be extended to provide Phase II studies on all major streams in the sub-basin and long-term Phase III studies on many others. In this respect, the Tri-Creeks Watershed Study, which forms a vital component in providing a scientific base for protection and management of sport fishing habitat in the region, should be continued or expanded.

Areas of intense logging activities could be studied with a view to reconstructive techniques for habitat and to developing standards for prevention of habitat damage in future forestry operations.

Fisheries Management Strategies

The fisheries management objective for the McLeod Sub-Basin is to maintain native fish populations at maximum population levels through natural reproduction, water and habitat quality maintenance and habitat and fish population enhancement for recreational fishing.

Summary

Habitat damage in portions of the McLeod Sub-Basin resulting from forestry and mining operations is, at times, pronounced. In the past, practices associated with logging road stream crossings have caused significant stream siltation, and the effects of vegetation removal (eg. increased stream temperatures, siltation, and runoff) have contributed to a general deterioration of fish habitat within the basin.

The upland tributaries of the McLeod River Sub-Basin could be maintained as significant sport fishery areas. The upper reaches of Groat Creek reportedly contains abundant rainbow trout, and Carrot Creek and Trout Creek are known for Arctic grayling. The lower McLeod has produced notable walleye catches, and supports an abundant mountain whitefish population. Indeed, the area could be tested as a development area for enhanced fishery operations. The Tri-Creeks Watershed Study area provides an almost ideal base of long-term data upon which such enhanced research and operational programs could be predicated.

VI THE CENTRAL SUB-BASINS (PEMBINA AND LESSER SLAVE)

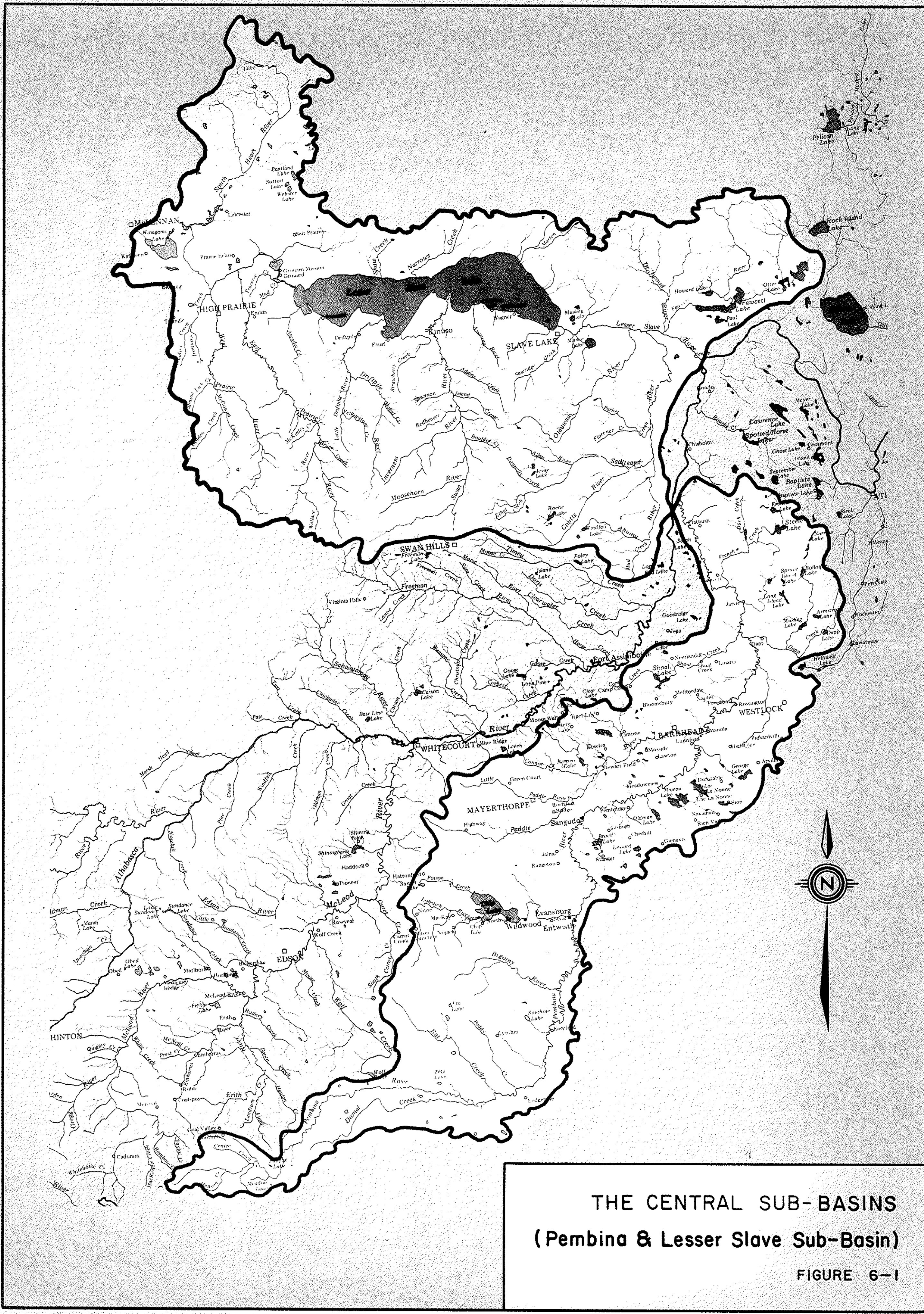
OVERVIEW

For the purposes of this report, the two central sub-basins of the Athabasca Basin are designated the Pembina and Lesser Slave sub-basins. Together, these two sub-basins drain an area of Alberta in excess of 34,000 km^2, of which the Pembina Sub-Basin drains 14,300 km^2, and the Lesser Slave Sub-Basin drains 20,600 km^2 (Figure 6-1). Each of the sub-basins is unique within the Athabasca and contributes elements of the diversity in land form and habitat type which typifies the Athabasca Basin.

The Pembina Sub-Basin is the most populous, industrialized, and agriculturally active sub-basin in the Athabasca system. Arising from a source in the eastern edge of the Front Ranges at 1,800 m elevation, the Pembina River flows eastward through the foothills and across the Interior Plains, to a confluence with the Athabasca River at 570 m above sea level.The bedrock beneath the Pembina Sub-Basin is Wapiti Formation sandstone. Neither substrate type is a prolific producer of groundwater.

The Lesser Slave Sub-Basin is the largest sub-basin within the Athabasca River system, and the lake is the second largest in the province (surface area of 1,200 km^2), after Lake Athabasca in the extreme northeast. The Lesser Slave Sub-Basin is underlain by shales, so only shallow-bored wells into buried channels or sand lenses provide groundwater.

In the past 20 years, agricultural development and hydrocarbon production (chiefly oil, but more recently sour gas) have significantly affected both sub-basins. Within the Pembina Sub-Basin, there are vast oil resources. Most fields here are already in production, and secondary or tertiary oil recovery techniques are increasingly employed to bring the reservoirs to complete production. Groundwater resources are increasingly used in these processes, and,



THE CENTRAL SUB-BASINS
(Pembina & Lesser Slave Sub-Basin)

FIGURE 6-1

should needs expand, surface waters could also be required for this use.

Over the past 20 years, agricultural development and oil exploration have also grown significantly in the Lesser Slave Sub-Basin. In this sub-basin, flood control is a major problem. The intense storms which develop in the Swan Hills cause flash floods, which overflow streams and lead to downstream drainage problems.

The western edge of Lesser Slave Lake is very flat, and even modest flows in this marshy terrain often lead to flooding. Indeed, the probability of flooding occurring at any place around the lake is 20%. The topographic characteristics of the lake reveal why this should be so: the Lesser Slave River is 75 km long; however, the highly sinuous region in its upper half has a gradient of only 0.095 m/km. The swollen tributary streams empty, during the spring freshet, into the lake; however, since water cannot escape at an equivalent rate through the very level Lesser Slave River, the lake level rises and frequently floods areas above the 576.68 m contour (the level above which flooding is deemed to have occurred).

This same capacity for storage of water, however, allows the lake to act as a large reservoir, naturally regulating streamflow leaving the sub-basin to flow into the Athabasca River.

The Pembina Sub-Basin is characterized by a wide variety of fish habitats.

In the upper reaches of the Pembina Sub-Basin, rainbow trout are the most abundant and widespread sportsfish. Though rainbow trout are probably native to the Athabasca Basin (Scott and Crossman 1973); many, if not all, of the populations of this species inhabiting the Pembina, Embarras and McLeod watersheds are the result of stocking programs.

Although generally sparsely distributed, except in localized areas, northern pike probably contribute most to the annual catch for anglers on the Pembina River with, as might be expected, most occurrences recorded at the confluence of the Athabasca. Overall, the habitat offered by the river is marginal for pike.

In terms of angling effort, walleye represent the principal gamefish in the mainstem of the Pembina River, and most of the effort is directed to areas where concentrations are, or have been, known to occur. Walleye are most abundant in the lower reaches (Sangudo to Flatbush) of the Pembina, especially in those reaches possessing good-quality pools. Pools in the upper reaches are probably of a quality capable of supporting walleye; however, low summer and winter flows may limit the habitat quality of these areas.

Anglers concentrate their efforts at the confluences of the Lobstick, Paddle, and Athabasca rivers, which are the points of abundance for walleye. Anonymous (1971) indicated substantial walleye populations were found at the Pembina-Athabasca confluence, one specimen of which weighed 1.84 kg. The 1960 record was a walleye weighing 6.3 kg, taken in the Pembina River. Nevertheless, the river probably does not support a large walleye population throughout its total length. Those individuals that do occur concentrate in selected, prime habitat areas.

Anglers have reported occasional catches of mountain whitefish at the Pembina River confluence with the Athabasca River; however, these reports are infrequent. Surveys indicate the presence in the Pembina River of walleye, Arctic grayling, longnose and white suckers, spoonhead sculpin, mountain whitefish, brown trout, Dolly Varden, goldeye, northern pike, rainbow trout, burbot, trout-perch, longnose dace, lake and flathead chub, and trout-perch (Anonymous 1981, 1982; Alberta Fish and Wildlife Division, unpublished data).

The Lesser Slave River ranges from 20 to 50 m in width, and has generally stable banks over most of its length. The river harbours mountain whitefish, Arctic grayling, northern pike, walleye, goldeye, suckers, burbot, spottail and emerald shiners, perch, trout-perch, and brown trout. The river represents a transition zone--fish common to both warmwater and coldwater aquatic habitat are found here. Of the coldwater species, mountain whitefish are probably the most numerous, although brown trout are also present. Pike, walleye, and perch make up the warmwater species. In many respects, the fish populations of the Lesser Slave River are intermediate between those of the much larger Athabasca River and Lesser Slave Lake.

The Lesser Slave River is well-utilized by anglers in spring, and, to a lesser extent, over the rest of the year. Areas exploited include both the east and west ends of the lake, Dog Island, and Canyon Creek. The mouth of Swan River is heavily angled in June due to the concentration of walleye which occurs there. Other early studies on the South Heart River (Hartman 1957) found that, although there was not a large resident pickerel population in the river, there appeared to be a general movement upstream by the species for spawning near the confluence of the Heart and Prairie rivers.

Lesser Slave Lake is a large, but rather shallow, central Alberta lake which has provided a commercial fishery for four fish species in the last half-century. Unfortunately, the history of the fishery has been somewhat uneven (Handford et al. 1977), with lake whitefish and walleye being the last remaining commercially fished species. The commercial fishery of Lesser Slave Lake is well-developed and of major significance in Alberta. This fishery has focused primarily on whitefish, although lake cisco was the second most important commercial species until the 1960's, when the lake cisco populations in the lake declined. The Buffalo Bay region at the western extremity of Lesser Slave Lake is noted for its walleye run in spring and is easily accessible to fishermen.

Arctic grayling, the major sportsfish of the Swan River system is well-distributed throughout many tributaries of that river. In the Swan River itself, however, the lake chub is the most abundant fish species (Berry 1978), and is common throughout the system as well. Lake chub spawning was observed in the river in early June. Rearing also appears to occur there and throughout the tributaries. Although a few lake whitefish occur in the upper Swan River, northern pike and walleye occur only in the lower part of the Swan River system. Trout-perch, spottail shiners, emerald shiners, and yellow perch are also found in the lower reaches of the system.

Angling licence sales for the Pembina and Lesser Slave sub-basins totalled 9,498 in 1980/81, 3.2% of the licences sold in the province during those years (Table 3-3).

Since these sub-basins have not been extensively studied for their recreational fisheries potential, the development of future fisheries management strategies to maintain or enhance fish production will require further data, particularly in the following areas:

- Species distributions, occurrences, and movements of fish

- Limiting effects of water quality and water management programs on fish production

- Recreational use of fish populations throughout the central sub-basins.

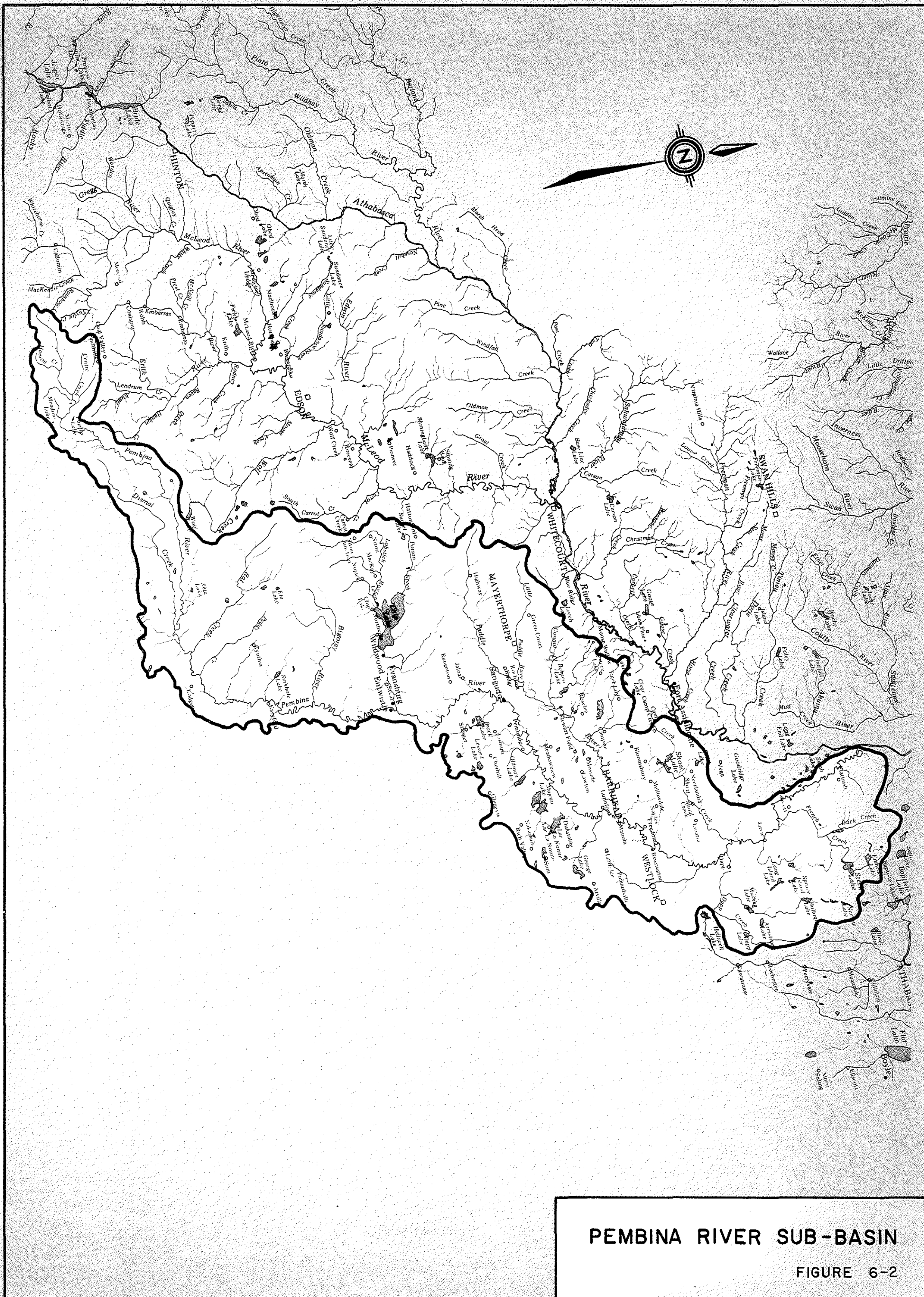
THE PEMBINA SUB-BASIN

The River Environment

The Pembina Sub-Basin developed as an ice marginal channel, which formed during the retreat of the Marlboro glacier at the end of the last glaciation. Draining an area of 14,300 km^2, the Pembina is the most developed and populous sub-basin within the Athabasca drainage (Figure 6-2).

The Pembina River receives its headwater flow from elevations as high as 2,393 m on Redcap Mountain, and flows northeast through the foothills and across the plains, to enter the Athabasca at an elevation of 570 m above sea level. The gradient of the upper reaches of the river is steep; that which occurs in the lower reaches (near Barrhead) is much shallower. The plateau-type geography in the lower part of the sub-basin causes frequent flooding in the Pembina River and its tributary, the Paddle River. As a result, the dominant characteristic and form of the sub-basin is that of an alluvial plain. In the lower sections, numerous oxbows occur, arising over lacustrine deposits in the relatively flat topography.

Major tributaries, from the headwaters of the Pembina River to its confluence with the Athabasca, include the following streams: Dismal Creek, the Bigoray River, the drainage from Chip Lake (entering at Evansburg), the Paddle River (entering near Barrhead) and Shoal, Dapp, and French creeks (Figure 6-2). Hunt (1977) prepared a summary listing of all the primary lakes in the sub-basin (66 lakes in total, all but 16 unnamed) which make up a total lentic area of 9,105 ha. Though shallow (approximately 3 m), Chip Lake is the largest (6,926 ha) single waterbody in the sub-basin, representing approximately 76% of the total lake surface area.



PEMBINA RIVER SUB-BASIN

FIGURE 6-2

The Pembina River and its tributaries embrace a wide variety of fish habitat, ranging from cold, clear-running, rocky, gravel-cobble mountain brooks to slow, warmwater, oxbows with eroding banks and silty substrates. Many small pothole lakes surround the much larger Chip Lake, again presenting a wide range of lacustrine fish habitat.

In the highland region of the watershed, aquatic habitats in Centre Creek (a swift-flowing stream with a high pool-riffle ratio) are known to have a much greater suitability for populations of coldwater sportfish than those of the Lovett River. The stream has a greater mean gradient and its waters tend to be faster flowing (Graves et al. 1975). Banks are stable, waters are clear, and there is a relatively high pool-riffle ratio. Other tributaries to the Pembina River are clean, brownwater streams with rocky substrates. Crooked Creek, which is a high-gradient stream, flows parallel to the Pembina River in the Coalspur Lease area, and merges with the Pembina further downstream. Crooked Creek has an average width of 5 m, and is shaded by alder, willow and spruce over most of its length, as are adjacent tributaries. By contrast, the Lovett River rises in a muskeg headwater, is low-lying, and flows primarily through slow reaches with eroded banks (Withler 1980).

While the upland areas of the Pembina River are fairly well forested, the lower reaches (from Sangudo to Fawcett) receive intensive agricultural use. A survey carried out in 1971 (Anonymous 1971) from the mid-upper reaches of the Pembina River (near Easyford, just upstream of the Bigoray River confluence) to the mouth of the Pembina (past Flatbush) defined six gradient zones, four of which occurred between Easyford and Sangudo. Habitat analyses for fisheries potential indicated that diversity of habitat declined with distance downstream, with up to 98% of the total surface area in the lower reaches characterized by low-quality pools, a silt-sand substrate, and sandbars. These factors, combined with light to moderate siltation and turbidity, significantly reduce stream productivity in downstream areas. In the higher-gradient reaches near Easyford, low mean flows and subsequent heavy siltation also result in relatively low water quality and fish habitat. Where they occur, pool-riffle habitat areas provide more favourable environments.

High-elevation streams generally provide much more suitable sportfish habitat than low-elevation streams. This is evidenced by the benthic invertebrate populations in the upland tributaries (Anonymous 1971) which support a rich macrobentic population of typically clean water species (Ephemeroptera, Plecoptera and Trichoptera). Measures of diversity included 13 genera for Ephemeroptera, 7 for Plecoptera, and 6 for Trichoptera. Abundance and diversity for these species were highest in the upland tributaries where coarse rubble substrates and high current velocities were more common. At the sites examined, current velocity was thought to have been a major determinant in preventing siltation.

The sporadic occurrence of high-quality riffles throughout the drainage results in localized distribution of suitable habitat, and hence of aquatic invertebrates and fishes. A lack of submergent macrophytes in many potentially suitable sections of the Pembina Sub-Basin is thought to limit the spawning, rearing and feeding success of northern pike. The cause of the relatively poor machrophytic communities is, in part, linked to the fluctuating discharge, the sustained turbidity, and, in places, the severe siltation which occur in the Pembina watershed.

The lower-gradient sections between the Paddle River confluence to the Athabasca River confluence do not provide habitat suitable for sportfish, and are characterized by a low habitat diversity and an unproductive, silt-sand substrate.

Throughout much of its length, the Pembina River has considerable aesthetic appeal, which enhances its ultimate recreational and potential value. However, extensive deforestation in the upper reaches, and extensive grazing of cattle along riverbanks have led to some deterioration of the area. If these practices are allowed to continue, the aesthetic potential will continue to deteriorate.

The potential for recreational use of the Pembina River should not be underestimated. In spite of intensive industrial oil field developments, agricultural use, and significant urbanization within the sub-basin, the proximity of the population centers at Whitecourt, Mayerthorpe, Barrhead, Westlock, Fort Assiniboine, and Edmonton make the Pembina Sub-Basin a potentially valuable recreational resource for future development and management programs for fisheries and wildlife.

The Fish Population

Variations in discharge, and, in some places, high turbidity and associated excessive siltation, reduce the quality of habitat in much of the Pembina Sub-Basin for all game fish species. On the basis of earlier studies (Anonymous 1971), only limited reaches of the streams in the sub-basin are capable of a significant sport fishery. Where favourable habitat areas do occur, however, the potential for good-to-excellent angling success is substantial.

In the upper reaches of the Pembina Sub-Basin, rainbow trout are the most abundant and widespread sportfish. Although rainbow trout are probably native to the Athabasca Basin (Scott and Crossman 1973); many, if not all, of the populations of this species inhabiting the Pembina, Embarras and McLeod watersheds are the result of stocking programs. Brook trout, which have been established entirely by stocking, also flourish in these cold, tributary waters. These two species may be responsible for restricting, or perhaps even reducing, the distributions of two native salmonid species, Arctic grayling and Dolly Varden. While the native species are highly sought after sportfishes, they are relatively poor competitors for food and habitat.

Scott and Crossman (1973), McPhail and Lindsey (1970) and Paetz and Nelson (1970) provide information on the life histories of fish species in the area. Clifford (1978) gives a valuable summary of the invertebrates in the brownwater Bigoray system. Among the sportfishes, rainbow trout, Arctic grayling, pike, and walleye spawn in spring or early summer. Dolly Varden, brook trout, and mountain whitefish are all fall-spawners. In general, these salmonid species use silt-free, well-oxygenated gravel substrates for spawning; but stream depth and flow, water temperature, and substrate size preferences vary among species.

In the upper tributaries of the Pembina Sub-Basin, the excellent water quality is exemplified by the presence of Arctic grayling (Paetz and Nelson 1970, Anonymous 1971). One of the best-studied brownwater streams in Alberta, the Bigoray River is known to support Arctic grayling, as are other upland tributaries (eg. Rat Creek) (Cunningham 1961). Substantial populations of this species are unlikely to occur in the sub-basin, however, as most of the habitat conditions are unsuitable.

In a reach extending from Easyford at the outflow from Sinkhole Lake, downstream to a point below Entwhistle (Figure 6-2), Anonymous (1971) documented extensive distributions of mountain whitefish in areas of favourable habitat. This study area was characterized by numerous riffles, which provided the highest percentage of fish habitat in the sub-basin at that time. Substantial whitefish populations were reported in this area, with other lesser occurrences noted in the river section downstream of that point. Turbidity and substrate siltation probably accounts for the progressively decreasing numbers of sportfish in the Bigoray River.

Anglers have reported occasional catches of mountain whitefish at the Pembina River confluence with the Athabasca River; however, these reports are infrequent. Surveys indicate the presence in the Pembina River of walleye, Arctic grayling, longnose and white suckers, spoonhead sculpin, mountain whitefish, brown trout, Dolly Varden, goldeye, northern pike, rainbow trout, burbot, trout-perch, longnose dace, lake and flathead chub and trout-perch (Anonymous 1981, 1982; Alberta Fish and Wildlife Division, unpublished data).

In terms of angling effort, walleye represent the principal gamefish in the mainstem of the Pembina River, and most of the effort is directed to areas where concentrations are, or have been, known to occur. Walleye are most abundant in the lower reaches (Sangudo to Flatbush) of the Pembina, especially in those reaches possessing good-quality pools. Pools in the upper reaches are probably of a quality capable of supporting walleye; however, low summer and winter flows may limit the habitat quality of these areas.

Anglers concentrate their efforts at the confluences of the Lobstick, Paddle, and Athabasca rivers, which are the points of abundance for walleye. Anonymous (1971) indicated substantial walleye populations were found at the Pembina-Athabasca confluence, one specimen of which weighed 1.84 kg. Nevertheless, the Pembina River probably does not support a large walleye population throughout its total length. Those individuals that do occur concentrate in selected, prime habitat areas.

Anonymous (1971) also found substantial populations of goldeye in the lower reaches of the Pembina River, particularly at the Athabasca confluence, with some individuals occasionally occurring as far upstream as the Lobstick River confluence.

Although generally sparsely distributed, except in localized areas, northern pike probably contribute most to the annual catch for anglers on the Pembina River with, as might be expected, most occurrences recorded at the confluence of the Athabasca. Overall, the habitat offered by the river is marginal for pike. The lack of established macrophyte communities in the Pembina may present significant limits to spawning, rearing, and maintenance of this species.

Longnose suckers are the most abundant non-game fish in the Pembina Sub-Basin. This species prefers the faster waters of riffle areas. Next in abundance, white suckers exhibit more localized distributions, and tend to prefer quiet, deep pools.

Sport Fishing Opportunities

As noted above, anglers have traditionally concentrated their efforts in selected areas of the Pembina Sub-Basin. Though the upland tributaries are exploited, the primary angling areas are at the confluences of the Athabasca, Lobstick, and Paddle rivers.

Early reports (Cunningham 1959) noted the decline of the Arctic grayling populations, probably due to over-fishing, in streams surrounding the Chip Lake-Cynthia area. These streams had been known to support good populations of Arctic grayling as had Rat Creek, further to the west (Cunningham 1961).

Some of the earliest Alberta fisheries surveys were conducted on the Lobstick River and its tributaries (Anonymous 1948, Miller and McDonald 1949), and many of the streams surrounding the Chip Lake region were then known for some sportfish capability, including grayling (Turner 1949). Similarly, the Bigoray was early recognized for some natural sportsfish (Arctic grayling, pike) potential (Thomas 1956). The Pembina River, because of its proximity to many population centres and excellent access throughout its length, is heavily fished. Similarly, the Paddle River is heavily exploited, chiefly for walleye, pike, and, occasionally, grayling.

Crooked Creek and Centre Creek are accessible in their lower reaches and are fished for brook trout, grayling, mountain whitefish, Dolly Varden, and brown trout, although populations of the latter have been reported as suffering from siltation and a lack of riparian vegetation (Hawryluk 1975). The Lovett River is known for its rainbow trout, eastern brook trout, Arctic grayling, and longnose and white suckers (Withler 1980). Lac La Nonne is known for its populations of walleye, perch, and pike. Many Edmontonians use summer cabins at the locale for sportfishing recreation.

Chip Lake (area 6,926 ha, maximum depth 3 m) has had a viable pike fishery (Lynch 1971), and has populations of white suckers and burbot. Though periodic winter kills (1958 and 1964) have been noted (Alberta Fish and Wildlife Division, internal memo), pike were transplanted from the lake in 1979 and 1980 to augment existing populations in Minnow and Surprise lakes. Hunt (1977) analysed commercial fishing records for Chip Lake from 1942 to 1976 (34 years, of which 32 years had been fished) and rated the mean annual production of pike as 11,799 kg during that time. More recent records (Appendix C) indicate that the issuance of commercial licences dropped from three to zero from 1979 to 1983, and landings of pike declined from 6,681 kg in 1975 to 630 kg in 1982. In the latter year, walleye and goldeye landings amounted to 42 and 308 kg, respectively, for a total commercial landing of 980 kg in 1982. While there is a little potential for recreational/ commercial conflict in Chip Lake, the low prices and poor demand for pike, resulting from the decline in mink ranching, have led to a proportionate decline in the fishery there.

Stocking programs for rainbow and/or eastern brook trout have been carried out in Fairfax Lake (Hawryluk 1972a, 1972b), Narrow Lake (MacDonald 1964), and Ruxton's Lake (Thomas 1955). In 1982, 40,780 yellow perch were stocked into Chip Lake. Both pike and perch have been stocked into Wolf and Minnow lakes.

Mountain whitefish (and probably Dolly Varden) spawn in Dismal Creek. The stream is an important spawning area for these two fall-spawning species, though not for spring-spawners. It is probable that Dismal Creek is also a summer rearing area for mountain whitefish fry, and a spring migration route for Arctic grayling (Dickson and McCart 1981).

Mountain whitefish are widely distributed throughout the Lovett River. This species is the most abundant coldwater fish in the upper reaches of the Pembina River, the Lovett River, and Coal Creek. In the Lovett River, grayling constitute as much as 20% of the overall catch (Graves et al 1975). Brook trout are reported for Centre Creek, a stream which has a favourable environment for the species, and a resident population is thought to have developed there (Graves et al 1975). Longnose sucker and spoonhead sculpin are common, and are widely distributed throughout the Lovett River drainage.

Among the tributaries, Centre Creek has the highest fishing potential, especially since brook trout appear to have become established there. In terms of total fish fauna, however, the upland tributaries of the Pembina River appear to be of only low to moderate productivity (Graves et al 1975).

Access to the Pembina Sub-Basin from the major population centers of Edmonton and Drayton Valley is facilitated by Highway 16 (the Yellowhead) and Highway 22, respectively. The lower reaches of the Pembina River are completely ringed by highways, including numbers 753, 621, 22, and 16. The latter crosses the Pembina at Entwhistle, and skirts the southern edge of Chip Lake just west of that point.

The mid to upper portions of the sub-basin are far less accessible by year-round provincial highways, though Highway 40 crosses the headland streams of the McLeod Sub-Basin, Hanson and Centre creeks in the Pembina Sub-Basin, and the Brazeau River in the North Saskatchewan drainage.

Availability of Alternative Sport Fishing Opportunities

Several lakes within the North Saskatchewan drainage provide alternative recreational opportunities close to the Pembina Sub-Basin. These include Wabamun, Isle, Lac Ste. Anne and Devil's lakes. Some, such as Chickacoo, Hasse, and Star lakes have been stocked with rainbow trout. Other nearby lakes include Thunder Lake, which has been stocked with pike; Steele Lake, which has been stocked with perch and pike; and Dolbert and Peanut lakes, both of which are stocked with rainbow trout. Streams in the McLeod and Berland sub-basins are easily accessible from the Mayerthorpe-Barrhead region of the Pembina, as are those streams (eg. the Freeman River) draining the Swan Hills region.

Water Quality

Although water quality in the upper reaches of the Pembina Sub-Basin is known to be high, game fish capability deteriorates rapidly with distance downstream. The maximum sustained temperature for coldwater game fish (salmonids and mountain whitefish) is 20°C. During the summer, this temperature is frequently exceeded for substantial periods in the mid to lower reaches, where maximum values have been known to reach 28°C (Anonymous 1971). These extremely high temperatures would limit the distribution and occurrence of salmonids throughout the watershed. The 17-year mean for freeze-up in this sub-basin is November 3; the mean date for breakup is April 21 (Kellerhals et al. 1972).

The habitat of the Pembina Sub-Basin is suitable for walleye, northern pike, goldeye and other warmwater species; however, sustained high flows in the spring and low flows in winter, combined with high turbidity and siltation levels contribute to limited fish productivity. The latter factors are probably increasingly influenced by agricultural land use in the basin.

In the upland tributaries of the sub-basin, total alkalinity (as $CaCO_3$) ranges from 40 to 209 mg/L, and total hardness ranges from 27 to 215 mg/L. Short-term, heavy rainfall often results in elevated turbidity values in headland streams, although Centre Creek has been documented as remaining relatively clear even under high rainfall conditions (Anonymous 1980). By comparison, water quality data from the water quality station at Jarvie (BC0001, operated from 1967 to 1977) show total hardness ranging from 88.1 to 341 mg/L, and total alkalinity from 78.5 to 393 mg/L. During the same period, pH ranged from 7.0 to 8.6.

Nitrogen, phosphorus and silica levels are low in the upland tributaries, particularly in summer, when nitrite/nitrate values less than 0.05 mg/L are reported. Phosphate is often highest in summer (approximately 0.045 mg/L). Total organic carbon ranges from 2 to 20 mg/L, and is generally at its lowest in summer. Water temperatures in these upland tributaries (eg. Lovett River) range from 0°C in winter to 13 to 15°C in July (Graves 1975). The streams are well-buffered, with pH ranging from 7.5 to 8.6, and oxygen concentrations are high, even under winter ice. Conductivity (100 to

300 µmhos/cm) is characteristic of foothills streams with high proportions of surface drainage.

Detailed data on stream habitats and water quality parameters in the West Pembina region have been compiled in several recent consultant reports commissioned by the oil and gas industry (eg. Charney 1983, Withler 1980).

Water Quantity

The three hydrometric stations (Barrhead, Entwhistle, and Jarvie) on the Pembina River record patterns of flow similar to those of the McLeod River. Over its length, the Pembina River passes through three physiographic zones, alpine, foothills, and interior plains. The very low flows in winter are followed by a large spring freshet in April, with peak values observed in May. After August, the rate of flow declines rapidly to the same low flows observed in winter. Gauging stations on the Paddle River, the major tributary to the Pembina, show a similar pattern of annual flow values.

Kellerhals et al. (1972) described flows on the Pembina River (at the Entwhistle hydrometric station 07BB002) as having a long-term mean discharge (14 years' data) of 18.5 m^3/sec, ranging from a low of 0 m^3/sec (which has occurred on several occasions) to a peak of 557 m^3/sec in July 1965.

In the past, water management projects in the Pembina Sub-Basin have concentrated on flood and erosion control, through stabilization of lakes (Dapp and Cross lakes), realignment of channels (Little Paddle River) and, more recently, through construction of dams (Paddle River). The engineering difficulties being experienced at the latter project site, at the time of writing, have a precedent in terms of operational uses. Dyking installed along the Paddle River encountered significant problems, and disagreements as to cost-sharing stopped flood control projects on Majeau Lake.

The Paddle River parallels the Pembina River from Mayerthorpe to Barrhead, after which it joins the Pembina. About 50 km of the parallel reach is flat floodplain, where the river has periodically inundated up to 10,000 ha of agricultural land. After severe flooding in 1921, a three-stage flood control plan was established which, after Environment Conservation Hearings (1975) and an environment impact assessment (1982), led to the construction of the Paddle River Dam at a point 110 km northwest of Edmonton, near Sangudo. The new reservoir (originally slated for filling by the summer of 1984) is designed to store 42.2 million m^3 of water over a flooded area of 356 ha. Maximum depth is anticipated to be 30 m, and maximum length 6.8 km.

Environmental Problems

1. Natural

Low winter flows and excessive freshets during spring runoff or severe rainstorms, may cause bank instabilities, streambed scour, and siltation in the slower lower reaches. In some years, fish kills in streams (Pembina River in 1968, Paddle River in 1965) have been documented (Alberta Fish and Wildlife Division, Edmonton). These kills have probably resulted from low oxygen tensions at high temperatures in summer, or from low oxygen concentrations under the ice during winter. Similar incidents in lakes within the watershed have been documented. Fish kills in Nakamun Lake, Lac La Nonne (Paetz 1955), and Brock Lake (Paterson 1960) were attributed to oxygen depletion during the winter.

2. **From Water Management Practices**

The Paddle River dam reservoir near Mayerthorpe will present new challenges for fisheries managers.

3. **Other Sources**

Other sources of impacts in the Pembina Sub-Basin are associated with agricultural expansion, industrial development, and mining. Environmental concerns associated with these activities are discussed below.

Throughout the Pembina Sub-Basin, vegetative cover has often been removed for agricultural or industrial purposes. When edges of stream banks are cleared, high water temperatures, bank instability, and stream siltation often result. Bank cover is essential to the maintenance of water quality for fish, especially in the lengthy reaches of low-gradient waters with reduced summer flows, conditions which are characteristic of much of the Pembina. Other agricultural practices have adversely affected the Pembina watershed, particularly heavy cattle grazing and stock pen operations. These practices can lead to bank instability, bank destruction, and substrate disturbance. In places (eg. downstream from Entwistle), strip mining along the banks of the Pembina River has caused slope denudation and bank instability (Anonymous 1971). Since the sides of channelized sections of river are characteristically steep, they are susceptible to bank erosion (Anonymous 1971). Areas so handled (eg. near Dapp) are devoid of vegetation and low in habitat diversity.

Recently, two prolonged gas-well blowouts (1979 and 1982) in the Lodgepole-Drayton Valley area, contributed significant amounts of sulphur gas (chiefly H_2S) to the airshed of the region. At the time of writing, the effects of these blowouts on aquatic organisms are the subject of both an Energy Resources Conservation Board investigation and some environmental studies. Preliminary indications are that no catastrophic impacts on aquatic environments occurred as a result of the most recent blowout, although the lower reaches of Zeta Creek may have been affected.

Coal mining activity in the upper tributary reaches of the Lovett River and Coal Creek has disrupted some aquatic environments, and the major source of sediment in the Lovett River was reported to originate from disturbed areas in Coal Creek (Graves et al. 1975). The region continues to be actively explored and assessed for commercial potential (Anonymous 1980), and the Coalspur/Robb Block Lease area has been the subject of several recent assessments for environmental impact (Withler 1980, McCart et al. 1982).

Data Gaps

The details of fish population structure, movements, life histories, and occurrence throughout the Pembina mainstem and tributaries are not well-known. Fishing success studies (creel surveys) are needed, especially for heavily fished areas along mainstem confluences. Tributary rivers, especially those in the higher elevations which may have sustained flows year-round, should be carefully studied for enhanced sportfishing potential.

Fisheries Management Strategies

The fisheries management objective for the Pembina Sub-Basin is to maintain native fish population at maximum levels of production through natural reproduction, water and habitat quality maintenance, habitat and fish population enhancement, for recreational fishing.

Summary

The Pembina Sub-Basin is characterized by a wide variety of fish habitats. The Pembina River arises high in the Front Range, flows through the foothills of the East Slopes region, meanders onto the Interior Plain, and forms a confluence with the Athabasca River. High summer temperatures occur along most of the watershed, especially in the slow, exposed, lower reaches; however, these temperatures do not appear to exceed warmwater species tolerance. The quality of fish habitat, of potential value to resource managers, is limited by low seasonal flows in the headwaters, seasonal flooding in the lower reaches, and the impact of the most intensive industrial, urban, and agricultural development within the Athabasca Basin.

Documentation for specific tributaries clearly indicates that the sportfish potential of the Pembina Sub-Basin has declined in the past 40 years; however, stocking programs in lakes have tended to offset this decline. The mainstem reaches, particularly at the primary confluences (Paddle, Bigoray and Lobstick) are heavily angled, as is the confluence with the Athabasca River. Access throughout the sub-basin is excellent, and fishery programs, where implemented, have received significant attention from sportsmen.

Although alternative sportfishing opportunities exist within the Pembina Region (Berland, McLeod, and North Saskatchewan sub-basins), the potential for development and maintenance of the Pembina River should not be overlooked. In view of the large urban population in the watershed, the enhancement or rehabilitation of degraded (chiefly by agriculture) stream reaches, could constitute valuable recreational enhancement to the area.

Stocking programs in lakes throughout the sub-basin are well-received and should be continued or expanded. New water management projects within the sub-basin will present new challenges to resource managers, and opportunities associated with new reservoirs should be fully investigated for their fish resource potential.

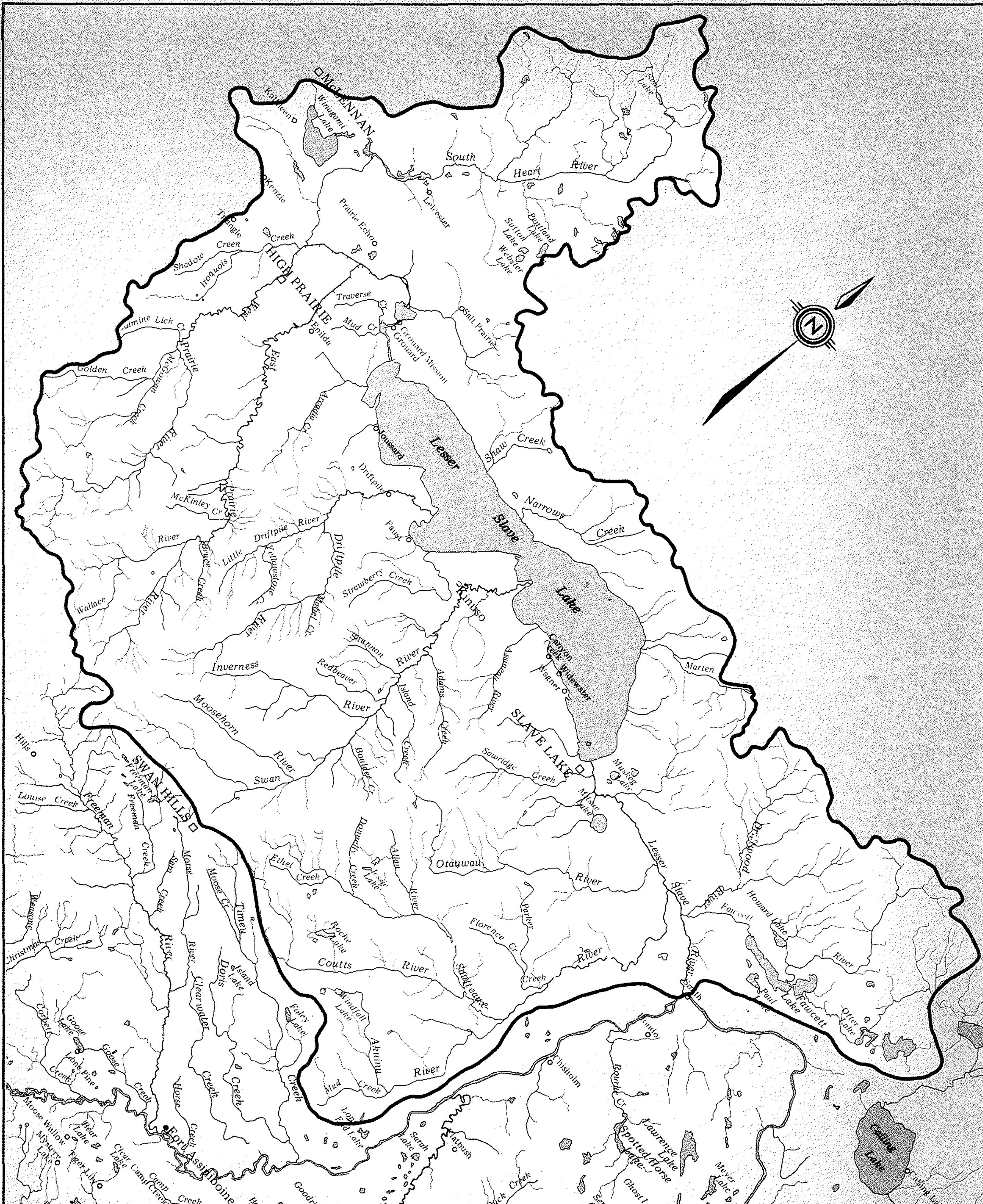
THE LESSER SLAVE SUB-BASIN

The River Environment

The tributary streams and rivers of the Lesser Slave Sub-Basin make up the the largest (20,600 km^2) contiguous watershed within the Athabasca River system. Lesser Slave Lake, which has an area of 1,200 km^2, and a maximum depth of 35 m, is the second largest lake in the province of Alberta. The communities of High Prairie and Slave Lake which lie, respectively, at the western and eastern extremities of the lake, constitute the major urban centers of the sub-basin (Figure 6-3).

The Lesser Slave Sub-Basin falls within the Interior Plain, an area dominated by Boreal Forest. The southern part of the plains (below the line connecting Lesser Slave Lake and Lac La Biche) is dominated by aspen poplar, with spruce poplar transitional forest occurring in high areas (North 1976).The Swan Hills represent the southern central drainage boundary of the Lesser Slave Sub-Basin. Here, there are a number of adjacent drainage boundaries (see section on Athabasca I Sub-Basin and Figure 6-3), and this diverse region contains areas of special ecological interest, such as the Goose Mountain Ecological Preserve.

The Swan Hills are relict uplands, capped by a resistant calcareous shale derived from the Paskapoo Formation, which has resisted erosion and left the hills as an upland, erosional remnant. At several points, the Swan Hills rise above 1,350 m, and the resulting orographic effects and airflow patterns combine to create different precipitation regimes between the valley and uplands (Nemanishen and Meers 1980). In general, the Swan Hills region can be said to be climatically distinct from the rest of the basin. Most (500 mm) of the 900 mm precipitation which falls there annually, falls from May to September, as airflows appear to funnel into the Swan Hills



THE LESSER SLAVE SUB-BASIN

FIGURE 6-3

area, where uplift causes frequent summer storms. During these storms, heavy rainfall results in flash flooding and severe erosion in the Swan Hills, which are partly drained through the Swan River into Lesser Slave Lake.

To the west and the southwest of Lesser Slave Lake, a broad flat plateau, which contrasts sharply with the hills to the south, extends through the High Prairie region. These low-lying areas represent portions of the former lake bed, and are utilized as highly productive agricultural soils for cereal crops. The area is subject to periodic flooding from the East and West Prairie rivers, causing soil and nutrients to be washed into the west basin of the lake.

Flows from the Lesser Slave Sub-Basin, as gauged by a station on the Lesser Slave River, appear fairly constant throughout the year, with a peak July flow rate only 2.5 times greater than minimal January flows. Though Lesser Slave Lake acts as a large, stable reservoir to the sub-basin, and naturally regulates streamflow from it, flood control is a significant concern within the sub-basin. Flash flooding from the Swan Hills, from flat, poorly-drained land, and from marshy terrain all combine to produce floods. These conditions have come under study in the past (Janssen 1967), but have not yet led to major water control developments.

Lying within a very flat basin, the Lesser Slave River drops only 0.095 m/km in its 75 km course from the lake to its confluence with the Athabasca River. Spring melt causes a sudden rush of water from the tributaries, which, because of the flat topography, often results in rapidly elevated water levels in Lesser Slave Lake. The lake is located about 240 km northwest of Edmonton, and consists of three major basins: an east basin, a west basin, and a large shallow area known as Buffalo Bay. The east and west basins are relatively large, measuring 58,793 ha and 54,908 ha in area, respectively.

Major tributaries entering Lesser Slave Lake are the South Heart, West Prairie, East Prairie, Driftpile, and Swan rivers. Downstream of Lesser Slave Lake, the Salteaux, Otauwau, and Driftwood rivers flow directly into Lesser Slave River, which drains the lake and joins the Athabasca River near the town of Smith, about 75 km downstream. In general, these rivers are highly susceptible to flooding. They have waters which range from silty to turbid, and substrates which range from silt to rubble.

The Swan River rises in the upland region of Swan Hills, and drains slightly less than 2,000 km^2. Over its 175 km course to Lesser Slave Lake, the river receives flows from the Moosehorn and Inverness rivers, and Adams, Island, Shannon and Chambers creeks. In its upper reaches, the Swan River flows through glacial tills vegetated with white spruce and lodgepole pine, and, closer to the river, aspen-willow stands. This vegetation gives way to lowland aspen parkland, which is extensively developed for agricultural use. The smaller Driftpile River also arises in the Swan Hills, and drains 840 km^2. Slope-terrain characteristics are similar to those of the Swan River.

The South Heart River system is the largest (5,900 km^2) of the river systems flowing to Lesser Slave Lake. This river system drains the area northwest of Lesser Slave Lake; and, by means of the East and West Prairie rivers, about the same area to the southwest of the lake. Grassland to willow vegetation characterizes the flat lowland reaches of the South Heart River system. The West Praire River(about 160 km in length) drains 1,160 km^2 through level to gently rolling parkland, which is agriculturally well-developed. The East Prairie River, which is 170 km long and drains about 1,440 km^2, flows from steep woodlands, through rolling parkland, into level marsh grasslands. For the years 1973 to 1977, mean flows were 16.8 m^3/sec (range 0.3 to 384 m^3/sec) for the East Prairie River, and 7.1 m^3/sec (range 0.1 to 161 m^3/sec) for the West Prairie River (Berry 1978). During peak flows, transport of suspended sediment is a factor in these rivers, causing sedimentation in Buffalo Bay and Lesser Slave Lake. In the past, flooding in the region (eg. near Kinuso on the Swan River in 1973) has caused problems for water treatment plants and water reservoirs.

Paetz and Zelt (1974) provide a comprehensive overview of the lakes in this region of northern Alberta.

The Fish Population

Lesser Slave Lake has been the focus of numerous fishery studies in the past, and continues to be an area of major importance to the Alberta fishery resource (Miller 1940, 1941, 1942a, 1944, 1945, 1953, 1955; Bidgood 1967a, 1967b; Bishop 1969, 1970a, 1970b, 1971a; Zelt 1975; Paetz and Zelt 1974). Fish species occurring there include northern pike, walleye, perch, lake whitefish, lake cisco, burbot, and suckers.

In 1971, partly as a consequence of the collapse of the whitefish fishery in 1965, and the lake cisco fishery in 1971, Alberta Fish and Wildlife launched the Slave Lake Project to deal with problems of the lake fishery (Dietz and Tulman 1981). This work led to a number of intensive investigations, including walleye studies in the South Heart River (Berry 1979); whitefish studies (Dietz and Griffiths 1980) and walleye life history studies (Dietz and Tulman 1981) in Lesser Slave Lake; and a fisheries survey of its east and west basins (Berry 1981).

Two smaller lakes, Winagami, a shallow lake to the west of Lesser Slave Lake, and Fawcett, a relatively deep lake to the east, maintain commercial and recreational fisheries as well. In 1963 and 1964, Winagami Lake (area 4,276 ha, maximum depth 5 m) received extensive perch stockings, consisting of both adults and fingerlings

(Alberta Fish and Wildlife Division, internal records). Some summer fish kills, probably as a result of low oxygen tensions, have been recorded for this lake. The stocked whitefish are of export quality, and the pike and perch have shown good returns per effort of harvest. At present, a commercial fishery based on whitefish is under consideration for Winagami Lake, although a conflict with the recreational fishery may result if this proposal is carried out.

Fawcett Lake (area 2,980 ha, maximum depth 19 m) is commercially fished (Alberta Fish and Wildlife Division, internal records). The lake supports cisco, lake whitefish, walleye, northern pike, suckers, and some Arctic grayling. The whitefish and cisco are of export quality, and commercial quantities of lake cisco, whitefish, and walleye are produced. The primary recreational users of Fawcett Lake originate from Edmonton.

Lesser Slave River ranges from 20 to 50 m in width, and has generally stable banks over most of its length. The river harbours mountain whitefish, Arctic grayling, northern pike, walleye, goldeye, suckers, burbot, spottail and emerald shiners, perch, and trout-perch. The river represents a transition zone--fish common to both warmwater and coldwater aquatic habitat are found here. Of the coldwater species, mountain whitefish are probably the most numerous, although brown trout are also present. Pike, walleye and perch make up the warmwater species. In many respects, the fish populations of the Lesser Slave River are transitional between those of the much larger Athabasca River and Lesser Slave Lake.

The commercial fishery of Lesser Slave Lake is well-developed and of major significance in Alberta (Appendix C). This fishery has focused primarily on whitefish, which is of generally low quality as a consequence of cyst infestations, and lake cisco was the second most important commercial species until the 1960's, when the population in the lake declined. Over the same period, a decline in the mink ranching industry in Alberta occurred.

Following the collapse of the whitefish fishery in 1963, the small-mesh lake cisco fishery in the lake was closed. Subsequently, the population of whitefish showed a strong recovery, and the lake whitefish quota was increased from 68,000 kg in 1972 to almost 250,000 kg in 1979. By the early 1980's, the sustained yield of whitefish in the lake was considered to be more than 272,000 kg per annum (Alberta Fish and Wildlife Division Report, Peace River, unpublished). Pike are commercially harvested, and good angling at the east end of the lake been reported for this species.

Over-fishing and suspected environmental impacts on walleye habitat, resulting from water diversions and control works on the East and West Prairie rivers and the South Heart River, kept the walleye population in the lake at low levels throughout the 1960's up to the mid-1970's. Since 1975, however, the walleye population in the lake has shown a steady increase in numbers. In 1979, for instance, the commercial quota was increased from the 1972 level of 9,070 kg to 27,210 kg. The increase in population was thought to be largely a result of the combined effects of stabilization of walleye habitat in the Buffalo Bay region, protection of the population by removal of the small-mesh net fishery in Lesser Slave Lake, and closure of areas to commercial fishing in the western regions of the lake (Alberta Fish and Wildlife Division Report, Peace River, unpublished). More recently, walleye catches in the lake reached 27,494 kg in 1980 and 14,342 kg in 1981 (Appendix C). Good sport fishing for walleye is known for the west end of the lake and at Swan River.

In summary, Lesser Slave Lake is a large, but rather shallow, central Alberta lake which has provided a commercial fishery for four fish species in the last half-century. Unfortunately, the history of the fishery has been somewhat uneven (Handford et al.

1977), with lake whitefish and walleye being the last remaining commercially fished species. In 1982, the commercial fishery in Lesser Slave Lake provided approximately 16.3% by weight of the commercial fish landings in Alberta, and about 12.6% of the dollar value to fishermen.

As noted above, after a period of slow decline (records indicate the beginning of the slide in the early 1940's), the Lesser Slave Lake whitefish commercial fishery collapsed in the mid-1960's. The lake was subsequently closed to commercial fishing for a five-year period to allow for recovery of fish populations. By the early 1970's, populations had recovered to the point where commercial operations were once again permitted.

The Buffalo Bay region at the western extremity of Lesser Slave Lake is noted for its walleye run in spring and is easily accessible to fishermen. Studies done on the feasibility of using trap nets to harvest burbot in winter indicated that the yields, even with these enhanced methods, were insufficient to support a viable commercial operation (Zelt 1975). Zelt (1972) also examined the possible causes of poor lake whitefish production from Lesser Slave Lake and suggested that more data were needed regarding the effects of flooding and silt transport to the lake, especially at the Swan and Driftpile river confluences with the lake.

The incidence of whitefish and lake cisco infested with tapeworm (<u>Triaenophorus</u>) was noted in early studies of Lesser Slave Lake (Miller 1940, 1941), and has a major impact on the fishery even today. Since the turn of the century, the lake trout has become extinct in Lesser Slave Lake (Paetz and Zelt 1974), a loss thought to be primarily a result of unsatisfactory ecological conditions coupled with commercial over-fishing. These populations, which naturally declined a century ago, were thought to be highly susceptible to commercial exploitation which, in the early 1900's, was sufficient to bring about their extinction in the lake.

With respect to both habitat and fish species in the immediate region, the Swan River drainage is probably typical. Berry (1978) observed longnose suckers spawning in the riffles of the Swan River in May, and also reported spawning activity in the tributary Inverness, Sloan, Adams, Island, and Chambers creeks. During that survey, longnose suckers vastly outnumbered white suckers in the Swan River, as is typical of many of the rivers in the region, as they moved upstream to spawn in mid-May.

Arctic grayling, the major sportfish of the Swan River system is well-distributed throughout many tributaries of that river. In the Swan River itself, however, the lake chub is the most abundant fish species (Berry 1978), and is common throughout the system as well. Lake chub spawning was observed in the river in early June. Rearing also appears to occur there and throughout the tributaries. Although a few lake whitefish occur in the upper Swan River, northern pike and walleye occur only in the lower part of the Swan River system. Trout-perch, spottail shiners, emerald shiners and yellow perch are also found in the lower reaches of the system.

So abundant are longnose suckers in the Driftpile River that Zelt (1973) considered the feasibility of harvesting spring spawning migrations for commercial harvest. Between 6,800 and 9,070 kg of fish per day were estimated as being available for a period of 10 to 12 days per annum. Longnose suckers, lake chub, and Arctic grayling are known to occur in the Driftpile system and in Arcadia Creek (Berry 1978). Arctic grayling have also been reported in the Nine Mile Creek watershed and the Assineau River.

Strawberry Creek (lying between the much larger Driftpile and Swan rivers) is 41 km in length, drains an area of 160 km^2, and empties directly into Lesser Slave Lake. Berry (1978) noted that excellent habitat for northern pike occurs along the lakeshore mouth of the creek and in reaches of the creek itself.

Sport Fishing Opportunities

Several studies have been conducted on the Lesser Slave River with respect to its angling potential (Miller 1955). Earlier studies indicated that, in spite of its very attractive appearance, the Lesser Slave River was not a good angling stream. In general, the difficult access to tributary streams and rivers prevents angling from occurring there to any great extent. For instance, the grayling population known to inhabit the Driftpile River is difficult to reach and is consequently subject to reduced levels of angling. Where access is possible, pike, perch, and walleye are angled on a seasonal basis.

Today, Lesser Slave River is well-utilized by anglers fishing for pike in spring and, to a lesser extent, over the rest of the year. Areas exploited include both the east and west ends of the lake, Dog Island, and Canyon Creek. The mouth of Swan River is heavily angled in June due to the concentration of walleye which occur there. Other early studies on the South Heart River (Hartman 1957) found that, although there was not a large resident pickerel population in the river, there appeared to be a general movement upstream by the species for spawning near the confluence of the Heart and Prairie rivers.

Angling is reported to be popular at Winagami Lake, because of the high catch-per-unit-effort for pike and perch. Whitefish and suckers also occur (Bishop 1976), although the lake is not fished commercially for these species. The area is accessible by Highway 749 which leads to Winagami Lake Provincial Park. The park is very popular, and has a well-used summer and winter campground. Fawcett Lake is equally as popular with anglers.

Paetz and Zelt (1974) summarized the history (1942 to 1972) of the commercial fishery on Lesser Slave Lake, and compared it with the other significant lakes of the region. (A fuller description of the Lesser Slave commercial fishery is contained in Appendix C). The excellent pike-perch fishery which has developed in Winagami Lake since water control facilities were constructed in 1951 and 1962 has also been paralleled in more recent years by the growth of a whitefish population. Schroeder (1983) noted that a commercial fishery could be contemplated on the lake, although this could entail a conflict between the commercial and recreational interests.

Recreational access to the region is provided through several provincial parks: Hilliard's Bay and Lesser Slave Provincial Parks at the western and eastern extremities of Lesser Slave Lake, respectively; and Winagami Provincial Park at the east end of that lake. Other camp facilities include Kinuso Beach and Spruce Point Park, Fawcett Lake, and the Assineau, Lesser Slave and Mitsue rivers.

In general, the recreational fishery of Lesser Slave Lake is significantly under-utilized, and is an area which could be examined as to future potential development. The recreational fishery that does exist there, however, is orientated toward walleye, as is that of Fawcett Lake. Lily Lake is stocked with eastern brook trout (4,000 in 1982) and represents a walk-in recreational fishery. Christina and Edith lakes are also stocked with this species and receive good recreational demand from anglers in the immediate region as well as from those originating in Edmonton. Christina (Windy) Lake received 24,000 eastern brook trout in 1982. Blue Lake has also been stocked.

Availability of Alternative Sport Fishing Opportunities

Bishop (1976) compared the use of Snipe Lake in the Peace River drainage with that of Winagami Lake in the Lesser Slave Sub-Basin and found that angling was more popular at the latter. This preference was attributed to the relatively higher catch-per-unit-effort of pike and perch. Snipe Lake nevertheless does provide an alternative for anglers.

Recreational opportunities and alternatives in the region have been extensively studied (Janssen 1968; Baker 1971; Anderson 1967, 1975; Anonymous 1970, 1972a, 1972b, 1972c). Many of the programs recommended in these studies have been implemented and there are numerous camping or park facilities throughout the region.

Streams and lakes within the Peace River drainage provide the closest northwestern access in the Lesser Slave Region, via Highway 2 to Peace River. Highway 67 provides access north to the Peace drainage, chiefly to the Wabasca River and its tributaries, but also to Utikuma, Peerless, and Graham lakes. To the west, Sturgeon Lake (with Young's Point Provincial Park) near Valleyview, and the Meekwap-Iosegun-Raspberry lakes group near Fox Creek, are accessible by means of Highways 34 and 43. In the east within the Peace River drainage, the North and South Wabasca lakes, which are accessible via Highway 754, and Calling Lake, with its Provincial Park, provide significant alternative lake recreational potential. Further east, Lac La Biche, with Sir Winston Churchill Provincial Park, and the many smaller lakes dotted around it also provides alternative recreation. This lake is dealt with in more detail in subsequent sections. Peerless Lake is very popular for angling of lake trout, walleye, and pike, and the walleye of Utikuma and Utikumasis lakes are similarly sought after.

Water Quality

Storms, particularly in the upland reaches of the Swan River sub-drainage, cause a heavy sediment load to be transported into the Lesser Slave system. In 1971, sediment loads in excess of 635,000 tonnes were reported for the Swan River (Berry 1978). This exceedingly high rate of transport results in substantial deposition into Lesser Slave Lake. Similarly, the Driftpile River, showing a wide range in maximum and minimum flows, carries a considerable suspended sediment load, especially during storms.

Water quality data for the Lesser Slave River (at Slave Lake--Water Survey Station No. 00AL07BK0005) indicate that the river water is well-buffered (81 mg/L $CaCO_3$), neutral (pH 7.0 to 7.4), and relatively clear (12.8 JTU), on an average annual basis. Nutrients, total and dissolved nitrogen (0.8 and 0.04 mg/L, respectively) and phosphorus (0.022 mg/L) were relatively low. Dissolved oxygen concentrations (8.4 mg/L) were sufficient for maintenance of fish populations. Heavy metals (eg. nickel, copper, zinc) were present in very low concentrations. No concentrations of herbicides or pesticides exceeded 0.032 µg/L, and most were far below that value, although sample analyses were limited (refer to extensive data compilation in Appendices of Alberta Environment 1979). Thermal stratification is virtually nonexistent in Lesser Slave Lake, where surface area and basin morphometry permit near-continuous mixing. Mean freeze-up and spring breakup dates for the Lesser Slave are November 4 and April 15, respectively (Kellerhals et al. 1972).

Lake whitefish production has been suggested to be influenced by silt transport to Lesser Slave Lake via the Driftpile and Swan rivers (Zelt 1972), and several small, shallow lakes throughout the sub-basin are known to have summer kills.

A comparative analysis of the water quality, bathymetry and fisheries of Lesser Slave, Wabamun, Lac La Biche, and Cold lakes is presented in Paetz and Zelt (1974).

Water Quantity

Storms, particularly through the Swan Hills region, cause sudden, dramatic flows through rivers draining to Lesser Slave. Rainfalls exceeding 51 mm have occurred in less than 24 hours, causing a range of flows from 0.09 m^3/sec to 338.18 m^3/sec in the Swan River.

Water Survey of Canada records indicate that the mean (1973 to 1977) discharge for the small Driftpile River was 10.1 m^3/sec. As would be expected for a sub-drainage so similar to the Swan River, the stream showed extreme variability in discharge (0.2 m^3/sec to 207.8 m^3/sec). Mean flows were recorded at 16.8 m^3/sec (range 0.3 to 384 m^3/sec) for the East Prairie River, and 7.1 m^3/sec (range 0.1 to 161 m^3/sec) for the West Prairie River. These flows obviously cause significant sediment transport.

Storms in the area probably cause significant disturbance to aquatic, particularly spawning, habitat in rivers that are subject to runoff from the Swan Hills. Berry (1978) observed such an occurrence in the Swan River (May, 1978) and found fertilized longnose sucker eggs more than 36 km downstream from suspected spawning areas.

Kellerhals et al. (1972) noted that, for the water survey station on the Lesser Slave River at Slave Lake (07BK006, Highway 2) mean discharge (20 years' data) was 43.4 m^3/sec. Minimum and maximum discharges were 5.32 m^3/sec and 238 m^3/sec on January, 1923 and July, 1935, respectively. Generally, however, flows from the lake are fairly constant throughout the year, with a peak flow in July which is usually only about 2.5 times greater than the January minimum. The relatively small difference in flows indicates the extent to which the lake acts as a large reservoir, in effect naturally "regulating" the streamflow leaving the sub-basin.

Other water regulation systems have been installed on Winagami Lake to control lake levels, and on the South Heart River system to control excessive sudden flows of water.

Environmental Problems

1. Arising from Natural Causes

In May 1971, a large pike die-off, which occurred at the Winagami Lake outlet, was thought to have been caused by abnormally low runoff (Bishop 1971b),although algal blooms were implicated as well. In many respects, however, the lake is considered ideal as pike habitat, especially since 1951 when a dam diverted additional water into the previously stagnant lake (Thomas 1955). Sudden high discharges have been shown to have caused drops in the numbers of macroinvertebrates in the Moosehorn and Swan rivers (Bishop 1976).

In an early study, Miller (1945) suggested that the relatively sparse population of whitefish in Lesser Slave Lake was due to limited or poor spawning conditions caused by flooding, especially at tributary inflows to the lake. The major tributary rivers to Lesser Slave Lake are subject to intense rainfall, which causes very large fluctuations in flow rates through the Swan, East Prairie, and West Prairie rivers. The result is very high levels of sediment transport through these sub-drainages to Lesser Slave Lake.

In all but the lower reaches, these rivers have steep gradients, and significant sedimentation occurs in these areas. Erosion in the East and West Prairie rivers is a prime concern. Channelization attempts have often resulted in increased bank and channel erosion, a problem that has received continuing attention from government personnel and landowners in the region.

Bishop (1970b) indicated that low water levels in Lesser Slave Lake may have been a factor in reducing the number of cisco in the lake in 1970. In Winagami Lake, Bishop (1976) noted that blue-green algae (Aphanizomenon) were common in summer, and were probably responsible for periodic summer kills of fish in that lake. Walty (1976) noted that algal blooms resulting in summer fish kills develop in other large, but shallow, lakes throughout the region. The extensive algal blooms in Winagami Lake continue up until present, and have received attention from local residents, fishery managers, and the press. Residents from McLennan have recently approached Alberta Environment to assist in solving the "algae problem" (Record Gazette July 20, 1983). In winter, dissolved oxygen concentrations are low in Winagami Lake.

2. Arising from Water Management Practices

The Lesser Slave Lake region has experienced water management problems since the area was settled in the early 1900's. After the high water levels which occurred in 1965, a number of studies were commissioned to assess water regulation schemes. In 1977, Alberta Environment initiated the Lesser Slave Lake Basin Study which led, in 1978, to recommendations for measures to control the lake level. An environmental impact assessment was done to examine the two major alternatives proposed to regulate the level of Lesser Slave Lake. The assessment noted that the lake-lowering controls would cause a loss of spawning and rearing habitat for northern pike, and probably reduce spawning habitat for walleye in Buffalo Bay. A loss of fish habitat in the Lesser Slave River, as a consequence of by-passing river channels, was also predicted (Lesser Slave Lake Regulation, Environmental Impact Assessment, Alberta Environment 1978, 1979).

During 1981 and 1982, extensive works were undertaken to regulate the lake levels. Weirs and fishways were incorporated into the control structures, and fish boxes will be installed in 1984. Efforts have been made to conserve some channels as fish spawning habitat. The Lesser Slave River was straightened, and a weir with a fishway installed in 1983/1984.

In the Swan River Delta, other "dewatering" programs have been undertaken under the auspices of the Swan Delta Flood Relief Program. Ditches have been constructed east, north, and west of Swan River. During 1960, rechanneling operations were undertaken in the East and West Prairie rivers, work which has continued until present. Bed and bank degradation have been a continuing concern for the West Prairie River, resulting in significant efforts at bank protection. Parts of the South Heart and lower sections of the East Prairie and West Prairie rivers have been channelized over a length of about 45 km. Dams built on the South Heart River in 1950 and 1961 have reduced the river's peak rate of discharge, as well as turbidity levels below the point of discharge.

In the Peace River watershed, water levels on Snipe and Winagami lakes are controlled. Bishop (1976b) indicated that fish migration was prevented in the latter by the man-made structures. Bishop (1976b) noted that spawning fish leaving the lake via two outlets (McLennan- Girouxville Canal and the main outlet stream) are unable to return to the lake. At these outlets, angling success is highest in May, as the pike congregate during their spawning run. Winagami Lake has complex water control structures to control lake water levels: two dams on the upper South Heart River, which divert water to the north end of the lake, and another structure at the south end which controls water outflow.

The South Winagami Lake Spillway, designed to control excess waters, directs flow to Winagami and to Heart Dam 1 via the South Heart River. There is no facility to permit upstream fish movement at dams 1 or 2, or on the spillway to the South Heart River. Bishop (1971a) first noted the fish blockage problem at Winagami Lake. The dam, constructed in 1951, diverted water through the then stagnant, salty lake, which was incapable of supporting fish over winter. A second dam, built in 1962 along with the outlet dam, controls water flows to the lake. Other than the upstream migratory blockages, major fish problems do not occur in the lake, except in years of unusually low flows (eg. May 1971) or when winterkills occur in the upper reservoir.

Bishop (1976b) also noted that a water quality problem occurred in the Heart Lake reservoir, apparently due to eutrophication caused by the failure to remove sufficient vegetation before flooding was initiated. A damaged water outlet control structure was replaced on Fawcett Lake in 1976.

3. Arising from Other Sources

Paetz and Zelt (1979) noted that lumbering was once one of the chief industries in the Lesser Slave Sub-Basin, up until the rapid development of the petroleum industry in the Swan Hills, Mitsue Lake, and Marten Hills regions in the 1960's. They reported that "...this development has had a dramatic effect on the watersheds along the south shore of the lake. Erosion of road ditches, seismic lines, and altered stream channels has resulted in the Swan and Driftpile rivers depositing huge amounts of soil and silt in the lake."

More recently, oil and gas activities in the sub-basin have resulted in occasional direct impacts to fish habitat. In 1972, oil sump leakages to streams near Mitsue Lake, near the southeast end of Lesser Slave Lake, were investigated, but little measurable damage had occurred (Bishop 1972). In 1973, an oil line puncture made by a bullet caused an oil spill into the East Prairie and South Heart rivers (Bishop 1973); however, the oil was effectively contained and did not reach Lesser Slave Lake. In 1976, another oil spill occurred in the Moosehorn and Swan rivers (Bishop 1976). Damage to the benthic macroinvertebrate communities as a result of oil in the rivers was reported, but no report was made concerning fish populations.

The area around the Swan and Inverness rivers and tributaries has been, and will continue to be, extensively explored by companies planning to drill for oil, and the northern end of the North Heart River will undergo both seismic and drilling activity as well (Personal Communication, D. Walty, Fish and Wildlife Division, Peace River). These trends are indicative of the levels of activity which may generally be experienced in the region.

Some reaches (over a length of about 19 km) of the West Prairie River are channelized. Berry (1978) reported that a man-made weir appeared to present a height and velocity barrier to fish such as walleye and pike.

Siltation resulting from stream crossings for the oil and gas industry has occurred in the Swan River watershed, and forestry operations also contribute to outwash problems where these occur near tributaries. Similarly, improvements to the Swan Hills-Slave Lake highway poses potential problems for grayling streams along that route.

Agricultural development and stream channelization in the East and West Prairie River watersheds have significantly contributed to siltation in that region. Erosion of channelized sections of the Lesser Slave River (at the south end of Lesser Slave Lake) is tending to lower the water level in the lake as a whole, and may result in a decrease of fish habitat (particularly for walleye) in Buffalo Bay (D. Berry, pers. comm., Alberta Fish and Wildlife Division, Edmonton).

Data Gaps

Creel census data on the sportfisheries on Winagami and Fawcett lakes are needed to evaluate present levels of exploitation. The data should include numbers of anglers, effort expended, and catch results by species. To enable comparisons, creel census surveys should be repeated regularly every five years. Data on spawning and rearing of sportfish in these lakes are also lacking, as are data on user and stocking rates. Such information is vital to long-term fisheries management programs.

More data are required on the effects of the existing outlet canals on fish populations in Winagami Lake. Pike and perch spawning areas in the lake should be identified and protected in order to maintain or enhance fish populations.

More data are needed on the total recreational use of lakes and streams (eg. the Upper Prairie River) throughout the Lesser Slave Sub-Basin, especially relating to total catch by species, and catch-per-unit-effort. Although the major tributaries of the sub-basin have been surveyed, few reports in the form of Phase I surveys are available on the smaller, but more numerous, tributaries. In those streams, few data on spawning areas and fish habitat exist and there are even fewer data available on domestic fishery use.

Preliminary inventory surveys (such as the excellent survey by Berry 1978) of tributary streams should be continued and expanded to include fish species and distributions for all the upper tributary reaches of the drainages associated with Lesser Slave Lake. This work should be concentrated in areas of present high use by recreational fishermen. The research should be aimed at further elucidating fish population structure, movements, life histories, and occurrence throughout the Lesser Slave tributary system.

Fisheries Management Strategies

The fisheries management objective for the Lesser Slave Sub-Basin is to maintain native fish population at maximum levels of production through natural reproduction, water and habitat quality maintenance, habitat and fish population enhancement for recreational, commercial, and domestic fishing.

Summary

The range from coldwater to warmwater fish habitat which occurs throughout the Lesser Slave Sub-Basin results in a diverse fish population which includes coldwater species inhabiting the upland tributaries and warmwater species inhabiting the tributaries of the Lesser Slave Lake flatlands.

The Lesser Slave Lake fishery is the oldest and most productive commercial fishery in the Athabasca Basin. Factors limiting productivity of fishes include siltation, erosion, and severe flooding in tributary rivers, summer fish kills in smaller lakes, and high summer temperatures in some of the slow-moving lowland tributary rivers.

Channelization of tributaries may have caused as yet undefined problems for fish populations. Water control structures may also present some difficulties for migratory and spawning populations. Although there have been occasional impacts resulting from oilfield developments, including some oil spills to tributaries, given the magnitude of development in the Swan Hills region, these incidents have been infrequent.

Agricultural practices and incidents of severe flooding have probably degraded fisheries habitat throughout the Lesser Slave

Sub-Basin, but no clearly documented research has summarized these effects. The wetlands around Buffalo Bay could be an area of resource conflict in future, as agricultural interests expand into wetland and fish habitat in the region.

VII THE LOWER SUB-BASINS (LAC LA BICHE AND CLEARWATER)

OVERVIEW

For the purposes of this report, the two lower sub-basins of the Athabasca Basin are the Lac La Biche and Clearwater sub-basins. This division distinguishes these two sub-basins from the mountain foothill and high plains sub-basins further upstream. The Lac La Biche and Clearwater sub-basins fall within the physiographic zone of Alberta known as the Interior Plain (Figure 7-1). Parts of the Lesser Slave and Pembina sub-basins also fall within the Interior Plain, which is the largest continuous physiographic zone in the Athabasca Basin.

The Interior Plain is generally uniform, exhibiting a gently rolling to a rolling terrain. Though the topographic relief of the plain is interrupted occasionally by landforms of higher elevation (the Swan Hills and the Birch Mountains, for instance), none of these features is of great enough significance to affect the regional climate. The Interior Plain is dominated by boreal forest and, below a line roughly connecting Lesser Slave Lake and Lac La Biche, by aspen poplar. To the north, jackpine-white spruce associations, poplar-birch associations, and muskeg bogs predominate.

Temperature and precipitation at Lac La Biche, which probably closely resemble those of the more poorly known, adjacent Clearwater Sub-Basin, are as follows:

Mean Annual Air Temperature	1.2 °C
January Average Air Temperature	-17 °C
July Average Air Temperature	16.8°C
Mean Annual Precipitation	460 mm

THE LOWER SUB-BASINS

(La Biche & Clearwater Sub-Basin)

FIGURE 7-1

Annual Snowfall	147 mm
Precipitation (May - September)	280 mm
Frost-free Period	65 days

In short, this north-central region of Alberta exhibits a continental climate, where temperature variations over the area are small in summer, but tend to be influenced by elevation, waterbodies, and local topography.

The geology of the lower sub-basins consists of rocks, overlying the 600 million year-old Precambrian, which are made up of deposition layers after various marine intrusions. These carbonates and evaporites from the Paleozaic and Mesozaic eras are, in turn, topped by Cretaceous and Tertiary sandstone, shales, and clays. The Lac La Biche Sub-Basin, like the Lesser Slave Sub-Basin, is underlain by shales. As a result, only shallow-bored wells which intersect buried channels or sand lenses yield significant groundwater. Residents in each of these sub-basins also share a common concern for the stabilization of lake levels to reduce the incidence of flooding. Toward the north, the Clearwater Sub-Basin has glacial tills underlain by a non-porous bedrock. Since these tills are seldom interspersed with aquifers or sand lenses, potable groundwater supplies tend to be limited.

The Clearwater Sub-Basin extends from the southern portion of the Saskatchewan Canadian Shield to the Alberta Interior Plain. Since the sub-basin spans the Alberta-Saskatchewan border, it is often excluded from planning or basin studies reports. The divided jurisdictional lines, and the relative remoteness of this sub-basin, tend to make it different from previously discussed sub-basins which lie wholly within Alberta. While much of the Clearwater Sub-Basin lies within Saskatchewan, the Alberta sections of the sub-basin which ultimately drain to the Athabasca River at Fort McMurray, represent a substantial portion of the Alberta Athabasca drainage, exceeding the Berland, McLeod and Lac La Biche sub-basins in area.

Tripp and McCart (1979) and Jones et al. (1978) summarized water quality data for the Clearwater River, and Akena and Christian (1981) summarized the data for the Athabasca region surrounding the sub-basin. Tripp and McCart (1979) found dissolved oxygen levels that declined from 11.0 mg/L in May to 8.0 mg/L in June, the decline being attributable to increasing water temperatures. Maximum summer temperature rarely exceeded 18°C, and turbidity was generally highest (35 FTU) just after breakup in late April to early June, declining to below 5 FTU by mid-summer.

Lac La Biche is one of the most important commercial fisheries within the Athabasca Basin (Appendix C). Increasing commercial, recreational, and domestic fishing demands in the Lac La Biche Sub-Basin has led to heightened pressure for enhanced fisheries management and assessment programs. Similarly, the increasing recreational pressures for the Clearwater Sub-Basin, the development of fly-in fishing, and the use of all-terrain vehicles for access to previously remote fishing locations have led to a marked decline of sportsfish stocks in specific streams (eg. the Hangingstone River). Throughout the area, Arctic grayling and walleye are the primary sportsfish.

The Lac La Biche Sub-Basin has received increasing attention as a recreational area, particularly with the sudden growth of the Fort McMurray urban area. Lakes and streams throughout the sub-basin contain highly sought-after populations of walleye and pike. Anglers from Fort McMurray have increasingly used the Clearwater as a recreational resource due to its proximity to the city and relative ease of access by small boat. The Clearwater Sub-Basin could be considered as a prime region for potential future recreational development, especially given the significant overloading of facilities within easy reach of Fort McMurray.

LAC LA BICHE SUB-BASIN

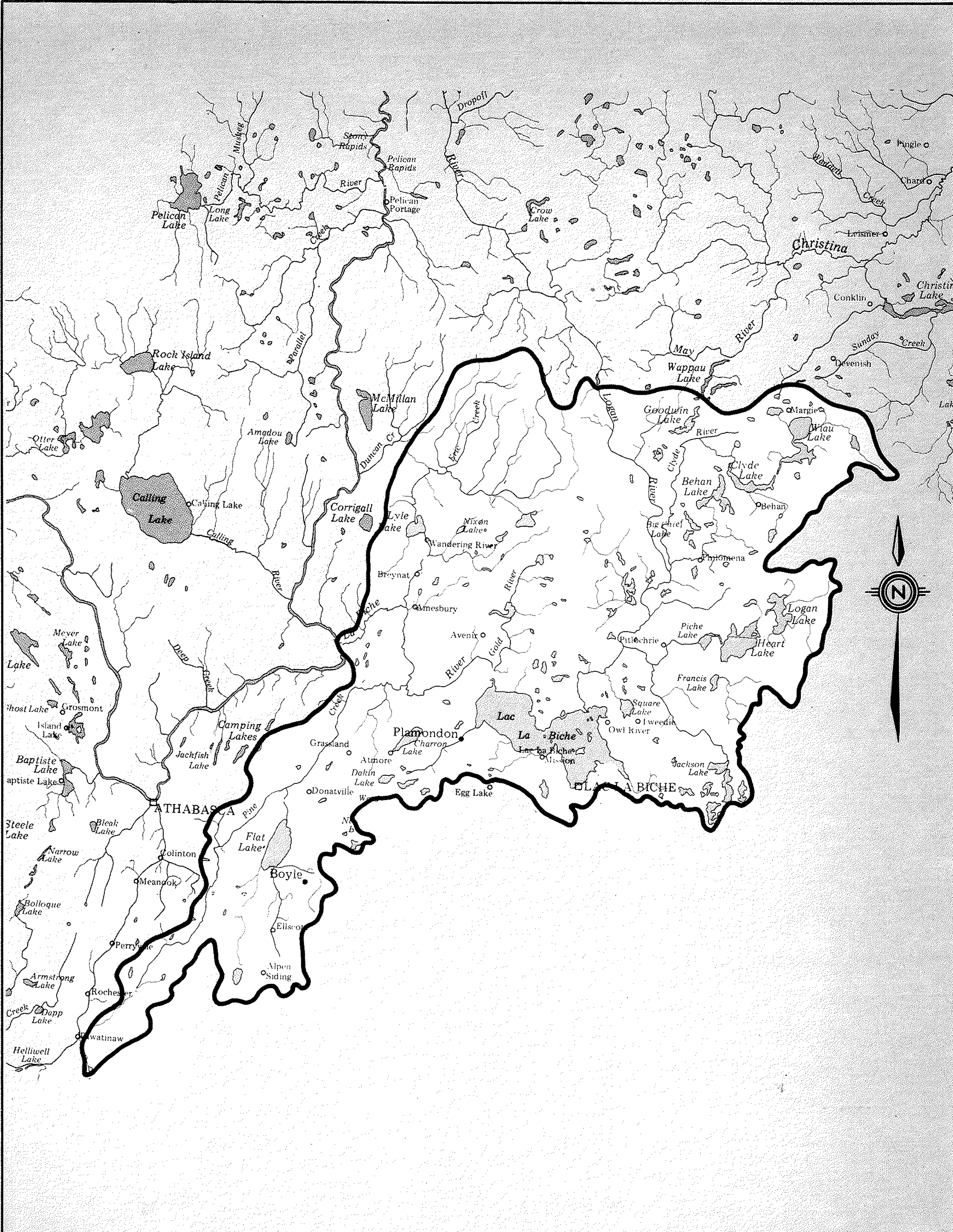
The River Environment

The Lac La Biche Sub-Basin is sited in the Eastern Alberta Plains, a region characterized by undulating, rolling terrain. The Lac La Biche River spans the 80 km between Lac La Biche and the Athabasca mainstem, and drains an area of 8,800 km^2. The low-lying topography, in which the highest points of land are below 610 m, is dotted with numerous lakes and areas of poorly-drained marshland. As a result, many small lakes have received attention as to level stabilization.

The largest lake in the sub-basin, Lac La Biche, lies at the extreme southern edge of the drainage. The eastern third of the sub-basin is drained into Lac La Biche through the Logan River, which ultimately receives flows from Jackson Lake in the south, Heart Lake in the east, and Wiau, Clyde and Behan lakes in the northeast. Flat Lake, located in the southwest near Boyle, drains through Pine Creek into the La Biche River. Eric Creek, Lyle Lake, and Wandering River complete the sub-basin to the west (Figure 7-2). The communities of Lac La Biche and Plamondon lie near the southern edges of Lac La Biche.

The Lac La Biche Sub-Basin constitutes a transition zone from aspen to boreal forest, and the streams are generally small, slow and meandering. The exception is the Logan River which, in places, is fast-flowing and possesses a rocky-gravel substrate. The major watercourse, the Lac La Biche River, is slow-moving, with a substrate made up of muddy clays occasionally interspersed with pebbles.

A soil survey and land capability study of the Lac La Biche Sub-Basin was completed in 1979 (Knapik and Carson 1979). Factors such as soil capability, physiography, drainage, and vegetation were studied in selected areas within the sub-basin. In general, the region



LA BICHE SUB-BASIN

FIGURE 7-2

is characterized by sparse settlement and an agricultural capability which is limited by the nature of the soils (Paetz and Zelt 1974). Agriculture, some lumbering, and mink ranching are among the most important regional industries.

At 24,624 ha, Lac La Biche is one of the largest lakes in the region. Its waters are divided into eastern and western portions which are similar in area but which are sufficiently different in depth to cause distinctive limnological conditions (Paetz and Zelt 1974). The eastern portion of Lac La Biche does not undergo any summer stratification; whereas, in the deeper western portion, Pinsent (1967) found stratification occurring from early June to early September with the thermocline located 12 to 17 m below surface.

The Fish Population

The many unpublished reports which have been completed on the fishery of Lac La Biche (Fish and Wildlife Division, Edmonton files) note that the predominant species are lake whitefish, perch, northern pike, lake cisco, burbot, suckers, and pickerel. Overall, Lac La Biche contains 13 species of fish. It is not known whether conditions in Lac La Biche were suitable for lake trout in earlier years, but conditions are now, apparently, not suitable. Age-length data for the fish of several lakes in the region are summarized by Paetz and Zelt (1974). Growth of lake whitefish in Lac La Biche is similar to that reported for Cold Lake and Lesser Slave Lake. The lake whitefish and lake cisco generally inhabit deeper waters; however, the former species will move into shallower reaches with sand-gravel substrates to spawn. Walleye, which also frequent the deeper waters of the lake, move into shallower areas and inlet creeks to spawn at night. The weedy embayments and adjacent sloughs are used by pike for spawning, as are some sand-gravel lake edge areas by whitefish and lake cisco. The precise locations are poorly defined at present.

Behan Lake (1,359 ha) was heavily fished by commercial interests in 1966 for northern pike. Heart Lake, which contains populations of lake whitefish, perch, pike, pickerel, lake cisco, burbot, and suckers, has sustained a moderate commercial fishery in the past and is accessible via a fair weather road.

Dietz (1983) assessed the spawning migration of walleye from Heart Lake into the Heart River, northeast of Lac La Biche. This shallow, slow stream originates in Logan Lake and is fed by small brownwater streams. During this study, though walleye and white suckers were the most abundant species noted at a fence trap, the relatively low numbers of walleye indicated a small potential for use as an egg source. Some pike, burbot, and yellow perch were also taken.

The Lac La Biche River has been the subject of sporadic, but no concerted, fisheries studies since the early 1960's (Bidgood 1966, 1967; Robertson 1967). It was noted then that walleye used the river as a migration route and possibly as a spawning channel. Square Lake, immediately east of Lac La Biche, has been surveyed and contains resident populations of pike, perch, lake cisco, white sucker, and burbot. Except for burbot all these species are known to spawn in the littoral areas of the lake. Square Lake was the site of early attempts to control *Triaenophorus crassus* by poisoning the pike population (Miller 1950).

Sport Fishing Opportunities

Because of its size and susceptibility to severe storms, the potential of Lac La Biche for a sport fishery based on pike, walleye, and perch is not being exploited to its maximum (Paetz and Zelt 1974). Earlier work (Paetz 1953) indicated that the populations of lake whitefish were "in good condition" and since that time, angling pressure in the region has steadily increased. Relative abundances of fish species are listed and compared for lakes in the region by Paetz and Zelt (1974).

The Lac La Biche River is reported to have a good population of pike, which is exploited by anglers. Angling pressure is heaviest in spring at the lower sections of the river where anglers are seeking walleye and pike. Local reports (H. Norris, pers. comm., Alberta Fish and Wildlife Division, St. Paul) indicate that a significant population of walleye are known to undertake a run from Richardson Lake to Lac La Biche. The onset of heavy commercial fishing in Richardson Lake reportedly led to a decline in the Lac La Biche fishery, and the Lac La Biche River is presently on the Fish and Wildlife Division list for re-stocking. After significant angling pressure occurred in the late 1950's to early 1960's on the Owl River, the walleye spring run was all but eliminated. As a result, spring angling on the river is currently closed.

The Lac La Biche Sub-Basin has undergone heavy increases in angling pressure, especially from the developing centres of Athabasca and Fort McMurray. The Sir Winston Churchill Provincial Park on Lac La Biche is heavily used by tourists for fishery access. Nearby Jackson, Guppet, Kennaird and Blacket lakes are known to support lake cisco, walleye, and pike and, in spite of the poor access, are receiving increasing exploitation. The Owl River Alberta Transportation campground also provides access in that area. Sport fishermen fish for pike, perch, and walleye in Lac La Biche, particularly during the annual July fishing derby. Nevertheless, the sport fishing pressure on the lake is considered to be relatively light, with a potential for increased use in the future.

Licence sales to resident anglers more than doubled in the sub-basin from 1972/73 to 1980/81, rising from 956 to 2,093 (0.71% of Alberta resident licence sales) (Table 3-3).

Limitations on the commercial catch of some species in Lac La Biche have been in effect since 1917 (Paetz and Zelt 1974). The principal commercial fish species in the lake have been lake whitefish, lake trout, and ciscoes (Appendix C). The latter species has been heavily exploited as a source of mink food. The Lac La Biche whitefish fishery has experienced sharp fluctuations (notably from 1958 to 1962 and from 1963 to 1967) but, since that time, quotas have assisted in stabilizing the year-class structure of the population. The peak year occurred in 1960 when 353,328 kg of whitefish were harvested from the lake. It is presently the largest single producer of fish in the region providing good commercial catches of lake cisco (196,600 kg), lake whitefish (144,970 kg), and northern pike (39,098 kg) during the annual winter and summer seasons (data for 1982/83, Table C5, Appendix C). In 1982, the commercial catch from Lac La Biche accounted for 19.4% of the landed weight and 8.6% of the dollar value to fishermen in Alberta.

Jackson Lake and Heart Lake are commercially fished, and Clyde Lake and Behan Lake are open on request for commercial exploitation. Conflicts between commercial fishermen and the increasing number of anglers have occurred in the Jackson Lake area over the set commercial quota and the recreational limits (H. Norris, pers. comm., Alberta Fish and Wildlife Division, St. Paul). Similar conflicts of interest have occurred on Square Lake, where a lakeshore subdivision, located on a bay serving as a prime spawning habitat for pike and perch, was noted as potentially affecting those populations (Internal Memo, B. Rippin 1977, Alberta Parks Recreation and Wildlife).

Availability of Alternative Sport Fishing Opportunities

There exist a number of alternative fishing locations in the vicinity of the Lac La Biche Sub-Basin. Many lakes occur to the east of Lac La Biche between it and Cold Lake. The Moose Lake Provincial Park near Bonnyville, and Gardiner Lake Provincial Park, are both accessible via Highway 36 south from Lac La Biche. Although less accessible, Beaver, Touchwood, and Pinehurst lakes are also sought out by sport fishermen.

To the west, Long Lake Provincial Park, Cross Lake Provincial Park on Steele Lake, and Calling Lake Provincial Park provide anglers access to sport fishing lakes. To the north, in the adjacent Clearwater Sub-Basin, access is greatly limited, although anglers seek out streams and lakes such as Winefred, Christina and Bohn lakes, in the area around the Christina River.

Water Quality

Water quality parameters for Lac La Biche were extensively reviewed and summarized by Paetz and Zelt (1974). Measurements for pH ranged from 7.4 to 8.8 units at the surface, and mean hardness and total alkalinity were 118 and 141 mg/L, respectively. Dissolved surface oxygen concentrations ranged from a high of 10.6 to a low of 8.6 mg/L. The maximum high water temperature (25.7°C) occurred at the surface in mid-summer. Paetz and Zelt (1974) indicate that Lac La Biche could be considered eutrophic, according to the Hutchinson classification, based on dominant limnetic algal types, or as eutrophic-mesotrophic according to Rawson's classification.

No water quality station data are available for the La Biche River (V. Beaubien, pers. comm., Alberta Environment Planning Division).

Water Quantity

The water elevation levels for Lac La Biche between 1933 and 1971 are graphically illustrated by Paetz and Zelt (1974). Extensive hydrometric studies have been done in the Pine Creek area with respect to flood control (see extensive reports commissioned by Alberta Environment Planning Division from 1971 to 1977). Other stabilization projects within the Lac La Biche Sub-Basin include Cache Lakes (1977), Claude Lake (1976), and Lac La Biche lakeshore erosion control (1974 to 1975).

Environmental Problems

1. Natural

Lac La Biche, probably due to wind-induced mixing in its shallow portions, has been classified as ranging from eutrophic to eutrophic-mesotrophic. For instance, waterfowl mortality was reported from the lake in 1958 caused by, what was believed at the time, poisonous algae (Webb 1958). Sewage inflows from the community of Lac La Biche may have further contributed to the trend toward eutrophication in the lake.

2. From Water Management Practices

No data are available which indicate fisheries impacts resulting from the stabilization programs in the Pine Creek or Lac La Biche regions. A control structure on Flat Lake may present a barrier to fish movements; however, the fish resource there is relatively limited.

3. Other Sources

The single largest, man-made impact on water quality in the region would probably be the sewage inflow to Lac La Biche from that community. The problem has been identified, and the sewage outflow has been altered in conjunction with improvements to the existing lagoon sewage system.

An oil spill into Pine Creek was investigated by Haugen in 1966, and again by Lane in 1970. Although the spill had eliminated benthic invertebrates for almost six miles below the point of entry in 1966, the stream appeared to have recovered from the incident by 1970.

Data Gaps

Spawning areas utilized by fish populations in Lac La Biche have not been adequately identified, and critical management data on fish movements, population sizes, and seasonal distributions are seriously limited. The total catches from both the recreational and domestic fisheries in the lakes of the sub-basin in the region are poorly documented at present, so that group quotas, when assigned, are based on severely limited data. Baseline limnological surveys of lakes in the region need to be updated. Fish population and water quality research could be appropriately targeted for Behan, Clyde and Wiau lakes.

Stream survey data for the major streams and rivers in the region are needed, as are morphometric and stream benthic surveys. Seasonal distributions of important game fish species in the rivers require more research, especially in the principal tributaries such as the Lac La Biche, Logan, and Wandering rivers.

Fisheries Management Strategies

The fisheries management objective for the Lac La Biche Sub-Basin is to maintain the native fish populations at maximum population levels through natural reproduction, and to maintain water and habitat quality. Habitat and fish population enhancement is directed at recreational, commercial, and domestic fishing. Enhancement of walleye populations in the Lac La Biche Sub-Basin will be a major objective over the next five years.

Summary

The Lac La Biche Sub-Basin is receiving increasing attention from recreational fishermen. Lakes and streams throughout the sub-basin contain highly sought-after populations of walleye and pike. Significant angling pressure in the Owl River area may have contributed to the decline of fish stocks there, and there are reports of conflict between commercial and recreational fishing interests throughout the region. Lac La Biche is one of the most important commercial fisheries in the entire Athabasca Basin (74 licences issued in 1982/83), one which has been exploited for well over 40 years. Increasing commercial, domestic, and recreational fishing pressures in the sub-basin will undoubtedly lead to requirements for enhanced fish management and assessment programs.

CLEARWATER SUB-BASIN

The River Environment

The sparsely populated region of the Alberta portion of the Clearwater Sub-Basin is characterized by limited agricultural capability. The rolling topography of the sub-basin is covered by a relatively undisturbed mixed wood forest.

The Clearwater River was once one of the most important links in the early fur trade. After having crossed the now-famous Methy Portage from Lac La Loche in the Hudson Bay Watershed, early canoeists crossed into the MacKenzie drainage via the Clearwater River to reach the mainstem Athabasca River at what was to become Fort McMurray. It is ironic that the Alberta river with the longest history of use by Europeans is today probably one of the least disturbed by human activity and settlement.

The Clearwater River rises in the southern portions of the Canadian Shield in Saskatchewan and its clear-running waters, relative to the more characteristic brownwater rivers of the area, undoubtedly served as the inspiration for its name. Its headwaters, originating with the Mirror and Virgin rivers in the north and the Black and Birch lakes to the south, make the Clearwater one of the most significant transboundary watersheds in the region. As it flows from Saskatchewan to Alberta, a steady change in the landform occurs along the river, reflecting the decreasing influence of the Precambrian Shield. As it flows toward its confluence with the Athabasca River at Fort McMurray the Clearwater River cuts deeply into the alluvial tills of surrounding countryside.

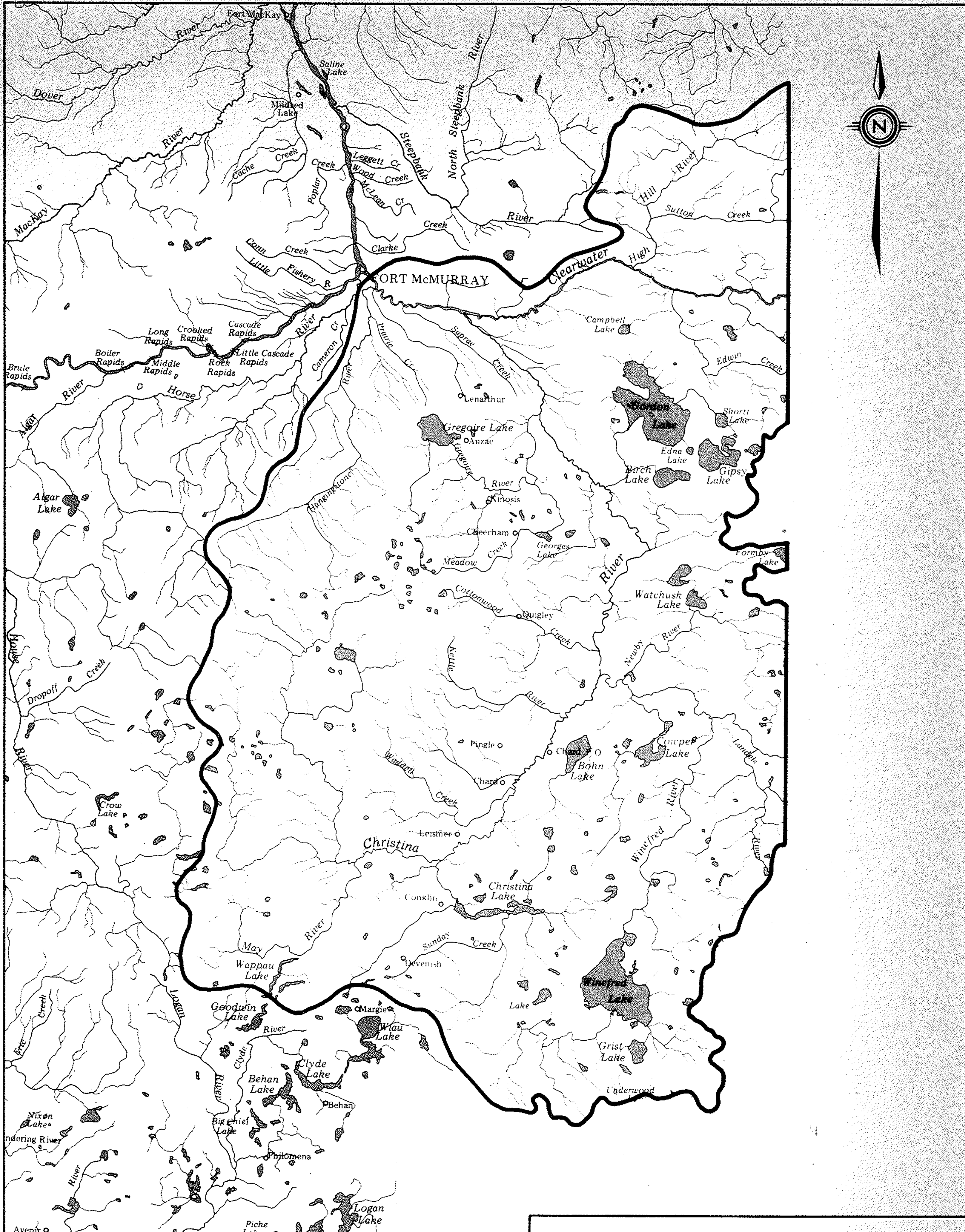
Approximately 70 km upstream of the confluence, the Clearwater flows over a series of waterfalls, the largest of which is the Whitemud Falls. These falls were of a magnitude sufficient to require a second portage by the fur traders following the Methy Portage canoe route to Lake Athabasca in the late 1700's and early 1800's.

Overall, the Clearwater River is a slow, meandering river which flows westward from the Saskatchewan border for about 75 km before joining the Athabasca (Figure 7-3). It drops at a gradient of 0.2 m/km, and the river banks are generally low and eroding, especially where faster currents occur on the outside of meanders.

The substrate is chiefly sandy with gravels overlying moderately erodible dolomite rock. Numerous small islands occur during lower flows, especially in the upper reaches of the Alberta section of the river. Aquatic macrophytes are relatively abundant in the side channel sections formed by the larger of these islands.

The closest meteorological records for the Clearwater Sub-Basin are recorded at Fort McMurray. The annual temperature (mean -0.5 °C) reflects the cold annual cycle of the Polar and Continental air masses. The relatively low annual precipitation (mean 435.4 mm) further reflects the increase in severity of temperature and the slight decrease in precipitation which occurs in the northernmost parts of the sub-basin (Alberta Environment 1978).

Mean dates for spring breakup and winter freeze-up on the Clearwater River are April 29 and November 3, respectively. Discharge is relatively consistent, but has varied from a summer high of 706 m^3/sec in June to a winter base flow of 32 m^3/sec (mean 134 m^3/sec) in February (Kellerhals et al. 1972).



CLEARWATER RIVER SUB-BASIN

(Alberta portion)

FIGURE 7-3

The Fish Population

There have been several studies of fish populations in the Clearwater River and its tributaries, including Griffiths (1973); Jones et al. (1978); Tripp and McCart (1979); and Tripp and Tsui (1980). Table 7-1 summarizes the available information from these studies describing the distribution of fish species within the Clearwater Sub-Basin, including nine streams and one lake (Gregvine Lake). The waterbodies with the largest representation of species, 20 or more, are the two largest streams in the sub-basin, the Clearwater River itself and its major tributary, the Christina River. In the Clearwater River, 20 species have been reported from the reach downstream of the Christina River, while only nine have been reported upstream. This may be, in part, the result of the fact that studies upstream have been less detailed.

Among the sportsfish species, the most widely distributed are Arctic grayling (eight locations), northern pike (six locations), and walleye (five locations). Among non-sports species, the most widespread were the longnose and white suckers (eight and nine waterbodies, respectively); several species of minnows (lake chub, spottail shiner and pearl dace in six waterbodies each; longnose dace in five); trout-perch (five waterbodies); and slimy sculpin (six waterbodies). Of interest to ichthyologists is the tentative identification of the shortjaw cisco from Gregvine Lake (Tripp and Tsui 1980), a species previously reported in Alberta only from Lake Athabasca and Barrow Lake in the Slave River drainage.

Tripp and McCart (1979) report that the Clearwater River, upstream of its confluence with the Christina River, is a major spawning and rearing area for both northern pike and burbot while the Christina River is a major spawning area for longnose and white suckers. Many of the latter may be fish which originate in Lake Athabasca and migrate upstream to spawn. Tripp and McCart (1979)

TABLE 7-1

DISTRIBUTION OF FISH SPECIES

CLEARWATER SUB-BASIN

Scientific Name	Common Name	Clearwater River A	Clearwater River B	Clearwater River T	Hanging-stone River	Prairie Creek	Saline Creek	Saprae Creek	Christina River	Gregoire River	Surmont Creek	High Hill River	Gregoire Lake	Water-bodies
Family Salmonidae														
Salvelinus malma	Dolly Varden													
Coregonus clupeaformis	Lake whitefish		P	P					P				P	3
Coregonus zenithicus	Short cisco												P	1
Prosopium williamsoni	Mountain whitefish	P	P	P	P				P			P		4
Thymallus arcticus	Arctic grayling	P	P	P	P		P	P	P	P	P	P		8
Family Hiodontidae														
Hiodon alosoides	Goldeye		P	P					P					2
Family Esocidae														
Esox lucius	Northern pike	P	P	P	P				P	P		P	P	6
Family Cyprinidae														
Chrosomus eos	Northern redbelly dace													
Chrosomus neogaeus	Finescale dace		P	P					P					2
Couesius plumbeus	Lake chub	P	P	P	P		P		P	P		P		6
Hybognathus hankinsoni	Brassy minnow													
Notropis atherinoides	Emerald shiner		P	P										1
Notropis hudsonius	Spottail shiner	P	P	P					P	P	P	P	P	6
Pimephales gracilis	Fathead minnow		P	P										1
Platygobio gracilis	Flathead chub		P	P					P					2
Rhunichtys cataractae	Longnose dace		P	P	P				P	P		P		5
Semotilus margarita	Pearl dace		P	P	P	P	P		P	P				6
Family Catostomidae														
Catostomus catostomus	Longnose sucker	P	P	P	P		P		P	P	P	P	P	8
Catostomus commersoni	White sucker		P	P	P		P	P	P	P	P	P	P	9
Family Gadidae														
Lota lota	Burbot		P	P					P				P	3

TABLE 7-1 CONCLUDED

Scientific Name	Common Name	Clearwater River A	Clearwater River B	Clearwater River T	Hanging-stone River	Prairie Creek	Saline Creek	Saprae Creek	Christina River	Gregoire River	Surmont Creek	High Hill River	Gregoire Lake	Water-bodies
Family Gasterosteidae														
Culaea inconstans	Brook stickleback				P	P	P		P					4
Pungitius pungitius	Ninespine stickleback													
Family Percopsidae														
Percopsis omiscomaycus	Trout-perch	P	P	P	P				P	P		P		5
Family Percidae														
Perca flavescens	Yellow perch		P	P					P			P	P	4
Stizostedion vitreum	Walleye	P	P	P	P				P	P			P	5
Etheostoma exile	Iowa darter													
Family Cottidae														
Cottus cognatus	Slimy sculpin		P	P	P			P	P	P	P			6
Cottus ricei	Spoonhead sculpin	P		P					P					2
Total Species Reported (No)		9	20	21	12	2	6	3	20	11	5	10	9	

Notes: 1. Data for Clearwater River above and below confluence of Christina counted as single waterbody in determining number of waterbodies in which individual species occur.
2. Codes for Clearwater River are: A = above Christina; B = below Christina; T = total of above and below Christina.

Source: Data from Griffiths 1973, Jones et al. 1978, Tripp and McCart 1979, and Tripp and Tsui 1980 and Tripp and Tsui (1980) found no evidence of any large concentrations of walleye spawning in the Clearwater River or elsewhere in the sub-basin.

Tripp and Tsui (1980) examined the distribution of young-of-the-year grayling in that portion of the Clearwater Sub-Basin which lies within the AOSERP Study Area and concluded that Saline, Sapral, and Surmont creeks were the major grayling spawning streams, though some spawning did occur in the Gregoire and Hangingstone rivers. Grayling populations in the latter stream are thought to have been much reduced as the result of over-fishing by residents of Fort McMurray.

Sport Fishing Opportunities

The Christina River constitutes the largest portion of the Clearwater Sub-Basin which lies within Alberta. The Christina River has experienced increasing angling pressures beginning near the time of construction of the nearby Northern Alberta Railroad and, more recently, increasing with the growth of the population center at Fort McMurray.

Arctic grayling are highly sought after in the Christina River, with fishing pressure extending from its headwaters in the vicinity of Christina Lake, to its confluence with the Clearwater near Fort McMurray. During the spring, the walleye inhabiting the Clearwater and lower Christina rivers receive moderate to heavy angling pressure, largely due to the influx of sport fishermen from the Fort McMurray area (H. Norris, pers. comm., Alberta Fish and Wildlife Division, St. Paul). Pike, walleye, and Arctic grayling are sought after from Chard, near Bohn Lake on the Northern Alberta Railway, upstream to the May River, near Wappau Lake (John Doonanco, pers. comm., Alberta Fish and Wildlife Division, St. Paul). The May

River is known for its population of large Arctic grayling, which also occur in the upstream reaches of the Christina River.

Since access is limited throughout the Clearwater Sub-Basin, especially in the upper reaches of the Christina River, the sub-basin constitutes one of the last largely undisturbed sport fisheries in the entire Athabasca Basin. Nevertheless, significant declines in sportsfish populations have been observed. On the Christina, near the Northern Alberta Railway crossing, Arctic grayling were very abundant in the early 1940's. This abundance was maintained up until the early 1970's, after which population declines were noticed (J. Doonanco, pers. comm., Alberta Fish and Wildlife Division, St. Paul). Similarly, the sportsfish population in the Jackfish River, which drains Christina Lake to the Christina River, has declined from an excellent to a fair fishery in the past five years.

Tripp and Tsui (1980) provide further evidence for the decline of Arctic grayling populations in the sub-basin. Before their study of the Hangingstone River, the river was reputed to be one of the finest Arctic grayling streams in the region. The apparent scarcity of this species by 1979 is significant. The authors note that, before 1977, anglers had no problem catching large, mature grayling at the Hangingstone River by Highway 63 during spring spawning. An old weir, which apparently obstructed upstream movements, concentrated the fish below that point. It was considered quite likely that the relative ease of access to the stream, and its reputation as excellent grayling habitat among the numerous sport fishermen in the growing Fort McMurray urban region, led to quick over-exploitation and a commensurate severe reduction in Arctic grayling populations in that river.

The Winefred River, which drains Winefred Lake and is located in the extreme southeast portion of the Alberta Clearwater Sub-Basin, is also known for grayling populations, but due to very poor access, fishing pressure here is low. In the spring, a good walleye run is known to occur in the Winefred River, especially at the point where the Newby River, which drains Watchusk Lake, joins the Winefred. This walleye run is known to be fished by native peoples from the nearby community of Janvier on Bohn Lake. The Arctic grayling population there is known to be inconsistent from year to year (J. Doonance, pers. comm., Alberta Fish and Wildlife Division, St. Paul). An active fly-in sport fishery occurs in Winefred Lake (an Alberta trophy lake), especially for walleye in the rapids and pools in the outflow of the lake to the Winefred River.

In the Clearwater Sub-Basin, pressure for recreational access is exceedingly high, but very restricted. Access by road is highly limited and the one widely-accessible Provincial Park at Gregoire Lake is used far beyond its capacity during summer peak seasons. Small fishing lodges are common in the sub-basin. A lodge on Gipsy Lake, east of Gordon Lake, serves a pike fishery, one on Christina Lake a walleye fishery, and one on Grist Lake, south of Winefred lake, serves a lake trout fishery. There is also a lodge on Winefred Lake, which is a trophy lake for walleye and pike.

The sparse population of the region is reflected in resident angling licence sales which were among the smallest for any sub-basin in Alberta, rising to 29 (0.01% of the Alberta total) in 1980/81 from 14 in 1972/73 (Table 3-3).

Gordon Lake (7,608 ha) is shallow (1 to 2 m) and is judged to have relatively low fisheries potential. Gipsy Lake (3,470 ha) has a relatively low fishing exploitation pressure and harbours northern pike, lake whitefish, perch and Iowa darters. Accessed by winter roads or aircraft, the lake is thought to possess considerable recreational potential due to its scenic characteristics, water depth (mean 5 m), sandy beaches, and clear waters.

Gregoire Lake (3,387 ha, mean depth 4.2 m) is accessible by road and has camping facilities. Sportsfish species occurring there include lake whitefish, cisco, northern pike, and walleye, although the latter have been significantly reduced. Griffiths (1973) noted that the lake is used for domestic and recreational fishing, but has little commercial potential.

Winefred Lake (11,190 ha) was commercially fished from 1975 to 1978 and experimentally in 1980. In 1982, 1,181 kg of lake whitefish were harvested from the lake (Appendix C). This relatively large, deep (mean 9 m) lake is accessible only by air, and harbours lake whitefish, walleye, burbot, and lake cisco. A small commercial fishery is in place on Christina Lake for lake whitefish and walleye (625 kg and 240 kg, respectively in 1982) (Table C10, Appendix C). Similar commercial catches have been taken on Kirby and Jumbo lakes (Appendix C).

Availability of Alternative Sport Fishing Opportunities

The Clearwater Sub-Basin is very sparsely settled. The closest major community to the north is Fort McMurray where, given the highly restricted access to recreational and sport fishing resources, there is a significant outflow of people during peak recreational months into the Lac La Biche Sub-Basin. Recreational pressures within the Clearwater originate largely outside the sub-basin from the communities of Fort McMurray, Lac La Biche, and Plamondon.

Access to areas west, north, and east of the Clearwater Sub-Basin is highly restricted, with air access to the lakes a primary route for keen sport fishermen. Access by all-terrain vehicles has greatly enhanced ground access to remote portions of the region and is probably the single most significant factor in the decline of sportsfish populations in selected reaches. Immediately to the south, the Cold Lake Air Weapons Range presents a large region of restricted, controlled access.

Water Quality

Of all the sub-basins within the Athabasca Basin, the Clearwater Sub-Basin is probably the least disturbed by man-made activities. From 1960 to 1981, a water quality station (CD 2300) located 2,000 m upstream of Waterways, recorded water quality parameters attesting to the pristine waters there. Alkalinity and hardness ranged from 45 to 94.9 mg/L, and from 43.9 to 109.1 mg/L, respectively. Specific conductivity ranged from 129 to 309 USIE/cm, total dissolved solids from 72 to 161 mg/L, turbidity from 1.1 to 450 JTU (mean 38.1), and pH from 6.6 to 8.6 units. The wide variability reflected in the pH is probably due to the increased proportion of acidic basal flows through the sub-basin during low-flow months. Oxygen concentrations are usually at, or near, saturation. Values for metals (mercury, aluminum, cadmium, copper, and nickel) are exceedingly low, as are coliform counts (0 to 78 MPN/100 mL).

A fuller summary of water quality parameters for the Clearwater and other rivers in the oil sands area is contained in Akena and Christian (1981).

Water Quantity

A water control structure on the Gregoire River was washed out in the spring of 1969. Elsewhere within the region, two hydrometric stations, one above the Christina River confluence with the Clearwater and the other below, at Draper, reflect of the influence on the Clearwater Sub-Basin of waters from Saskatchewan and Alberta. The station above the confluence measures flows which largely originate in Saskatchewan; whereas the station at Draper records flows which are mainly derived from Alberta. The significance of the very large portion of the Clearwater Sub-Basin which lies outside Alberta is indicated by the more than triple maximum flows at the Draper Station. The differences are indicated below:

Station	Long-term Mean Discharge (m^3/s) (8 years' data)	Minimum Flow (m^3/s)	Maximum Flow (m^3/s)	Drainage area(km^2)
Above Christina	79.8	62.4	205.5	15,902.6
Below Christina (Draper)	133.6	32.2	705.6	24,294.2

Eleven years' data collected at the Draper Station indicate that the mean freeze-up occurs on November 3, and the mean date for breakup on April 29 (Kellerhals et al. 1972).

Environmental Problems

1. Natural

Bank stability problems are known to occur on the Christina River at its confluence with the May River. High cutbanks and relatively fast water flows at that, and other, locations in the Christina-Clearwater area have led to some siltation. Generally, riverbanks on the Clearwater consist of silt-sand and gravel overlain with Dolomite, an erodible form of rock. This bank composition leads to frequent slumping along deeply cut sections of the river (Kellerhals et al. 1972).

2. From Water Management Practices

None known.

3. Other Sources

The degree of access provided by all-terrain vehicles and aircraft has had a substantial impact on fish populations in some stream sections of the Clearwater Sub-Basin. In the early 1970's, for instance, Arctic grayling were very abundant in the May River. Since then, both the numbers angled and the average size has significantly declined (J. Doonanco, pers. comm., Alberta Fish and Wildlife Division, St. Paul). This decline is probably indicative of the types of pressure beginning to be exerted on even these relatively remote tributary reaches in this generally poorly accessible sub-basin.

Data Gaps

Although the lower reaches of the Clearwater River are reasonably well-studied, the upper reaches are poorly known. Clearly, jurisdictional interests come into play with this watershed, since much of it lies across the Saskatchewan-Alberta border. Nevertheless, fish population movements in the Christina River drainage are poorly known. Many deficiencies in our knowledge of existing spawning areas and fish habitat hamper formulation of both regulatory and management strategies.

This deficiency points out the need to increase our knowledge of the Clearwater Sub-Basin. Although the region is relatively remote, significant reductions in sportsfish populations are known to have occurred both over the long term, since 1939, and over the short term since the early 1970's. Access by all-terrain vehicles and aircraft has greatly facilitated ease of entry to the region. Hence, fishing pressure may not only be more significant than is easily estimated, it may be much more selective, and therefore damaging, to prime sportsfish populations.

The importance of observations from personnel with experience in the region over the last 40 years should not be missed: most of the decline in "remote" sportsfish populations has occurred within the last five years. An acceleration of such trends could significantly alter the sportsfish populations in these regions unless management and conservation strategies, based on sound data, are soon implemented.

Fisheries Management Strategies

The fisheries management objective for the Clearwater Sub-Basin is to maintain the native fish populations at maximum population levels through natural reproduction, water and habitat quality maintenance. Habitat and fish population enhancement is directed toward recreational, commercial, and domestic fisheries.

Summary

The Clearwater Sub-Basin contains some of the most pristine running and standing waters of the Athabasca Basin. Although access to the area is limited, angling pressures at specific, sought-after sites have had an impact on populations of sportsfish, particularly Arctic grayling and walleye. The development of all-terrain vehicle and air access to streams and lakes within the sub-basin has greatly facilitated the use of previously inaccessible reaches. Pressures for recreational access, chiefly originating from La Biche and Fort

McMurray, have outstripped the capacity of the limited provincial park capability at Gregoire Lake.

Given the trend, which began in the late 1970's, toward increasing recreational demand, the Clearwater Sub-Basin should be considered as a priority area for development of new recreational facilities and for preservation of pristine fisheries habitat. Conservation measures for choice populations of Arctic grayling in the once-remote, but now accessible, tributaries should be implemented immediately. Stream habitat and fish population surveys will be necessary in order to predict impacts before they occur, and to provide a baseline for subsequent management strategies.

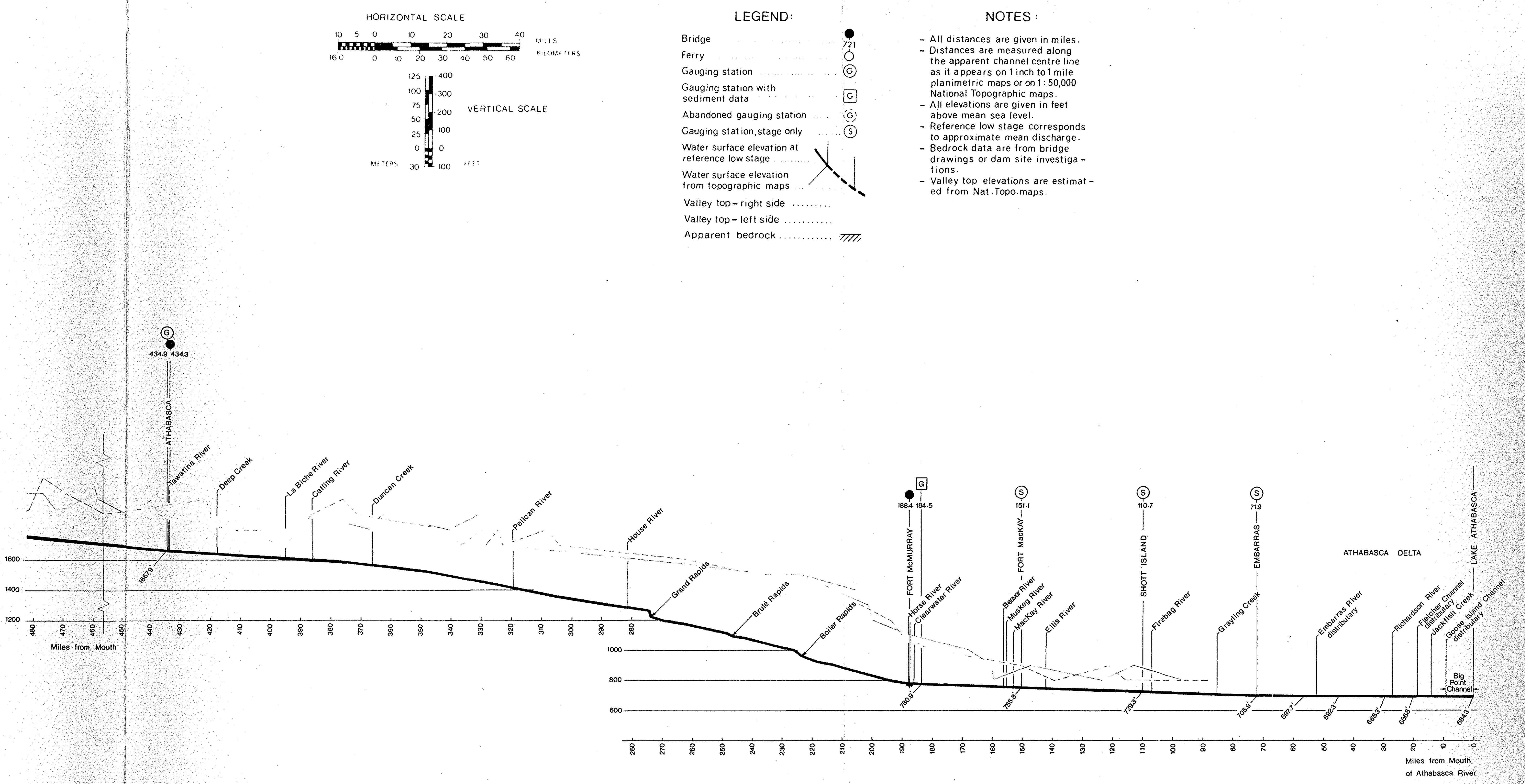
VIII THE ATHABASCA SUB-BASINS

OVERVIEW

Except for the highest western extreme of the Athabasca River, which falls within a discrete jurisdictional and physiographic sub-unit and has been dealt with previously (Section V, Jasper Park Sub-Basin), that portion of the Athabasca mainstem which lacks tributary sub-basins is divided into three mainstem sub-basins: Athabasca I, II, and III (Figure 2-5). These three sub-basins roughly correspond to the mainstem reaches extending from the eastern border of Jasper Park to the community of Athabasca (I), from Athabasca northeastward to Fort McMurray (II), and from Fort McMurray north to the Peace-Athabasca Delta (III). Of the total Athabasca drainage in Alberta (147,000 km^2), these sub-basins drain in excess of 62,822 km^2. Over their combined length, a total distance of 1,225 km, they flow from high-mountain, alpine glacial sources, through the foothills, across the Interior Plain, to the delta of the Athabasca. A longitudinal profile of the Athabasca mainstem is shown in Figure 8-1.

The Athabasca sub-basins are chiefly influenced by two air masses, the continental polar and the maritime polar. In winter, the Arctic air mass extends south, often to the southern limits of the basin. The "continentality" of the climate in the sub-basins results from their inland location distant from the moderating effects of large bodies of marine water.

Three distinct physiographic zones occur within the Athabasca River Sub-Basins: the mountains, the foothills, and the Interior Plains. In the mountains, temperatures range from -12.2 in January to 15.2 °C in July, (mean 2.8 °C). Generally, the frost-free period is 88 days, although July is the only month in which frost does not usually occur.



SOURCE – Research Council of Alberta, 1972
Hydraulic and Geomorphic Characteristics
of Rivers in Alberta

PROFILE OF THE LOWER PORTIONS OF THE ATHABASCA RIVER

FIGURE 8 – 1

Further downstream, in the foothills region, temperatures range from -13.4 in January to 14.6 °C in July (mean 2.3 °C), with 66 frost-free days. The foothills town of Entrance, which is located in a narrow part of the Athabasca River valley, is thought to be more susceptible to cold-air movements than Jasper, which is located in a broad valley. Summer storm systems moving down into the foothills zone can suddenly deposit large amounts of rain, temporarily causing floods and extensive erosion. As a result, sediment transport and deposition downstream can occur in foothills streams, especially in high-gradient streams or in places where stabilizing vegetation has been removed. The effects of such floods on fish populations and fish habitat is discussed elsewhere in more detail, but may include significant streambed and streambank erosion and destruction of spawning habitat.

The Interior Plain has temperatures ranging from about -15 °C in January to 14 °C in July, (mean 1.7 °C). The plains towns of Edson and Whitecourt average 74 and 75 frost-free days, respectively, though the latter is less influenced by warm-winter chinook winds than the former. Further north, the temperatures become more severe in winter and precipitation decreases somewhat. Athabasca, for instance, receives an average of 464.5 mm precipitation annually, whereas Fort McMurray receives only 435.4 mm.

In general, the feature of the Athabasca River sub-basins which distinguishes them from other major Alberta river basins is that their flows are entirely natural. No major flow control structures have been constructed, and smaller projects, such as bridges and pipelines, exercise only a minimal effect on the mainstem portions of the river. The Paddle River Dam, when operational, will be the only major exception to this general rule.

Mean flows for the mainstem of the Athabasca River are shown in Table 8-1. The seasonal flows in the upper reaches of the river are low through the winter months, increase dramatically in May,

TABLE 8-1

MEAN FLOWS (m^3/sec) RECORDED OVER 20 YEARS

(1960 TO 1979) OF THE ATHABASCA RIVER

Location	Years Data	Mean Flow	Drainage Area (km2)
Jasper	10	87.4	3,885
Hinton	18	147.0	9,790
Windfall	20	254.8	19,891
Athabasca	20	452.9	74,572
Below Fort McMurray	20	710.5	132,866

crest in July, and plummet in October--a flow-regime typical of glacier-fed rivers in which ice and snow melt late in the spring at high elevations, and the peak flood is delayed until mid-summer. Further north, at Fort McMurray, the spring flood begins in April and peaks in July, but flows generally remain strong until late October. To the south, on the Interior Plains, snowmelt runoff occurs in early June, but the substantial mountain flows that reach the lower areas in July and August maintain high flows into the summer.

Along its length, the Athabasca River displays most of the classic channel patterns from broad, mainstem reaches, to meanders and braided, alluvial tills. In the mountains, the river slopes 4 m/km, but trails off to 0.2 m/km in its lower reaches. Substrate materials change from 100 to 150 mm cobbles in the headwaters to 0.1 to 0.2 mm silt at the delta.

The Athabasca River passes through the Paleozoic sedimentary shales of the foothills, the Tertiary sandstone and clays of the Interior Plains, and the Canadian Shield which lies at the extreme northeast corner of the basin. The vegetation ranges from the sub-alpine forest of the foothills to the Boreal Forest of the Interior Plains, with a transitional Boreal sub-alpine forest occurring between them. To the north, large areas of Sphagnum moss-black spruce muskeg occur, causing the characteristic brown water of tributaries to the more silty Athabasca.

Reports in the Alberta Oil Sands Environmental Research Program (AOSERP) series extensively document the water quality of the region. Other summaries (Akena and Christian 1981) provide references for data collected outside the AOSERP Study Area.

The Athabasca River mainstem serves as a major migratory route for important fish species in the region, especially as they use the river to reach overwintering, spawning, or summer feeding-rearing habitat. For instance, as many as a million lake trout leave Lake Athabasca in summer to reach fall spawning habitat upstream of Fort McMurray. The longnose sucker exhibits a similar type of migratory behaviour in late winter or the spring. At the upper end of the river system, suckers, Dolly Varden, burbot, Arctic grayling, and mountain whitefish also use the Athabasca mainstem as a primary migratory route into tributary basins. The mainstem river section of the Athabasca functions, in essence, as a linking corridor for fishes distributed among the numerous sub-basins.

Tributary streams and rivers of Athabasca Sub-Basin I, the sub-basin at the highest elevation, contain typically coldwater sportsfish. This sub-basin, ranging from highland Eastern Slopes terrain to Interior Plain, is a popular sport fishing region. Several lakes, Obed and Carson, for instance, are heavily stocked with rainbow trout and, to a lesser extent, eastern brook trout. A significant use of these recreational lakes is made by anglers living within a 200 km radius, the majority of which live in Edmonton.

Athabasca Sub-Basin II is the least understood fisheries area along the Athabasca mainstem. To the north, the House River once yielded Arctic grayling to anglers, but catches have declined in the last decade as a result of over-exploitation. The Calling River is heavily angled, mostly for Arctic grayling and walleye. Calling, Orloff, Rock Island, and Baptise lakes are used extensively for sport fishing, especially by residents from the Edmonton region.

Athabasca Sub-Basin III, extending from Fort McMurray in the south, at the confluence of the Clearwater River, north to the Peace-Athabasca Delta, constitutes some of the most diverse fisheries habitat in Alberta. Drawing from an enormous tributary network, the sub-basin picks up flows from large areas of Saskatchewan, chiefly through the Firebag and Richardson rivers. To the east, the MacKay, Dover, and Ells rivers drain the Namur-Gardiner Lakes region of the

Birch Mountains. Growing population centres, such as Fort McMurray, have placed increasing demands on the recreational fisheries throughout the sub-basin and focus attention for the need for more access to suitable recreational outlets.

ATHABASCA SUB-BASIN I

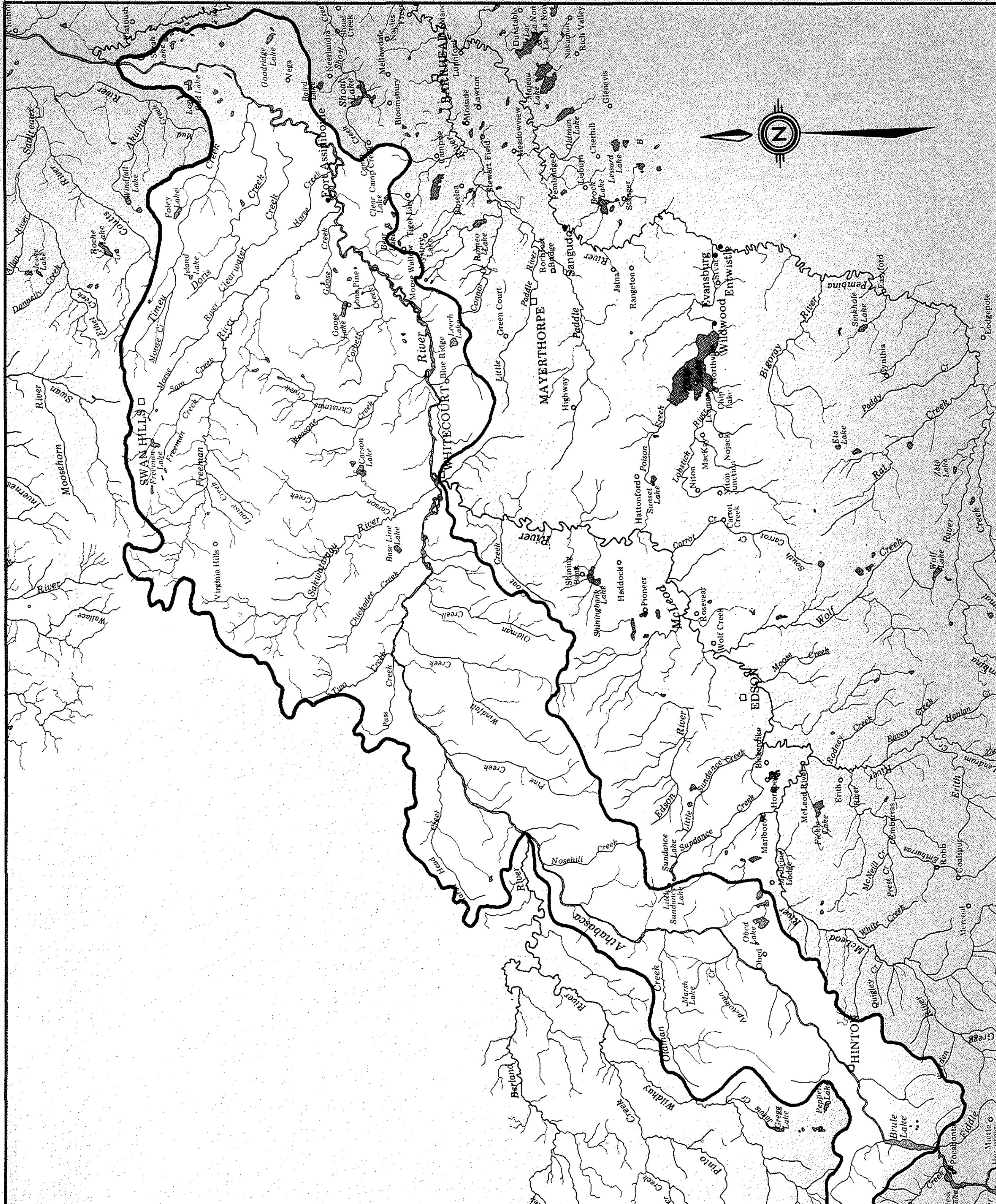
The River Environment

Athabasca Sub-Basin I, extending from the eastern boundary of Jasper Park to a point east of Fort Assiniboine (Figure 8-2), drains an area in excess of 8,500 km^2. Exiting the Jasper Park through the shallow gravels of Brule Lake, the Athabasca falls from an elevation of 980 m to slightly more than 655 m over its 255 km course to Christmas Creek just east of Whitecourt. The sub-basin receives flows from Oldman Creek and Obed Lake in the west, and from Sakwatamau River, Christmas Creek, and the Freeman River, which originates in the Swan Hills, in the east. The communities of Hinton, Whitecourt, Fort Assiniboine, and Swan Hills fall within the Athabasca Sub-Basin I. All except Swan Hills are located on the Athabasca mainstem.

The streambed of Athabasca Sub-Basin I is gravel, and its course is often sinuous and split with frequent mid-channel and point bars. The terraced, stream-cut valley exhibits sparse forest cover and occasional bedrock outcroppings. The tributary streams, including Oldman Creek, Pine Creek, and Windfall Creek, exhibit the cold, clearwater habitat typical of Eastern Slopes streams. To the west, the Sakwatamau and Freeman rivers are more representative of transition-zone fish habitat of the Interior Plains.

The Fish Population

Early studies found that Athabasca Sub-Basin I supported populations of rainbow trout, Dolly Varden, Arctic grayling, northern pike, and lake and mountain whitefish (Dempsey 1945). Other fish included brook stickleback, northern pearl dace, white suckers, and longnose suckers. In 1955, surveys by Miller indicated that similar fish species occurred from Hinton to Fort Assiniboine. More recent



ATHABASCA SUB-BASIN I

FIGURE 8-2

(Hawryluk 1980) studies indicate the presence of walleye, flathead chub, and goldeye.

The upper tributaries of Athabasca Sub-Basin I provide typical coldwater sportsfish habitat. Oldman Creek, for instance, is known for Arctic grayling, mountain whitefish, and rainbow trout. Further downstream, Windfall Creek contains Arctic grayling, mountain whitefish, Dolly Varden, and rainbow trout. Christmas and Chickadee creeks are both known to support Arctic grayling. Marsh Head Creek was extensively surveyed as part of the Canadian Gas Arctic Pipeline Study, and was found to support similar fish species, including Arctic grayling. More recently, Seidel (1982) found Sandstone Creek to contain rainbow trout. Growth rates of fishes in this sub-basin are generally slow, due to the typically coldwater conditions.

Carson Lake, just north of Whitecourt, supports a viable rainbow trout recreational fishery (Hildebrand 1978). The lake has been extensively studied (Mentz 1980, Hawryluk 1981) and was confirmed as a well-known rainbow trout fishery. Prior to 1970, the lake supported native populations of northern pike, lake whitefish, and white suckers. In 1970, the lake was stocked with walleye (Lane and Crutchfield 1970). Carson Lake, which has had winterkills (Mentz 1980 and Water Quantity section of this chapter) has been stocked with rainbow trout since 1971. In 1975, trout caught in the lake achieved a Provincial record of 7.48 kg. In 1976, before a rotenone treatment to remove pike and suckers, a salvage fishery was instituted on the lake (Hunt 1977).

Emerald Lake, approximately 25 km north of Whitecourt, contains a native population of finescale dace. It was first planted with eastern brook trout fingerlings in 1967, and was stocked with rainbow trout from 1963 to 1976 (Hawryluk 1977).

Sport Fishing Opportunities

The Athabasca Sub-Basin I sport fishery, from Hinton downstream to Whitecourt, has become increasingly popular in recent years (Hawryluk 1980). Improved road access throughout the region allows more contact with the river. Angler reports of good catches along the mainstem indicates that not only is it well-known among sport fishermen of the region but that it may possess a strong potential for increased use in the future.

Oldman Creek (rated Class 2 in the ARDA sportsfish capability survey) provides good Arctic grayling, mountain whitefish, and rainbow trout sport fishing. Similarly, Windfall Creek, Pine Creek, Marsh Head Creek, and Beaver Creek are all viable sportsfish habitat areas, and are commonly frequented by anglers. Carson and Emerald lakes are stocked with trout as a continuing program, and Pegasus Lake has native pike, perch, and whitefish (Hunt 1979). Laura Lake was stocked from 1967 to 1977, but planting was stopped because of frequent winter kills and low angling pressure.

Absorbing much of the angling pressure within the region, Carson Lake is a well-known recreational source of rainbow trout and pike. Close to Whitecourt, the lake accounted for 16,809 angler-days in 1978 (Hildebrand 1978). Ninety-eight percent of the anglers live within a 200 km radius of the lake; 76% originate from the Edmonton area (Hawryluk 1980). These figures emphasize the growing recreational resource pressure evident in the Eastern Slopes region of the Athabasca Basin.

Carson Lake was chemically treated in 1976, and restocked with rainbow trout in 1977 (Hawryluk 1981). In 1977 and 1978, respectively, 433,000 and 436,000 fingerlings were stocked into the lake and reduced plants of 220,000 trout were made in 1979 and 1980.

Approximately 232,800 and 216,000 trout were added to the lake in 1981 and 1982, respectively. Near Whitecourt, Emerald Lake is another popular angling area, and was stocked in 1982 with just under 4,000 eastern brook trout. Further west at Obed Lake, near Hinton, 30,000 10 cm rainbow trout were stocked in 1982. The lake enjoys considerable local recreational popularity, and is regularly stocked.

Availability of Alternative Sport Fishing Opportunities

Athabasca Sub-Basin I is surrounded by prime sport fishing areas to the west (Berland, McLeod, and Jasper Park Sub-Basins), to the south (Pembina Sub-Basin), and to the east (Lac La Biche Sub-Basin). To the north, the Lesser Slave Sub-Basin and the southern extreme of the Peace River Basin complete the adjoining sub-basins. The recreational areas of latter sub-basins are less accessible than those in the former.

Water Quality

A major land-use activity in the Athabasca Sub-Basin I is a Pulp Mill located at Hinton. There has been a history of complaints from anglers regarding undesirable mill effluent odours or tainted fish flesh in fish caught downstream of the effluent (Hawryluk 1980). Earlier water quality and biological surveys of this sub-basin (Beak 1960, 1965) were followed by research by the Federal Government (Ruggles and Sergy 1975), and the Alberta Department of Health (1960 to 1970) to assess the effects of mill effluents on the river (Hawryluk 1980). These, in turn, set the stage for a study by Beak Consultants (1980) of the problem. They concluded that the 520 tonnes per day of kraft pulp mill effluent discharged into the Athabasca River near Hinton did not quantitatively affect benthic invertebrate communities outside of a zone 0.32 km below the mill outlet. More recent reports (Alberta Environment Pollution Control Division 1981) indicate that the mill has achieved a 97% performance compliance record, but that bark pile leachates entering Hardisty Creek remained "an area of concern". The annual volume of industrial effluent discharged from the St. Regis Mill is more than twice that of Suncor at Fort McMurray, and is the highest (94.7 to 85.7 1,000 m^3/day in 1979 and 1981, respectively) of any other plant in the entire Athabasca Basin.

The water quality station (AG2080) near Whitecourt recorded a range of water quality parameters in the mainstem from 1970 to 1976. Over that period, pH ranged from 7.4 to 8.3 units, total dissolved solids from 115 to 264 mg/L, alkalinity from 77 to 231 mg/L, and turbidity from 1 to 20 JTU. Dissolved oxygen ranged from 7.2 to 14.1 mg/L, and phenols from 0.001 to 0.015 mg/L. Total coliforms showed a striking range from 0 to 1,800 NDL, with an average of 128 (Alberta Environment).

Water Quantity

No man-made structures are known to affect the waters of Athabasca Sub-Basin I. In the mainstem flow measured near Whitecourt, seasonal flows ranged from 23.2 m^3/sec (March 1964) to 2,106 m^3/sec (July 1965), with a mean of 272 m^3/sec (7AE-1 Water Survey of Canada Station) (Kellerhals et al. 1972). Based on seven years' data, mean dates for freeze-up and breakup in this sub-basin occur on November 7 and April 28, respectively. Prior to 1970, winter water levels in Cason Lake were significantly lowered to supply water for the Judy Creek field. Thereafter, severe winter kills occurred in 1970 and 1971. To stabilize the lake level, a pipeline was built from the Athabasca River, and the lake was subsequently stocked with trout (Personal communication, Fish and Wildlife Division personnel).

Environmental Problems

1. Naturally Occurring

The moderately-forested plain characteristic of this region gives rise to a terraced, stream-cut valley with occasional slumping. Valley walls are generally sparsely-forested with the occasional bedrock cliff. Some bank instability has been observed along tributary streams such as Windfall Creek, a stream which maintains several coldwater sportsfish (Hawryluk 1980).

2. From Water Management Practices

None known.

3. Other Sources

The industrial waste effluents from the St. Regis Pulp and Paper Mill and the sewage outfalls from Edson, Hinton, and Fort Assiniboine each contribute successive loadings to the mainstem Athabasca. Some tributary streams in the sub-basin chiefly Beaver Creek and Pine Creek have been affected by forestry activities. The latter was "highly polluted" by an oil spill in 1966 (Hawryluk 1980).

Gravel removal within the floodplains of the McLeod, Berland, and Pembina sub-basins has been a matter for attention by resource agencies. Some areas of the McLeod (Marlboro and Peers) have been stripped of gravel bars, causing channel changes. Sources of gravel within the high water mark should be prohibited, and effluents from gravel washing should be disposed of in settling ponds.

Data Gaps

Levels of recreational fishing pressure are poorly quantified for many points in Athabasca Sub-Basin I. Some streams, such as Windfall Creek and Oldman Creek in the upper reaches, are well-known and widely exploited.

Throughout Athabasca Sub-Basin I, particularly in the tributaries, spawning sites and overwintering habitat areas are poorly surveyed, and fish productivity and angler demand are not well quantified. Long term, qualitative impacts from the industrial and urban effluents to the Athabasca River have not been identified, with the result that the ecological causes and consequences of fish tainting problems in the Athabasca River are not understood.

Hawryluk (1980) detailed a number of specific management and conservation proposals for tributary rivers in Berland Forest Management Area, of the Eastern Slopes region. Recommendations were made for use of land use restrictions near fish-producing lakes and streams, and for a curtailment of campground facilities near lakes, and especially, streams. These recommendations should be followed up with detailed studies for regional fisheries habitat management.

Detailed surveys should be done on the Sakwatamau and Freeman rivers, and other major Athabasca Sub-Basin I tributaries, to identify fish species, populations, migration routes, ranges, spawning habitat, and overwintering areas for all sportsfish populations. The greatest potential for fisheries development in the Carson Lake area is dependent on a complete inventory of unsurveyed lakes throughout the district (Hunt 1979).

Fisheries Management Strategies

The fisheries management objective for Athabasca Sub-Basin I is to maintain native fish populations at maximum population levels through natural reproduction, water and habitat quality maintenance, and habitat and fish population enhancement for recreational fishing.

Summary

Athabasca Sub-Basin I, extending from the Jasper Park boundary to just east of Fort Assiniboine, contains a diverse, and highly utilized fish population. Typically coldwater fishes are found within the area, and angling for Arctic grayling and rainbow trout is provided in several mainstem, tributary (Windfall Creek, Marsh Head Creek, and Oldman Creek) and lake (Obed, Carson, and Emerald) settings. The region is heavily exploited by anglers from the Edmonton urban centre. Industrial and urban water usage along the Athabasca mainstem has been a center of controversy, especially as incidents of fish-tainting downstream from the major industrial users have been reported and investigated.

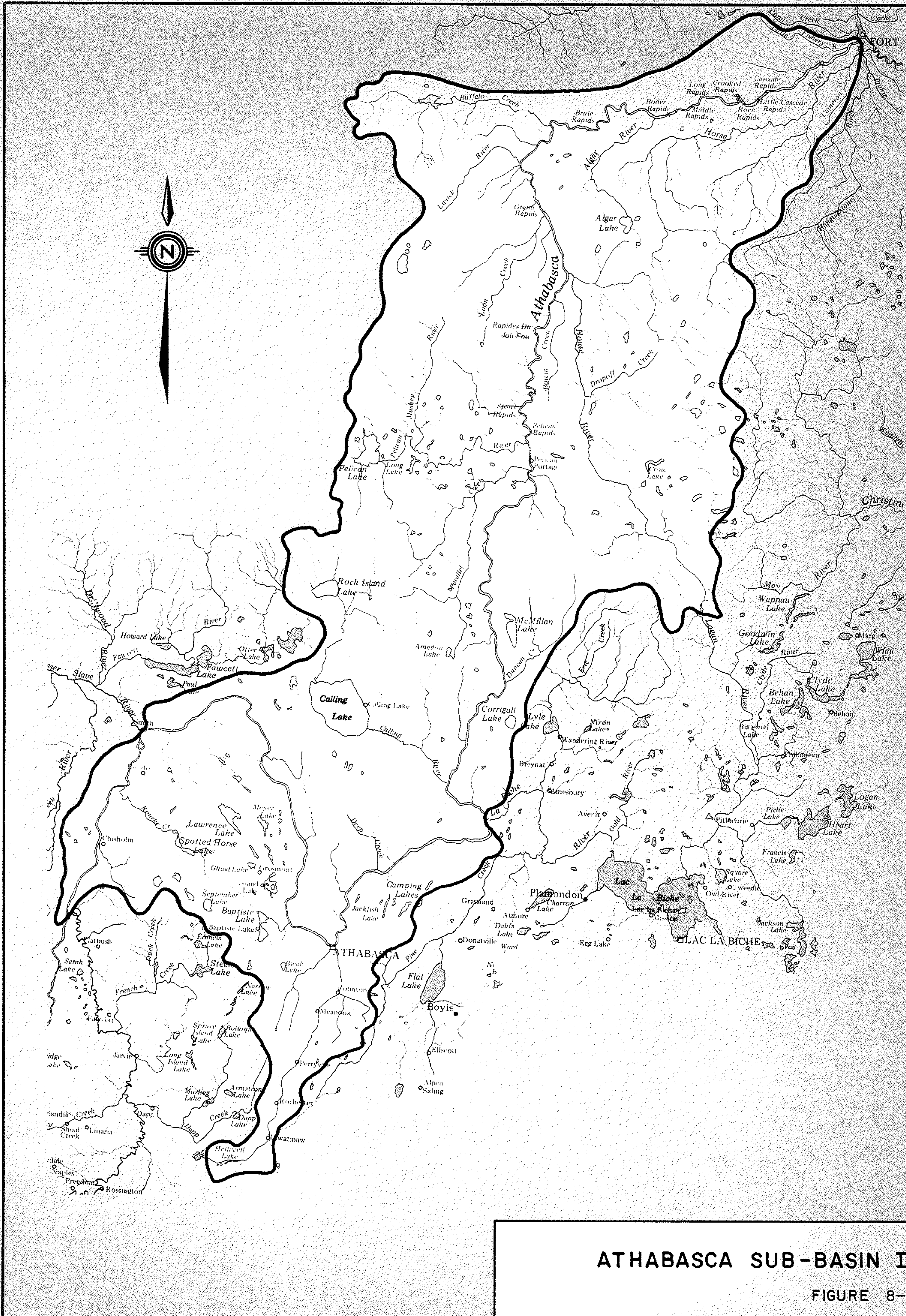
ATHABASCA SUB-BASIN II

The River Environment

Athabasca Sub-Basin II extends from a point mid-way between the communities of Fort Assiniboine and Athabasca to Fort McMurray, and drains an area of more than 6,000 km^2 (Figure 8-3). The river, after gradually dropping in elevation from Fort Assiniboine to Athabasca, begins a sudden, and final drop in the vicinity of the Pelican River inflow. Between Athabasca and Fort McMurray, the river declines in elevation from 508 m to 238 m. The declines occurring at the Grand, Brule, and Boiler rapids are the last major changes in the elevation of the river. The elevation change between Fort McMurray and Lake Athabasca, for instance, is only 32.2 m (Figure 8-1). To the south, the sub-basin drains Calling, Rock Island, and Baptiste lakes. In the central and northern portions, the drainage is completed by Pelican Lake and Pelican River on the western side of the Athabasca, and the House and Horse rivers on the eastern side (Figure 8-3).

Within Athabasca Sub-Basin II, the Athabasca mainstem is relatively shallow (3 m) and carries a high sediment load. The river flows over gravel mixed with local sand and cohesive clays (Kellerhals et al. 1972); its valley walls are moderately to sparsely forested, and occasional slumping occurs along sharp meanders. As it flows north, the silt-laden Athabasca receives progressively more input from brownwater streams. The changing character of the water reflects the increasing influence of the muskeg-boreal land form of the northern regions. At the same time, the relatively flat agricultural lands of the Athabasca district slowly give way to the black spruce and muskeg terrain commonly identified with the northern Athabasca.

Access to the Athabasca Sub-Basin II is highly limited, the exception being to Calling Lake Provincial Park via Highway 813 from Athabasca and via Highway 63 from Fort McMurray. Few people live



ATHABASCA SUB-BASIN II

FIGURE 8-3

within the sub-basin, Athabasca representing the only major population centre.

The Fish Population

Fish populations in Athabasca Sub-Basin II have been little studied except for the part of the sub-basin which lies within the former AOSERP Study Area. This part of the sub-basin extends from Grand Rapids to Fort McMurray, a distance of about 140 km. Table 8-2 details the distribution of fishes in the Athabasca mainstem above and below Cascade Rapids, a major spawning area for several species, and two tributary watersheds, the Horse and Algar.

In this reach, Athabasca Sub-Basin II serves as a major spawning area for several major species of fish, including populations of lake whitefish, which originates in Lake Athabasca and undertakes a summer migration upstream. These fish spawn in the fall in the vicinity of Mountain and Cascade rapids, upstream of Fort McMurray. McCart et al. (1982) estimated that a minimum of 300,000, and a possible maximum of over a million, lake whitefish spawn in this area. Catches of young-of-the-year suggest that walleye originating in Lake Athabasca and the lower Athabasca River may also spawn in the reach of the river from Grand Rapids to Mountain Rapids, but this has not yet been confirmed by captures of spawning fish (Tripp and McCart 1979).

Tripp and McCart (1979) found that the same reach of the Athabasca Sub-Basin II serves as spring spawning habitat for large numbers of longnose suckers, thought to originate in Lake Athabasca. Upstream of the Cascade Rapids, longnose suckers are smaller and slower growing and probably represent a distinct resident population. Cascade Rapids seems to be at least a partial barrier to the movements of fish and the existing data suggest that densities of fish are consistently higher in the reach of the Athabasca River from Fort

TABLE 8-2

COMPARISON OF CATCH-PER-UNIT-EFFORT FOR GILLNET AND MINNOW SEINE CATCHES

BELOW AND ABOVE CASCADE RAPIDS, ATHABASCA RIVER

Year	Season	Gear	Units	Catch-per-unit-effort Below Cascade	Catch-per-unit-effort Above Cascade	Ratio Below/ Above
1977	Fall	Gillnet	catch/hr	0.70	0.16	4.4
1978	Spring/Summer	Gillnet	catch/hr	0.82	0.45	1.8
		Minnow Seine	catch/haul	40.1	25.9	1.5

Source: Data for 1977 from Jones et al. 1978; for 1978 from Tripp and McCart 1979

McMurray to Cascade Rapids than in the reach immediately upstream (Table 8-3).

Fish populations in the Horse and Algar river watersheds (Table 8-4), were examined by Tripp and Tsui (1980). The Horse River supports 14 species of fish, though some of them are confined to its lower reaches. The Algar River is a small brownwater, muskeg stream with only five fish species in total. Of these, only two species, pearl dace and brook stickleback, were found in the upper reaches of the stream and in Algar Lake which it drains.

The Calling River is known to harbour Arctic grayling, walleye, and northern pike, but access is generally poor. The river is also subject to rapid fluctuations in water levels, depending on the amount of precipitation received by the watershed. Cunningham (1969) surveyed the Calling River and concluded that severe water fluctuations, high water temperatures, and the presence of pike made it an unlikely habitat for trout or trout stocking. Griffiths (1974) conducted a preliminary reconnaissance in the Pelican Lake area and Miller and Thomas (1954) conducted an earlier survey of lakes in the Athabasca area.

Sport Fishing Opportunities

Since access to Athabasca Sub-Basin II is very limited, lakes accessible by road are of great importance to the sport fisherman. The Horse River, once reputed to be a good source of Arctic grayling, has undergone significant reductions in those populations since road access to Fort McMurray was constructed (H. Norris, pers. comm., Alberta Fish and Wildlife Division, St. Paul). Other rivers, such as the Algar, Lovick, and Pelican are also very difficult of access.

TABLE 8-3

DISTRIBUTION OF FISH SPECIES

ATHABASCA SUB-BASIN II, AOSERP STUDY AREA

Scientific Name	Common Name	Athabasca River: Fort McMurray to Cascade River	Athabasca River: Above Cascade River	Athabasca River: Total	Horse River	Algar River	Algar Lake	Waterbodies
Family Salmonidae								
Salvelinus malma	Dolly Varden		P	P				1
Coregonus clupeaformis	Lake whitefish	P		P				1
Prosopium williamsoni	Mountain whitefish	P	P	P				1
Thymallus arcticus	Arctic grayling	P	P	P	P			2
Family Hiodontidae								
Hiodon alosoides	Goldeye	P	P	P	P			2
Family Esocidae								
Esox lucius	Northern pike	P	P	P	P			2
Family Cyprinidae								
Chrosomus eos	Northern redbelly dace							
Chrosomus neogaeus	Finescale dace	P	P	P				1
Couesius plumbeus	Lake chub	P	P	P	P	P		3
Hybognathus hankinsoni	Brassy minnow	P	P	P				1
Notropis atherinoides	Emerald shiner	P	P	P				1
Notropis hudsonius	Spottail shiner	P	P	P	P			2
Pimephales gracilis	Fathead minnow	P	P	P	P			2
Platygobio gracilis	Flathead chub	P	P	P	P			2
Rhunichtys cataractae	Longnose dace	P	P	P	P	P		3
Semotilus margarita	Pearl dace	P	P	P		P	P	3
Family Catostomidae								
Catostomus catostomus	Longnose sucker	P	P	P	P	P		3
Catostomus commersoni	White sucker	P	P	P	P			2
Family Gadidae								
Lota lota	Burbot	P	P	P				1

TABLE 8-3 CONCLUDED

Scientific Name	Common Name	Athabasca River: Fort McMurray to Cascade River	Athabasca River: Above Cascade River	Athabasca River: Total	Horse River	Algar River	Algar Lake	Waterbodies
Family Gasterosteidae								
Culaea inconstans	Brook stickleback		P	P		P	P	3
Pungitius pungitius	Ninespine stickleback							
Family Percopsidae								
Percopsis omiscomaycus	Trout-perch	P	P	P	P			2
Family Percidae								
Perca flavescens	Yellow perch	P		P	P			2
Stizostedion vitreum	Walleye	P	P	P	P			2
Etheostoma exile	Iowa darter							
Family Cottidae								
Cottus cognatus	Slimy sculpin	P		P	P			2
Cottus ricei	Spoonhead sculpin	P	P	P				1
Total Species Reported (No)		22	21	24	14	5	2	

Notes: 1. Data for Athabasca River above and below Cascade Rapids counted as single waterbody in determining number of waterbodies in which individual species occur.

Source: Data from Tripp and McCart 1979, and Tripp and Tsui 1980

TABLE 8-4

DISTRIBUTION OF FISH SPECIES IN STREAMS

ATHABASCA SUB-BASIN III

Scientific Name	Common Name	Athabasca River PA	MI	T	FI	MA	EL	MK	DO	DU	ST	MU	HA	BE	PO	CA	PI	EY	AS	Water-bodies
Family Salmonidae																				
Salvelinus malma	Dolly Varden		P	P							P	P								3
Coregonus clupeaformis	Lake whitefish	P	P	P	P		P	P			P	P		P		P		P		9
Coregonus artedii	Lake cisco										P	P								2
Prosopium williamsoni	Mountain whitefish	P	P	P		P	P	P			P	P	P							7
Thymallus arcticus	Arctic grayling		P	P	P	P	P	P		P	P	P	P	P	P	P	P	P		14
Family Hiodontidae																				
Hiodon alosoides	Goldeye	P	P	P			P	P			P					P		P		6
Family Esocidae																				
Esox lucius	Northern pike	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		15
Family Cyprinidae																				
Chrosomus eos	Northern redbelly dace		P	P	P						P	P								4
Chrosomus neogaeus	Finescale dace		P	P				P	P											3
Couesius plumbeus	Lake chub	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	16
Hybognathus hankinsoni	Brassy minnow		P	P							P									2
Notropis atherinoides	Emerald shiner	P	P	P	P			P								P				4
Notropis hudsonius	Spottail shiner	P	P	P	P		P	P			P	P				P	P			8
Pimephales gracilis	Fathead minnow		P	P							P	P			P					4
Platygobio gracilis	Flathead chub	P	P	P	P		P	P			P							P		6
Rhunichtys cataractae	Longnose dace	P	P	P	P	P	P	P	P		P	P	P				P	P		11
Semotilus margarita	Pearl dace		P	P	P	P	P	P	P	P	P	P	P			P	P			12
Family Catostomidae																				
Catostomus catostomus	Longnose sucker	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		15
Catostomus commersoni	White sucker	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		15
Family Gadidae																				
Lota lota	Burbot	P	P	P	P	P	P	P			P	P		P	P			P		10

TABLE 8-4 CONCLUDED

Scientific Name	Common Name	Athabasca River PA	MI	T	FI	MA	EL	MK	DO	DU	ST	MU	HA	BE	PO	CA	PI	EY	AS	Water-bodies
Family Gasterosteidae																				
Culaea inconstans	Brook stickleback	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	16
Pungitius pungitius	Ninespine stickleback	P	P	P	P							P								3
Family Percopsidae																				
Percopsis omiscomaycus	Trout-perch	P	P	P	P	P	P	P	P	P	P	P		P		P	P	P		13
Family Percidae																				
Perca flavescens	Yellow perch	P	P	P	P		P	P	P		P	P				P				8
Stizostedion vitreum	Walleye	P	P	P	P		P	P			P	P		P		P	P	P		10
Etheostoma exile	Iowa darter		P	P																1
Family Cottidae																				
Cottus cognatus	Slimy sculpin		P	P	P	P	P	P	P	P	P	P	P	P		P	P			13
Cottus ricei	Spoonhead sculpin	P	P	P	P	P	P	P			P									6
Total Species Reported (No)		18	27	27	20	13	19	21	11	9	24	21	10	11	8	15	12	13	2	

Notes: 1. Data for Athabasca River near Peace-Athabasca Delta and near Mildred Lake counted as a single waterbody in determining number of waterbodies in which individual species occur.

2. Two letter codes are: AS = Asphalt Creek; BE = Beaver Creek (natural); CA = Calumet River; DO = Dover River; DU = Dunkirk River; EL = Ells River; EY = Eymundson Creek; FI = Firebag River; HA = Hartley Creek; MA = Marguerite River; MI = Mildred Lake; MK = MacKay River; MU = Muskeg River; PA = Peace-Athabasca Delta; PI = Pierre River; PO = Poplar Creek; ST = Steepbank River; T = Total of Peace-Athabasca Delta and Mildred Lake.

Source: Data from Bond 1980, Griffiths 1973, Herbert 1979, O'Neil 1982, Renewable Resources 1973, and Sekerak and Walder 1980

In the region between Edmonton and Athabasca, Baptiste, Calling, and Rock Island lakes form an important focus for recreational sport fishing. Near Athabasca, Boyle Pond and Westlock Recreational Pond were stocked in 1982 with 4,000 and 3,000 rainbow trout, respectively. Lower Chain and Horseshoe lakes were also stocked that year with 75,000 and 15,000 rainbow trout, respectively.

Baptiste, Rock Island, and Orloff lakes are well-utilized sport fishing lakes, and walleye, pike, and perch are taken there. Commercial fisheries occur at Island, Calling, and Rock Island lakes (Appendix C). Marginal sport fisheries are supported by Lawrence Lake (perch), Narrow Lake (walleye, pike, and perch), and Long Lake (pike).

At 13,478 ha, Calling Lake is the most substantial standing body of water in the Athabasca Sub-Basin II, followed by Pelican and Rock Island lakes. Far smaller (950 ha) Baptiste Lake is easily accessed from the community of Athabasca. Arctic grayling and mountain whitefish have been taken from most rivers associated with the Athabasca mainstem.

Availability of Alternative Sport Fishing Opportunities

The Lac La Biche Sub-Basin is easily accessed from the community of Athabasca. To the west, the Chip Lake region of the Pembina Sub-Basin is similarly accessible. Athabasca Sub-Basin I serving Whitecourt, and the McLeod Sub-Basin serving Edson, also provide alternative sport fishing. To the north, Fawcett and Lesser Slave Lake provide alternatives as well.

Water Quality

Many water quality studies have been carried out on the Athabasca mainstem, chiefly in the heavily industrialized Hinton-Whitecourt area, further northeast in the Fort McMurray oil sands region, and within the Peace-Athabasca Delta. By comparison, the central region occupied by the Athabasca Sub-Basin II is somewhat less well-known.

The water quality station (BE0001) located at the community of Athabasca records surface water temperatures ranging from 0 to 23°C (NAQUADAT Summary) and turbidities from 26.7 to 1,100 JTU. Between 1960 and 1982, phenols ranged from 0.0002 to 0.025 mg/L, dissolved oxygen from 7.2 to 13.6 (mean 10.2) mg/L, pH from 7.2 to 8.7 units, total alkinity from 39 to 194 mg/L, and total hardness from 83 to 214 mg/L. Highs for total phosphorous recorded at 0.5 mg/L and for chloride at 9.0 mg/L. Methoxychlor reached a concentration of 0.01 µg/L. Downstream of the community of Athabasca, the active treatment level for Simulium is 0.1 mg/L methoxychlor. Additions and mixing of methoxychlor insecticide in the Athabasca River downstream from Athabasca were evaluated by Beltaos and Gerard (1975). Total PCB's in the river have reached levels of 0.02 µg/L.

Water Quantity

At Athabasca, flows in Athabasca Sub-Basin II range from 45 m^3/sec (December 1956) to 5,589 m^3/sec (June 1954). Based on 30 years' data, mean flows are 426 m^3/sec. At the northern end of the sub-basin, downstream of Fort McMurray, total flows are higher, ranging from 95 m^3/sec (February 1964) to 4,217 m^3/sec (June 1960). Based on eight years' data, mean flows are 638 m^3/sec (Kellerhals et al. 1972). The higher average flow reflects the additional inputs from the northern tributary drainages, especially the Clearwater River. Mean dates for freeze-up and breakup are November 4 and April 23 for Athabasca, and November 5 and April 28 for Fort McMurray. The spring freshet typically begins by mid-April, and river flows peak within a few weeks. Reflecting the high mountain glacial melt which follows spring breakup, the river shows a second, usually large, peak in July.

Environmental Problems

1. Naturally Occurring

Along some reaches of the Athabasca, bank slumping occurs, but given the relatively high sediment loadings in those reaches, it cannot be considered to be a significant problem. The Calling River is subject to severe fluctuations, which may affect fish habitat. The House River is known to have unstable banks and significant slumping, especially following heavy rain, features which often cause localized siltation.

2. From Water Management Practices

None are known. The Alberta Fish and Wildlife Division operates a fish barrier at Ghost Lake to preserve the lake for rainbow trout.

3. Other Sources

The trophic levels of Baptiste Lake have recently been studied for possible impacts from shoreline development (Trew et al. 1978). Exner (1976) examined the effects on the House River of an oil spill which occurred in 1974 as a result of a major pipeline break. Few long-lasting effects were found.

In an attempt to ease the problem caused by biting flies (Simulium arcticum) on cattle in the region, annual spring or summer blackfly larvicide operations have been carried out on the Athabasca River near Athabasca since 1974. The treatments with methoxychlor have a significant effect on the macrobenthos in the river for very long distances downstream of Fort McMurray. Detailed studies conducted in the mid-1970's led to an acrimonious debate on the use of non-specific oil-formulation insecticides in the Athabasca River (Flannagan 1976, Lockhart et al. 1977, Wright 1975, de March 1975, and Flannagan et al. 1978). The long term ecological effects of these treatments on fish populations within the Athabasca River have yet to be determined. Treatments with methoxychlor emulsifiable concentrate, usually carried out 80 to 160 km downstream of the community of Athabasca, have been done continuously from 1979 to 1983 (Bruce Taylor, pers. comm., Alberta Environment, Pesticide Chemicals Division, Edmonton).

Data Gaps

The mainstem of the Athabasca River within Athabasca Sub-Basin II is the least understood section of the entire Athabasca Basin. Population structures, movements, life histories, and spawning habitats of fish are all poorly documented or totally unknown. This is particularly so for the reach of the Athabasca mainstem extending from upstream of the community of Athabasca to the Pelican Rapids. Access to remote lakes in the region by float plane is having an undefined impact on fish populations. Fish habitat survey data for the remote tributary streams from the Calling to Pelican rivers are insufficient.

Fisheries Management Strategies

The fisheries management objective for the Athabasca Sub-Basin II is to maintain the native fish populations at maximum population levels through natural reproduction, water and habitat quality maintenance, habitat and fish population enhancement for recreational, commercial, and domestic fishing.

Summary

Except for the river section extending from Grand Rapids north to Fort McMurray, the fish populations within the Athabasca Sub-Basin II have been little studied. The river is known as a major, and important, spawning area for a population of lake whitefish originating in Lake Athabasca, and for longnose suckers.

Tributaries such as the Horse, House, and Calling rivers harbour typical coldwater sportsfish species. The lakes of the sub-basin, including Baptiste, Calling, and Rock Island, form an important recreational resource for anglers from the Athabasca and Edmonton regions. The area north of Calling Lake is very poorly known and requires further fisheries research.

ATHABASCA SUB-BASIN III

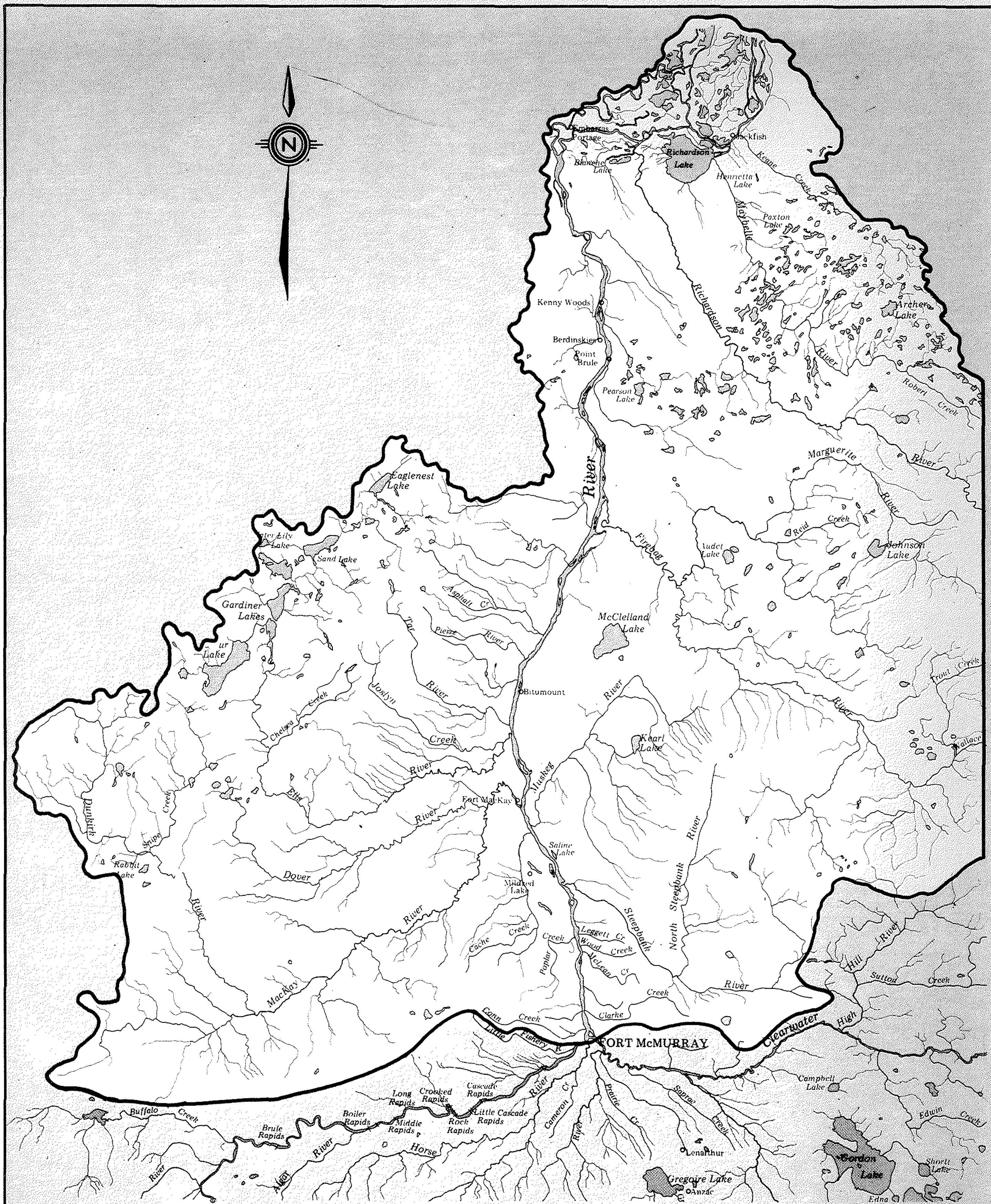
The River Environment

Athabasca Sub-Basin III, which extends from Fort McMurray to the Peace-Athabasca Delta, is one of the most intensively studied river sections in western Canada. Industrial research and government programs, such as the Alberta Oil Sands Environmental Research Program (AOSERP), have provided one of the most substantial data bases within the Athabasca Basin.

Between Fort McMurray and the delta, Athabasca Sub-Basin III receives flows from the Steepbank, Muskeg, MacKay, Ells, Tar, Pierre, Asphalt, Firebag, and Richardson rivers (Figure 8-4). Four major topographic features, the Birch Mountains, Muskeg Mountain, Stony Mountain, and the Thickwood Hills, dominate the landscape. Between the hills, the topography consists of a broad, flat plain sloping gradually toward the major rivers. The sub-basin is incised several hundred feet into the plain, resulting in tributary basins with a hydraulic grade that declines rapidly as the tributary nears the mainstem. In many places, precipitous gorges characterize the confluences of these tributaries (Hackbarth 1977).

As much as 50% of Athabasca Sub-Basin III is covered by muskeg bogs (Lindsay et al. 1962). Brownwater contributed by tributaries originating in these bogs makes up most of the flow in this sub-basin. The region is subject to long, cold winters and short, cool summers, and averages less than 100 frost-free days per year (Longley 1968). Precipitation, measured at Fort McMurray airport, averages 432 mm per year. The hydrology of the region is described by Hackbarth (1977) and the geology by Carrigy (1959).

Hydrographs located downstream of Fort McMurray and at Embarras generally show a rapid increase in flow from winter minima of



ATHABASCA SUB-BASIN III

FIGURE 8-4

less than 200 m^3/sec to a peak of between 1,100 to 2,800 m^3/sec in April. One or more higher peaks occur later in the summer. Roughly half the annual peaks in tributary flows are due to snowmelt, and may contribute substantially to net flows to the mainstem. During spring peaks in 1974 and 1976, for instance, the MacKay River contributed almost 25% of the total sub-basin flow past Embarras (Doyle 1977). Between Fort McMurray and Embarras, tributaries to Athabasca Sub-Basin III drain a total area of 25,400 km^2.

Kellerhals et al. (1972) noted that the Athabasca valley at the Water Survey of Canada (WSC) gauge below Fort McMurray has a maximum width of 3.2 km and a channel which lies 75 m below the valley walls. There is little flood plain in the vicinity, and the channel is relatively straight. Bed material is sand with local gravel over limestone, and occasional bars and islands occur in the channel (Doyle 1977).

At Fort McMurray, spring breakup is frequently marked by a sudden increase in water levels, possibly due to ice jams failing suddenly in the rapids upstream. The ice usually jams a short distance downstream of the community and causes flooding there. This problem has led to the consideration of constructing ice control structures in the river (Alberta Environment 1979). Fisheries studies on the potential impacts of such structures on the Athabasca River have been carried out (Tripp and McCart 1980, Tripp 1981).

There is a substantial body of published, technical, and scientific literature available on this region. Bibliographies of extensive environmental and socio-economic data are provided by Alberta Environment (1980, 1982).

The Fish Population

There have been a number of studies of fish populations within Athabasca Sub-Basin III. McCart et al. (1977), Bond (1980), and Bond and Berry (1980) examined fish populations in the Athabasca River mainstem, and there have been numerous studies of fish populations in tributary streams. Tributary studies have included several regional surveys (Griffiths 1973; Herbert 1979; Ash and Noton 1980a, 1980b) as well as more detailed studies of individual streams. Detailed studies have been done on the MacKay River (McCart et al. 1978 and Machniak et al. 1980), the Muskeg River (Bond and Machniak 1979), and the Steepbank River (Machniak and Bond 1979). Aside from studies of natural populations, there have been several studies of fish populations in two small streams (Beaver and Poplar creeks) affected by the Syncrude Canada Ltd. Project. These include Robertson 1970; Renewable Resources 1971, 1973, 1975; Noton and Chymko 1976, 1978; and O'Neil 1976, 1978.

Table 8-4 summarizes the distribution of fish in streams within Athabasca Sub-Basin III. In its middle reaches near Mildred Lake, the sub-basin has the largest representation of fish species (27), though several of the larger tributaries have 20 or more species. Many of these species are, however, confined to the lower reaches of the tributaries and are thought to be fish closely associated with the Athabasca mainstem which have made short spawning or feeding excursions.

Among the sportsfish, the most widely distributed in streams are Arctic grayling, northern pike, yellow perch, and walleye. Of the species important to domestic fishermen, the lake whitefish is most widely distributed (nine streams), though this species is one of those generally confined to the Athabasca River itself or the lowermost reaches of tributary streams which it enters to feed. Coarse species are widely distributed in streams in the sub-basin, most notably the lake chub, longnose dace, longnose and white suckers, brook stickleback, trout-perch and slimy sculpin.

Table 8-5 summarizes the distribution of fish species in the lakes of Athabasca Sub-Basin III. The list of lakes is not meant to be exhaustive, nor have all the lakes been surveyed in the same detail. Though, in some instances, species may have been missed, several generalizations can be made:

1. Fewer species occupy lakes than streams in this sub-basin. The average number of reported species in 16 streams is 14.7 (range 2 to 27) (Table 8-4) compared with 5.1 species (range 2 to 9) in 22 lakes (Table 8-5).

2. Among sports species, the most widespread are northern pike (which occur in 19 of 22 lakes), yellow perch (12 lakes), and walleye (10 lakes). Lake trout have been reported from only two lakes and grayling from only one. Among potential commercial species, the most widely distributed are lake whitefish (16 locations), and lake cisco (seven locations). In general, the lakes appear to be more hospitable to warmwater than coldwater species.

3. Few coarse species occur. The most widely distributed is the white sucker (13 locations reported) followed by the spottail shiner (nine locations) and ninespine stickleback (nine locations).

Bond (1980) has summarized the life histories of major fish species in Athabasca Sub-Basin III (Table 8-6). Many of these species utilize this reach of the Athabasca mainstem as a migratory route between overwintering, summer feeding, and spawning areas. Some

TABLE 8-5

DISTRIBUTION OF FISH SPECIES IN LAKES

ATHABASCA SUB-BASIN III

Scientific Name	Common Name	RU	MI	BI	EA	BG	GA	NA	PE	AR	BA	RI	Unnamed Lakes - Richardson Tower Area 1	2	3	4	5	6	7	8	9	10	11	Water-bodies
Family Salmonidae																								
Salvelinus namaycush	Lake trout							P															P	2
Coregonus clupeaformis	Lake whitefish				P	P	P	P	P	P			P	P	P	P	P	P	P		P	P	P	16
Coregonus artedii	Lake cisco					P	P	P	P			P					P	P						7
Prosopium williamsoni	Mountain whitefish																							
Thymallus arcticus	Arctic grayling							P																1
Family Hiodontidae																								
Hiodon alosoides	Goldeye																							
Family Esocidae																								
Esox lucius	Northern pike			P	P	P	P		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	19
Family Cyprinidae																								
Chrosomus eos	Northern redbelly dace																							
Chrosomus neogaeus	Finescale dace																							
Couesius plumbeus	Lake chub																							
Hybognathus hankinsoni	Brassy minnow																							
Notropis atherinoides	Emerald shiner																							
Notropis hudsonius	Spottail shiner								P					P	P	P	P	P		P	P	P		9
Pimephales gracilis	Fathead minnow	P	P																					2
Platygobio gracilis	Flathead chub																							
Rhunichtys cataractae	Longnose dace																							
Semotilus margarita	Pearl dace																							
Family Catostomidae																								
Catostomus catostomus	Longnose sucker						P	P																2
Catostomus commersoni	White sucker		P	P	P	P			P	P				P	P		P	P		P	P	P		13
Family Gadidae																								
Lota lota	Burbot							P	P								P							3

TABLE 8-5 CONCLUDED

Scientific Name	Common Name	RU	MI	BI	EA	BG	GA	NA	PE	AR	BA	RI	Unnamed Lakes - Richardson Tower Area 1	2	3	4	5	6	7	8	9	10	11	Water-bodies
Family Gasterosteidae																								
<u>Culaea inconstans</u>	Brook stickleback	P	P	P																				3
<u>Pungitius pungitius</u>	Ninespine stickleback										P		P		P	P	P	P			P	P	P	9
Family Percopsidae																								
<u>Percopsis omiscomaycus</u>	Trout-perch																							
Family Percidae																								
<u>Perca flavescens</u>	Yellow perch					P	P			P				P	P	P	P	P		P	P	P	P	12
<u>Stizostedion vitreum</u>	Walleye					P	P		P		P	P		P		P	P	P				P		10
<u>Etheostoma exile</u>	Iowa darter													P	P				P	P	P			5
Total Species Reported (No)		2	3	3	3	6	6	6	7	4	3	3	3	7	7	6	9	8	3	5	7	7	5	

Notes: Two letter codes are: AR = Archer Lake; BA = Barber Lake; BI = Birch Lake; BG = Big Island Lake; EA = Eaglenest Lake; GA = Gardiner Lake; MI = Mildred Lake; NA = Namur Lake; PE = Pearson Lake; RI = Richardson Tower Lake; RU = Ruth Lake (natural).

Source: Data from Ash and Noton 1980, Griffiths 1973, and Herbert 1979. Data for first unnamed lakes 1 through 10 from Ash and Noton 1980; unnamed lake 11 from Herbert 1979.

TABLE 8-6

SUMMARY OF RELATIVE ABUNDANCE OF FISH SPECIES

CAPTURED IN THE ATHABASCA RIVER IN THE VICINITY

OF MILDRED LAKE DURING 1976 AND 1977

	1976	1977	1976/77
Species	n=16,559	n=16,022	Mean
Dolly Varden		<0.1	<0.1
Lake whitefish	6.3	9.3	7.8
Mountain whitefish	0.1	<0.1	<0.1
Arctic Grayling	0.1	0.2	0.1
Goldeye	11.6	9.1	10.3
Northern pike	2.9	2.6	2.8
Northern redbelly dace		<0.1	<0.1
Finescale dace	<0.1	0.1	<0.1
Lake chub	5.9	3.4	4.7
Brassy minnow	0.1	<0.1	<0.1
Emerald shiner	6.4	3.9	5.2
Spottail shiner	1.9	0.7	1.3
Fathead minnow	<0.1	0.1	<0.1
Flathead chub	2.7	3.2	3.0
Longnose dace	0.1	0.2	0.2
Pearl dace	<0.1	<0.1	<0.1
Longnose sucker	1.4	7.2	4.3
White sucker	0.6	3.4	2.0
Unidentified suckers	18.6	33.2	25.9
Burbot 0.1	0.3	0.2	
Brook stickleback	<0.1	<0.1	<0.1
Ninespine stickleback	<0.1	<0.1	<0.1
Trout-perch	32.4	17.1	24.8
Yellow perch	1.0	1.3	1.2
Walleye	7.2	4.5	5.8
Iowa darter	<0.1		<0.1
Slimy sculpin	0.1	0.1	0.1
Spoonhead sculpin	0.2	0.2	0.2

Note: n = number of captures.

Source: Data from Bond 1980

examples are the large numbers of lake trout (estimated at over a million fish) which leave Lake Athabasca in summer, and migrate upstream to spawn in the autumn in the Athabasca mainstem upstream of Fort McMurray. Another example is the longnose sucker which undertakes a similar migration in late winter and spring. Unlike lake whitefish, however, this species also spawns in tributaries such as the Steepbank, Muskeg, and Mackay rivers, and in the Christina River in the Clearwater Sub-Basin. Any management plans for fisheries in Athabasca Sub-Basin III must take into account the highly migratory nature of its stream-dwelling fish.

Bond (1980) provides data comparing the relative abundance of various fish utilizing the Athabasca mainstem in the vicinity of Mildred Lake (Table 8-6). Trout-perch are probably the most abundant species in the area (24.8 % of all catches) followed by longnose and white suckers (32.2 % overall, including 25.9% unidentifiable). Lake whitefish (7.8%) and goldeye (10.3%) were common, and of interest to domestic fishermen; walleye (5.8%), northern pike (2.8%), and yellow perch (1.2%) were the most frequent sportsfish species. Arctic grayling, a popular sports species, constituted only 0.1% of all fish captured.

The AOSERP Study Area is characterized by brownwater muskeg streams fed by inflows of humic and fluvic acids from the surrounding bogs. As a consequence of past epilithic studies (Lock and Wallace 1978, Hickman et al. 1980), fisheries studies (Bond and Machniak 1979), and benthic invertebrate studies (Barton and Wallace 1980), and the work of Clifford on the Bigoray, detailed ecological data are available to researchers on these unique brownwater alkaline streams. Studies on this type of stream were pioneered in Alberta by Clifford, who studied the Bigoray River (Section VI, Pembina Sub-Basin). Studies of this river (Clifford 1969, 1970a, 1970b, 1972a, 1972b, 1972c, 1972d, 1976, 1978; Clifford et al. 1973; Clifford and Boerger 1974; Bond 1972; Hayden and Clifford 1974; Boerger 1978) are of direct applicability to understanding the ecology and dynamics of brownwater rivers in Athabasca Sub-Basin III.

Griffiths (1973) undertook a fisheries survey in the oil sands region and further intensive ecological research was carried out on the Muskeg-Steepbank tributaries by Bond and Machniak (1979), Barton and Wallace (1980), Lock and Wallace (1980), and on the Hartley Creek section of the Muskeg River drainage by Crowther (1979) and Hartland-Rowe et al. (1979). In an attempt to identify distinct habitats in the Muskeg and Steepbank rivers, Barton and Wallace (1980) used two indices of similarity in a Bray-Curtis ordination analysis to define five habitat types associated with substrate type.

Crowther and Griffing (1979) examined the trophic status of macroinvertebrates based on an October reconnaissance of the Ells, MacKay, Steepbank, Hangingstone, and Muskeg rivers. Short of the headwaters, the upstream areas of these rivers were dominated by algal-detrital and detrital-trophic groups and downstream ones by omnivores and detritivores. Although other taxa generally associated with the Chironomidae differ among streams, the Chironomidae are generally the dominant taxonomic group, although Crowther (1979) found the Trichoptera to be dominant in Hartley Creek. Further study is needed in order to develop models for macroinvertebrate communities in these muskeg streams.

Bond and Machniak (1979) found that several species of small fish (brook stickleback, lake chub, slimy sculpin, longnose dace, and probably pearl dace) were year-round residents in the Muskeg River. They also found large upstream spawning movements of longnose and white suckers in spring. Departure of the adults began by mid-May, and continued all summer. Fry hatched by late May and most drifted out through summer months. Arctic grayling were collected in mid-June suggesting that young-of-the-year overwinter in the Muskeg until the end of the second summer before moving out of the watershed.

Northern pike, walleye, mountain whitefish, and lake whitefish may feed at the lower reaches near the confluence, but do not spawn upstream. Subsequent to those studies Ash and Noton (1980) carried out a fisheries and water quality survey in the Richardson tower area. Northern pike were found in all 10 lakes surveyed, lake whitefish in nine, and walleye in five. All 10 lakes contained sportsfish, northern pike predominating in lakes with aquatic macrophytes, and walleye were generally present in the deeper lakes.

Sport Fishing Opportunities

Athabasca Sub-Basin III is characterized by extremely limited access. North of Fort McMurray, Highway 963 terminates at Fort MacKay. Only recently has road access across the Athabasca River (at the Alsands lease site) been completed with limited road construction completed to the east. Anglers commonly use jet or other flat-bottomed boats to fish the Athabasca River north to the Peace-Athabasca Delta, generally fishing the mouths of major rivers such as the Steepbank, Firebag, or Ells.

The bridge crossing at the MacKay River is heavily fished seasonally. Many boaters on the Athabasca, however, prefer to move south to the Clearwater, which is both close and relatively easy to access from Fort McMurray. For the more industrious, access to upstream tributaries by all-terrain vehicle or helicopter is possible.

Arctic grayling in several major tributaries are popularly sought-after during summer months. Fly-in fishing is known for Richardson Lake (7,258 ha) in the extreme northeast, chiefly for walleye, northern pike, and lake whitefish. The most popular lakes, accessible by air, are Namur (4,373 ha) and Gardiner (2,410 ha). Lying on the extreme western boundary of the sub-basin at the edge of the Birch Mountain region, they are well-known for good populations of walleye, lake trout, northern pike, and Arctic grayling. Both Gardiner and Namur lakes are classified as trophy lakes (1983 Sportfishing Regulations: Alberta Fish and Wildlife Division).

Availability of Alternative Sport Fishing Opportunities

The Fort McMurray region of Athabasca Sub-Basin III is one of the most limited sport fishing areas in the Athabasca Basin. Gregoire Lake Provincial Park (via Highway 63) is exceedingly well-utilized in summer, and is essentially the only easily accessible camping-fishing ground for the area. Further south, the Lac La Biche and Clearwater sub-basins are increasingly utilized by area residents. Sir Winston Churchill Provincial Park, Calling Lake, and Lesser Slave Provincial Parks are alternative parks via highways 63, 55, 813, and 2. Each is a significant distance from the Fort McMurray urban centre, however, necessitating lengthy trips out of the sub-basin.

Water Quality

A substantial body of data exists for water quality parameters in Athabasca Sub-Basin III, most of which are referenced in Alberta Environment (1980, 1982) and Akena and Christian (1981). Baseline data on water quality have been studied extensively through government agencies (AOSERP and Alberta Environment) and industry. Studies conducted by industry have included those by McCart et al. 1978 (MacKay River), McCart et al. 1977 (Athabasca River), Canstar 1980 (tributaries north of the MacKay River). In addition, environmental impact statements produced by Alsands, Canstar, and

Syncrude contain significant compilations and analyses of data on the region. Stream catalogues, such as that produced by Canstar (1982), also contain valuable lists of water quality parameters for many tributaries in the region.

Some streams in the region, such as Beaver Creek on Syncrude's Lease 17, have undergone alterations since the onset of oil sands mining operations. Others, such as the Muskeg River have experienced incremental impacts even as the Alsands development has ebbed. The river has received some "decant" waters from the Shell Test Pit nearby as surface and sub-surface flows to the Test Pit have been drawn down by pumping them into the Muskeg River. The "natural effects" on benthic populations of eroding oil sand, such as occurs in the Steepbank River, were studied by Barton and Wallace (1979a, 1980).

A regional water sampling program was conducted in the AOSERP Study Area as part of intensive studies connected with future, potential oil sands developments (Seidner 1980). In addition, several departments of Alberta Environment (Pollution Control Division and Water Quality Control Branch) and within the Federal Government (Inland Waters Directorate) maintain extensive studies and files on water quality in the Athabasca mainstem, as do both Suncor and Syncrude.

Increasingly, attention has been focused on the effects of acid rain on poorly-buffered lakes. The oil sands region is a prime target for such considerations due to the significant local sulphur emissions. Hesslein (1970) and Ash and Noton (1980) reviewed this risk. Lake basins within the Precambrian are particularly susceptible to such emissions, especially those which lie in northern Saskatchewan, downwind of the oil sands developments. Long term predictions of sulphur loadings in lakes have recently been a topic of debate, however, especially given the downturn in estimates for mineable oil sands production since the collapse of several oil sands projects in 1981.

Water Quantity

Water flows in the Athabasca mainstem, measured just below Fort McMurray, have ranged from 95.5 m^3/sec (February 1964) to 4,217 m^3/sec (June 1960), with a long term mean of 638 m^3/sec (Kellerhals et al. 1972). Based on 12 years' data, mean freeze-up and breakup dates are November 5 and April 28, respectively. After breakup, the first annual discharge peak in April is generally followed by a second pronounced peak in mid-summer, reflecting increased flows from high-mountain glacial meltwater.

Flooding which has occurred at Fort McMurray is caused by the collapse of ice jams upstream and their subsequent accumulation just downriver of that community. These, in turn, cause a sudden backing up of the river and has resulted in significant damage to low-lying portions of that community.

Environmental Problems

1. Naturally Occurring

As noted above, flooding and bank instabilities along the Athabasca mainstem cause slumping and substantial additions of sediment to that river. Tributary streams and rivers are subject to sudden floods after heavy rains, particularly in July when hot thermals can cause heavy, local downpours. These, along with high flows at breakup, have caused heavy bank erosion in the Steepbank, MacKay, Ells, and Firebag rivers. In some rivers, (Steepbank, Muskeg, and MacKay, in particular) riverbed erosion in the lower reaches has cut into oil sands formations, causing the formation of tar balls and the release of heavy oils to the river (Barton and Wallace 1979a, 1980).

2. From Water Management Practices

In the late 1970's, consideration was given to the construction of an overflow weir on the Athabasca River, as one of several options to prevent flooding of Fort McMurray during spring breakup (Alberta Environment 1979). The effects of such a structure on walleye and other fishes was assessed by Tripp and McCart (1980) and Tripp (1981).

Major diversions, such as that constructed on Beaver and Poplar creeks on Syncrude's Lease 17, were done as part of mineable oil sands developments. The former Alsands project, centred in the Hartley Creek area of the Muskeg River drainage had begun land clearing operations and the construction of some diversions before project termination.

3. Other Sources

Over the past 14 years, oil spills have been investigated at the Suncor Plant (formerly GCOS) on several occasions, notably in 1967 (Sewchuk 1968) and 1970 (Alberta Environment 1970). The report done after the 1970 spill concluded that adverse effects from the spill were relatively small. Other studies have been done on the Suncor effluent (Hrudey 1975), especially with respect to its toxicity. Recent incidents have led to charges being pressed against Suncor for alleged releases of material to the Athabasca. At the time of writing these charges are sub justice. Alberta Environment (1981) noted that "1981 was a poor year for Suncor as far as the environmental performance was concerned. Virtually all parameters were exceeded at one time or another." They note that Suncor "...will be required to improve the quality of the effluent."

Costerton (1979), Nix et al. (1979, 1981), Beltaos (1979), Strosher and Peake (1979), carried out research on the microbiology and assimilative capacity of the Athabasca River near Fort McMurray. Other monitoring studies have been done on dyke seepages from the Suncor facility, and small-scale simulations of spillages of oil sands tailings sludge into rivers have been carried out in the Muskeg River (Barton and Wallace 1979b).

Data Gaps

In spite of the heavy expenditure on research, by both government and industry, within Athabasca Sub-Basin III in the last decade, gaps in the knowledge concerning its fish populations and the environmental conditions which affect them remain. For instance, details of how fish tainting in Lake Athabasca recently occurred are still not elucidated. Habitat for spawning is not well-known for major sections of the Firebag and Richardson rivers. Fisheries in the Athabasca mainstem are the least understood as its large size and flow present enormous logistic difficulties for researchers. The cumulative effects of industrial, municipal, and agricultural (including blackfly larvicide applications) operations may have subtle, long term effects. The importance of investigating these effects is shown by the fact that as much as two-thirds of the total commercial walleye catch in Lake Athabasca may originate from spawning reaches in the mainstem. Any significant reduction in walleye spawning success in the river would have far-reaching consequences.

Access to remote fishing locations by all-terrain vehicle and float aircraft may be having an impact on sportsfish populations in selected tributaries. If current recreational demands continue, long-term fishery management programs, backed by adequate data, will probably be urgently required for the Namur-Gardiner Trophy Lakes region.

Fisheries Management Strategies

The fisheries management objective for Athabasca Sub-Basin III is to maintain the native fish populations at maximum population levels through natural reproduction, water and habitat quality maintenance, habitat and fish population enhancement for recreational, commercial, and domestic fisheries.

Summary

Athabasca Sub-Basin III contains some of the most intensively studied aquatic habitat in western Canada. Large industrial developments from oil sands mines and the resultant significant urban growth at Fort McMurray have caused rising recreational and sport fishing demands throughout the region. The region contains a wide variety of fish habitat, ranging from the mainstem spawning grounds for walleye in the silty mainstem, to cold brownwater habitat for Arctic grayling in the tributary rivers such as the Muskeg, MacKay, and Firebag.

Primarily as a consequence of restricted access, the Namur and Gardiner trophy lakes represent a unique resource for a region which is sadly deficient in adequate recreational outlets. Those areas that are accessible from Fort McMurray, such as Gardiner Lake to the south, are heavily over-utilized.

Among sportsfish, Arctic grayling, northern pike, yellow perch, and walleye are the most widely distributed in tributary streams. Lake whitefish, an important domestic fish, is widely distributed, but generally confined to confluences along the Athabasca. Trout-perch are probably the most abundant fish in Athabasca Sub-Basin III, followed by longnose and white suckers, goldeye, lake whitefish, walleye, and northern pike. Arctic grayling, a popular sportsfish, make up only a very small percentage of sportsfish captured.

A summary of important results for the major fish of the Athabasca River is presented in Table 8-7.

TABLE 8-7

SUMMARY OF IMPORTANT RESULTS RELATIVE TO THE MAJOR FISH SPECIES OF THE ATHABASCA RIVER

Species	Migrations	Spawning	Overwintering	Principal Foods	Predators	Competitors	Sensitive Locations and Times	Use by Man Within AOSERP Area
Lake Whitefish	Spawning migration Sep. to Oct. Post-spawning downstream movement begins immediately after spawning. Downstream fry migration probably April to June.	Mid-Oct. in Athabasca R. upstream of Fort McMurray (Cascade and Mountain Rapids).	Most likely in Lake Athabasca. Some overwintering suspected in Mildred Lake study area.	Benthic Invertebrates.	Pike, Walleye, Burbot	Bottom feeders, White Suckers, Longnose Suckers.	Tributary mouths serve as resting areas during spawning migration. Egg incubation Nov. to March.	Domestic
Arctic Grayling	Migrate into tributary streams of Mildred Lake area in late April and early May. Seldom found in Athabasca R. during summer. Never taken in delta. Migrate out of tributaries just prior to freeze-up in October. Tributaries provide summer feeding for adults and nursery areas for fry.	Late April and early May. Muskeg R. and Steepbank R. are known spawning streams.	Young-of-year may overwinter in spawning streams. Age 1+ and older fish overwinter in Athabasca R. probably in upper Mildred area or above Fort McMurray.	Mature and immature stages of aquatic and terrestrial insects.	Walleye, Pike, but probably little predation while in tributaries.	Few, because of varied diet.	Spawning, feeding and nursery areas in tributaries. Overwintering areas for young in tributaries. Susceptible to overharvest by anglers.	Sport
Goldeye	Feeding migration into Athabasca R. occurs in early spring (April) under ice. All immature fish (ages 4 to 6). Leave feeding grounds in Sep. or Oct. for overwintering areas.	N/A As adults these fish will probably spawn in Peace-Athabasca Delta.	Suspected in Lake Athabasca or the Peace River.	Benthic and surface insects,	Pike, Walleye, Burbot	Few, because of varied diet.	Entire Athabasca R. up to (and probably) beyond) Fort McMurray serves as summer feeding area from April to October.	Commercial Domestic Sport

TABLE 8-7 CONTINUED

Species	Migrations	Spawning	Overwintering	Principal Foods	Predators	Competitors	Sensitive Locations and Times	Use by Man Within AOSERP Area
Northern Pike	Spawning movements in April and early May. Upstream migrations noted in some tributaries in May consist of ripe, spent and immature fish. Frequent lower reaches and mouth areas of tributaries during summer.	Probably late April and early May in marshy areas adjacent Athabasca R. and in some tributaries.	Probably Athabasca R. in Mildred Lake area. Those in delta may over-winter in Athabasca R. upstream of delta or in Lake Athabasca.	Mainly fish of several species Some immature insects.	Pike, Burbot, Walleye	Walleye, Burbot	Marshy areas in late April and early May. Lower reaches of tributaries important feeding areas in summer.	Sport Domestic
Lake Chub	Seldom found in delta but common in Mildred Lake study area and in tributaries. Fry appear in Athabasca R. in July. Few matures captured.	Locations unknown, Probably spawn in lower reaches of tributaries or along edges of Athabasca R. in Mildred Lake area during May or June.	Athabasca R. or tributaries in Mildred Lake study area.	Benthic invertebrates, (Mostly insects).	Walleye, Pike, Goldeye, Burbot.		Probably spawn in May or June.	None
Emerald Shiner	Spawning migration into Mildred study area assumed in May and June. Seldom enter tributaries. Most spawners age 2. Large post-spawning mortality suspected. Fry migrate down-stream during summer and remain in delta and/or Lake Athabasca until age 2.	Areas unknown but assumed in Athabasca R. within or upstream of Mildred Lake area. Probably spawn in June and July.	Suspected in delta and/or Lake Athabasca.	Benthic invertebrates (Mostly insects).	Walleye, Pike, Goldeye, Burbot		Spawning and egg incubation in Athabasca R. during June and July.	None

TABLE 8-7 CONTINUED

Species	Migrations	Spawning	Overwintering	Principal Foods	Predators	Competitors	Sensitive Locations and Times	Use by Man Within AOSERP Area
Spottail Shiner	Occur throughout study area but more common in delta study area. Fry appear mid-July but not abundant until mid-August. Seldom enter tributaries.	Unknown but probably Athabasca R. or lower reaches of some tributaries in late June or early July.	Probably Athabasca R. and Lake Athabasca.	Benthic invertebrates (Mostly insects).	Walleye, Pike, Goldeye, Burbot.		Spawning and egg incubation in late June or early July.	None
Flathead Chub	May be resident in Athabasca R. Mature fish more common in Mildred than in delta study area. Decrease in abundance after June suggests movement but extent unknown. Seldom enter tributaries. Young-of-year appear in July. Nursery areas suspected in delta or Lake Athabasca.	Areas unknown but assumed in Athabasca R. within or upstream of Mildred Lake area during June and July.	Unknown. Suspected within Athabasca R. and Lake Athabasca.	Varied. Mainly mature and immature insects, both aquatic and terrestrial.	Pike, Walleye Goldeye, Burbot	Few, because of varied diet.	Spawning and egg incubation probably in Athabasca R. from mid-June to mid-August.	None but sometimes taken by anglers.
Longnose Sucker	Spawning migration begins under ice in late April to early May. Post-spawning, downstream movement begins in mid-May. Fry emerge late May to early June. Fry migration June to August. Some non-spawners remain in tributaries until freeze-up.	Over gravel in tributaries during first half of May. Muskeg R., Steepbank R., MacKay R. are known spawning streams. Also spawn in Athabasca R. upstream of Fort McMurray.	Probably Lake Athabasca. Some young-of-year overwinter in spawning streams.	Benthic invertebrates but feed little during spawning migration.	Pike, Walleye, Burbot, Grayling, Flathead Chub	Bottom feeders, Lake Whitefish, White Suckers	Athabasca R. during migration of adults and dry (April to August). Spawning and nursery areas in tributaries (May to July). Mouth areas of tributaries are important nursery areas.	Domestic (Dog Food)

TABLE 8-7 CONCLUDED

Species	Migrations	Spawning	Overwintering	Principal Foods	Predators	Competitors	Sensitive Locations and Times	Use by Man Within AOSERP Area
White Sucker	Spawning migration begins under ice in late April to early May. Downstream movement of spawners begins in mid-May. Fry emerge late May and early June. Fry migration June to August. Some non-spawners remain in tributaries until freeze-up.	Over gravel in tributaries during first half of May. Muskeg R., Steepbank R., MacKay R. are known spawning streams.	Probably Lake Athabasca. Some young-of-year overwinter in spawning streams.	Benthic invertebrates but feed little during spawning period.	Pike, Burbot, Grayling, Flathead Chub	Bottom feeders, Lake Whitefish, Longnose Suckers	Athabasca R. during migration of adults and fry. Spawning and nursery areas in tributaries (May to July). Mouth areas of tributaries are important nursery areas.	Domestic (Dog Food)
Burbot	A spawning migration into Mildred Lake area is suspected during the winter. Burbot leave Mildred area by mid-June. Young-of-year appear early June.	Spawning for this species usually occurs from Jan. to March under ice.	Probably Lake Athabasca.	Fish of many species.	Walleye, Pike	Walleye, Pike, Goldeye	Spawning and egg incubation in or upstream of Mildred Lake area Jan. to June.	Domestic Sport
Trout-perch	Probably resident in Athabasca R. Enter tributaries in May to spawn during late May or early June. Severe post-spawning mortality suspected. Fry emerge in early June and migrate out of tributaries to Athabasca R. during June and July.	Tributaries in late May and early June. Possibly Athabasca R. also.	Probably Athabasca R.	Benthic invertebrates (Mostly insects).	Walleye, Pike, Goldeye, Burbot		Spawning and egg incubation in tributaries from May to July.	None
Walleye	Spawning migration begins under ice in late April. Post-spawning downstream movement in May and June. Fry hatch in May to June and migrate downstream during June and July.	Sites unknown but probably in Athabasca R. upstream of Fort McMurray in late April and early May.	Suspected in Lake Athabasca.	Mainly fish of several species. Some aquatic insects.	Pike, Burbot, Walleye	Pike, Burbot	Athabasca R. during migration of adults and fry. Tributary mouths serve as resting areas for adults and as nursery areas.	Commercial Domestic Sport

IX CONCLUSIONS

The Athabasca Basin encompasses some of the most important recreational, commercial, and domestic fisheries in the Province of Alberta. The basin contains many of the diverse geographic, climatic and physiographic characteristics of western Canada. The waters of its streams range from fast-flowing, coldwaters in the mountains, to the slow-running, silty warmwaters on the plains, and those of its lakes from oligotrophic in the alpine areas to eutrophic in the lowlands. As a result, the Athabasca Basin presents a remarkable diversity of fish habitat.

Within the region, industrial and municipal development have occurred at a rate of growth which has few parallels. In the relatively brief historical interval since the turn of the century, a wilderness territory has been transformed into one with major urban centres and viable industries associated with agriculture, mining, forestry, and oil and gas production.

The pressure of urban, agricultural, and industrial growth has taken its toll on the fish habitat and fish populations of the region. The Athabasca Basin provides sport fishing opportunities for almost 9% of Alberta's licenced anglers. The mainstem of the Athabasca and tributary rivers, such as the Berland, McLeod, Pembina, and Clearwater, supply important, and in many cases well-utilized, sport fishing opportunities. At the same time, alternative angling opportunities for residents of the major urban centres either within, or bordering, the Athabasca Basin are limited particularly in the northeast and western-most portions. Although numerous tributaries and some lakes provide viable alternatives for anglers in the sub-basins, they are limited, and most fish populations are highly vulnerable to increasing, steady use. Even at existing levels of demand, stocking programs which significantly enhance the natural productivity of streams and lakes are, in some cases, just adequate to meet the sustained angling pressures.

Data from licence sales in the basin indicate that the demand for sport fishing will continue to increase in the future. This prediction indicates, therefore, that maintenance of the existing sportsfish habitat must be a priority. Further, development of new sport fishing opportunities and measures to enhance existing levels of fish production will probably be of continued importance if we are to maintain the Alberta sport fishery.

The productivity of the fish populations in the basin is highly variable, ranging from extremely low in cold, nutrient-limited, high-altitude waters to relatively high in the warmer, nutrient-rich habitats. Undoubtedly, alterations in our present practices of water and land use will have to be made in order to protect, or even maintain, sportsfish habitat in the region. These problems will be especially acute in regions where agricultural or industrial impacts are high, or where angling pressure is sustained at high levels in locations of relatively low fish productivity. All future land and water uses which have qualitative or quantitative effects on waters in the basin will have to be carefully assessed and monitored if we are to achieve a balance between development and conservation of fish habitat.

Water quality in some parts of the basin must be improved to meet criteria designated by Longmore and Stenton (1981) for the enhancement or maintenance of sportsfish populations. These wide-ranging water quality criteria should, nevertheless, be reviewed on a regular basis to take into consideration new data or new chemical compounds which may appear through urban, agricultural, or industrial applications.

Water and land use are the major factors which presently limit fish production and habitat conservation in the Athabasca Basin. Annual water level fluctuations (in the Lesser Slave Lake and Lac La Biche sub-basins, for instance) influence fish production, but more important, man-made alterations to control high water levels have led to disruptions in fish habitat which have affected lake and tributary fish populations. In future, it will be important to continue to carefully assess the environmental consequences of all lake and river control structures in advance of construction. Equally as important, mitigative measures during and after construction will be needed to assess impacts which may have occurred and to compensate for them. Although it is not a major issue, as yet, within the Athabasca Basin, minimum discharges will have to be assessed and established for each sub-basin. This will entail enhanced water quality and quantity measurements within the basin and will necessitate regular reviews as new data are made available. In conjunction with these new or expanded monitoring programs, considerably more research will be required to better define fish habitat and production of the tributary and mainstem river systems within the Athabasca Basin. Further data are also needed to understand the relationship of fish productivity to water discharges, so that criteria can be derived for minimum, or stabilized, discharges.

Water quality monitoring will have to be considerably enhanced. Industrial uses in the region will almost certainly continue to grow in the remaining decades of this century and beyond. Each new water use will have to be assessed and monitored. The standard water use approvals system will need more precise data on water quality information in order to properly assess and monitor water use. This may entail a significantly enhanced water quality modeling capability and a better water quality field monitoring network. Clearly, increasing agricultural, industrial and urban demands on water use in the Athabasca Basin will continue to force enhanced water quality monitoring and enforcement.

The present system of monitoring recreational, commercial and domestic fishing pressures on the fish populations of the Athabasca Basin is rather limited. Jurisdictional lines between and within government departments will have to be clarified to adjust to the fast-changing realities of fishing pressures in the basin. Significantly more, and better, data are needed in order to better understand, monitor and manage fish populations in the region. Specifically, for recreational, commercial, and domestic fisheries in the various sub-basins, data are needed on current fishing pressures, their locations, timing, and total catch. These data need to be assessed together for each sub-basin where they occur, and an integrated fishery management plan needs to be formulated to take into account each pressure. Unquestionably, it will be necessary to assess all the impacts on a fish population in order to evolve adequate, integrated fish management strategies. Without such an approach, strategies for conservation or enhancement of fish stocks will be significantly limited. Worse still, we may find that some fish populations are seriously impacted before adequate mitigative measures can be adopted.

An integrated, sub-basin inventory needs to be developed for fish stocks of the Athabasca Basin. Without such an approach, it will not be possible to develop a quantitative measure for fish demand and supply in the basin as a whole. Each watershed will have to be monitored as a contiguous sub-basin and assessed as to the adequacy of fish stocks, fish habitat and fishery (recreational, commercial and domestic) demands. In the absence of such integrated approaches, conflicts between the various "user" groups are inevitable. Further, satisfying recreational experiences will become rare or infrequent in many regions, and viable commercial or domestic fishing operations will suffer from unexpected changes or, perhaps, arbitrary measures. There is every reason to expect that existing agencies can establish better water and habitat requirements in order to provide sufficient quantity and quality of fishes from the Athabasca Basin, given necessary funding and program support.

X RECOMMENDATIONS

1. The Athabasca Basin presently provides recreational fishing for approximately 9% of Alberta's licenced anglers. This recreational demand has increased significantly in the recent past and there is every reason to expect that it will continue to increase.

   It is, therefore, recommended that the preservation and enhancement of fish production in the sub-basin tributaries and mainstem of the Athabasca River be considered as a priority water use in the basin.

   There is a significant economic return to the Province from the recreational, commercial, and domestic fisheries in the Athabasca Basin. However, in many cases, few alternative fishing sites are easily available or accessible throughout the region due to, in many cases, a lack of fish-producing waters. It must be recognized that the Athabasca's fish and fish habitat are a finite and valuable resource in an expanding economic region of Canada.

2. Water and land use practices, in addition to direct fishery exploitation, are the major factors presently limiting fish production and habitat conservation in the Athabasca Basin.

   Criteria for land use and water management practices need to be established for operational and planned developments in the basin as a whole. Minimum discharge values for fisheries need to be assessed and recommended for several sub-watersheds in the basin, especially with a view to impacts from water level control structures (Paddle, East Prairie, and West Prairie rivers, and structures in the Lac La Biche Sub-Basin). Recommendations in each sub-basin should be reviewed and revised as new data become available.

3. It is recommended that the criteria for water quality for protection of fish and aquatic life, as outlined in Longmore and Stenton (1981), be adopted for all the sub-basins and the mainstem of the Athabasca River. Surveys should be conducted to confirm maintenance of those standards and, where fishes are at risk due to lapses from those standards, measures should be implemented to improve the water quality. This may necessitate a considerable expansion in current capabilities for monitoring and modeling water quality parameters within basins.

   All criteria adopted for water quality should be reviewed or revised as new data are made available. Research and monitoring on the long-term effects of treated sewage discharged to waters of the Athabasca Basin need to be more fully addressed. Chlorination of subsequent treated waters should be fully assessed and monitored where they occur. The conservation and enhancement of habitat and water quality should be made a priority for those Athabasca Basin waters which flow through, or near, large urban centers.

   Special steps should be undertaken to assess the effects on aquatic life of the group of chemical compounds known as phenols, particularly with respect to their aquatic toxicity and their ability to impart taste to fish flesh. The latter program is of special importance in areas of the Athabasca in which major water use occurs.

Further research is required on the effects of pesticides and herbicides used in agricultural applications adjacent to the Athabasca River, or added directly to the river water (such as the blackfly control program at Athabasca). Very little has been established regarding long-term residues in fishes in the region, or of the acute or sub-acute toxicities to aquatic organisms of chemical compounds used throughout the basin.

4. It is recommended that more basic, ecological data be collected on the fish and the fisheries of the Athabasca Basin. Surveys which embrace all the components of aquatic ecosystems (benthos, periphyton, and fishes) are urgently needed as long-term, continuing studies in order to formulate and assess ongoing management strategies. Without a sound base of ecological data strategies for enforcement, management and enhancement of fish populations can be, at best, only haphazard.

   Levels of fish production, the routes of fish migrations, and habitat capability need to be carefully assessed throughout the basin.

The recreational, commercial, and particularly domestic use and catch need to be examined throughout the Athabasca Basin, especially as these levels of "demand" relate to fish production.

5. A supply and demand model for fisheries in all the sub-basins of the Athabasca Basin needs to be developed, especially in areas where recreational, commercial, and domestic fisheries are situated. Data should be collected and appropriate management strategies implemented on a sub-basin basis. This would reflect the ecological realities of the fish populations in the regions and would allow for the development of management strategies suitable to each of the widely different sub-basins which make up the Athabasca Basin.

   More data on the recreational, commercial, and domestic use of fisheries are required for each sub-basin. These data, once available, should be further assessed in the development of an Athabasca Region Fisheries Management Program.

6. Experimental methods should be employed to assess various fish production enhancement methods. The Tri-Creeks Watershed Study, for instance, should be expanded to include augmented, experimental studies on freshwater fish production. Long-term studies such as these could have a profound, positive influence on the development and management of the coldwater sport fishery so important to recreational interests throughout the region.

In line with this, more liaison and communication should occur between federal and provincial authorities in the long-term management and monitoring of the fisheries within, or immediately adjacent to, the Jasper National Park area.

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APPENDIX A

A SELECTED LISTING OF ATHABASCA RIVER BASIN LAKES, RIVERS, AND STREAMS AND THEIR ASSOCIATED FISH SPECIES

Key

MW	Mountainwhitefish	SU	Sucker
WE	Walleye	AG	Arctic grayling
LC	Lake cisco	BU	Burbot
NP	Northern pike	WS	White sucker
LW	Lake whitefish	LS	Longnose sucker
YP	Yellow perch		

Data acquired from Alberta Fish and Wildlife Division Sources: fish resources maps, Regional Office data files, fisheries survey reports, and lake/stream surveys. Given the large amount of data available, this list is not intended to be comprehensive, but is meant to provide a selection of the types of fish species and aquatic habitats which occur in the Athabasca River Basin.

APPENDIX A

SUB-BASIN: BERLAND

LAKES:	FISH:
Blue Lake	EB, BT, NP
Cache Lake	LW, NP
Graveyard Lake	NP, RB, BT
Gregg Lake	LW, NP
Jarvis Lake	LW, NP, LW

RIVERS AND STREAMS:	
Barbara Creek	RB
Berland	RB, MW, DV, AG, MW movement upstream to confluence with the Athabasca
Collie Creek	RB
Fox Creek	DV
Moberly Creek	AG, RB movement
Moon Creek	MW, DV
Pinto Creek	no present fish use
Wildhay River	DV, MW, RB, AG possible spawning area upstream of confluence with Pinto Creek

APPENDIX A CONTINUED

SUB-BASIN: MCLEOD

LAKES:	FISH:
Beaver Lake	
Fickle Lake	NP, YP, LW, WE
Jackfish Lake	NP
Wolf Lake	NP, YP

RIVERS AND STREAMS:	
Anderson Creek	RB, SU, BT, MW, DV
Dummy Creek	no present fish use
Edson River	RB, MW, AG
Erith River	no present fish use
Embarras River	MW, AG
Gregg River	RB, DV, MW
Groat Creek	tributary poor, heavily fished
Hanlan Creek	
Lendrum Creek	no present fish use
Little Sundance Creek	RB, MW, BT
Lund Creek	no present fish use
Mary Gregg Creek	
McLeod River	MW, WE
McLeod River	RB, DV, MW in some of its tributaries
McLeod River	MW, AG, DV, EB, RB, NP, WE, BT near Athabasca confluence
Sundance Creek	RB, MW, AG
Wampus Creek	spawning area RB, DV, MW ?
Wolf Creek	RB, AG, MW

APPENDIX A CONTINUED

SUBBASIN: PEMBINA

LAKES:	FISH:
Oldman Lake	no present fish use
Poison Lake	spawning area

RIVERS AND STREAMS:

Dismal Creek	no present fish use
Lobstick River	NP spawning area
Paddle River	NP
Pembina River	AG, EB, DV, GE, MW, BT, NP, WE, RB, SU, B
Pembina River	spring fishing in Tp 62 R1 in south end
Pembina River	downstream of French Creek confluence - AG, EB, DV, GE, WE, RB, SU, B
Shoal Creek	obstructions to fish movement throughout the length

APPENDIX A CONTINUED

SUB-BASIN: LESSER SLAVE

LAKES:	FISH:
Edith Lake	EB
Fawcett Lake	LC, LW, WE, SU, NP, B
Lesser Slave Lake	LW, WE, YP, NP, LC, BS
Hunts Lake	.....
Mitsue Lake	YP, NP
Orloff Lake	
Roche Lake	NP
Unnamed Lake East of Otter	LW, NP, WE +++++
Winagami Lake	YP, LW, WS, NP +++++

RIVER AND STREAMS:

Adams Creek	LS +++++
Assineau River	AG +++++
Boulder Creek	LS, AG +++++
Chalmers Creek	AG, LS +++++
Coalmine Lick Creek	NP +++++
Coutts River	NP
Driftpile River	AG, S *****
Driftwood River	AG, LS, WS +++++
East Prairie River	LS, NP, WS, LW, W +++++
Fawcett River	LS, BU, WS, NP, WE spawning area for WE +++++
Inverness River	AG, LS +++++

Island Creek	AG, LS +++++
Jerry Creek	LS, AG +++++
Marten Creek	AG, RB +++++
Mitsue Creek	NP -----
Moosehorn River	AG, NP +++++
Muskeg Creek	NP -----
Narrows Creek	tribuatries NP -----
Otauwau River	AG -----
Saulteaux River	AG, NP resident
Sawridge (Prairie) Creek	RB, AG -----
Shaw Creek	-----
Sloan Creek	AG, LS +++++
South Heart River	NP, MW, AG, YP, STW *****
Swan River	AG, LW, MW, NP, SU, WE, LW movement north +++++
Wallace River	-----
West Prairie River	WE, WS, LW, NP, LS

Information taken from D. Walty's fish maps, Peace River:

1. Lakes----- D.O. and depth (Phase I inventory)
Lakes+++++ Preliminary survey (Phase II and up)

2. Rivers----- Two or fewer stations, one time of year, very little information (Phase I)
Rivers+++++ Two or more stations sampled during several seasons (Phase II inventory)
Rivers*** Detailed survey, spawning runs, numerous stations (Phase III)**

APPENDIX A CONTINUED

SUB-BASIN: LAC LA BICHE

LAKES:	FISH:
Beaver Lake	YP
Behan Lake	WE, NP, YP
Clyde Lake	NP, LC
Francis Lake	YP, NP
Goodwin Lake	NP, SU
Heart Lake	LC, LW, YP, NP, WE, SU, spawning for LC, LW, NP in top portion of lake, LW spawn in lower part of lake
Jackson Lake	WE, YP, LW, NP, SU
Kinnaird Lake	LC, WE, NP
Lac La Biche	MW, WE, LC, NP, LW, YP, SU
Logan Lake	NP, YP, LC, WE
McGuffin Lake	WE, NP, YP, LC
Piche Lake	LC, NP, WE, LW, YP, SU
Square Lake	NP, YP, LC, SU

RIVERS AND STREAMS:

Biche (La Biche?) River	NP, WE
Clyde River	NP
La Biche River	NP, WE, MW, RB, AG, DV, GE
Logan River	NP, WE fish movement
Owl River	NP, WE? fish movement
Piche River	NP, WE
Wandering River	NP, WE, SU, AG

APPENDIX A CONTINUED

SUB-BASIN: CLEARWATER

LAKES:	FISH:
Bohn Lake	NP
Birch Lake	NP, SU
Christina Lake	WE, YP, LW, NP, SU, LC
Georges Lake	LC, NP, YP, WE
Gipsy Lake	LW, NP, YP
Gregoire Lake	WE, LW, LC, NP, SU, YP
Grist Lake	LT west side
High Lake	SU
Watchusk Lake	NP
Winefred Lake	LT, WE, NP, YP, SU, LC, LW
RIVERS AND STREAMS:	
Christina River	AG, NP, WE, SU, GE, YP, MW
Clearwater River	MW, AG (spawning in High Hills area) WE, NP, AG, SU, GE,LW, SU, AG overwintering area near Rainbow Creek tributary
Gregoire River	AG, WE, NP, SU downstream Gregorie Lake obstruction to fish passage, unspecified obstruction for fish
Hangingstone River	AG, SU, AG spawning area, spawning for AG downstream provinc provincial campsite
Kettle River	AG, SU
Landels River	SU
May River	AG, NP
Surmont Creek	AG, SU spawning area?
Winefred River	AG, YP, NP, WE spawning for WE near outlet Winefred Lake

APPENDIX A CONTINUED

SUB-BASIN: ATHABASCA I

LAKES:	FISH:
Carson Lake	RB
Fish Lake	NP
Kinky Lake	EB, RB
Windfall Lake	NP

RIVERS AND STREAMS:	
Athabasca River	near Pine Creek - Head Creek area AG, MW movement downstream
Athabasca River	Flatbush area BU, SU, NP, WE, MW, RB, AG, DV, GE
Athabasca river	McLeod confluence - upstream BU, SU, NP, WE, MW, RB, AG, DV, GE - downstream BU, NP, WE, MW, RB, AG, DV, GE
Athabasca River	upstream Five Mile Island (near Blue Ridge) BU, SU, NP,
WE,MW	RB, AG, DV, GE
Athabasca River	Freeman River confluence - upsteam - BU, SU, NP, WE, MW, RB, AG, DV downstream - the same plus GE
Athabasca River	Brule Lake area MW, RB, NP
Baseline Creek	RB, EB, MW
Carson Creek	AG, RB
Cold Creek	MW, RB, EB
Fish Creek	MW, RB, EB
Freeman River	AG, NP, WE, RB, few RB in tributaries
Gorge Creek	RB, MW, BT, EB
Hardisty Creek	RB
Marsh Head Creek	AG, DV congregate just upstream of Athabasca confluence
Maskuta (Prairie) Creek	Athabasca River confluence RB, MW fish movements

Oldman Creek	RB, MW, DV
Oldman Creek	RB, AG
Pine Creek	RB, DV, MW, AG
Plante Creek	MW
Ponoka Creek	RB, EB?
Sakwatamau River	limited AG, RB - heavily fished, north sections poor access - AG, RB, some BT
Timeu Creek	AG
Weasone Creek	AG
Windfall Creek	MW, AG

APPENDIX A CONTINUED

SUB-BASIN: ATHABASCA II

LAKES:	FISH:
Calling Lake	YP, SU, LW, LC, NP, BU, WE
Jackfish Lake	
Rock Island Lake	LC, LW, WE, YP, NP

RIVERS AND STREAMS:	
Athabasca River	downstream section of this subbasin - MW, GE, NP, WE, LW, SU AG,
Athabasca River	Cascade Rapids to Fort McMurray - overwintering areas spawning for LW upstream Fort McMurray
Athabasca River	Calling River area - YP
Athabasca River	McMillian Lake area and Parallel Creek area - YP
Athabasca River	Grand Rapids area - LW, NP, MW, SU - upstream SU, MW
Athabasca River	Brule Rapids area - SU, ME, MW - upstream SU, MW downstream to Middle Rapids GE
Baptiste Creek	seasonal movements of AG, MW
Calling River	
Horse River	AG, SU - spawning area for SU
House River	AG, NP, MW, WE, SU
Jackfish Creek (?)	AG, NP, WE

APPENDIX A CONCLUDED

SUB-BASIN: ATHABASCA III

LAKES:	FISH:
Ruth Lake	SU
RIVERS AND STREAMS:	
Athabasca River	AG, LW, MW, GE
Beaver River	AG
MacKay river	spawning area for AG, SU
Poplar Creek	NP, AG (overwintering area) SU (spawn)
Steepbank River	AG, SU, NP, WE, LW , spawning for AG , overwintering for AG downstream Fort McMurray

APPENDIX B

NUMBER OF RESIDENT ANGLERS AS A PERCENT OF ALBERTA TOTAL IN THE ATHABASCA RIVER BASIN

APPENDIX B

NUMBER OF RESIDENT ANGLERS
(PERCENT OF ALBERTA TOTAL)

Location	Town	1972/73 (No)	1972/73 (%)	1977/78 (No)	1977/78 (%)	1980/81 (No)	1980/81 (%)
Upper Drainage							
Jasper Park Sub-Basin	Jasper	31	0.018	107	0.04	105	0.04
Berland Sub-Basin	no towns with licensed sales						
McLeod Sub-Basin	Cadomin	24		36		40	
	Marlboro	15		4		3	
	Edson	946		1458		2314	
	Peers	77		164		207	
	Carrot Creek	28		27		42	
	Whitecourt	725		1,124		1,916	
McLeod Sub-Basin Total		1,815	1.06	2,813	1.09	4,522	1.54
Upper Drainage Total		**1,846**	**1.08**	**2,920**	**1.13**	**4,627**	**1.57**
Central Drainage							
Pembina Sub-Basin	Lodgepole	55		73		54	
	Cynthia	9		20		20	
	Entwhistle	62		98		148	
	Evansburg	146		207		349	
	Wildwood	147		192		345	
	Niton	8		9		3	
	Mayerthorpe	294		428		703	
	Green Court	28		48		36	
	Sangudo	160		247		289	
	Lisburn	7		2		-	
	Cherhill	35		68		98	
	Glenevis	14		18		27	
	Tiger Lily	37		32		42	

APPENDIX B CONTINUED

Location	Town	1972/73 (No)	1972/73 (%)	1977/78 (No)	1977/78 (%)	1980/81 (No)	1980/81 (%)
Pembina Sub-Basin (cont)							
	Meadow View	42		52		48	
	Lac La Nonne	2		13		1	
	Camp Creek	30		26		35	
	Bloomsbury	36		23		7	
	Barrhead	948		1,227		1,535	
	Manola	3		5		4	
	Neerlandia	87		89		82	
	Pickardville	79		122		160	
	Vega	27		52		53	
	Westlock	727		1,088		1,413	
	Pibroch	38		51		43	
	Dapp	75		96		130	
	Jarvie	78		80		114	
	Fawcett	82		91		125	
	Flatbush	56		59		84	
Pembina Sub-Basin Total		3,312	1.94	4,516	1.75	5,948	2.02
Lesser Slave Sub-Basin							
	High Prairie	648		898		1,293	
	Enilda	65		79		84	
	Grouard	36		95		104	
	Joussard	49		60		94	
	Driftpile	8		15		26	
	Faust	40		79		94	
	Kinuso	86		139		162	
	Canyon Creek	21		90		41	
	Widewater	26		22		54	
	Wagner	1		-		-	
	Slave Lake	736		1,036		1,424	
	Smith	155		204		174	
Lesser Slave Sub-Basin Total		1,871	1.10	2,717	1.06	3,550	1.21
Central Drainage Total		5,183	3.04	7,233	2.81	9,498	3.23

APPENDIX B CONTINUED

Location	Town	1972/73 (No)	1972/73 (%)	1977/78 (No)	1977/78 (%)	1980/81 (No)	1980/81 (%)
Lower Drainage							
Lac La Biche Sub-Basin							
	Ellscott	16		12		7	
	Boyle	266		345		385	
	Grassland	64		83		117	
	Atmore	27		49		106	
	Plamondon	87		134		234	
	Lac La Biche	454		759		1,144	
	Barnegat	1		-		-	
	Imperial Mills	4		6		1	
	Breynat	6		25		30	
	Wandering River	31		42		69	
Lac La Biche Sub-Basin Total		956	0.56	1,455	0.57	2,093	0.71
Clearwater Sub-Basin	Conklin	7		13		21	
	Chard	1		3		5	
	Anzac	6		8		3	
Clearwater Sub-Basin Total		14	0.01	24	0.01	29	0.01
Lower Drainage Total		**970**	**0.57**	**1,479**	**0.57**	**2,122**	**0.72**
Athabasca Drainage							
Athabasca I Sub-Basin							
	Brule	12		15		9	
	Entrance	11		14		14	
	Hinton	1,055		1,745		2,159	
	Obed	3		-		-	
	Hurdey	-		1		-	
	Windfall	-		3		-	
	Swan Hills	331		586		715	
	Blue Ridge	54		96		83	

APPENDIX B CONCLUDED

Location	Town	1972/73 (No)	1972/73 (%)	1977/78 (No)	1977/78 (%)	1980/81 (No)	1980/81 (%)
Athabasca I Sub-Basin (cont)							
	Lone Pine	5		15		22	
	Ft Assiniboine	138		206		253	
	Vega	27		52		53	
Athabasca I Sub-Basin Total		1,636	0.96	2,733	1.06	3,308	1.12
Athabasca II Sub-Basin							
	Chisholm	16		24		19	
	Chisholm Mills	2		-		1	
	Hondo	17		34		34	
	Tawatinaw	34		29		39	
	Perryvale	36		42		53	
	Meanook	2		-		-	
	Colinton	46		67		75	
	Athabasca	566		885		1,272	
	Island Lake	1		-		-	
	Ft McMurray	1,619		4,773		5,269	
Athabasca II Sub-Basin Total		2,339	1.37	5,854	2.24	6,762	2.30
Athabasca III Sub-Basin							
	Mildred Lake	-		281		11	
	Ft Mackay	3		13		18	
Athabasca III Sub-Basin Total		3	0.002	294	0.11	29	0.01
Athabasca I, II and III Total		**3,978**	**2.33**	**8,881**	**3.45**	**10,099**	**3.43**
Total Number of Resident Anglers in Alberta		**170,714**		**257,405**		**294,358**	

Source: File data, Fisheries Section, Altberta Fish and Wildlife Division, Edmonton.

APPENDIX C

COMMERCIAL FISHERIES STATISTICS SHOWING YEARLY CATCH OF FISH SPECIES BY QUOTA, QUANTITY, AND ESTIMATED VALUE IN THE ATHABASCA SUB-BASINS

APPENDIX TABLE C1

COMMERCIAL FISHERIES STATISTICS
SHOWING YEARLY CATCH OF FISH SPECIES BY QUOTA, QUANTITY, AND ESTIMATED VALUE
CHIP LAKE, PEMBINA SUB-BASIN

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Goldeye	Total
1975 (Jan, Apr, Sep, Nov)		5									
Quota (kg)					45,350						
Quantity (kg)					6,681	544	45				7,270
Value ($)					2,935	30					2,965
1976 (May)		2									
Quota (kg)					11,340						
Quantity (kg)					6,255						6,255
Value ($)					1,479						1,479
1977/78	0										
Quota (kg)											
Quantity (kg)					0						0
Value ($)					0						0
1979 (Sept)	3										
Quota (kg)											
Quantity (kg)					907						907
Value ($)					360						360
1980 (Mar)											
Quota (kg)					11,350 (Nov-Mar) 22,700 (Apr-Oct)						
Quantity (kg)					0						0
Value ($)					0						0

Continued

APPENDIX TABLE C1 CONCLUDED

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Goldeye	Total
1981 (Feb, May)	2										
Quota (kg)											
Quantity (kg)					2,053						2,053
Value ($)											
1982	1										
Quota (kg)					22,700 (Apr-Oct) 11,350 (Nov-Mar)						
Quantity (kg)					630				42	308	980
Value ($)					250				0	0	250
1983 (Feb)	0										
Quota (kg)											
Quantity (kg)											0
Value ($)											0

Notes: 1. na means not available.
2. Where combined quotas for lake whitefish, lake cisco, and walleye occur, the combined quota for the three species is given for lake whitefish and lake cisco; but only the relevant proportion of the combined quota is given for walleye.

Source: Commercial Fisheries Catch Statistics for Alberta 1942 to 1975, Fisheries Management Report No. 22, Dept. of Recreation Parks and Wildlife, Fish and Wildlife Division, November 1976. Other data from Fish and Wildlife Division fisheries statistics.

APPENDIX TABLE C2

COMMERCIAL FISHERIES STATISTICS
SHOWING YEARLY CATCH OF FISH SPECIES BY QUOTA, QUANTITY, AND ESTIMATED VALUE
FAWCETT LAKE, LESSER SLAVE SUB-BASIN

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Goldeye	Total
1975 (Sep)	32										
Quota (kg)			15,876	15,876					907		
Quantity (kg)			18,238	441	281				143		19,103
Value ($)			8,916	480	81				218		9,695
1976 (Sep)	33										
Quota (kg)			15,876	15,876					907		
Quantity (kg)			17,058	3,762	626	635			237		22,318
Value ($)			6,694	2,820	246	0			328		10,088
1977 (Sep)	36										
Quota (kg)			15,876	15,876					907		
Quantity (kg)			21,215	5,851	1,037				312		28,415
Value ($)			9,354	5,800	229				413		15,796
1979 (Sep)	36	36									
Quota (kg)			15,876	15,876					907		
Quantity (kg)			4,744	4,143	866	159			926		10,838
Value ($)			2, 092	3,653	286	17			1,429		7,478
1981 (Sep)	60										
Quota (kg)			15,850	15,850					900		
Quantity (kg)			16,707	5,556	597	74			900		23,834
Value ($)			5,847	5,500	394	8			1,485		13,235

Continued

APPENDIX TABLE C2 CONCLUDED

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Goldeye	Total
1982 (Sep)	46										
Quota (kg)			15,850	15,850					900		
Quantity (kg)			6,407	7,134	722	1,148	18	1	634		16,064
Value ($)			1,857	4,595	396	2	0	0	921		7,771

Note: Where combined quotas for lake whitefish, lake cisco, and walleye occur, the combined quota for the three species is given for lake whitefish and lake cisco; but only the relevant proportion of the combined quota is given for walleye.

Source: Commercial Fisheries Catch Statistics for Alberta 1942 to 1975, Fisheries Management Report No. 22, Dept. of Recreation Parks and Wildlife, Fish and Wildlife Division, November 1976. Other data from Fish and Wildlife Division, fisheries statistics.

APPENDIX TABLE C3

COMMERCIAL FISHERIES STATISTICS
SHOWING YEARLY CATCH OF FISH SPECIES BY QUOTA, QUANTITY, AND ESTIMATED VALUE
ORLOFF LAKE, LESSER SLAVE SUB-BASIN

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Goldeye	Total
1974/75	11										
Quota (kg)											
Quantity (kg)			4,620	4,715	318				68		9,721
Value ($)											
1975/76	5										
Quota (kg)											
Quantity (kg)			12,263	6,072	213	235	202		71		19,056
Value ($)											
1978 (Nov)	45										
Quota (kg)			15,850	8,150					1,150		
Quantity (kg)			21,448	6,813	2,351				492		31,104
Value ($)			14,185	9,012	1,295				759		25,251
1979 (Dec)	42										
Quota (kg)			15,850	8,150					1,150		
Quantity (kg)			15,405	7,503	941				610		24,459
Value ($)			11,887	11,579	1,037				1,681		26,184
1980 (Nov)	57										
Quota (kg)			15,850	8,150					1,150		
Quantity (kg)			17,108	9,985	1,782		5,546		1,031		35,452
Value ($)			8,896	8,222	912				1,586		29,616

Continued

APPENDIX TABLE C3 CONCLUDED

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Goldeye	Total
1982 (Dec)	28										
Quota (kg)			15,850	8,150					1,150		
Quantity (kg)			5,669	8,477	1,073	145	667		172		16,203
Value ($)			6,235	13,987	1,108				566		21,969

Note: Where combined quotas for lake whitefish, lake cisco, and walleye occur, the combined quota for the three species is given for lake whitefish and lake cisco; but only the relevant proportion of the combined quota is given for walleye.

Source: Commercial Fisheries Catch Statistics for Alberta 1942 to 1975, Fisheries Management Report No. 22, Dept. of Recreation Parks and Wildlife, Fish and Wildlife Division, November 1976. Other data from Fish and Wildlife Division, fisheries statistics.

APPENDIX TABLE C4

COMMERCIAL FISHERIES STATISTICS
SHOWING YEARLY CATCH OF FISH SPECIES BY QUOTA, QUANTITY, AND ESTIMATED VALUE
LESSER SLAVE LAKE, LESSER SLAVE SUB-BASIN

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Others	Total
1973/74	35										
Quota (kg)			102,041					11,338			
Quantity (kg)				79,351	44,400			168	2,385	907	127,211
Value ($)				26,730	7,934			27	1,422	94	36,207
1974/75	32										
Quota (kg)				172,336					11,338		
Quantity (kg)				164,834	54,742			212	1,088	3,175	224,051
Value ($)				74,762	8,853			157	14,465	0	98,237
1975/76	40										
Quota (kg)				122,449					4,535		
Quantity (kg)			1,845	115,248	42,018			283	3,005		162,399
Value ($)			173	71,020	12,103			108	2,932		86,336
1976/77	51										
Quota (kg)			500,000	136,054					14,059		
Quantity (kg)				172,760	39,878			440	14,486		227,564
Value ($)				74,762	8,853			157	14,465		98,237
1977/78	39										
Quota (kg)			500,000	204,082					25,397		
Quantity (kg)			1,427	213,557	51,457			542	17,581	73,952	358,516
Value ($)			118	90,825	13,322			298	23,836	869	129,268
1978/79	47										
Quota (kg)				158,730					29,478		
Quantity (kg)				264,302	67,893			410	16,187		348,792
Value ($)				111,539	22,978			217	28,543		163,277

Continued

APPENDIX TABLE C4 CONCLUDED

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Others	Total
1979/80	83										
Quota (kg)			500,000	204,082					43,084		
Quantity (kg)			4,640	233,905	77,695			488	27,494	92,063	436,285
Value ($)			38	251,986	62,715			434	54,048	1,804	371,025
1980/81	71										
Quota (kg)			226,750	333,333					36,270		
Quantity (kg)			5,351	337,926	65,870			226	19,084		428,457
Value ($)			10	201,865	34,824			251	39,717		276,667
1981/82	70										
Quota (kg)			226,750	385,500	90,750				36,250		
Quantity (kg)			22,648	195,249	66,202			134	31,034		315,267
Value ($)			2,233	81,843	45,886			76	71,615		201,653
1982/83	58										
Quota (kg)				327,000					13,000		
Quantity (kg)				310,134	57,073			65	23,926	93,074	484,272
Value ($)				128,598	41,252			74	51,833	1,447	223,204
Average	53										
Quota (kg)				214,561					22,475		
Quantity (kg)			3,591	208,727	56,723			297	15,627	26,317	311,282
Value ($)			257	111,393	25,872			180	30,288	421	168,411

Note: Where combined quotas for lake whitefish, lake cisco, and walleye occur, the combined quota for the three species is given for lake whitefish and lake cisco; but only the relevant proportion of the combined quota is given for walleye.

Source: Commercial Fisheries Catch Statistics for Alberta 1942 to 1975, Fisheries Management Report No. 22, Dept. of Recreation Parks and Wildlife, Fish and Wildlife Division, November 1976. Other data from Fish and Wildlife Division, fisheries statistics.

APPENDIX TABLE C5

COMMERCIAL FISHERIES STATISTICS
SHOWING YEARLY CATCH OF FISH SPECIES BY QUOTA, QUANTITY, AND ESTIMATED VALUE
LAC LA BICHE, LAC LA BICHE SUB-BASIN

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Others	Total
1973/74	35										
Quota (kg)			68,027	70,295	22,670				22,670		
Quantity (kg)			405,340	53,323	27,352			4,415	50	19,567	510,047
Value ($)			40,456	25,434	4,366			436	55	2,045	72,792
1974/75	35										
Quota (kg)			68,027	70,295	22,670				22,670		
Quantity (kg)			650,839	65,605	12,021			1,134	136	26,704	756,439
Value ($)			64,580	36,387	3,261			250	150	1,879	106,507
1975/76	22										
Quota (kg)			770,975	65,760	45,350				45,350		
Quantity (kg)			428,617	68,617	14,438			2,381	252	14,558	528,863
Value ($)			37,927	40,613	3,007			316	278	1,417	83,558
1976/77	50										
Quota (kg)			770,975	77,098	31,746				31,746		
Quantity (kg)			199,932	73,741	8,190			2,381	272	6,916	291,432
Value ($)			22,143	40,950	1,683			514	313	722	66,325
1977/78	77										
Quota (kg)			816,327	79,365	24,943				24,943		
Quantity (kg)			214,113	82,340	30,757			907	102	18,606	346,825
Value ($)			21,245	42,106	5,251			90	154	1,601	70,447
1978/79	37										
Quota (kg)			770,975	117,914	55,738				55,738		
Quantity (kg)			200,297	92,989	19,219			2,316	161	44,534	359,516
Value ($)			24,291	48,307	4,774			299	191	5,988	83,850

Continued

APPENDIX TABLE C5 CONCLUDED

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Others	Total
1979/80	59										
Quota (kg)			770,975	111,110	29,479				29,479		
Quantity (kg)			159,850	114,523	19,769			2,311	172	28,600	325,225
Value ($)			19,638	76,610	7,414			934	265	6,747	111,608
1980/81	65										
Quota (kg)			770,972	122,473	40,828				40,828		
Quantity (kg)			169,599	118,916	19,354			2,306	240	22,772	358,187
Value ($)			29,493	83,848	5,925			519	346	4,924	125,055
1981/82	77										
Quota (kg)			771,200	147,400	34,000				34,000		
Quantity (kg)			200,965	117,625	24,925			1,389	248	31,138	376,290
Value ($)			35,314	88,026	10,131			241	495	3,799	138,006
1982/83	74										
Quota (kg)			771,200	147,400	34,000				34,000		
Quantity (kg)			196,600	144,970	39,098			1,050	210	29,760	411,688
Value ($)			33,578	112,123	15,693			176	359	4,150	166,079
Mean Value per Fisherman			394.49	1,081.48	95.37	1.43	41.40	8.05	5.11	42.43	1,669.76

Note: Where combined quotas for lake whitefish, lake cisco, and walleye occur, the combined quota for the three species is given for lake whitefish and lake cisco; but only the relevant proportion of the combined quota is given for walleye.

Source: Commercial Fisheries Catch Statistics for Alberta 1942 to 1975, Fisheries Management Report No. 22, Dept. of Recreation Parks and Wildlife, Fish and Wildlife Division, November 1976. Other data from Fish and Wildlife Division, fisheries statistics.

APPENDIX TABLE C6

COMMERCIAL FISHERIES STATISTICS
SHOWING YEARLY CATCH OF FISH SPECIES BY QUOTA, QUANTITY, AND ESTIMATED VALUE
PICHE LAKE, LAC LA BICHE SUB-BASIN

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Others	Total
1975/76	0										
Quota (kg)											
Quantity (kg)											0
Value ($)											
1981 (Dec)	2										
Quota (kg)			2,250		2,250			2,250			
Quantity (kg)			135		135	5	2	.5			277.5
Value ($)			11		67						79
1982 (Dec)	0										
Quota (kg)			2,250		2,250			2,250			
Quantity (kg)											
Value ($)											

Note: Where combined quotas for lake whitefish, lake cisco, and walleye occur, the combined quota for the three species is given for lake whitefish and lake cisco; but only the relevant proportion of the combined quota is given for walleye.

Source: Commercial Fisheries Catch Statistics for Alberta 1942 to 1975, Fisheries Management Report No. 22, Dept. of Recreation Parks and Wildlife, Fish and Wildlife Division, November 1976. Other data from Fish and Wildlife Division, fisheries statistics.

APPENDIX TABLE C7

COMMERCIAL FISHERIES STATISTICS
SHOWING YEARLY CATCH OF FISH SPECIES BY QUOTA, QUANTITY, AND ESTIMATED VALUE
KINNAIRD LAKE, LAC LA BICHE SUB-BASIN

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Others	Total
1975 (Mar, Nov)		5									
Quota (kg)			10,900		10,900			10,900	3,600		
Quantity (kg)			431		476		68	236	254		1,465
Value ($)			238		262		7	130	280		917
1976 (Nov)		5									
Quota (kg)			5,450		5,450			5,450	1,800		
Quantity (kg)			1,971		463	45	68	57	431		3,035
Value ($)			645		95		30	35	628		1,433
1977 (Nov, Dec)	6										
Quota (kg)			5,450		5,450			5,450	1,800		
Quantity (kg)			3,130	1,343				105	702		5,280
Value ($)			1,311	266				58	928		2564
1978 (Nov)	4										
Quota (kg)			5,450		5,450			5,450	1,800		
Quantity (kg)			1,338		1,145	45	91	113	249		2,981
Value ($)			456		234		11	62	412		1,176
1979 (Nov, Dec)	3										
Quota (kg)			5,450		1,800			5,450	1,800		
Quantity (kg)			2,851		1,143	68	91	83	899		5,135
Value ($)			1,563		552			79	1,641		3,835
1980 (Nov, Dec)	3										
Quota (kg)			5,450		1,800			5,450	1,800		
Quantity (kg)			2,452		186			161	553		3,552
Value ($)			1,387		76			204	1,105		2,771

Continued

APPENDIX TABLE C7 CONCLUDED

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Others	Total
1981 (Dec)	1										
Quota (kg)			5,450		1,800				1,800		
Quantity (kg)			468		27			12	46		553
Value ($)			242		12			14	120		388
1982 (Nov)	4										
Quota (kg)			5,450		1,800				1,800		
Quantity (kg)			2,595		185		10	95	580		3,465
Value ($)			1,059		89			143	1,159		2,452

Note: Where combined quotas for lake whitefish, lake cisco, and walleye occur, the combined quota for the three species is given for lake whitefish and lake cisco; but only the relevant proportion of the combined quota is given for walleye.

Source: Commercial Fisheries Catch Statistics for Alberta 1942 to 1975, Fisheries Management Report No. 22, Dept. of Recreation Parks and Wildlife, Fish and Wildlife Division, November 1976. Other data from Fish and Wildlife Division, fisheries statistics.

APPENDIX TABLE C8

COMMERCIAL FISHERIES STATISTICS
SHOWING YEARLY CATCH OF FISH SPECIES BY QUOTA, QUANTITY, AND ESTIMATED VALUE
JACKSON LAKE, LAC LA BICHE SUB-BASIN

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Others	Total
1975 (Mar, Nov)		5									
Quota (kg)			9,100		9,100			9,100	2,700		
Quantity (kg)			370		538		136	454	84		1,582
Value ($)			204		296		13	250	92		856
1976 (Nov)		5									
Quota (kg)			4,550		4,550			4,550	1,800		
Quantity (kg)			3,860		1,420	45	45	68	816		6,254
Value ($)			1,258		188		5	45	1,125		2,621
1977 (Nov, Dec)	7										
Quota (kg)			4,550		4,550			4,550	1,350		
Quantity (kg)			3,037		1,360			142	594		5,133
Value ($)			1,205		270			78	786		2,339
1978 (Nov)	6										
Quota (kg)			4,550		4,550			4,550	1,350		
Quantity (kg)			862		1,383	45	113	181	272		2,856
Value ($)			321		317		14	100	450		1,202
1979 (Nov, Dec)	5										
Quota (kg)			4,550		1,350			4,550	1,350		
Quantity (kg)			433		1,749	45	45	14	787		3,073
Value ($)			475		873			13	1,437		2,798
1980 (Nov)	8										
Quota (kg)			4,550		1,350				1,350		
Quantity (kg)			3,377		936	9	11	46	684		5,064
Value ($)			2,042		381			58	1,356		3,837

Continued

APPENDIX TABLE C8 CONCLUDED

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Others	Total
1981 (Dec)	2										
Quota (kg)			4,550		1,350				1,350		
Quantity (kg)			172		101			3	59		335
Value ($)			93		44			4	153		295
1982 (Nov)	6										
Quota (kg)			4,550		1,350				1,350		
Quantity (kg)			4,389		334		18	63	493		5,297
Value ($)			1,535		150			100	1,000		2,786

Note: Where combined quotas for lake whitefish, lake cisco, and walleye occur, the combined quota for the three species is given for lake whitefish and lake cisco; but only the relevant proportion of the combined quota is given for walleye.

Source: Commercial Fisheries Catch Statistics for Alberta 1942 to 1975, Fisheries Management Report No. 22, Dept. of Recreation Parks and Wildlife, Fish and Wildlife Division, November 1976. Other data from Fish and Wildlife Division, fisheries statistics.

APPENDIX TABLE C9

COMMERCIAL FISHERIES STATISTICS
SHOWING YEARLY CATCH OF FISH SPECIES BY QUOTA, QUANTITY, AND ESTIMATED VALUE
HEART LAKE, LAC LA BICHE SUB-BASIN

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Whitefish Roe	Total
1975 (Aug, Dec)	15										
Quota (kg)			40,800	9,100	27,200				6,800		
Quantity (kg)			17,464	725	10,215	227	839	9	3,277		32,756
Value ($)			1,730	653	1,301		83	2	3,188		6,956
1976 (Aug, Nov)		26									
Quota (kg)			40,800	9,075	9,075 (Aug) 27,216 (Nov)				2,268 (Aug) 27,216 (Nov)		
Quantity (kg)			1,905	1,088	3,901	341	363		1,497		9,095
Value ($)			210	1,014	580		40		1,838		3,682
1977 (Aug, Nov, Dec)		24									
Quota (kg)			40,800	9,075	27,200				4,550		
Quantity (kg)			3,923	3,089	2,448	272	567		1,871		12,170
Value ($)			438	2,714	455		62		2,373		6,042
1978 (Aug, Dec)		13									
Quota (kg)			40,800	9,075	22,680				4,080		
Quantity (kg)			3,538	1,928	249	136	363		1,134		7,348
Value ($)			390	1,988	72		40		1,993		4,483
1979 (Sep)	17										
Quota (kg)			13,600	6,800	4,550				1,800		
Quantity (kg)			9,389	3,574	1,783	363	227		1,179		16,515
Value ($)			1,138	2,748	786		28		1,938		6,638

Continued

APPENDIX TABLE C9 CONCLUDED

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Others	Total
1980 (Mar,Apr,Jun,Jul,Nov)	49										
Quota (kg)			88,450	13,600	58,970				5,000		
Quantity (kg)			14,503	6,825	5,288	846	677	5	509		28,648
Value ($)			2,207	6,486	2,548		4		809		12,054
1981 (Jun, Aug)	51										
Quota (kg)			33,900	11,300	22,600				2,700		
Quantity (kg)			10,716	4,093	987	257	827		324		17,204
Value ($)			1,886	3,387	511		145		652		6,581
1982 (Oct)	22										
Quota (kg)				9,050	2,250				1,350		
Quantity (kg)			2,238	1,491	663	322	84		2,166	78	6,964
Value ($)			394	900	200		15		2,701	222	4,654

Note: Where combined quotas for lake whitefish, lake cisco, and walleye occur, the combined quota for the three species is given for lake whitefish and lake cisco; but only the relevant proportion of the combined quota is given for walleye.

Source: Commercial Fisheries Catch Statistics for Alberta 1942 to 1975, Fisheries Management Report No. 22, Dept. of Recreation Parks and Wildlife, Fish and Wildlife Division, November 1976. Other data from Fish and Wildlife Division, fisheries statistics.

APPENDIX TABLE C10

COMMERCIAL FISHERIES STATISTICS
SHOWING YEARLY CATCH OF FISH SPECIES BY QUOTA, QUANTITY, AND ESTIMATED VALUE
CHRISTINA LAKE, CLEARWATER SUB-BASIN

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Others	Total
1974/75	3										
Quota (kg)											
Quantity (kg)			227	2,812	32		454		220		3,745
Value ($)											
1975/76	1										
Quota (kg)											
Quantity (kg)				91			9		2		102
Value ($)											
1980 (Mar)	0										
Quota (kg)				5,443	680				680		
Quantity (kg)				0	0				0		0
Value ($)											
1981 (Mar)	3										
Quota (kg)				5,450	700				700		
Quantity (kg)			1	20	42		5				68
Value ($)				24	19		1				44
1982 (Aug)	2										
Quota (kg)				5,450	700				700		
Quantity (kg)				625	25				240		890
Value ($)				367	11				451		829

Note: Where combined quotas for lake whitefish, lake cisco, and walleye occur, the combined quota for the three species is given for lake whitefish and lake cisco; but only the relevant proportion of the combined quota is given for walleye.

Source: Commercial Fisheries Catch Statistics for Alberta 1942 to 1975, Fisheries Management Report No. 22, Dept. of Recreation Parks and Wildlife, Fish and Wildlife Division, November 1976. Other data from Fish and Wildlife Division, fisheries statistics.

APPENDIX TABLE C11

COMMERCIAL FISHERIES STATISTICS
SHOWING YEARLY CATCH OF FISH SPECIES BY QUOTA, QUANTITY, AND ESTIMATED VALUE
KIRBY LAKE, CLEARWATER SUB-BASIN

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Others	Total
1975 (Nov, Dec)	0										
Quota (kg)			2,950								
Quantity (kg)											
Value ($)											
1976 (Nov, Dec)	3										
Quota (kg)				2,950							
Quantity (kg)				3,307	181	454	9		11		3,962
Value ($)				2,290	100	90			12		2,493
1977 (Nov, Dec)	0										
Quota (kg)				3,175							
Quantity (kg)											
Value ($)											
1978 (Mar, Nov)	3										
Quota (kg)				6,350							
Quantity (kg)				4,513	107	454	23				5,097
Value ($)				4,330	21						4,351
1979 (Nov)	3										
Quota (kg)				4,100							
Quantity (kg)				1,359	206	141	2				1,708
Value ($)				1,407	74						1,481
1980 (Nov, Dec)	3										
Quota (kg)				4,100							
Quantity (kg)				2,034	1,109	23	9				3,175
Value ($)				2,032	457						2,490

Continued

APPENDIX TABLE C11 CONCLUDED

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Others	Total
1981 (Aug, Nov, Dec)	2										
Quota (kg)				8,200							
Quantity (kg)				425	20						445
Value ($)				348	6						353
1982 (Oct)	3										
Quota (kg)				4,100							
Quantity (kg)				680	25						705
Value ($)				875	12						888

Note: Where combined quotas for lake whitefish, lake cisco, and walleye occur, the combined quota for the three species is given for lake whitefish and lake cisco; but only the relevant proportion of the combined quota is given for walleye.

Source: Commercial Fisheries Catch Statistics for Alberta 1942 to 1975, Fisheries Management Report No. 22, Dept. of Recreation Parks and Wildlife, Fish and Wildlife Division, November 1976. Other data from Fish and Wildlife Division, fisheries statistics.

APPENDIX TABLE C12

COMMERCIAL FISHERIES STATISTICS
SHOWING YEARLY CATCH OF FISH SPECIES BY QUOTA, QUANTITY, AND ESTIMATED VALUE
WINEFRED LAKE, CLEARWATER SUB-BASIN

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Others	Total
1975 (Dec)	5										
Quota (kg)				11,340	1,135				1,135		
Quantity (kg)				12,880	302				14		13,196
Value ($)				5,352	165				15		5,533
1976 (Dec)		11									
Quota (kg)				11,340	1,135				1,135		
Quantity (kg)				11,978	2,204				68		14,795
Value ($)				5,048	302				108		5,558
1977 (Aug, Nov, Dec)	7										
Quota (kg)				11,340	1,135				1,135		
Quantity (kg)				3,531	1,027	123	40		34		4,755
Value ($)				2,013	571				56		2,640
1978 (Dec)	5										
Quota (kg)				11,340	1,135				1,135		
Quantity (kg)				11,343	1,041	203	64		23		12,674
Value ($)				4,752	1,148				38		5,937
1980 (Jan, Dec)	10										
Quota (kg)				22,680	2,270				2,270		
Quantity (kg)				15,054	1,192	2,534	187		109		19,077
Value ($)				9,182	511				229		9,922

Continued

APPENDIX TABLE C12 CONCLUDED

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Others	Total
1982 (Feb)	6										
Quota (kg)				11,350	1,150				1,150		
Quantity (kg)				1,831	253	35	11		3		2,133
Value ($)				593	241				6		840
1983 (Feb)	0										
Quota (kg)				11,340	1,150				1,150		
Quantity (kg)											0
Value ($)											

Note: Where combined quotas for lake whitefish, lake cisco, and walleye occur, the combined quota for the three species is given for lake whitefish and lake cisco; but only the relevant proportion of the combined quota is given for walleye.

Source: Commercial Fisheries Catch Statistics for Alberta 1942 to 1975, Fisheries Management Report No. 22, Dept. of Recreation Parks and Wildlife, Fish and Wildlife Division, November 1976. Other data from Fish and Wildlife Division, fisheries statistics.

APPENDIX TABLE C13

COMMERCIAL FISHERIES STATISTICS
SHOWING YEARLY CATCH OF FISH SPECIES BY QUOTA, QUANTITY, AND ESTIMATED VALUE
JUMBO LAKE, CLEARWATER SUB-BASIN

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Others	Total
1975 (Dec)	0										
Quota (kg)				1,350							
Quantity (kg)											0
Value ($)											
1976 (Jul, Aug)	0										
Quota (kg)				1,350							
Quantity (kg)											0
Value ($)											
1977 (Jul, Aug)	2										
Quota (kg)				1,350							
Quantity (kg)				2,347							2,347
Value ($)				1,727							1,727
1978 (Aug)	0										
Quota (kg)				1,350							
Quantity (kg)											
Value ($)											
1979 (Aug)	0										
Quota (kg)				900							
Quantity (kg)											
Value ($)											

Continued

APPENDIX TABLE C13 CONCLUDED

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Others	Total
1981 (Mar)	2										
Quota (kg)				900							
Quantity (kg)				847	81		9				937
Value ($)				1,089	39						1,128
1982 (Mar)	0										
Quota (kg)				900							
Quantity (kg)											
Value ($)											

Note: Where combined quotas for lake whitefish, lake cisco, and walleye occur, the combined quota for the three species is given for lake whitefish and lake cisco; but only the relevant proportion of the combined quota is given for walleye.

Source: Commercial Fisheries Catch Statistics for Alberta 1942 to 1975, Fisheries Management Report No. 22, Dept. of Recreation Parks and Wildlife, Fish and Wildlife Division, November 1976. Other data from Fish and Wildlife Division, fisheries statistics.

APPENDIX TABLE C14

COMMERCIAL FISHERIES STATISTICS
SHOWING YEARLY CATCH OF FISH SPECIES BY QUOTA, QUANTITY, AND ESTIMATED VALUE
ROCK ISLAND LAKE, ATHABASCA II SUB-BASIN

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Others	Total
1974/75	18										
Quota (kg)											
Quantity (kg)			9,163	2,067	2,268	246			23		13,767
Value ($)											
1976 (Jan, Dec)	34										
Quota (kg)			18,150	4,550							
Quantity (kg)			6,496	2,643	2,259	204			288		11,890
Value ($)			5,062	3,239	1,458				388		10,147
1977 (Dec)	11										
Quota (kg)			9,050	2,250							
Quantity (kg)			9,831	1,489	387	409	10		143		12,269
Value ($)			6,502	1,970	213				220		8,905
1978 (Dec)	8										
Quota (kg)			9,050	2,250							
Quantity (kg)			1,163	2,223	191	34	34		59		3,704
Value ($)			770	2,940	105				91		3,906
1979 (Dec)	21										
Quota (kg)			9,050	2,250							
Quantity (kg)			7,405	2,147	530				669		10,751
Value ($)			5,714	3,314	584				1,842		11,454
1980 (Dec)	13										
Quota (kg)			9,050	2,250							
Quantity (kg)			7,132	2,562	1,217				1,088		11,999
Value ($)			4,017	2,310	600				1,723		8,730

Continued

APPENDIX TABLE C14 CONCLUDED

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Others	Total
1981 (Dec)	19										
Quota (kg)			9,050	8,150							
Quantity (kg)			10,263	2,202	934	1,167	83		1,218		15,867
Value ($)			4,310	2,773	634				2,485		10,202
1982 (Dec)	15										
Quota (kg)			9,050	2,250							
Quantity (kg)			8,527	2,675	853	331	380		444		13,210
Value ($)			9,380	4,414	938				1,464		16,196

Note: Where combined quotas for lake whitefish, lake cisco, and walleye occur, the combined quota for the three species is given for lake whitefish and lake cisco; but only the relevant proportion of the combined quota is given for walleye.

Source: Commercial Fisheries Catch Statistics for Alberta 1942 to 1975, Fisheries Management Report No. 22, Dept. of Recreation Parks and Wildlife, Fish and Wildlife Division, November 1976. Other data from Fish and Wildlife Division, fisheries statistics.

APPENDIX TABLE C15

COMMERCIAL FISHERIES STATISTICS
SHOWING YEARLY CATCH OF FISH SPECIES BY QUOTA, QUANTITY, AND ESTIMATED VALUE
CALLING LAKE, ATHABASCA II SUB-BASIN

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Others	Total
1974/75	5										
Quota (kg)											
Quantity (kg)				200	1,275	66	1,771		914		4,226
Value ($)											
1976 (Mar, Apr)	3										
Quota (kg)					4,550				900		
Quantity (kg)				81	1,021	875	3,315		562		5,854
Value ($)				89	788				867		1,743
1977 (Mar, Apr)	4										
Quota (kg)					4,550				900		
Quantity (kg)				38	365	78	122		118		721
Value ($)				42	241				182		465
1978 (Mar, Apr)	3										
Quota (kg)					4,550				900		
Quantity (kg)			714	60	628	472	1,179		214		3,267
Value ($)				66	416	62	156		330		1,030
1979 (Mar, Apr)	2										
Quota (kg)					4,550				900		
Quantity (kg)				31	136	76	225		80		548
Value ($)				5	105	12	35		140		296
1980 (Mar, Apr)	3										
Quota (kg)					4,550				900		
Quantity (kg)				111	1,231	45	1,715		436		3,538
Value ($)				122	1,086	6	227		962		2,403

Continued

APPENDIX TABLE C15 CONCLUDED

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Others	Total
1981 (Mar)	4										
Quota (kg)					4,550				900		
Quantity (kg)				298	950	70	2,000		404		3,722
Value ($)				179	475	7	500		505		1,666
1982 (Mar)	3										
Quota (kg)					4,550				900		
Quantity (kg)				29	242	26	810		84		1,191
Value ($)				9	126				154		288
1983 (Jan)	5										
Quota (kg)					4,550				900		
Quantity (kg)			1	23	391	3	548		29		995
Value ($)			1	38	430				97		565

Note: Where combined quotas for lake whitefish, lake cisco, and walleye occur, the combined quota for the three species is given for lake whitefish and lake cisco; but only the relevant proportion of the combined quota is given for walleye.

Source: Commercial Fisheries Catch Statistics for Alberta 1942 to 1975, Fisheries Management Report No. 22, Dept. of Recreation Parks and Wildlife, Fish and Wildlife Division, November 1976. Other data from Fish and Wildlife Division, fisheries statistics.

APPENDIX TABLE C16

COMMERCIAL FISHERIES STATISTICS
SHOWING YEARLY CATCH OF FISH SPECIES BY QUOTA, QUANTITY, AND ESTIMATED VALUE
ISLAND LAKE, ATHABASCA II SUB-BASIN

Year (months)	Licenses Issued (No)	Active Fishermen (No)	Lake Cisco	Lake Whitefish	Northern Pike	Suckers	Burbot	Yellow Perch	Walleye	Others	Total
1974/75											
Quota (kg)											
Quantity (kg)				3,493				98			3,591
Value ($)											
1977 (Mar)	13										
Quota (kg)				4,550							
Quantity (kg)				2,034	10	1		1			2,046
Value ($)				3,364	8						3,372
1981 (Mar)	70										
Quota (kg)				4,550							
Quantity (kg)				3,285	94			1			3,380
Value ($)				6,156	73						6,229
1983 (Feb, Mar)	47										
Quota (kg)				4,550							
Quantity (kg)				5,185	283	30		1			5,499
Value ($)				11,406	311						11,720

Note: Where combined quotas for lake whitefish, lake cisco, and walleye occur, the combined quota for the three species is given for lake whitefish and lake cisco; but only the relevant proportion of the combined quota is given for walleye.

Source: Commercial Fisheries Catch Statistics for Alberta 1942 to 1975, Fisheries Management Report No. 22, Dept. of Recreation Parks and Wildlife, Fish and Wildlife Division, November 1976. Other data from Fish and Wildlife Division, fisheries statistics.