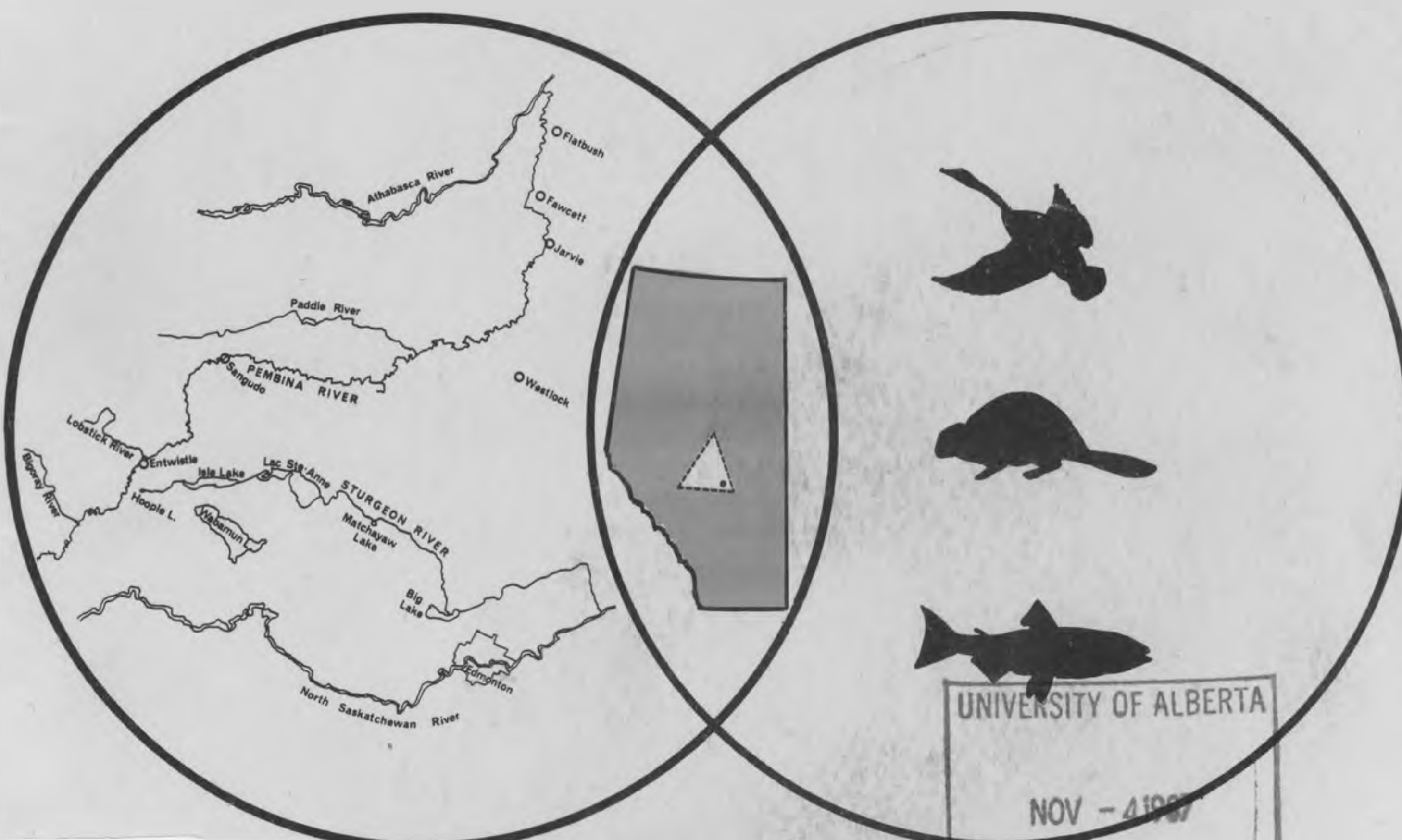
AN ECOLOGICAL STUDY OF WILDLIFE AND FISHERIES IN THE PEMBINA AND STURGEON RIVER BASINS

— Volume 1 —

RESULTS OF ECOLOGICAL STUDIES



PREPARED FOR

Water Resources Division
ALBERTA DEPARTMENT OF THE ENVIRONMENT

BY

ENEWABLE RESOURCES CONSULTING SERVICES LTD.

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I. INTRODUCTION:

An evaluation of the expected environmental impacts of a proposed dam-diversion project involving the Pembina and Sturgeon rivers was undertaken by Renewable Resources Consulting Services Ltd. in the summer of 1971. The water management project involves a proposed dam and reservoir on the Pembina River, an adjacent reservoir, a diversion of water from the Pembina River to the Sturgeon River, channel modification of the Sturgeon River, and stabilization of lake levels.

Field studies were initiated in May and continued until the end of September. The primary objectives of the field investigations were to determine the quantity and quality of wildlife habitat and the quality of fish habitat in areas which will be subjected to environmental change. In addition, information on present populations of waterfowl, upland bird game, furbearers, and big game was gathered. Distribution and relative abundance of the various species of fish inhabiting the Sturgeon and Pembina rivers was determined.

On the basis of information collected on the habitat and populations of fish and wildlife, and with a knowledge of the proposed water management projects, the projected impacts of such projects upon the fish and wildlife in the Sturgeon and Pembina river basins are predicted. The first volume of the report presents results of detailed ecological studies carried out in the areas to be affected along the two rivers. In the second volume is a discussion of the impacts on fish and wildlife which are predicted to result if the dam-diversion project is carried out. In addition, recommendations for mitigation of losses, remedial measures, and management required to optimize habitat conditions are outlined.

II. THE STUDY AREA:

The study area includes portions of two major drainage basins in Alberta - the Athabasca and the North Saskatchewan.

The Pembina River, part of the Athabasca drainage system receives water from the foothills region of western central Alberta from an elevation as high as 7,852 feet on Redcap Mountain. It flows northeast through the plains to empty into the Athabasca River at an elevation of 1,875 feet. The gradient in the upper portion of the river is steep while that of the lower reaches, in the vicinity of Barrhead, is shallow. This results in frequent flooding by the Pembina River and its tributary, the Paddle River, with the consequent formation of an alluvial plain. In the lower section of the river numerous oxbows are found adjacent to the main river channel. Most of the river within the study area flows through lacustrine deposits with relatively flat topography.

The land along the Pembina River from Sangudo to Fawcett receives intensive agricultural use. The remainder of the watershed is fairly well forested.

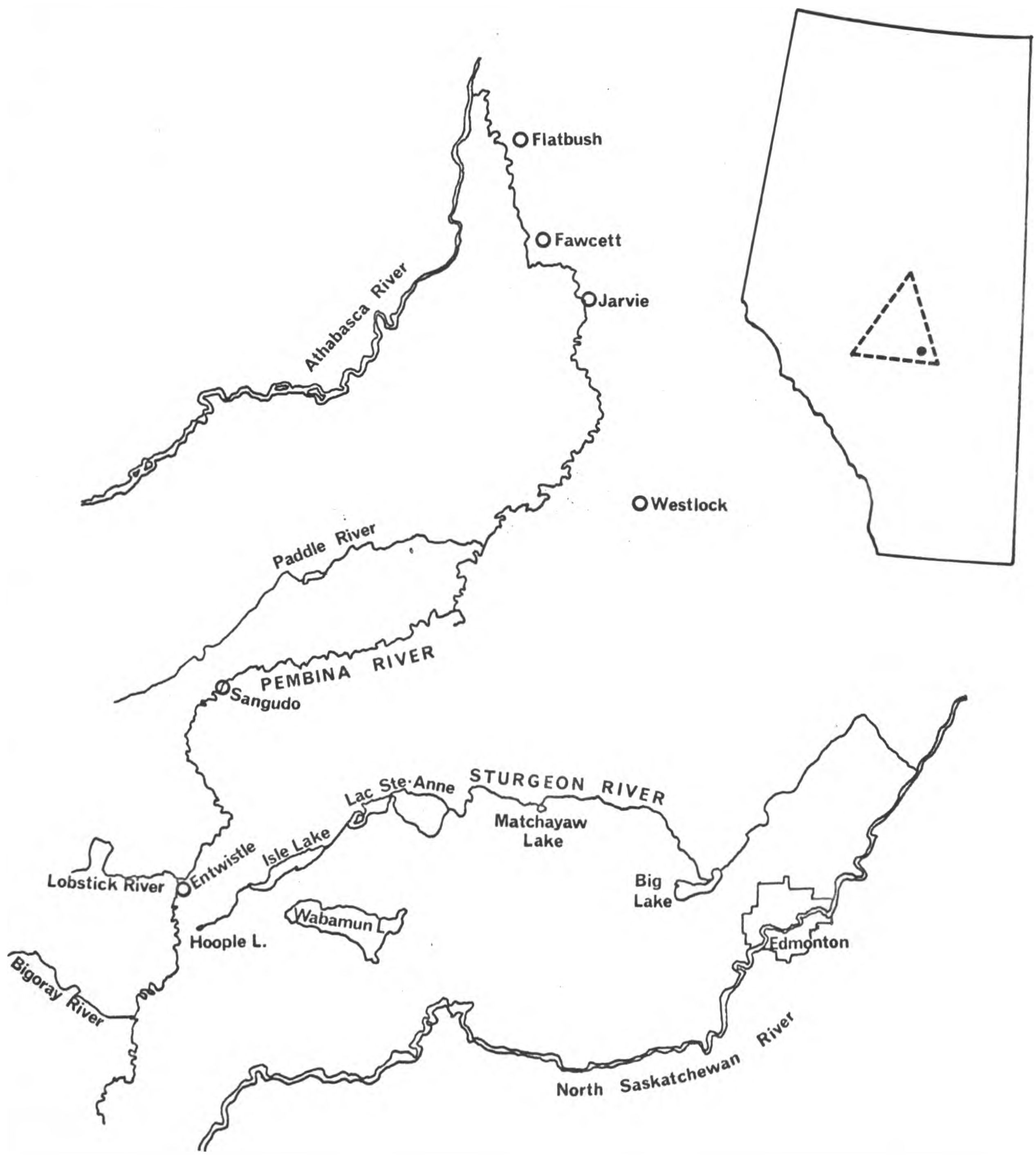
The Sturgeon River is part of the Saskatchewan drainage system. It originates at Hoople Lake, a pond about 60 miles west of Edmonton at an elevation of 2,492 feet, and empties into the North Saskatchewan River northeast of Fort Saskatchewan at an elevation of approximately 1,970 feet. The gradient along the entire length of the river is shallow.

The entire Sturgeon River is within the plains region and the area through which it flows is covered with lacustrine deposits. The topography of the river basin is relatively flat. Most of the forest cover in the Sturgeon River watershed has been cleared for agriculture.

Four lakes occur along the Sturgeon River: Isle Lake, Lac Ste. Anne, Matchayaw Lake, and Big Lake. Isle Lake covers an area of 8.2 square miles and contains approximately 28 miles of shoreline. Maximum depth is approximately 30 feet. Lac Ste. Anne, covering 20.6 square miles, contains approximately 42 miles of shoreline and reaches a maximum depth of 30 feet. Matchayaw Lake covers 0.6 square miles, contains 4 miles of shoreline, and has a maximum depth of 35 feet. The permanent portion of Big Lake contains 5.8 square miles and 16.7 miles of shoreline. Inclusion of the portion subject to inundation increases the area to nearly 9.0 square miles and the miles of shoreline to 20. Big Lake is much shallower than the other lakes and likely contains little or no water over 10 feet in depth. All of the lakes are eutrophic in varying degrees. Figure 1 shows the location of the study area.

FIGURE 1

Map of the Study Area



III. WILDLIFE STUDY

A. Wildlife Habitat:

A primary requirement for any study of the ecological impact of environmental modification is an investigation of wildlife habitat. Studies of wildlife populations alone over as short a period of time as one or two summers do not provide adequate information upon which to project changes in those populations as a result of changes in the environment. Fluctuations in numbers of animals occur from year to year. Populations in any one year may be far below the carrying capacity of the habitat. The Canada Land Inventory has already classified areas within the study area primarily on the basis of abiotic components of the ecosystem as to their potential capability to produce wildlife. Lacking, is quantitative and qualitative information on the biotic components of the environment taking into consideration present land use practices. Accordingly, an effort was made to gather information on the extent and composition of both terrestrial and aquatic plant communities present on the study area.

1.) Terrestrial Vegetation:

a.) Methods:

Vegetation within approximately one mile on each side of the Sturgeon River and within one-half mile of the lakes as well as within the proposed sites of the Pembina and Magnolia reservoirs was classified and delineated on aerial photographs. Classification of forest types on the aerial photographs was supplemented with direct observations in the field. A total of nine forest types were identified in addition to cleared land. They are as follows:

1.) Aspen poplar forest
2.) Balsam poplar forest
3.) White spruce forest
4.) Lodgepole pine forest
5.) Mixed forest - deciduous dominant
6.) Mixed forest - coniferous dominant
7.) Black spruce bog
8.) Willow community
9.) Birch forest

The relative amounts of each of the above forest types along the Sturgeon River was determined.

Along the Pembina River, since terrestrial vegetation will not be directly affected by such projects proposed for the Sturgeon as canalization, only the vegetation immediately bordering the river was considered. The extent and type of forest bordering the Pembina River for 138 miles of a total of 290 miles of river in the study area was noted from aerial photographs and while travelling down the river by boat.

The first seven of the forest types mentioned above were characterized in more detail by analyzing plots in each community. Five plots in each of five forests of each type (a total of 25 plots in each forest type) were analyzed in the aspen poplar forest, balsam poplar forest, deciduous dominated mixed forest, and the black spruce bog. Ten plots were analyzed in the white spruce forest, five were analyzed in lodgepole pine, and twenty were analyzed in the coniferous dominated mixed forest.

Plots were located at 50-pace intervals through the forest. Each plot contained a circular area of 1/100 acre and was delineated by crossing two ropes at right angles. Each rope was the length of the diameter of the circle. Within each plot, vegetation was divided into three layers: overstory (trees which reached breast height and above), middlestory (shrubs and trees under breast height) and understory (forbs and grasses).

In each plot, the number of trees and their diameter were recorded. The amount of cover provided by species and by total vegetation in the overstory and middlestory, and by forbs and grasses in the understory was estimated using a modification of Daubenmire's (1959) scale of values:

Coverage Class	Range of Coverage
0	absent
1	present to 5%
2	>5% to 25%
3	>25% to 50%
4	>50% to 75%
5	>75% to 95%
6	>95% to 100%

In addition to an estimation of the cover provided by forbs in the understory, observations of the most abundant forbs present were recorded.

b.) <u>Results</u>:

<u>Extent of Forest Types along the Sturgeon and Pembina Rivers</u>:

1.) <u>Sturgeon River</u>:

Table 1 summarizes data collected on the extent of forest types along the Sturgeon River between the North Saskatchewan River and Big Lake. Forest types within approximately 53.5 square miles of land along this reach of the river were mapped. Aspen and deciduous dominated mixed forest were the most common forest types in this area, covering 31.5 acres per square mile and 25.6 acres per square mile respectively. Balsam poplar was the third most common forest type, and covered 16.3 acres, on the average, of each square mile. Balsam poplar was distributed primarily adjacent to the river while aspen replaced balsam on higher and drier ground. Willow was present on the river banks but made up only a very small portion of the total forest cover. Coniferous dominated mixed forest, white spruce, and black spruce bog were also present in small amounts.

Within the area studied along the Sturgeon River between Big Lake and the North Saskatchewan River, an average of 76 acres was forested in each square mile. In other words, approximately 12% of the area was forested while the remaining 88% was cleared. Cleared areas were primarily agricultural cropland. Over half of the forested area was made up of forest communities smaller than 20 acres in size. Most of the forest was restricted to the river valley.

TABLE 1

Size and Extent of Forest Communities along the Sturgeon River between Big Lake and the North Saskatchewan River

Forest Type	1-3	3-20	20-50	50-100	100-200	200-300	300+	Total	Actual Area (acres)
	Size Class of Woodlots in Acres								
Aspen	211* (3.94)**	53 (0.99)	14 (0.26)	4 (0.07)	1 (0.02)				1685 (31.50)***
Balsam	120 (2.24)	34 (0.64)	8 (0.15)	1 (0.02)					873 (16.32)
Willow	25 (0.48)	3 (0.06)							51 (0.95)
White Spruce	5 (0.10)								6 (0.11)
Mixed Deciduous	57 (1.07)	33 (0.62)	15 (0.28)	1 (0.02)	2 (0.04)				1367 (25.55)
Mixed Coniferous	6 (0.11)	5 (0.09)	1 (0.02)						97 (1.81)
TOTAL	424 (7.94)	128 (2.40)	38 (0.71)	6 (0.11)	3 (0.06)			599 (11.22)	4079 (76.24)
Calculated Area	848	1472	1330	450	450			4550	

Total area studied: 34,240 acres or 53.5 square miles.

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* Number of woodlots, ** Average number of woodlots per square mile, *** Area per square mile.

The extent and sizes of forest communities surrounding Big Lake are shown in Table 2. The distribution appears to be very similar to that found along the section of the Sturgeon River considered above. Deciduous dominated mixed forest and aspen were the most common forest types. Balsam poplar was the third most common type. Willow was more prevalent around Big Lake because of the extensive flat marshy areas. Coniferous dominated mixed forest and white spruce forest were present in small amounts. The average area forested per square mile was 82.5 acres. This represents a forest cover of 13% around Big Lake. As in the case of the section of the Sturgeon River described above, over half of the forest was comprised of woodlots smaller than 20 acres in size.

Forest cover along the Sturgeon River between Big Lake and a point north of Calahoo was very sparse and restricted almost entirely to the river bank (Photo 1). Table 3 shows that the forest types present in order from greatest to least extent are deciduous dominated mixed forest, balsam poplar, aspen, and willow. Forest cover averaged a total of 33.7 acres per square mile or approximately 5% of the area studied. Small woodlots comprised the majority of the forest cover and none were larger than 50 acres in size.

Table 4 summarizes the extent and sizes of forest communities along the Sturgeon River between a point north of Calahoo and Lac Ste. Anne. Forest cover along this section was more extensive than along the sections which have been described above. An average of 154.7 acres of forest was present for every square

TABLE 2

Size and Extent of Forest Communities Surrounding Big Lake

Forest Type	Size Class of Woodlots in Acres 1-3	3-20	20-50	50-100	100-200	200-300	300+	Total	Actual Area (acres)
Aspen	46* (2.75)**	5 (0.30)			1 (0.06)				319 (19.04)***
Balsam	37 (2.21)	13 (0.78)	2 (0.12)	1 (0.06)					274 (16.35)
Willow	46 (2.75)	8 (0.48)	1 (0.06)						165 (9.85)
White Spruce		1 (0.06)							15 (0.89)
Mixed Deciduous	15 (0.90)	30 (1.79)	3 (0.18)	2 (0.12)					548 (32.71)
Mixed Coniferous	9 (0.54)	5 (0.30)							61 (3.64)
TOTAL	153 (9.13)	62 (3.71)	6 (0.36)	3 (0.18)	1 (0.06)			225 (13.44)	1382 (82.48)
Calculated Area	306	713	210	225	150			1604	

Total area studied: 10,720 acres or 16.75 square miles.

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* Number of woodlots; ** Average number of woodlots per square mile; *** Area per square mile.

Photo 1: Illustration of the extent of forest cover along the Sturgeon River between Big Lake and Calahoo. The sparse forest cover confined to the river bank is typical of this section. Little habitat remains for big game and upland game.

TABLE 3

Size and Extent of Forest Communities along the Sturgeon River between Big Lake and a Point

Due North of Calahoo

Forest Type	Size Class of Woodlots in Acres 1-3	3-20	20-50	50-100	100-200	200-300	300+	Total	Actual Area(acres)
Aspen	67* (2.68)**	6 (0.24)	1 (0.04)						142 (5.68)***
Balsam	38 (1.52)	8 (0.32)							167 (6.68)
Willow	25 (1.00)	1 (0.04)	1 (0.04)						79 (3.16)
Mixed Deciduous	37 (1.48)	24 (0.96)	3 (0.12)						454 (18.16)
TOTAL	167 (6.68)	39 (1.56)	5 (0.20)					211 (8.44)	842 (33.68)
Calculated Area	334	448.5	175					875.5	

Total area studied: 16,000 acres or 25 square miles.

* Number of woodlots; ** Average number of woodlots per square mile; *** Area per square mile.

TABLE 4

Size and Extent of Forest Communities along the Sturgeon River between a Point Due North of Calahoo and Lac Ste. Anne

Forest Type	Size Class of Woodlots in Acres 1-3	3-20	20-50	50-100	100-200	200-300	300+	Total	Actual Area (acres)
Aspen	139* (5.79)**	9 (0.38)	1 (0.04)						988 (41.17)***
Balsam	29 (1.21)	9 (0.38)	1 (0.04)	1 (0.04)					299 (12.46)
Willow	14 (0.58)	8 (0.33)							77 (3.21)
Pine	2 (0.08)	2 (0.08)							44 (1.83)
Black Spruce	14 (0.58)	11 (0.46)	2 (0.08)		1 (0.04)				267 (11.12)
Mixed Deciduous	67 (2.79)	35 (1.46)	11 (0.46)	2 (0.08)	3 (0.12)		2 (0.08)		2007 (83.62)
Mixed Coniferous	3 (0.12)	3 (0.12)							31 (1.29)
TOTAL	268 (11.15)	77 (3.21)	15 (0.62)	3 (0.12)	4 (0.16)		2 (0.08)	369 (15.34)	3713 (154.70)
Calculated Area	536	885.5	525	225	600		800	3571.5	

Total area studied: 15,360 acres or 24.0 square miles.

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* Number of woodlots; ** Average number of woodlots per square mile; *** Area per square mile.

mile of land studied. This represents a forest cover on 24% of the land. Deciduous dominated mixed forest was the most common forest type and comprised an average of 84 acres per square mile of land. Aspen followed with 41 acres per section. Balsam poplar, black spruce bog, willow, pine, and coniferous dominated mixed forest were present in lesser amounts. Less than one-half of the forest cover consisted of woodlots smaller than 20 acres in size.

Table 5 shows that forest cover surrounding Lac Ste. Anne was more extensive than any of the areas downstream on the Sturgeon River considered above. An average of 296.9 acres per section of land (46.5%) was forested. Relatively large woodlots over 100 acres in size, made up the majority of the forest cover in contrast to areas downstream on the Sturgeon River. Deciduous dominated mixed forest was by far the most common forest type and averaged 236.1 acres per square mile of land. Aspen forest was the second most common forest type with an average of only 23.4 acres per section of land. Other forest types present included balsam poplar, coniferous dominated mixed forest, black spruce bog, and willow.

Forest cover surrounding Isle Lake was even more extensive than that surrounding Lac Ste. Anne (Table 6). Sixty per cent of the land within approximately one-half mile of Isle Lake was forested. Deciduous dominated mixed forest was the most common forest type making up 253.4 acres per square mile of land on the average. Aspen was the second most common forest type with 107

TABLE 5

Size and Extent of Forest Communities Surrounding Lac Ste. Anne

Forest Type	Size Class of Woodlots in Acres 1-3	3-20	20-50	50-100	100-200	200-300	300+	Total	Actual Area
Aspen	17* (0.81)**	5 (0.24)	8 (0.38)	1 (0.05)					491 (23.38)***
Balsam	39 (1.86)	11 (0.52)	1 (0.05)	1 (0.05)					288 (13.71)
Willow	6 (0.29)	5 (0.24)	2 (0.10)						119 (5.67)
Black Spruce	6 (0.29)	7 (0.33)	2 (0.10)	1 (0.05)					175 (8.33)
Mixed Deciduous	106 (5.05)	38 (1.81)	7 (0.33)	7 (0.33)	4 (0.19)	1 (0.05)	7 (0.33)		4958 (236.1)
Mixed Coniferous	5 (0.24)	6 (0.29)	3 (0.14)						204 (9.1)
TOTAL	179 (8.54)	72 (3.43)	23 (1.1)	10 (0.48)	4 (0.19)	1 (0.05)	7 (0.33)	296 (14.12)	6235 (296.9)
Calculated Area	358	828	805	750	600	250	2800	6391	

Total area studied: 13,440 acres or 21.0 square miles.

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* Number of woodlots; ** Average number of woodlots per square mile; *** Area per square mile.

TABLE 6

Size and Extent of Forest Communities Surrounding Isle Lake

Forest Type	Size Class of Woodlots in Acres 1-3	3-20	20-50	50-100	100-200	200-300	300+	Total	Actual Area
Aspen	20* (1.08)**	10 (0.54)	6 (0.32)	4 (0.22)	3 (0.16)	2 (0.11)	1 (0.05)		1977 (106.86)***
Balsam	2 (0.11)	5 (0.25)							29 (1.57)
Willow	4 (0.22)	2 (0.11)							40 (2.16)
Black Spruce	9 (0.49)	33 (1.78)	6 (0.32)		1 (0.05)				421 (22.8)
Mixed Deciduous	48 (2.60)	52 (2.81)	10 (0.54)	6 (0.32)	3 (0.16)	1 (0.05)	4 (0.22)		4688 (253.40)
TOTAL	83 (4.50)	102 (5.51)	22 (1.18)	10 (0.54)	7 (0.37)	3 (0.16)	5 (0.27)	232 (12.53)	7155 (386.76)
Calculated Area	166	1173	770	750	1050	750	2000	6659	

Total area studied: 11,840 acres or 18.5 square miles.

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* Number of Woodlots; ** Average number of woodlots per square mile; *** Area per square mile.

acres per section of land. Black spruce bog, willow, and balsam poplar forest types were also present. Relatively large forests, over 100 acres in size, comprised the majority of the forest cover around Isle Lake as they did around Lac Ste. Anne.

The extent of forest cover in the proposed areas of the Pembina and Magnolia reservoirs is shown in Table 7 (see also Photo 2). On the average, a total of 269.3 acres per section of land (42% of the area) was forested. As with the forest cover surrounding Isle Lake and Lac Ste. Anne, forests over 100 acres in size comprised the majority of the cover in the Magnolia and Pembina reservoir areas. Deciduous dominated mixed forest was the most common forest type found in this area and comprised 205 acres per square mile of land. Black spruce bog was the second most common forest community and comprised 51.2 acres per square mile of land on the average. Balsam poplar, aspen, willow, and birch forest types were also present.

2.) Pembina River:

Forest bordering the Pembina River was almost entirely mixed forest. White spruce were scattered within a forest in which aspen was the dominant species. The presence of this forest type is a reflection of the geographical location of the study area - the transition area between aspen parkland and boreal forest.

Forest cover was heaviest adjacent to the river from Easyford

TABLE 7

Size and Extent of Forest Communities within the Areas of the Proposed Magnolia and Pembina Reservoirs.

Forest Type	Size Class of Woodlots in acres: 1-3	3-20	20-50	50-100	100-200	200-300	300+	Total	Actual Area
Aspen			1* (0.02)**	1 (0.02)					116 (2.82)***
Balsam							1 (0.02)		460 (11.16)
Willow	2 (0.05)								2 (0.05)
Birch	5 (0.12)								5 (0.12)
Black Spruce	22 (0.53)	19 (0.46)	7 (0.17)	4 (0.10)	2 (0.05)	2 (0.05)	1 (0.02)		2109 (51.19)
Mixed Deciduous	210 (5.10)	63 (1.53)	21 (0.51)	11 (0.27)	12 (0.29)	1 (0.02)	6 (0.15)		8403 (203.95)
TOTAL	239 (5.80)	82 (1.99)	29 (0.70)	16 (0.39)	14 (0.34)	3 (0.07)	8 (0.19)	391 (9.48)	11095 (269.29)
Calculated Area	478	943	1015	1200	2100	750	3200	9686	

Total area studied: 26,368 acres or 41.2 square miles.

* Number of Woodlots; ** Average Number of Woodlots per square mile; *** Area per square mile.

Photo 2: Typical forest cover in the proposed Magnolia reservoir site. Note the good interspersion of woodlots with cleared land resulting in good habitat for big game and upland game. Hoople Lake, at the headwaters of the Sturgeon River, is in the left central portion of the photograph.

to Sangudo and from Fawcett to the mouth of the Pembina River. These reaches correspond to the zones of the river with a relatively steep gradient. The zone characterized by a very shallow gradient, from Sangudo to Fawcett, was more lightly forested. However, in only a few cases was forest cover cleared to the edge of the river. In general, at least a thin strip of mixed forest extended along the banks of the Pembina River for almost its entire length.

Composition of Forest Associations Studied in the Sturgeon and Pembina River Basins:

Table 8 shows the density of stems in four diameter classes of the overstory tree species in 25 plots within the aspen dominated deciduous forest. Balsam poplar and paper birch were the only trees observed besides aspen. Small trees are much more numerous than large trees - a reflection of the relatively young age of the forest. The density of the trees over one inch in diameter in the aspen forests investigated average 1,360 stems per acre.

Table 9 shows the cover values recorded for overstory and middlestory species and for forbs and grasses in the understory in the aspen forest. Overstory cover was, of course, primarily provided by aspen and secondarily by balsam poplar and paper birch. Cover by overstory in the aspen forest was most commonly in the 50% - 75% range.

Middlestory species present in more than half of the plots

TABLE 8

Forest Type: Aspen

Stem Density by Diameter Class of the Overstory Tree Species in 25 1/100-acre Plots.

Species	Diameter Class (inches) 1-4	4-8	8-12	12+	Total
Aspen (*Populus tremuloides*)	167	84	12	4	267
Balsam (*Populus balsamifera*)	34	32	-	-	66
Birch (*Betula papyrifera*)	7	-	-	-	7
Larch (*Larix laricina*)	-	-	-	-	0
Pine (*Pinus contorta*)	-	-	-	-	0
Spruce, Black (*Picea mariana*)	-	-	-	-	0
Spruce, White (*Picea glauca*)	-	-	-	-	0
Willow (*Salix* spp.)	-	-	-	-	0
Total	208	116	12	4	340

Stems per acre:	Range*:	100-2320	0-760	0-120	0-80	1020-2320
	Mean:	832	464	48	16	1360

* Smallest and greatest density of trees in a particular forest based on 5 plots per forest.

TABLE 9

Number of Cover Values Recorded for Individual and Combined Species in the Overstory, Middlestory, and Understory on 25 Plots within the Aspen Forest.

Overstory:

Species	Cover Value* 0	1	2	3	4	5	6
Aspen (Populus tremuloides)	-	-	4	12	8	1	-
Balsam (Populus balsamifera)	10	3	6	6	-	-	-
Birch (Betula papyrifera)	22	-	3	-	-	-	-
Larch (Larix laricina)	25	-	-	-	-	-	-
Pine (Pinus contorta)	25	-	-	-	-	-	-
Spruce, Black (Picea mariana)	25	-	-	-	-	-	-
Spruce, White (Picea glauca)	25	-	-	-	-	-	-
Willow (Salix spp.)	25	-	-	-	-	-	-
Total overstory value	-	-	3	6	14	2	-

Middlestory:

Species	0	1	2	3	4	5	6
Alder (Alnus spp.)	10	6	7	1	1	-	-
Aspen (Populus tremuloides)	17	8	-	-	-	-	-
Balsam (Populus balsamifera)	22	3	-	-	-	-	-
Bracted Honeysuckle (Lonicera involucrata)	25	-	-	-	-	-	-
Bog Birch (Betula glandulosa)	24	1	-	-	-	-	-
Chokecherry (Prunus virginiana)	18	6	1	-	-	-	-
Cranberry (Viburnum edule)	15	8	2	-	-	-	-
Currant (Ribes sp.)	25	-	-	-	-	-	-
Gooseberry (Ribes oxyacanthoides)	22	3	-	-	-	-	-
Labrador tea (Ledum groenlandicum)	25	-	-	-	-	-	-
Pincherry (Prunus pennsylvanica)	22	2	1	-	-	-	-
Raspberry (Rubus strigosus)	19	5	1	-	-	-	-
Red osier dogwood (Cornus stolonifera)	8	3	14	-	-	-	-
Rose (Rosa spp.)	2	13	7	3	-	-	-
Saskatoon (Amelanchier alnifolia)	6	11	4	3	1	-	-
Snowberry (Symphoricarpos albus)	2	16	7	-	-	-	-
Spruce (Picea glauca)	25	-	-	-	-	-	-
Twining Honeysuckle (Lonicera dioica)	21	4	-	-	-	-	-
Willow (Salix spp.)	23	1	1	-	-	-	-
Total middlestory value	-	-	2	15	7	1	-

Understory:

Species	0	1	2	3	4	5	6
Forbs	-	-	2	18	5	-	-
Grasses	-	9	14	2	-	-	-

* 0 = absent, 1 =<5%, 2 = >5-[illegible], 3 = >25-50%, 4 = >50-75%, 5 = >75-95%, 6 = >95-100%

studied included rose, snowberry, saskatoon, red osier dogwood, and alder. Middlestory cover in the aspen forest was most commonly in the range of 25% - 50%.

In the understory, forbs most commonly provided cover of 25% - 50% while grasses usually provided 5% - 25% cover. The frequency of occurrence of common forbs observed in all forest community types studied is shown in Table 10. The most common forbs seen in the aspen forest (recorded on more than 50% of the plots) included strawberry, bedstraw, dewberry, aster, bunchberry, wintergreen, representatives of the lily family (Liliaceae) and wild sarsaparilla.

Photo 3 illustrates typical aspen forest.

Data on the density and diameter of trees in balsam poplar forests studied in the Sturgeon River Basin are presented in Table 11. Aspen, paper birch, and willow were present in addition to the dominant species. As with the aspen forest, small trees were more numerous than larger ones. The density of trees in the balsam forest was somewhat less than in the aspen forest (912 stems per acre).

Table 12 gives the cover values recorded for overstory, middlestory, and understory on plots in the balsam forest. Total overstory cover was very similar to that for aspen with "4" as the most commonly recorded cover value.

In the middlestory, cover was greater in the balsam poplar forest than that found in aspen. However, fewer species were

TABLE 10

Frequency of Common Understory Species Observed in 1/100 Acre Plots in Seven Different Forest Community Types in the Sturgeon and Pembina River Basins.

Species	Aspen[1]	Balsam[1]	Mixed Dec[1]	Mixed Conif[2]	Bog[1]	Spruce[3]	Pine[4]
Aster (*Aster* spp.)	19	14	24	17	-	1	3
Baneberry (*Actea rubra*)	2	2	3	1	-	-	-
Bearberry (*Arctostaphylos uva-ursi*)	-	-	-	-	-	-	4
Bedstraw (*Galium* spp.*)	22	22	20	20	1	4	4
Bishop's cap (*Mitella nuda*)	1	7	8	8	6	9	-
Blueberry (*Vaccinium caespitosum*)	-	-	-	-	2	-	4
Bog Cranberry (*Vaccinium vitis-idaea*)	-	-	2	-	25	3	5
Bunchberry (*Cornus canadensis*)	14	7	15	10	-	4	2
Clover (*Trifolium repens*)	1	1	2	3	-	-	1
Coltsfoot (*Petasites palmatus*)	7	13	11	2	6	-	-
Cow Parsnip (*Heracleum lanatum*)	3	2	2	-	-	-	-
Dandelion (*Taraxacum officinale*)	5	5	5	7	1	-	1
Dewberry (*Rubus* spp.)	19	15	16	6	12	1	-
Fairybells (*Disporum trachycarpum*)	3	8	1	3	-	-	-
Fireweed (*Epilobium angustifolium*)	9	11	12	2	1	-	-
Goldenrod (*Solidago* sp.)	1	1	1	-	-	-	1
Grasses (*Gramineae*)	25	24	25	19	18	3	5
Harebell (*Campanula rotundifolia*)	-	-	1	1	-	-	3
Horsetail (*Equisetum* spp.)	1	10	12	4	4	-	1
Lilies (Liliaceae)	14	4	7	12	2	-	5
Meadow Rue (*Thalictrum venulosum*)	9	5	12	7	-	-	-
Orchids (*Orchidaceae*)**	-	-	-	-	12	1	-
Stinging nettle (*Urtica gracilus*)	-	3	-	6	-	-	-
Strawberry (*Fragaria virginiana*)	23	17	23	12	2	-	4
Twin Flower (*Linnaea borealis*)	4	4	9	9	-	7	4
Vetch (*Vicia americana*)	8	6	9	4	-	-	4

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* Both *Galium boreale* and *Galium triflorum*.
** Both *Spiranthes romanzoffiana* and *Habenaria* spp.

Species (continued)	Aspen[1]	Balsam[1]	Mixed Dec.[1]	Mixed Conif.[2]	Bog[1]	Spruce[3]	Pine[4]
Wild Sweet Pea (*Lathyrus ochroleucus*)	8	4	6	9	-	-	5
Wild Sarsaparilla (*Aralia nudicaulia*)	13	14	-	4	-	-	-
Wintergreen (*Pyrola* spp.)***	14	8	11	11	-	2	1
Wood violet (*Viola rugulosa*)	7	6	3	4	-	-	-
Yarrow (*Achillea millefolium*)	1	3	6	2	-	-	-

1 Based on 25 plots (i.e. 5 in each of 5 forests).

2 Based on 20 plots (i.e. 5 in each of 4 mixed forests).

3 Based on 10 plots (i.e. 5 in each of 2 spruce forests).

4 Based on 5 plots (5 in 1 pine forest).

*** Both *Pyrola secunda* and *Pyrola asarifolia*.

Photo 3: Typical deciduous forest dominated by aspen poplar. Note the abundance of middle-story species which are used for food and cover by ungulates and ruffed grouse.

TABLE 11

Forest Type: Balsam

Stem Density by Diameter Class of the Overstory Tree Species in 25 1/100-acre Plots.

Species	Diameter Class (inches) 1-4	4-8	8-12	12+	Total
Aspen (*Populus tremuloides*)	30	33	10	1	74
Balsam (*Populus balsamifera*)	69	60	16	4	149
Birch (*Betula papyrifera*)	1	1	-	-	2
Larch (*Larix laricina*)	-	-	-	-	0
Pine (*Pinus contorta*)	-	-	-	-	0
Spruce, Black (*Picea mariana*)	-	-	-	-	0
Spruce, White (*Picea glauca*)	-	-	-	-	0
Willow (*Salix* spp.)	3	-	-	-	3
TOTAL	103	94	26	5	228
Stems per acre:					
Range*:	140-740	260-480	40-220	20-60	500-1180
Mean:	412	376	104	20	912

* Smallest and greatest density of trees in a particular forest based on 5 plots per forest.

TABLE 12

Number of Cover Values Recorded for Individual and Combined Species in the Overstory, Middlestory, and Understory on 25 Plots within the Balsam Forest.

Overstory:

Species	Cover Value* 0	1	2	3	4	5	6
Aspen	6	2	9	4	2	2	-
Balsam	2	-	5	7	7	4	-
Birch	22	2	1	-	-	-	-
Larch	25	-	-	-	-	-	-
Pine	25	-	-	-	-	-	-
Spruce, Black	25	-	-	-	-	-	-
Spruce, White	25	-	-	-	-	-	-
Willow	24	-	1	-	-	-	-
Total overstory value	-	-	-	5	14	6	-

Middlestory:

Alder	20	3	2	-	-	-	-
Aspen	20	4	1	-	-	-	-
Balsam	22	3	-	-	-	-	-
Bog Birch	25	-	-	-	-	-	-
Bracted Honeysuckle	24	1	-	-	-	-	-
Chokecherry	19	3	2	1	-	-	-
Cranberry	18	2	4	1	-	-	-
Currant	23	2	-	-	-	-	-
Gooseberry	16	9	-	-	-	-	-
Labrador tea	25	-	-	-	-	-	-
Pincherry	24	-	1	-	-	-	-
Raspberry	13	11	1	-	-	-	-
Red osier dogwood	2	1	15	5	2	-	-
Rose	7	5	10	3	-	-	-
Saskatoon	17	2	6	-	-	-	-
Snowberry	10	10	5	-	-	-	-
Spruce	25	-	-	-	-	-	-
Twining Honeysuckle	24	1	-	-	-	-	-
Willow	20	5	-	-	-	-	-
Total middlestory value	-	1	2	8	12	2	-

Understory:

Forbs	-	1	5	14	4	1	-
Grasses	1	6	15	3	-	-	-

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* 0 = absent, 1 =<5%, 2 = >5-25%, 3 = >25-50%, 4 = >50-75%
5 = >75-95%, 6 = >95-100%

as common in the balsam as in the aspen. This difference in species composition and greater density of cover of species there is probably a reflection of the more mesic conditions in which balsam poplar communities are found. Red osier dogwood grew denser in the balsam forest than in the aspen. Rose and snowberry were also common in the balsam poplar forest.

Density of cover provided by forbs and grasses in the understory of the balsam forest was similar to that in the aspen with the most common cover value for forbs being "3" and the most common cover value for grasses, "2". Table 10 shows that the most common forbs present in the balsam poplar forests studied included bedstraw, strawberry, dewberry, aster, wild sarsaparilla, and coltsfoot.

Photo 4 illustrates the dense middlestory of the balsam poplar forest.

Stem density by diameter class of trees in the white spruce forest is shown in Table 13. In contrast to the aspen and balsam poplar forests, the 4" - 8" diameter class contained the most trees in the spruce forest. Only one tree (paper birch) other than white spruce was seen in ten plots analyzed in the spruce forest. The average density of trees was 1,480 stems per acre.

Table 14 shows that the most common cover value of overstory in the spruce forest was "4". Middlestory and understory cover was relatively sparse (see Photo 5). Rose was the

TABLE 13

Forest Type: White Spruce

Stem Density by Diameter Class of the Overstory Tree Species in 10 1/100-acre Plots.

Species	Diameter Class (inches) 1-4	4-8	8-12	12+	Total
Aspen (*Populus tremuloides*)	-	-	-	-	0
Balsam (*Populus balsamifera*)	-	-	-	-	0
Birch (*Betula papyrifera*)	1	-	-	-	1
Larch (*Larix laricina*)	-	-	-	-	0
Pine (*Pinus contorta*)	-	-	-	-	0
Spruce, Black (*Picea mariana*)	-	-	-	-	0
Spruce, White (*Picea glauca*)	63	69	9	6	147
Willow (*Salix* spp.)	-	-	-	-	0
Total	64	69	9	6	148
Stems per acre:					
Range*:	200-1080	420-960	20-160	0-120	900-2060
Mean:	640	690	90	60	1480

* Smallest and greatest density of trees in a particular forest based on 5 plots per forest.

TABLE 14

Number of Cover Values Recorded for Individual and Combined Species in the Overstory, Middlestory, and Understory on 10 Plots within the White Spruce Forest.

Overstory:

Species	Cover Value* 0	1	2	3	4	5	6
Aspen	10	-	-	-	-	-	-
Balsam	10	-	-	-	-	-	-
Birch	9	1	-	-	-	-	-
Larch	10	-	-	-	-	-	-
Pine	10	-	-	-	-	-	-
Spruce, Black	10	-	-	-	-	-	-
Spruce, White	-	-	-	1	7	2	-
Willow	10	-	-	-	-	-	-
Total overstory value	-	-	-	1	7	3	-

Middlestory:

Alder	9	1	-	-	-	-	-
Aspen	10	-	-	-	-	-	-
Balsam	9	1	-	-	-	-	-
Bog Birch	8	2	-	-	-	-	-
Bracted Honeysuckle	10	-	-	-	-	-	-
Chokecherry	10	-	-	-	-	-	-
Cranberry	10	-	-	-	-	-	-
Currant	10	-	-	-	-	-	-
Gooseberry	9	1	-	-	-	-	-
Labrador tea	5	3	2	-	-	-	-
Pincherry	10	-	-	-	-	-	-
Raspberry	8	1	1	-	-	-	-
Red osier dogwood	6	4	-	-	-	-	-
Rose	4	6	-	-	-	-	-
Saskatoon	10	-	-	-	-	-	-
Snowberry	6	4	-	-	-	-	-
Spruce	8	2	-	-	-	-	-
Twining Honeysuckle	10	-	-	-	-	-	-
Willow	9	1	-	-	-	-	-
Total middlestory value	-	5	4	1	-	-	-

Understory:

Forbs	-	2	4	1	1	2	-
Grasses	7	3	-	-	-	-	-

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* 0 = absent, 1 =<5%, 2 = >5-25%, 3 = >25-50%, 4 = >50-75%
5 = >75-95%, 6 = >95-100%

TABLE 15

Forest Type: Pine

Stem Density by Diameter Class of the Overstory Tree Species in 5 1/100-acre Plots.

Species	Diameter Class (inches) 1-4	4-8	8-12	12 +	Total
Aspen (*Populus tremuloides*)	-	-	-	-	0
Balsam (*Populus balsamifera*)	-	-	-	-	0
Birch (*Betula papyrifera*)	-	-	-	-	0
Larch (*Larix laricina*)	-	-	-	-	0
Pine (*Pinus contorta*)	12	23	6	-	41
Spruce, Black (*Picea mariana*)	-	-	-	-	0
Spruce, White (*Picea glauca*)	-	-	-	-	0
Willow (*Salix* spp.)	-	-	-	-	0
Total	12	23	6	0	41
Mean:	240	460	120	0	820

Photo 4: Typical deciduous forest dominated by balsam poplar. As in the aspen forest, food and cover for ungulates and ruffed grcuse are abundant.

Photo 5: Illustration of the sparse middle-story and understory of the white spruce forest. Although there is little browse for big game, the spruce forest provides excellent shelter during winter for big game and ruffed grouse.

only shrub species present in more than 50% of the ploss. Table 10 shows that the sparse understory of forbs in the spruce forest was composed primarily of bishop's cap and twin flower. Moss covered much of the ground.

The lodgepole pine forest investigated was a nearly pure stand. Table 15 shows that the 4" - 8" diameter class contained the most trees and that the average density of all trees was 820 stems per acre.

Table 16 shows the cover values recorded for overstory, middlestory and understory in the pine forest. Overstory cover was 51% - 75%. Middlestory cover was sparse, (see Photo 6) under 5%, with rose and saskatoon as the most common shrub species. Forbs and grasses in the understory were each usually present with a cover value of "3". Table 10 shows that common understory species included bog cranberry, wild sweet pea, representatives of the lily family (Liliaceae), twin flower, strawberry, blueberry, bedstraw, bearberry, and harebell.

Stem density and diameters of trees in the deciduous dominated mixed forest are shown in Table 17. The most common tree species were aspen, balsam poplar, and white spruce. The presence of spruce represents a later successional stage of the aspen forest characterized previously. Bird (1961) states that the aspen poplar community in contact with the northern coniferous forest is a sub-climax to white spruce. The presence of fewer small trees and more larger aspen trees attests to the

TABLE 16

Number of Cover Values Recorded for Individual and Combined Species in the Overstory, Middlestory, and Understory on 5 Plots within the Pine Forest.

Overstory:

Species	Cover Value* 0	1	2	3	4	5	6
Aspen	5	-	-	-	-	-	-
Balsam	5	-	-	-	-	-	-
Birch	5	-	-	-	-	-	-
Larch	5	-	-	-	-	-	-
Pine	-	-	-	-	5	-	-
Spruce, Black	5	-	-	-	-	-	-
Spruce, White	5	-	-	-	-	-	-
Willow	5	-	-	-	-	-	-
Total overstory value	-	-	-	-	5	-	-

Middlestory:

Species	0	1	2	3	4	5	6
Alder	5	-	-	-	-	-	-
Aspen	4	1	-	-	-	-	-
Balsam	4	1	-	-	-	-	-
Bog Birch	5	-	-	-	-	-	-
Bracted Honeysuckle	5	-	-	-	-	-	-
Chokecherry	5	-	-	-	-	-	-
Cranberry	5	-	-	-	-	-	-
Currant	5	-	-	-	-	-	-
Gooseberry	5	-	-	-	-	-	-
Labrador tea	5	-	-	-	-	-	-
Pincherry	5	-	-	-	-	-	-
Raspberry	5	-	-	-	-	-	-
Red osier dogwood	5	-	-	-	-	-	-
Rose	-	4	1	-	-	-	-
Saskatoon	2	3	-	-	-	-	-
Snowberry	4	1	-	-	-	-	-
Spruce	5	-	-	-	-	-	-
Twining Honeysuckle	4	1	-	-	-	-	-
Willow	4	1	-	-	-	-	-
Total middlestory value	-	5	-	-	-	-	-

Understory:

Species	0	1	2	3	4	5	6
Forbs	-	-	-	4	1	-	-
Grasses	-	-	2	3	-	-	-

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* 0 = absent, 1 =<5%, 2 = >5-25%, 3 = >25-50%, 4 = >50-75%
5 = >75-95%, 6 = >95-100%

Photo 6: Illustration of the composition of the only pine forest in the study area. Note the sparse middlestory but fairly abundant understory.

TABLE 17

Forest Type: Mixed - Deciduous Dominant

Stem Density by Diameter Class of the Overstory Tree Species in 25 1/100-acre Plots.

Species	Diameter Class (inches) 1-4	4-8	8-12	12+	Total
Alder (*Alnus* sp.)	18	-	-	-	18
Aspen (*Populus tremuloides*)	50	30	16	9	105
Balsam (*Populus balsamifera*)	35	19	1	3	58
Birch (*Betula papyrifera*)	8	4	-	-	12
Larch (*Larix laricina*)	-	-	-	-	0
Pine (*Pinus contorta*)	-	-	-	-	0
Spruce, Black (*Picea mariana*)	-	-	-	-	0
Spruce, White (*Picea glauca*)	22	33	2	2	59
Willow (*Salix* spp.)	14		-	-	14
Total	147	86	19	14	266
Stems per acre:					
Range*:	140-1080	140-980	20-140	20-100	600-1300
Mean:	588	344	76	56	1064

* Smallest and greatest density of trees in a particular forest based on 5 plots per forest.

greater age of the mixed forest. A density of 1,064 stems per acre was found in this mixed forest.

Cover provided by the overstory in the deciduous dominated mixed forest was primarily in the 51% - 75% range (Table 18). Middlestory cover was similar to that in the aspen forest, with a most common cover value of "3" and common shrubs including rose, snowberry, and red osier dogwood. Cover provided by forbs and grasses was also very similar to that of the aspen forest. Common understory species (aster, strawberry, bedstraw, dewberry, and bunchberry) closely paralleled those of the aspen forest.

The coniferous dominated mixed forest was, as expected, more similar in its characteristics to the white spruce forest than to the aspen or balsam forest. Table 19 shows that white spruce, balsam poplar, and aspen were the most common tree species with white spruce the most numerous. As with the white spruce forest, the 4" - 8" diameter class contained the greatest number of trees. The density of trees in the forest was 785 stems per acre - somewhat higher than the density in the white spruce forest.

Table 20 shows that the overstory cover in the coniferous dominated mixed forest was usually in the 51% - 75% range. Middlestory cover values generally averaged "3". Common middle-story species; rose, snowberry, and red osier dogwood reflect the influences of both the aspen and the white spruce forest

TABLE 18

Number of Cover Values Recorded for Individual and Combined Species in the Overstory, Middlestory, and Understory on 25 Plots within the Mixed - Deciduous Dominant Forest.

Overstory:

Species	Cover Value* 0	1	2	3	4	5	6
Alder (*Alnus* spp.)	21	1	1	2	-	-	-
Aspen	1	3	6	9	4	2	-
Balsam	11	3	7	2	2	-	-
Birch	19	3	2	1	-	-	-
Larch	25	-	-	-	-	-	-
Pine	25	-	-	-	-	-	-
Spruce, Black	25	-	-	-	-	-	-
Spruce, White	15	1	3	4	2	-	-
Willow	22	1	2	-	-	-	-
Total overstory value	-	1	-	4	13	7	-

Middlestory:

Species	0	1	2	3	4	5	6
Alder	22	2	1	-	-	-	-
Aspen	18	5	2	-	-	-	-
Balsam	19	6	-	-	-	-	-
Bog Birch	23	2	-	-	-	-	-
Bracted Honeysuckle	23	2	-	-	-	-	-
Chokecherry	23	2	-	-	-	-	-
Cranberry	18	6	1	-	-	-	-
Currant	25	-	-	-	-	-	-
Gooseberry	16	9	-	-	-	-	-
Labrador tea	24	1	-	-	-	-	-
Pincherry	25	-	-	-	-	-	-
Raspberry	18	2	5	-	-	-	-
Red osier dogwood	11	2	7	5	-	-	-
Rose	4	15	5	1	-	-	-
Saskatoon	15	4	4	1	1	-	-
Snowberry	6	12	7	-	-	-	-
Spruce	25	-	-	-	-	-	-
Twining Honeysuckle	22	3	-	-	-	-	-
Willow	15	2	6	2	-	-	-
Total middlestory value	-	4	2	12	4	3	-

Understory:

Species	0	1	2	3	4	5	6
Forbs	-	-	1	16	8	-	-
Grasses	-	5	9	6	5	-	-

* 0 = absent, 1 =<5%, 2 = >5-25%, 3 = >25-50%, 4 = >50-75%, 5 = >75-95%, 6 =>95-100%

TABLE 19

Forest Type: Mixed - Coniferous Dominant

Stem Density by Diameter Class of the Overstory Tree Species in 20 1/100-acre Plots.

Species	Diameter Class (inches) 1-4	4-8	8-12	12+	Total
Aspen (*Populus tremuloides*)	15	14	-	3	32
Balsam (*Populus balsamifera*)	5	21	7	3	36
Birch (*Betula papyrifera*)	1	-	-	-	1
Larch (*Larix laricina*)	-	-	-	-	0
Pine (*Pinus contorta*)	-	-	-	-	0
Spruce, Black (*Picea mariana*)	-	-	-	-	0
Spruce, White (*Picea glauca*)	24	29	15	20	88
Willow (*Salix* spp.)	-	-	-	-	0
Total	45	64	22	26	157
Stems per acre:					
Range*:	80-420	120-520	40-160	60-200	620-1180
Mean:	225	320	110	130	785

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* Smallest and greatest density of trees in a particular forest based on 5 plots per forest.

TABLE 20

Number of Cover Values Recorded for Individual and Combined Species in the Overstory, Middlestory, and Understory on 20 Plots within the Mixed - Coniferous Dominant Forest.

Overstory:

Species	Cover Value* 0	1	2	3	4	5	6
Aspen	11	1	5	3	-	-	-
Balsam	5	2	7	6	-	-	-
Birch	19	-	1	-	-	-	-
Larch	20	-	-	-	-	-	-
Pine	20	-	-	-	-	-	-
Spruce, Black	20	-	-	-	-	-	-
Spruce, White	1	-	-	8	10	1	-
Willow	20	-	-	-	-	-	-
Total overstory value	-	-	-	2	12	6	-

Middlestory:

Species	0	1	2	3	4	5	6
Alder	17	3	-	-	-	-	-
Aspen	11	9	-	-	-	-	-
Balsam	11	8	1	-	-	-	-
Bracted Honeysuckle	20	-	-	-	-	-	-
Bog Birch	20	-	-	-	-	-	-
Chokecherry	19	1	-	-	-	-	-
Cranberry	17	2	1	-	-	-	-
Currant	20	-	-	-	-	-	-
Gooseberry	11	8	1	-	-	-	-
Labrador tea	20	-	-	-	-	-	-
Pincherry	20	-	-	-	-	-	-
Raspberry	10	6	3	-	1	-	-
Red osier dogwood	7	9	3	1	-	-	-
Rose	4	9	5	2	-	-	-
Saskatoon	16	3	1	-	-	-	-
Snowberry	7	10	3	-	-	-	-
Spruce	17	-	2	1	-	-	-
Twining Honeysuckle	17	3	-	-	-	-	-
Willow	19	1	-	-	-	-	-
Total middlestory value	-	-	8	8	3	1	-

Understory:

Species	0	1	2	3	4	5	6
Forbs	-	1	1	10	7	1	-
Grasses	1	9	4	6	-	-	-

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* 0 = absent, 1 = <5%, 2 = >5-25%, 3 => 25-50%, 4 = >50-75%, 5 = >75-95%, 6 => 95-100%

types. The most common cover value of forbs was "3" while that of grasses was "1". Table 10 shows that understory species characteristic of the coniferous dominated mixed forest included bedstraw, aster, strawberry, Liliaceae, and wintergreen.

Stem density by diameter class of overstory tree species in 25 plots in black spruce bog is shown in Table 21. A large number of small black spruce trees resulted in the highest tree density of any of the forest types investigated. The average density was 2,908 stems per acre. The only tree species present besides black spruce was tamarack (larch). Tamarack is replaced by black spruce with a lowering of the water table (Bird, 1961).

Despite the high density of black spruce in the bog, cover by overstory was generally in the 26% - 50% range (Table 22). This relatively light overstory cover allowed for a dense growth of Labrador tea (see Photo 7). Small black spruce and bog birch were almost the only other middlestory species present.

Cover by forbs and grasses was light. Table 10 shows that the understory species common to the bog were bog cranberry, orchids, and dewberry. A heavy mat of sphagnum moss, (Sphagnum spp.) was also characteristic of the bog.

c.) Summary:

Within approximately one mile of the Sturgeon River between

TABLE 21

Forest Type: Black Spruce Bog

Stem Density by Diameter Class of the Overstory Tree Species in 25 1/100-acre Plots.

Species	Diameter Class (inches) 1-4	8-8	8-12	12+	Total
Aspen (*Populus tremuloides*)	-	-	-	-	0
Balsam (*Populus balsamifera*)	-	-	-	-	0
Birch (*Betula papyrifera*)	-	-	-	-	0
Larch (*Larix laricina*)	34	4	-	-	38
Pine (*Pinus contorta*)	-	-	-	-	0
Spruce, Black (*Picea mariana*)	667	22	-	-	689
Spruce, White (*Picea glauca*)	-	-	-	-	0
Willow (*Salix* spp.)	-	-	-	-	0
Total	701	26	0	0	727
Stems per acre:					
Range*:	420-5860	20-210	0	0	620-5960
Mean:	2804	104	0	0	2908

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* Smallest and greatest density of trees in a particular forest based on 5 plots per forest.

TABLE 22

Number of Cover Values Recorded for Individual and Combined Species in the Overstory, Middlestory, and Understory on 25 Plots within the Black Spruce Bog Forest.

Overstory:

Species	Cover Value* 0	1	2	3	4	5	6
Aspen	25	-	-	-	-	-	-
Balsam	25	-	-	-	-	-	-
Birch	25	-	-	-	-	-	-
Larch	18	2	4	1	-	-	-
Pine	25	-	-	-	-	-	-
Spruce, Black	-	2	7	8	6	2	-
Spruce, White	25	-	-	-	-	-	-
Willow	25	-	-	-	-	-	-
Total overstory value	-	-	6	10	7	2	-

Middlestory:

Alder	24	1	-	-	-	-	-
Aspen	24	1	-	-	-	-	-
Balsam	25	-	-	-	-	-	-
Bog Birch	13	5	3	4	-	-	-
Bracted Honeysuckle	24	1	-	-	-	-	-
Chokecherry	25	-	-	-	-	-	-
Cranberry	25	-	-	-	-	-	-
Currant	23	2	-	-	-	-	-
Gooseberry	25	-	-	-	-	-	-
Labrador tea	-	-	1	13	7	4	-
Pincherry	25	-	-	-	-	-	-
Raspberry	25	-	-	-	-	-	-
Red osier dogwood	25	-	-	-	-	-	-
Rose	25	-	-	-	-	-	-
Saskatoon	25	-	-	-	-	-	-
Snowberry	25	-	-	-	-	-	-
Spruce, Black	7	9	6	2	1	-	-
Twining Honeysuckle	25	-	-	-	-	-	-
Willow	17	8	-	-	-	-	-
Total middlestory value	-	-	1	7	12	5	-

Understory:

Forbs	-	12	13	-	-	-	-
Grasses	7	12	6	-	-	-	-

---

* 0 = absent, 1 = <5%, 2 = >5-25%, 3 = >25-50%, 4 = >50-75%
5 = >75-95%, 6 = >95-100%

Photo 7: Illustration of typical black spruce bog. Note the dense middlestory composed of Labrador tea.

the North Saskatchewan River and Calahoo, forest covered an average of 10% of the land. From Calahoo to Lac Ste. Anne forest cover averaged 24%. Around Lac Ste. Anne and Isle Lake, and in the Magnolia and Pembina reservoir sites, forest covered an average of approximately 47% of the land.

The two most common forest types were aspen and deciduous dominated mixed forest. While aspen was the dominant forest community along the lower portion of the Sturgeon River, mixed forest was predominant in the upper portion.

Aspen forest was characterized by balsam poplar and paper birch in addition to the dominant aspen in the overstory. The most common middlestory species were rose, snowberry, saskatoon, red osier dogwood, and alder. Common forbs in the understory included strawberry, bedstraw, dewberry, aster, bunchberry, wintergreen, lilies, and wild sarsaparilla.

Deciduous dominated mixed forest was characterized by aspen, balsam poplar, and white spruce as the most common trees. Rose, snowberry, and red osier dogwood were common species in the middlestory. Common understory species were aster, strawberry, bedstraw, dewberry, and bunchberry.

Balsam poplar forest was commonly found adjacent to the river and in other low damp areas. Aspen, paper birch, and willow were found in the overstory in addition to balsam poplar. In the middlestory, red osier dogwood, rose, and snowberry were the most common shrubs. Bedstraw, strawberry, dewberry, aster, wild sarsaparilla, and coltsfoot were common in the understory.

A small amount of pure white spruce forest was found northeast of St. Albert and on the south side of Big Lake. Almost all of the overstory was white spruce. The only common shrub in the sparse middlestory was rose. Moss covered much of the ground under the spruce canopy. Bishop's cap and twin flower were the most common forbs.

The only lodgepole pine forest was encountered on the south side of Matchayaw Lake. Pine was the only species of tree found in the overstory. The most common shrubs in the sparse middlestory were rose and saskatoon. Common understory species included bog cranberry, wild sweet pea, lilies, twin flower, strawberry, blueberry, bedstraw, bearberry, and harebell.

Coniferous dominated mixed forest was uncommon in the study area. The most common tree species in this community were white spruce, balsam poplar, and aspen. Rose, snowberry, and red osier dogwood were common shrubs in the middlestory. Common forbs included bedstraw, aster, strawberry, lilies, and wintergreen.

Black spruce bogs were fairly common along the upper portion of the Sturgeon River. Their overstory was characterized by black spruce and tamarack. Labrador tea, small black spruce, and bog birch composed most of the middlestory. The forbs, bog cranberry, orchids, and dewberry were common on a heavy mat of sphagnum moss.

Deciduous dominated mixed forest formed an almost continuous border along the Pembina River. In some cases, primarily between Sangudo and Fawcett bank forest cover was completely removed along short sections of the river.

2.) Aquatic Vegetation:

a.) Methods:

Six major emergent plant associations occurring in the littoral zone of Isle Lake, Lac Ste. Anne, Matchayaw Lake and Big Lake were recognized. These included cattail (*Typha*, sp.) sedge (*Carex* spp.), bulrush (*Scirpus* spp.), burreed (*Sparganium* sp.), reed (*Phragmites*, sp.), and burreed-cattail. Each of the first five associations appeared to be almost pure stands. The burreed-cattail association contained varying proportions of each of these species. The extent to which each of these associations occurred around the lakes was mapped while travelling along their shorelines by boat. In addition, the relative abundance of plants in each association was estimated according to a scale including five categories: rare, sparse, medium, abundant, and dense. Some measurements of the depth of water at the inner and outer edge of major plant associations were taken.

The relative abundance of submergent plant species was noted at intervals while mapping emergent vegetation. The five category scale above was used for this. No attempt was made to map the extent of submergent vegetation beds. In most cases, the water was clear enough to note the abundance of submergent plant species by direct observation. Occasionally a garden rake was used to sample the submergent vegetation.

The occurrence of emergent and submergent vegetation in the Sturgeon River was noted at intervals along the length of the river by using bridges as access points. Occurrence of vegetation was checked upstream and downstream from each bridge. Additional notes were kept on vegetation in the river while travelling along the river by boat.

Observations were made of the vegetation occurring along the Pembina River during boat trips.

b.) Results:

1.) Lakes:

Emergent plant associations exhibited a zonation according to the depth of the water. Sedge was found on dry land to depths of 2.5 feet of water. Reed occurred on dry land to 3 feet of water. Cattail was found in water between depths of approximately 2 and 3.5 feet. Burreed was generally found at water depths varying from 2.5 - 3.5 feet. Bulrush occupied a zone between 3.5 and 6 feet of water depth. Because of its tolerance of more variable water depths, bulrush invariably occupied the widest zone. Zonation thus progressed from shore towards deep water as follows: sedge→reed→cattail→cattail-burreed→burreed→bulrush. This zonation was similar to that reported by McLeod *et al* (1951) for marshes in Manitoba.

Table 23 summarizes the relative amounts of the different emergent plant associations on Isle Lake. Bulrush was the most abundant association with an average length of 2,455 feet per mile of lake shoreline. An average of 2.79 stands of bulrush occurred per mile. Most of the bulrush was either abundant or medium in density and stands were usually wider than stands of other emergent plants. The second most abundant association was burreed-cattail occurring at an average of 0.52 stands per mile and at an extent of 883 feet per mile. Most of this association was medium and abundant in density. Pure cattail was somewhat less extensive than burreed-cattail and was mostly abundant or dense. Cattail was most abundant at the west end of Isle Lake where the Sturgeon River enters. Sedge was abundant shoreward from the cattail and around small bays along the lake. Pure burreed stands and reed were the least extensive associations and were present at the rate of approximately one stand for every two miles of shoreline. A considerable amount of shoreline (1,429 feet per mile) was not occupied by emergent vegetation. This was the case along rocky shorelines in front of cottages.

Of the submergent plant species, water milfoil (Myriophyllum exalbescens) and clasping-leaf pondweed (Potamogeton richardsonii) were the most common being present at all of 24 sampling sites. Water milfoil was mostly medium in density while clasping-leaf pondweed was primarily medium and abundant. Sago pondweed (Potamogeton pectinatus) was present in over 80% of the sampling sites and varied from rare to abundant in density. Coontail

TABLE 23

Number and Length of Emergent Plant Associations in the Littoral Zone of Isle Lake in 1971

Density	Average Length in Feet (and number) of Plant Associations per Mile.						
	Cattail	Sedge	Bulrush	Burreed	Reed	Burreed - Cattail	Open
Rare					4 (0.04)		
Sparse	70 (0.07)		75 (0.25)		35 (0.07)	48 (0.07)	
Medium	57 (0.18)		848 (1.34)	164 (0.32)	22 (0.11)	180 (0.18)	
Abundant	193 (0.14)		1532 (1.20)	123 (0.21)	66 (0.18)	488 (0.32)	
Dense	215 (0.18)	391 (0.35)			75 (0.14)	167 (0.07)	
Total	535 (0.57)	391 (0.35)	2455 (2.79)	287 (0.53)	202 (0.54)	883 (0.64)	1429 (1.34)

Length of shoreline: 28.43 miles.

(*Ceratophyllum demersum*) present in 22 out of 24 plots was usually abundant or dense. Other pondweeds including *Potamogeton pusillus* were less common. Duckweeds, *Lemna minor* and *Lemna trisulca* were locally abundant, usually among emergent plant species. Yellow pond-lily (*Nuphar variegatum*), arrowhead (*Sagittaria cuneata*), and water smartweed (*Polygonum* sp.) were locally abundant.

In general, submergent plant growth in Isle Lake was abundant, a symptom of a high degree of eutrophication.

The number and extent of emergent plant associations along the shoreline of Lac Ste. Anne west of the Narrows are shown in Table 24. In contrast to Isle Lake, sedge and cattail were the most extensive plant associations in this portion of Lac Ste. Anne. These associations were almost the only emergent vegetation in the section west of the upstream narrows. Photo 8 illustrates the zone of cattail and sedge on the far west shore of Lac Ste Anne. Since most of this occurred as a solid band, a low average of 0.74 stands of sedge were present per mile of shoreline. Similarly, cattail occupied an average of 2,538 feet per mile and was present at a rate of 0.66 stands per mile. Both sedge and cattail associations were primarily rated as dense.

On the portion of the lake between the upstream and downstream narrows, medium and abundant stocked stands of bulrush were common. An average of 2.45 stands per mile and 1,449 feet of bulrush associations per mile were present on the west section of Lac Ste. Anne. Stands of reed were also relatively common

TABLE 24

Number and Length of Emergent Plant Associations in the Littoral Zone of Lac Ste.Anne

West of the Narrows in 1971

Density	Cattail	Sedge	Bulrush	Burreed	Reed	Burreed - Cattail	Open
	Average Length in Feet (and number) of Plant Associations per Mile						
Rare							
Sparse			22 (0.04)				
Medium	77 (0.09	27 (0.13)	728 (1.80)	104 (0.22)	91 (0.22)	537 (0.26)	
Abundant	362 (0.35)	16 (0.04)	699 (0.61)	11 (0.04)	455 (0.57)	345 (0.31)	
Dense	2099 (0.22)	2821 (0.57)			239 (0.35)		
Total	2538 (0.66)	2864 (0.74)	1449 (2.45)	115 (0.26)	785 (1.14)	882 (0.57)	110 (0.04)

Length of shoreline: 22.8 miles.

Photo 8: Zones of sedge and cattail along the far west shore of Lac Ste. Anne. Vegetation in these zones was typically dense with poor interspersion resulting in limited waterfowl use of this area.

with 1.14 stands per mile and 785 feet of the association per mile of shoreline. Burreed-cattail and burreed associations were also present. Non-vegetated shoreline was much less common than on Isle Lake. Only 0.04 sections per mile or 110 feet per mile of shoreline lacked emergent vegetation.

Submergent vegetation was almost entirely lacking in the section of the lake west of the upstream narrows. This was the section bordered by dense stands of sedge and cattail. Cattail appears to be relegated to organic soils which do not appear to support the growth of submergent vegetation communities (van der Valk, 1970). Duckweed (Lemna trisulca) was locally abundant in this section of the lake, often among the stalks of cattail.

Submergent vegetation in the portion of Lac Ste. Anne between the upstream and downstream narrows was similar to that of Isle Lake though generally not as abundant.

Table 25 summarizes information gathered on the number and extent of emergent plant associations on the section of Lac Ste. Anne east of the Narrows. Comparison with Table 23 indicates a high degree of similarity between the emergent vegetation of Isle Lake and the east section of Lac Ste. Anne. Bulrush was again the most common emergent plant association with an average extent of 3,308 feet per mile and occurring with a frequency of 2.06 stands per mile. Stands of cattail, burreed, burreed-cattail, reed and sedge were fairly common being quite similar in extent to the same stands on Isle Lake. The greatest difference involved reed which was somewhat more extensive on Lac Ste. Anne. The

TABLE 25

Number and Length of Emergent Plant Associations in the Littoral Zone of Lac Ste. Anne

East of the Narrows in 1971

Density	Cattail	Sedge	Bulrush	Burreed	Reed	Burreed - Cattail	Open
	Average Length in Feet (and number) of Plant Associations per Mile						
Rare							
Sparse	32 (0.25)		106 (0.36)	25 (0.05)	71 (0.15)		
Medium	161 (0.15)	393 (0.10)	2590 (1.34)	380 (0.72)	6 (0.05)	573 (0.41)	
Abundant	274 (0.31)		593 (0.31)	64 (0.15)	625 (0.98)	64 (0.15)	
Dense			19 (0.05)	39 (0.05)			
Total	467 (0.71)	393 (0.10)	3308 (2.06)	509 (0.97)	702 (1.18)	637 (0.56)	1648 (0.77)

Length of shoreline: 19.4 miles.

average length of shoreline lacking emergent vegetation was 1,648 feet per mile - similar to the situation on Isle Lake. However, the number of openings per mile were fewer on Lac Ste. Anne on the average. This was primarily a result of the extensive barren shoreline of Alberta Beach.

Submergent vegetation occurred with approximately the same species composition as that found in Isle Lake. However, growth was not as dense as on Isle Lake.

A possible explanation for this difference involves a comparison of the turbidity of water in the two lakes. The water in Lac Ste. Anne appeared to be more turbid than the water in Isle Lake. The retarding effect of turbid water on the growth of submergent vegetation because of reduced light penetration has been well documented (Bourn, 1932; Pearsall and Hewitt, 1933; Pearsall and Ullyott, 1964; Ellis, 1936; Chamberlain, 1948; and Edwards, 1969). A possible cause of the greater turbidity of the east section of Lac Ste. Anne is the strong wave action. Being a much larger lake than Isle Lake, wind results in larger waves on Lac Ste. Anne. These larger waves may stir up the bottom sediments to a greater extent thus resulting in greater turbidity. Chamberlain (1948) found that wave action was the chief cause of turbidity responsible for limited growth of submergent vegetation in a lake in Virginia.

A summary of the extent of emergent vegetation associations present around Matchayaw Lake is presented in Table 26. Cattail was very abundant in an average of 1.72 dense stands per mile

TABLE 26

Number and Length of Emergent Plant Associations in the Littoral Zone of Matchayaw Lake in 1971

Density	Average Length in Feet (and number) of Plant Associations per Mile						
	Cattail	Sedge	Bulrush	Burreed	Reed	Burreed - Cattail	Open
Rare							
Sparse							
Medium			2795 (1.97)	430 (0.25)			
Abundant							
Dense	3870 (1.72)	1646 (0.25)					
Total	3870 (1.72)	1646 (0.25)	2795 (1.97)	430 (0.25)			338 (0.98)

Length of shoreline: 4.07 miles

having an extent of 3,870 feet per mile. Unlike the shallow bay west of the upstream Narrows on Lac Ste. Anne, the band of cattail on Matchayaw Lake was followed by a band of bulrush almost as long. A fairly extensive sedge meadow was present on the west side of the lake. Burreed was present but not extensive. Four areas along the shoreline were without vegetation and extended for an average of 338 feet.

Submergent vegetation included sago pondweed which was abundant, clasping-leaf pondweed and water milfoil with medium densities, and coontail and duckweed (Lemna trisulca) which were abundant in stands of bulrush. Lemna minor was rare. Patches of water lilies were common at the deep water edge of the bulrush (Photo 9).

Characteristics of the aquatic vegetation of Big Lake were very different from those of the aquatic vegetation on the lakes discussed above. Table 27 shows the average number and length of emergent plant associations per mile of shoreline of Big Lake. Although the average length of sedge associations was not large, sedge was by far the dominant emergent plant association of Big Lake. The fairly extensive deltas of the Sturgeon River and Atim Creek were vegetated with sedge which during most of the summer of 1971 was almost entirely flooded. Bulrush was also abundant. Besides forming an interrupted band around the lake, it was present in clumps of varying sizes at a considerable distance from the shore. This occurred because the entire

Photo 9: Water lilies at the deep water edge of bulrush in Matchayaw Lake. Bulrush provides good cover for waterfowl and is also used by muskrats.

TABLE 27

Number and Length of Emergent Plant Associations in the Littoral Zone of Big Lake in 1971

Density	Average Length in Feet (and number) of Plant Associations Per Mile						
	Cattail	Sedge	Bulrush	Burreed	Reed	Burreed Cattail	Open
Rare							
Sparse							
Medium			861 (0.54)	659 (0.18)			
Abundant		599 (0.24)	3706 (8.02)	689 (0.48)			
Dense		97 (0.12)					
Total		696 (0.36)	4567 (8.56)	1348 (0.66)			

Length of shoreline: 16.7 miles.

lake is relatively shallow. An average of 8.56 bulrush stands were present per mile of shoreline and extended an average of 4,567 feet per mile. Burreed was the only other emergent plant association which was fairly common on the shoreward side of the bulrush.

Although all of Big Lake is probably sufficiently shallow for submergent plant growth, submergents were generally not as abundant as in the lakes discussed above. This may well be a result of the high degree of turbidity of water in Big Lake. The turbidity is attributed to the large amounts of erosion silt brought into the lake by the Sturgeon River and Atim Creek as evidenced by their deltas. However, submergent vegetation was locally abundant, water milfoil being abundant in stands of bulrush and sago pondweed common in shallow portions of the lake. Coontail and <u>Lemna trisulca</u> were also observed locally.

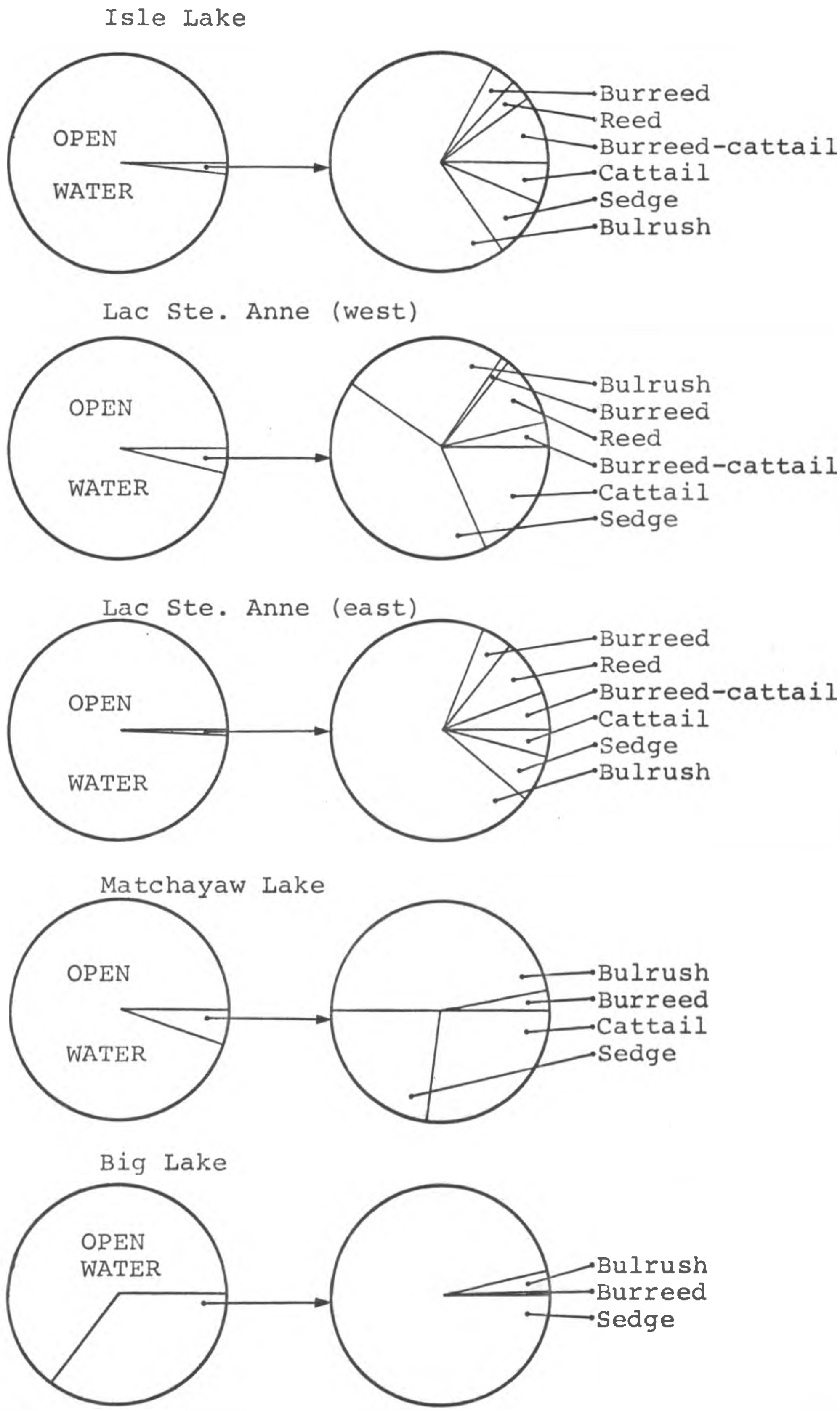
Around Hoople Lake, a continuous band of sedge was the only emergent plant association present. Submergent plant species included sago pondweed which was abundant, and clasping-leaf pondweed and water milfoil which were sparsely distributed. <u>Lemna trisulca</u> was fairly common.

<u>Summary</u>:

A summary of the information on emergent vegetation of the lakes, is presented in Figure 2. A comparison of the ratio of area covered by emergent vegetation to area covered by open water shows that Big Lake contains the greatest proportion of emergent

FIGURE 2

Extent and Composition of Emergent Vegetation in Lakes Along the Sturgeon River, 1971.



vegetation and is followed by Matchayaw Lake, the west section of Lac Ste. Anne, Isle Lake, and the east section of Lac Ste. Anne in order of decreasing proportion of emergent vegetation. The proportions of the different associations making up the fringe emergent cover of each lake is also shown. The composition of the vegetation around Isle Lake and the east section of Lac Ste. Anne is very similar. A large proportion of the vegetation surrounding the west section of Lac Ste. Anne is dense cattail and sedge. The emergent vegetation of Matchayaw Lake is composed of approximately 25% cattail, 25% sedge and 50% bulrush. In Big Lake, sedge makes up over 96% of the emergent vegetation. Although bulrush makes up only approximately 3% of the emergent growth in Big Lake it is more common there than in any of the other lakes.

2.) <u>Rivers</u>:

<u>Sturgeon River</u>:

Because of its relatively shallow gradient resulting in slow flows and this in turn resulting in a substrate largely composed of silt and mud, growth of emergent and submergent plants was fairly common in the Sturgeon River. The section between Hoople Lake and Isle Lake, which is subject to large fluctuations in water level depending on precipitation, supported a growth of sedge along most of its banks. Submergent vegetation was insignificant.

Between Isle Lake and Lac Ste. Anne, most of the river flowed through marshy areas with abundant growth of sedge, burreed, and cattail. Arrowhead and water smartweed were common close to the shore. Relatively clear water allowed a rich growth of submergent vegetation. Clasping-leaf pondweed exhibited an abundant growth in the central part of the channel while water milfoil was common adjacent to the sides. Some sago pondweed and duckweed (*Lemna minor*) were also observed.

From Lac Ste. Anne to Matchayaw Lake, emergent and submergent vegetation growth was moderate though locally abundant. Water in this section of the river appeared more turbid than between Isle Lake and Lac Ste. Anne. A possible explanation for this may be that forest cover on land adjacent to this section of the river was relatively light (see Table 4), resulting in some siltation of the river due to erosion. The gradient of the river between Isle Lake and Lac Ste. Anne was approximately 3.6 feet per mile while the gradient between Lac Ste. Anne and Matchayaw Lake was 6.3 feet per mile. The current velocity between Lac Ste. Anne and Matchayaw Lake would therefore be greater than between Isle Lake and Lac Ste. Anne. The combination of turbidity and increased current velocity was likely sufficient to reduce the amount of aquatic vegetation. Some sedge, burreed, cattail, and bulrush were observed as well as arrowhead, water smartweed and duckweed. Clasping-leaf pondweed and water milfoil were locally abundant.

For approximately the first 2.5 miles downstream from Matchayaw Lake, emergent marsh vegetation growth was abundant with dense stands of sedge and cattail bordering the river channel (Photo 10). From that point to the mouth of the Riviere Qui Barre, sedge, burreed, cattail, and bulrush occurred in less frequent stands along the river. Submergent vegetation growth in most of the length of the Sturgeon River from Matchayaw Lake to the mouth of the Riviere Qui Barre was abundant. Dense beds of clasping-leaf and sago pondweeds were extensive along this section. Water milfoil was also common. Both species of duckweed (Lemna minor) and Lemna trisulca were observed. The rich growth of submergents in this section of the river appeared to be correlated with a lack of turbidity of the water. Suspended silt in the water of the river between Lac Ste. Anne and Matchayaw Lake presumably settled out in Matchayaw Lake. The water leaving Matchayaw Lake was therefore relatively clear and remained clear to the mouth of the Riviere Qui Barre and allowed sufficient light penetration for good plant growth. The gradient of this section of the river was relatively shallow (approximately 2.3 feet per mile between Matchayaw Lake and Big Lake). Thus the slow current velocity combined with a relative lack of turbidity allowed submergent plant growth.

Downstream from the confluence of the Riviere Qui Barre and Sturgeon River to Big Lake, aquatic vegetation was almost nonexistent. The water in this section of the river was characteristically very turbid. Small amounts of clasping-leaf pondweed, sago pondweed, and water milfoil were observed. However, these plants were generally restricted to shallow water near the

Photo 10: Illustration of the abundant emergent vegetation growing along the Sturgeon River downstream from Matchayaw Lake providing waterfowl and muskrat habitat. Dense stands of cattail such as that seen in the foreground resulted in only moderate use of this section of river by waterfowl.

edge of the stream, the only places where sufficient light penetration occurred. The main source of siltation in this section of the river appears to be the Riviere Qui Barre. The land adjacent to this river has very little forest cover and erosion is undoubtedly significant. Forest cover along the Sturgeon River between the mouth of the Riviere Qui Barre and Big Lake is also very light with the probable result that erosion silt is contributed all along this section of the river during periods of rainfall and snow melt. Lack of forest cover results in flash floods in this portion of the river. Resulting violent fluctuations in water level combined with high turbidity make conditions for submergent plant growth extremely poor.

Much of the Sturgeon River's silt load settles out in Big Lake. The result is that water is relatively clear for approximately the first 10 miles downstream, enabling a fairly abundant growth of submergent plants. This growth is further enhanced by low current velocity since the gradient in this reach is less than one foot per mile. Extensive areas also have a good growth of sedge, cattail, burreed, and bulrush. Photo 11 shows a stand of burreed in the Sturgeon River near St. Albert. The water becomes progressively turbid downstream and current velocity increases with an apparently consequent reduction in growth of submergent vegetation. The presence of small patches of clasping-leaf pondweed, water milfoil, and coontail in relatively shallow water near the edge of the stream is similar to the situation along the turbid section of the river entering Big Lake. Vegetative cover along the banks

Photo 11: A stand of burreed in the Sturgeon River downstream from St. Albert. Burreed is used by waterfowl for brood and nest cover and by muskrats for food, cover, and building material. Much of this particular stand has been destroyed by an oil slick.

of the Sturgeon River from Big Lake to the North Saskatchewan River is probably not sufficient to prevent a significant amount of siltation by erosion.

In summary, the present situation on the Sturgeon River appears very similar to South African rivers about which Edwards (1969) wrote that "The damage done to drainage lines by uncontrolled utilization of the fringing vegetation remains one of the most widespread causes for siltation and disturbance of the ecological balance of rivers...Available data indicate a general decline in the aquatic vegetation as a result of the changed aquatic environments."

Pembina River

The Pembina River was found to contain no aquatic vegetation of any significance to waterfowl or muskrats. A combination of factors including a too swift current, turbidity, an unsuitable substrate and marked fluctuations in water level were probably responsible for the lack of aquatic vegetation. When water levels were low, the characteristic bank vegetation included a zone of horsetail followed by a zone of small willow, followed by mixed forest. In quiet stretches of the river, submergent plants such as sago pondweed and clasping-leaf pondweed are often locally abundant (van der Valk, 1970).

A series of natural and artificial oxbows along the Pembina River (Photo 12) were studied by van der Valk in 1970.

Photo 12: Oxbow lake along the Pembina River. Waterfowl and muskrat habitat and water levels in the oxbow are presently maintained by periodic flooding of Pembina River.

He found that a major factor controlling plant distribution and succession in these lakes was water level fluctuations caused by flooding of the Pembina River. As the connection between the river and oxbow becomes higher and higher with repeated depositions of silt, the oxbow becomes progressively less likely to receive flood water from the Pembina. The pattern of plant succession exhibited due to the increasingly mesic conditions is as follows: "Potamageton pectinatus, P. zosteriformis, P. richardsonii, and Ceratophyllum demersum ► Potamogeton pectinatus ► Nuphar variegatum or Potamogeton natans ► Equisetum fluviatale, Typha latifolia or Alisma plantago-aquatica and Eleocharis palustris ► Carex meadows ► Salix shrub ► Salix forest ► Populus balsamifera". (van der Valk, 1970). Van der Valk noted that the successional stage of plants in oxbows formed before 1900 is similar to that of oxbows formed 10 - 11 years ago. He interprets this phenomenon as being a result of increased sedimentation due to increased flooding since 1900 or later. This is probably a consequence of the spread of agriculture. Van der Valk estimated that based on 1969 sedimentation rates, it would take 25 - 75 years for plants in oxbows formed 10 - 11 years ago to go from the submerged to meadow stage in succession.

B. Wildlife Populations

1. Waterfowl in the Sturgeon and Pembina River Basins

Relatively few investigations of waterfowl use of lakes along the Sturgeon River have been done. Soper (1939) commented on waterfowl and their habitat on Isle Lake and Lac Ste. Anne. In 1965, the Alberta Fish and Wildlife Division reported on waterfowl use of Big Lake to the Edmonton Regional Planning Commission. Lane and Lynch (1969) censused populations of waterfowl on Isle Lake, Lac Ste. Anne, and Matchayaw Lake. During the late 1960's, Canadian Wildlife Service personnel rated land including the Sturgeon and Pembina river basins as to their production capability for waterfowl.

In the present study, waterfowl investigations were carried out during the period May through August, 1971. Investigations included determination of breeding pair use of the Sturgeon River and associated lakes and the Pembina River. Information on nesting on the lakes was gathered. Brood surveys of the Sturgeon River and associated lakes were undertaken. In addition, investigations were made of the relationships between waterfowl and their habitat on the lakes and rivers.

a.) Breeding Pair Survey

1.) Methods

The first aerial survey was conducted along the Sturgeon

River and associated lakes, and along the Pembina River on May 11th. On June 1st a second aerial survey was flown over the Sturgeon River and associated lakes. Boat surveys of Isle Lake, Lac Ste. Anne, Matchayaw Lake, and Big Lake were conducted during the period May 12 to 19. Selected sections of the Sturgeon River were surveyed by foot or boat from Hoople Lake to the North Saskatchewan River between May 4 and 25. The dates of these surveys fall within the optimum census periods recommended by Dzubin (1969).

Aerial surveys were conducted in the early morning between 0600 and 0900 hours using a Cessna 172 aircraft flown at an altitude of 50 to 100 feet and a speed of 85 to 95 m.p.h. The aircraft was flown in a counter clockwise direction around the lake shoreline about 100 yards offshore. On the three larger lakes, a pass was made down the middle of the lake. In addition, the shoreline of all major islands was followed. The Sturgeon and Pembina river channels were followed as closely as possible.

Observations of waterfowl on each side of the aircraft were recorded by two observers with the use of battery operated tape recorders. A third man acted as navigator and directed the course of the survey.

Waterfowl observations were recorded as to species and status whenever possible. Status categories include pairs, lone drakes, lone hens, flocked drakes, and mixed groups. It was often impossible to identify species of divers and dabblers during the aerial survey. Surveys conducted by boat and by foot enabled an accurate breakdown of species composition. These data were used to help interpret unclassified data collected during the aerial survey.

Boat surveys were conducted on Isle Lake, Lac Ste. Anne, Matchayaw Lake, Big Lake, and on navigable sections of the Sturgeon River. Species and breeding status of waterfowl were recorded by two observers using binoculars while cruising along the shoreline of the lake.

Breeding pair surveys by foot were done on selected sections of the Sturgeon river where it was not possible to travel by boat. Of the 135 miles of Sturgeon River channel, 74 miles were surveyed. During this survey, sections of the river were selected to ensure an adequate sample of the river and one which would be representative of the major riparian habitats.

2.) Results and Discussion

Species of waterfowl observed during the breeding pair survey included the following: mallard (*Anas platyrhynchos*), pintail (*Anas acuta*), green-winged teal (*Anas carolinensis*), blue-winged teal (*Anas discors*), shoveler (*Spatula clypeata*), American widgeon (*Mareca americana*), gadwall (*Anas strepera*), redhead (*Aythya americana*), canvasback (*Aythya valisineria*), lesser scaup (*Aythya affinis*), common goldeneye (*Bucephala clangula*), bufflehead (*Bucephala albeola*), white-winged scoter (*Melanitta deglandi*), surf scoter (*Melanitta perspicillata*), ruddy duck (*Oxyura jamaicensis*), ring-necked duck (*Aythya collaris*), oldsquaw (*Clangula hyemalis*), common merganser (*Mergus merganser*), and hooded merganser (*Lophodytes cucullatus*).

Lakes

Total numbers of dabbling and diving ducks seen during the aerial and boat surveys of four lakes along the Sturgeon River are recorded in Table 28. The table shows that numbers of dabblers remained relatively constant between the first and second aerial surveys indicating that they had probably chosen a breeding area. The numbers of dabblers recorded during the boat surveys were somewhat higher than the aerial counts on Isle Lake, Lac Ste. Anne, and Matchayaw Lake. The reason for this difference is that dabblers were generally restricted to emergent cover around the shoreline of the lake resulting in poor visibility from the aircraft. Visibility from the boat was excellent and it is felt that a nearly complete count of dabbler species was obtained. The counts may be biased slightly upwards due to recounts of ducks which flushed and landed ahead of the boat. However an attempt was made to see where ducks landed after being flushed, in order to avoid duplicate counts. Usually the ducks flushed ahead of the boat, circled, and landed behind the boat close to the area from which they originated.

TABLE 28

Total Numbers of Dabbling and Diving Ducks seen during Aerial and Boat Surveys of Four Lakes along the Sturgeon River in 1971.

	1st aerial survey (May 11)		Boat survey (May 12-19)		2nd aerial survey (June 1)	
Lakes	dabblers	divers	dabblers	divers	dabblers	divers
Isle Lake	391	1543	580	1579	381	649
	1934 *		2159		1030	
Lac Ste. Anne	392	606	924	470	426	192
	998		1394		618	
Matchayaw Lake	45	203	134	154	65	135
	248		288		200	
Big Lake	310	1472	383	1149	1110	977
	1782		1532		2087	

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* Total dabblers and divers.

Since numbers of dabblers appeared relatively stable and the boat survey resulted in a nearly complete count of ducks, the data collected during the boat survey were used to determine the number of indicated breeding pairs of dabblers on the lakes. On Big Lake, however, data gathered during the second aerial survey were used since much of the lake was inaccessible by boat.

There is no standarized method by which to estimate numbers of breeding pairs from direct count data. After a very thorough study of the components counted as indicated pairs by other authors, Dzubin (1969) recommended that "Pair, lone drake, and grouped drake components should be enumerated as indicated pairs for all dabbler species. The resultant pair figure should be corrected for the unmated male segment by applying a prelaying sex-ratio correction factor". This recommendation was followed in this study. Since prelaying sex ratios were unavailable for the area under investigation, the sex ratios found by Dzubin (1969) for dabblers on his Kindersley study area from 1956 to 1959 (see Table 29) were applied to our data.

With regard to the diver portion of the waterfowl population on the lakes, Table 28 shows that the number of divers seen on Isle Lake during the first aerial survey was very close to the number seen during the boat survey two days later. On the other lakes, more divers were seen during the first

TABLE 29

Prelaying Sex Ratios of Waterfowl

A. For dabblers as given by Dzubin (1969):

Species	Ratio (M:F)	Sample Size
Mallard	112:100	1032
Pintail	117:100	628
Green-winged teal	110:100	681
Blue-winged teal	120:100	522
Shoveler	119:100	563
American Widgeon	108:100	1534
Gadwall	110:100	773

B. For divers as determined in this study:

Species	Ratio	Sample Size
Redhead	120:100	90
Canvasback	148:100	154
Lesser Scaup	161:100	1056
Common Goldeneye	104:100	357
Bufflehead	70:100	121
White-winged Scoter	132:100*	
Ruddy Duck	158:100	116

* Average ratio for all diver species was used.

aerial survey than during the boat survey. Populations of divers were lowest at the time of the second aerial survey. Since divers are much more conspicuous than dabblers and because they were not as restricted to the emergent vegetation around the lake shore, probably nearly complete counts of divers were obtained during the aerial surveys as well as by the boat survey. There was obviously an egression of divers from the lakes during the period between the first and second aerial surveys. The ducks were probably using the lakes as resting areas during migration.

On the assumption that a complete count of divers on the lakes was made on June 1st and that by this date egression had ceased the second aerial census data were used to determine numbers of indicated breeding pairs. Rogers (1964) considered pairs and lone females as indicated pairs of lesser scaup. In a mixed group of divers, indicated pairs were difficult to determine by behavioral characteristics. It was therefore assumed that all females were potential breeders and indicate a potential pair. McKnight and Buss (1962) reported on the basis of histological examination of lesser scaup ovaries, that most yearlings of this species were physiologically capable of breeding. By June 1st, a few divers may have commenced nesting. The number of female divers seen on June 1st could therefore give an underestimate of the number of breeding pairs. Since the sex ratios in diver species are generally highly distorted in favor of males numbers of this segment of the population would give an overestimate of the breeding population. Consequently, the numbers of divers seen on June 1st were corrected for by using the prelaying sex ratio of each diver species. A sex ratio for each diver species was determined from the data which was accurately tabulated during the boat survey (see Table 29). This ratio was applied to total counts for each diver species obtained on June 1st to give numbers of females. Assuming that all female divers are potential breeders this value was used to give the number of indicated breeding pairs.

The numbers of breeding pairs of each species of waterfowl observed on Isle Lake are presented in Table 30. An estimated total of 521 breeding pairs of ducks were indicated on Isle Lake. Approximately 44% of the ducks were dabblers while 56% were divers. The most common dabbler, the mallard, was present in greater numbers than any other species of duck. The most common diver was the lesser scaup. Dabblers averaged 8 pairs per mile of shoreline while divers averaged 10 pairs per mile.

The breeding pair population of waterfowl on Isle Lake appears to have increased over the population in 1969. Lane and Lynch (1969) reported that an average of 206 breeding pairs of ducks were observed during early flights over Isle Lake in 1969. However, this figure is not directly comparable to the estimate determined in this study since Lane and Lynch used only aerial surveys for population estimates. The results of

TABLE 30

Numbers of Indicated Breeding Pairs of Waterfowl Observed on Isle Lake in 1971

Species	Pairs	Species Composition %	Prs. per mile of shoreline*
Dabblers			
Mallard	80	15.4	2.76
Pintail	12	2.3	0.41
Green-winged teal	6	1.1	0.21
Blue-winged teal	44	8.4	1.52
Shoveler	16	3.1	0.55
Am. Widgeon	67	12.9	2.31
Gadwall	6	1.1	0.21
Total Dabblers	231	44.3	7.97
Divers			
Redhead	10	1.9	0.34
Canvasback	42	8.1	1.45
Lesser Scaup	62	11.9	2.14
Common Goldeneye	76	14.6	2.62
Bufflehead	38	7.3	1.31
White-winged Scoter	60	11.5	2.07
Ruddy Duck	2	0.4	0.07
Ring-necked Duck			
Total Divers	290	55.7	10.00
GRAND TOTAL	521	100.0	17.97

* Miles of Shoreline = 29

this study indicate that aerial surveys alone would result in an underestimation of dabbler populations. In addition, Lane and Lynch do not specify their method of determining the number of breeding pairs from direct count data. It has previously been pointed out that there is no standardized method for doing this. Nevertheless, the much higher population observed in 1971 probably represents a real increase reflecting the general increase in waterfowl populations over the past few years in Alberta and the other prairie provinces. Data presented by Norman (1971) and Jensen (1971) indicate that there were an estimated 3.7 million breeding waterfowl in Alberta in 1968. This population increased to 5.3 million in 1969, 6.2 million in 1970, and 7.2 million in 1971.

Table 31 shows the number of breeding pairs of each species of waterfowl observed on the section of Lac Ste. Anne west of the Narrows. A total of 290 indicated breeding pairs were observed. Dabblers, comprising approximately 86% of the waterfowl population averaged 11 pairs per mile of shoreline while divers constituting 14% of the population averaged only 2 pairs per mile. The mallard was the most common species observed. The most common divers were common goldeneye and lesser scaup.

The results of the breeding pair survey on the east section of Lac Ste. Anne are presented in Table 32. A total of 335 indicated breeding pairs were observed. Dabblers, averaging 15 pairs per mile comprised 89% of the waterfowl population

TABLE 31

Numbers of Indicated Breeding Pairs of Waterfowl Observed on Lac Ste. Anne (West of the Narrows)

Species	Pairs	Species Composition %	Prs. per mile of shoreline*
Dabblers			
Mallard	103	35.5	4.52
Pintail	8	2.8	0.35
Green-winged teal	12	4.1	0.53
Blue-winged teal	40	13.8	1.75
Shoveler	1	0.3	0.04
Am. Widgeon	69	23.8	3.03
Gadwall	15	5.2	0.66
Total Dabblers	248	85.5	10.88
Divers			
Redhead			
Canvasback			
Lesser Scaup	12	4.1	0.53
Common Goldeneye	17	5.9	0.75
Bufflehead	11	3.8	0.48
White-winged Scoter			
Ruddy Duck			
Ring-necked Duck	2	0.7	0.09
Total Divers	42	14.5	1.85
GRAND TOTAL	290	100.0	12.73

* Miles of shoreline = 22.8

TABLE 32

Numbers of Indicated Breeding Pairs of Waterfowl Observed on Lac Ste. Anne (East of the Narrows)

Species	Pairs	Species Composition %	Prs. per mile of shoreline *
Dabblers			
Mallard	144	43.0	7.42
Pintail	27	8.1	1.39
Green-winged teal	27	8.1	1.39
Blue-winged teal	39	11.6	2.01
Shoveler	2	0.6	0.10
Am. Widgeon	42	12.5	2.16
Gadwall	16	4.8	0.82
Total Dabblers	297	88.7	15.29
Divers			
Redhead	2	0.6	0.10
Canvasback			
Lesser Scaup	26	7.7	1.34
Common Goldeneye	9	2.7	0.46
Bufflehead	1	0.3	0.05
Ruddy Duck			
Ring-necked Duck			
Total Divers	38	11.3	1.95
GRAND TOTAL	335	100.0	17.25

* Miles of shoreline = 19.4

while divers averaging 2 pairs per mile made up the remaining 11%. Mallards were the most common dabblers while lesser scaup were the most common divers.

Species composition on the two sections of the lake were fairly similar. However, waterfowl population density, especially for dabbler species, was greater along the shoreline of the eastern section.

The population of indicated breeding pairs observed on Lac Ste. Anne in 1971 was almost double the population observed by Lane and Lynch in 1969. For the reasons outlined in the discussion of the results of the Isle Lake survey, these figures are not directly comparable. The figures do, however, reflect the general increase in waterfowl populations during the past few years.

The results of the breeding pair survey of Matchayaw Lake are presented in Table 33. A total of 131 indicated breeding pairs of waterfowl were observed. The population was composed of 59% dabblers and 41% divers. The most common species observed on Matchayaw Lake was the lesser scaup. Mallards were the most common dabblers. Dabblers were present at a density of 19 pairs per mile of shoreline while divers averaged 13.5 pairs per mile.

Lane and Lynch (1969) reported a breeding pair index of 12.1 pairs per mile of shoreline in 1969. Once again, although this figure is not directly comparable to the index obtained

TABLE 33

Numbers of Indicated Breeding Pairs of Waterfowl Observed on Matchayaw Lake in 1971

Species	Pairs	Species Composition %	Prs. per mile of shoreline*
Dabblers			
Mallard	29	22.1	7.25
Pintail	7	5.3	1.75
Green-winged teal	6	4.6	1.50
Blue-winged teal	17	13.0	4.25
Shoveler	2	1.5	0.50
Am. Widgeon	12	9.2	3.00
Gadwall	4	3.1	1.00
Total Dabblers	77	58.8	19.25
Divers			
Redhead	1	0.8	0.25
Canvasback	5	3.8	1.25
Lesser Scaup	46	35.1	11.50
Common Goldeneye	2	1.5	0.50
Bufflehead			
White-winged Scoter			
Ruddy Duck			
Ring-necked Duck			
Total Divers	54	41.2	13.50
GRAND TOTAL	131	100.0	32.75

* Miles of Shoreline = 4.0

in this survey, the trend of an increased population is indicated.

The numbers of breeding pairs of each species of waterfowl observed on Big Lake are presented in Table 34. A total of 1477 indicated breeding pairs were observed on Big Lake. Approximately 75% of these were dabblers and 25% were divers. Mallards were the most common ducks and were followed closely in numbers by pintails. Redheads were the most common divers. Dabblers averaged 55 pairs per mile of shoreline while divers were present at a density of approximately 19 pairs per mile.

Whereas the waterfowl populations on Isle Lake, Lac Ste. Anne, and Matchayaw Lake were relatively high, the population on Big Lake was extremely high. Goodman (in Dirschl et al, 1967) in his evaluation of waterfowl capability in the Saskatchewan River delta designated lakes with 4+ divers and 4+ dabblers per mile of shoreline as having first rate capability. Applying this criterion to the lakes considered in this study, the four lakes would easily be rated as having first rate capability.

The marshes of the lake Winnipeg basins are well known as areas of excellent waterfowl habitat. Townsend (1969) reported that in 1965, the breeding pair population of the Netley - Libau Marshes was 23.2 pairs per mile of marsh shoreline. Ducks Unlimited (Canada) (1963) state that in an inventory of wetlands in Manitoba larger than 200 acres they

TABLE 34

Numbers of Indicated Breeding Pairs of Waterfowl Observed on Big Lake in 1971

Species	Pairs	Species Composition %	Prs. per mile of Shoreline*
Dabblers			
Mallard	421	28.5	21.0
Pintail	330	22.3	16.5
Green-winged teal	46	3.1	2.3
Blue-winged teal	115	7.8	5.8
Shoveler	37	2.5	1.8
Am. Widgeon	128	8.7	6.4
Gadwall	33	2.2	1.6
Total Dabblers	1110	75.1	55.4
Divers			
Redhead	119	8.1	6.0
Canvasback	59	4.0	3.0
Lesser Scaup	74	5.0	3.7
Common Goldeneye	18	1.2	0.9
Bufflehead	31	2.1	1.6
White-winged Scoter	59	4.0	3.0
Ruddy Duck	7	0.5	0.4
Total Divers	367	24.9	18.6
GRAND TOTAL	1477	100.0	74.0

* Miles of Shoreline (including inundated areas) = 20.0

assigned an excellent (Class 1) rating to wetlands that could be expected to support 30 or more breeding pairs per mile of shoreline. Using this criterion, Big Lake and Matchayaw Lake would be classed as excellent waterfowl lakes while Isle Lake and Lac Ste. Anne would be classed at a medium level.

Hoople Lake also proved to be an excellent waterfowl area based on its breeding pair population (Table 35). A total of 63 breeding pairs were observed on this lake. Approximately 24% were dabblers and 76% were divers. Lesser scaup were the most common ducks observed. American widgeon were the most common dabblers. There were approximately 17 pairs of dabblers and 54 pairs of divers per mile of shoreline.

Sturgeon River

The numbers of indicated breeding pairs on the Sturgeon River were determined from data collected during surveys by foot and by boat by the same method used for the lakes. Table 36 shows the numbers of pairs of waterfowl observed on 74 miles of the Sturgeon River. A total of 1030 pairs were observed; 85% of them dabblers and 15% divers. Mallards were the most common dabblers and lesser scaup the most common divers. There were approximately 12 pairs of dabblers and 2 pairs of divers per mile of stream.

Tables 37 and 38 show the numbers of pairs of waterfowl per mile of Sturgeon River in sections where channel modification has been proposed and the number of pairs in sections

TABLE 35

Numbers of Indicated Breeding Pairs of Waterfowl Observed on Hoople Lake in 1971

Species	Pairs	Species Composition %	Prs. per mile of Shoreline*
Dabblers			
Mallard	3	4.8	3.4
Am. Widgeon	9	14.3	10.1
Pintail	2	3.2	2.2
Green-winged teal	1	1.6	1.1
Total Dabblers	15	23.9	16.8
Divers			
Ruddy Duck	10	15.8	11.2
Canvasback	3	4.8	3.4
Lesser Scaup	21	33.3	23.6
Common Goldeneye	6	9.5	6.7
Bufflehead	8	12.7	9.0
Total Divers	48	76.1	53.9
GRAND TOTAL	63	100.0	70.7

* Miles of shoreline = 0.89

TABLE 36

Numbers of Indicated Breeding Pairs of Waterfowl Observed on

74 Miles of the Sturgeon River in 1971

Species	Pairs	Species Composition %	Prs. per mile of River
Dabblers			
Mallard	280.4	27.2	3.79
Pintail	240.2	23.3	3.25
Green-winged teal	74.5	7.3	1.01
Blue-winged teal	85.8	8.3	1.16
Shoveler	48.7	4.7	0.66
Am. Widgeon	131.5	12.8	1.78
Gadwall	14.5	1.4	0.20
Total Dabblers	875.6	85.0	11.85
Divers			
Redhead	4.1	0.4	0.06
Canvasback	8.7	0.8	0.12
Scaup	98.4	9.6	1.33
Goldeneye	32.7	3.2	0.44
Bufflehead	8.8	0.9	0.12
White-winged Scoter	1.3	0.1	0.02
Ruddy duck			
Ring-necked duck			
Total Divers	154.0	15.0	2.09
GRAND TOTAL	1029.6	100.0	13.94

TABLE 37

Numbers of Indicated Breeding Pairs of Waterfowl observed on 46.5 Miles of the Sturgeon River where Canalization is Proposed

Species	Pairs	Species Composition %	Prs. per mile of River
Dabblers			
Mallard	187.5	25.8	4.03
Pintail	228.0	31.4	4.90
Green-winged teal	33.6	4.6	0.72
Blue-winged teal	53.3	7.4	1.15
Shoveler	41.2	5.7	0.89
Am. Widgeon	90.7	12.5	1.95
Gadwall	8.2	1.1	0.18
Total Dabblers	642.5	88.5	13.82
Divers			
Redhead	1.8	0.3	0.04
Canvasback	7.6	1.1	0.16
Lesser Scaup	54.0	7.4	1.16
Common Goldeneye	13.4	1.8	0.29
Bufflehead	5.3	0.7	0.11
White-winged Scoter	1.3	0.2	0.03
Ruddy Duck			
Ring-necked Duck			
Total Divers	83.4	11.5	1.79
GRAND TOTAL	725.9	100.0	15.61

TABLE 38

Numbers of Indicated Breeding Pairs of Waterfowl Observed on 27.4 Miles of Sturgeon River where Canalization is not Proposed

Species	Pairs	Species Composition %	Prs. Per mile of River
Dabblers			
Mallard	92.6	30.5	3.38
Pintail	12.0	4.0	0.44
Green-winged teal	40.9	13.5	1.49
Blue-winged teal	32.5	10.7	1.19
Shoveler	7.6	2.5	0.28
Am. Widgeon	40.7	13.4	1.49
Gadwall	6.4	2.1	0.23
Total Dabblers	232.7	76.7	8.50
Divers			
Redhead	2.3	0.7	0.08
Canvasback	1.1	0.4	0.04
Lesser Scaup	44.4	14.6	1.62
Common Goldeneye	19.3	6.4	0.70
Bufflehead	3.6	1.2	0.13
White-winged Scoter			
Ruddy Duck			
Ring-necked Duck			
Total Divers	70.7	23.3	2.57
GRAND TOTAL	303.4	100.0	11.07

where canalization is not proposed. Of the former sections, 47 miles were censused while 27 miles of the latter sections were censused. Waterfowl populations were highest along sections where canalization is proposed.

Of the 61 miles of river not surveyed, there are no proposed channel modifications. Breeding pair density would probably approximate 11 per mile of stream. The total river channel would therefore be utilized by approximately 1,708 breeding pairs of ducks.

Lane and Lynch (1969) censused only the section of the Sturgeon River between Isle Lake and Lac Ste. Anne. They report an average of 10.6 breeding pairs of ducks per lineal mile between the two lakes. The increased population in 1971 is consistent with the provincial increase in waterfowl populations.

Pembina River

Data obtained during the aerial survey of the Pembina River on May 11th are presented in Table 39. An average of approximately two ducks per mile were observed along 113 miles censused. Although this was probably an underestimation of the waterfowl population, it is not likely that more than one breeding pair per mile of river were present.

TABLE 39

Numbers of Waterfowl Observed on 113 Miles of the Pembina River (Matthews Crossing to Rossington) in 1971

Species	Male	Female	Unknown	Prs.	Ducks/mile of River
Dabblers					
Mallard	18	-	13	7	0.398
Pintail	1	-	-	2	0.044
Am. Widgeon	1	-	2	3	0.080
Unknown	-	-	91	13	1.035
Total Dabblers	20	0	106	25	1.557
Divers					
Common Goldeneye	-	-	2	3	0.071
Canvasback	-	-	-	4	0.071
Unknown	-	-	5	4	0.115
Total Divers	0	0	7	11	0.257
Unidentified	-	-	12	3	0.159
GRAND TOTAL	20	0	125	39	1.973

b.) Incidence and Chronology of Nesting of Waterfowl in the Sturgeon River Basin:

1.) Methods:

Determination of the incidence of waterfowl nesting was restricted to an investigation of some of the islands on Lac Ste. Anne and Isle Lake. Chronology of the nesting season was determined from data gathered during the brood survey. Using the mean age in days given by Gollop and Marshall (1954) for the different age classes of broods of each species of waterfowl, the hatching dates for each brood were determined by back-dating. Using a mean incubation period of 25 days and laying period of approximately 10 days (determined from Godfrey, 1966 and Welty, 1962) the commencement of laying was determined by further back-dating. Townsend (1966) also used 35 days as the average interval between nest initiation and hatching.

2.) Results and Discussion:

The island on the eastern portion of Lac Ste. Anne was the only island which received concentrated use by nesting ducks. However, its very small size (approximately one acre) limited the number of nests. When the island was visited on June 3, six pintail nests, two mallard nests, and two very young mallard broods were observed in addition to 78 nests of common tern.

The dates of initiation of egg laying by 440 ducks in the

Sturgeon River basin are shown in Figure 3. The peak in mid-April represents commencement of nesting primarily by mallards. The second peak in mid-May reflects nesting starts by other dabblers and divers.

Figure 4 shows the hatching dates of 440 waterfowl nests. Most of the mallard clutches hatch at the end of May resulting in the first peak. The peak of hatching for other species is a month later.

Considering the data presented in Figures 3 and 4 together, it is apparent that the nesting period for waterfowl in the Sturgeon River basin extends from approximately April 10 to July 30. Stable water levels during this period would be of critical importance, especially for divers. After studying the breeding ecology of the redhead duck in Western Montana, Lokemoen (1966) stated that water levels beneath the emergent vegetation must remain stable during the nesting season and the vegetation should be flooded before the birds arrive on the area in the spring. He also pointed out that, "When water dried beneath the nest, it was usually deserted or destroyed", and that, "flooding is cited as an important cause of nest loss in most redhead studies". Rogers (1964) cited Mendall (1958) as reporting that if unfavorable water levels occurred just before nesting, low breeding populations of ring-necked and black ducks often resulted. A decrease in water levels resulted in a decline in nesting success of lesser scaup in southwestern Manitoba (Rogers, 1964). Presence of mudflats

FIGURE 3

Time of First Egg Laying by 440 Ducks in the Sturgeon River Basin, 1971.

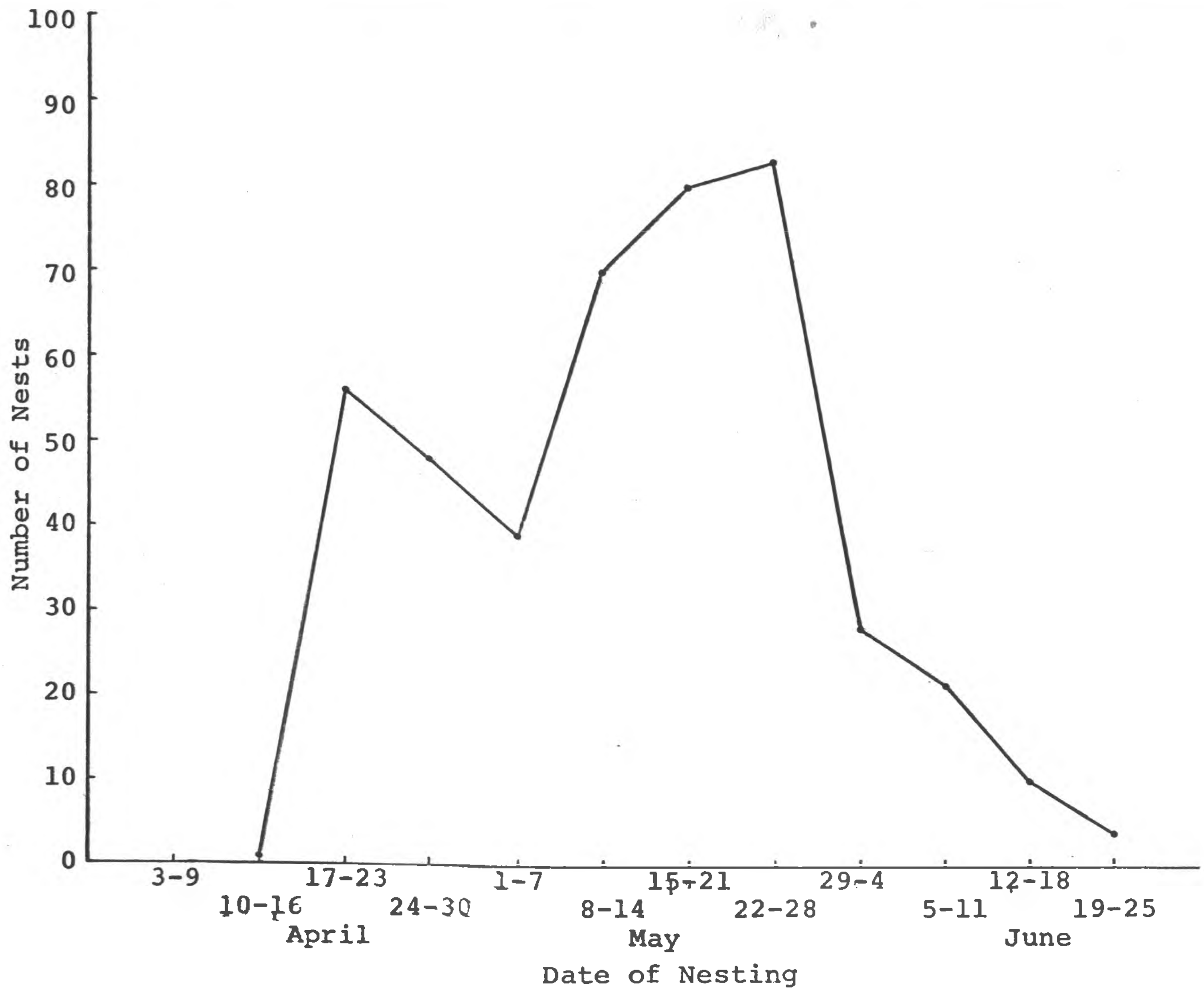
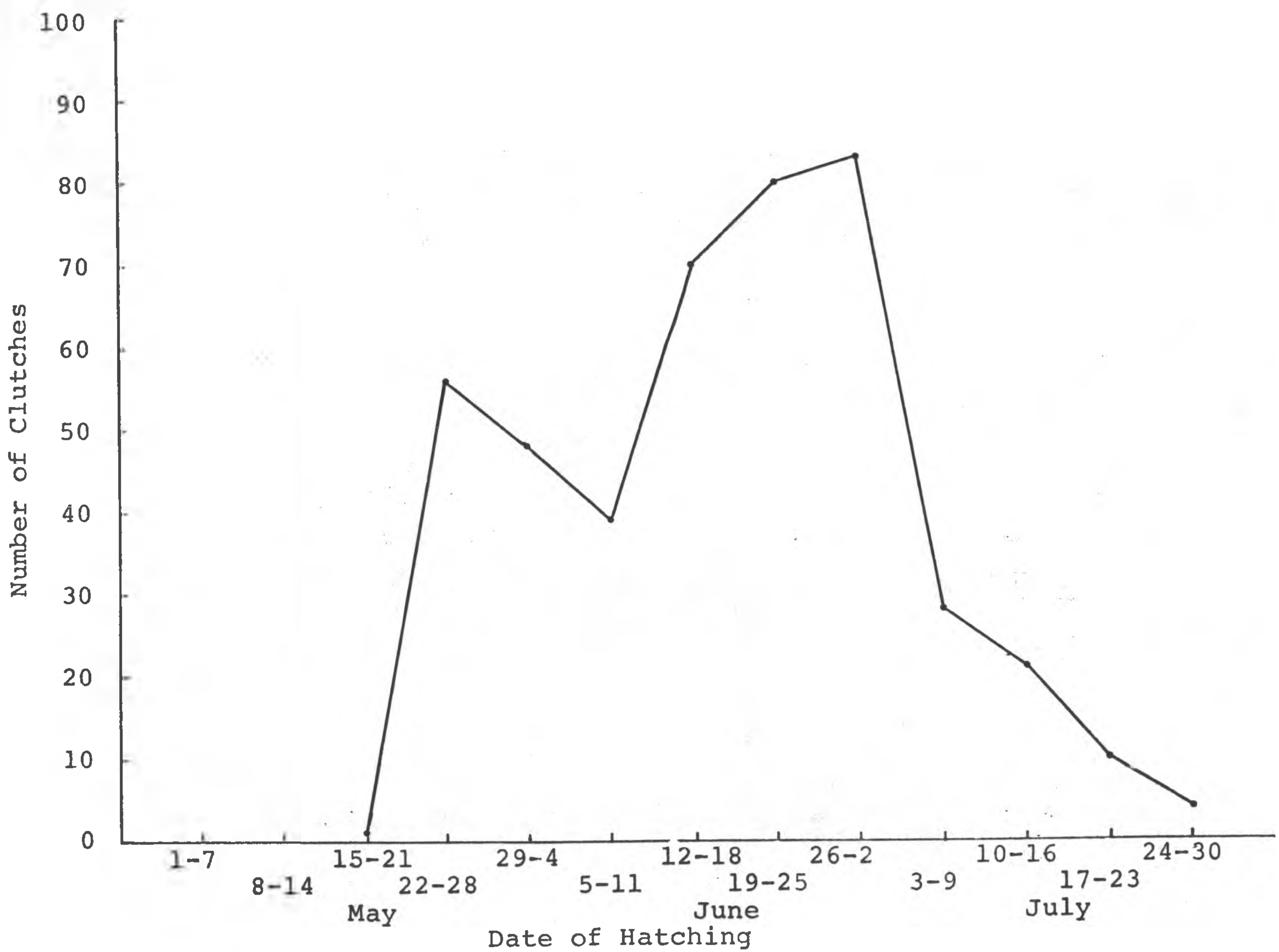


FIGURE 4

Time of Hatching in Waterfowl of the Sturgeon River Basin, 1971.



resulted in inhibition of nesting associated with follicular atresia*. Any nesting efforts were subject to heavy predation by skunks. Johnsgard (1956) who studied the effects of water fluctuations on vegetation and birds in the impoundment behind the O'Sullivan Dam in Washington concluded that flooding of larger potholes has greatly reduced total waterfowl production. Townsend (1966) stated that between ice breakup at the end of April and the beginning of waterfowl nesting on the Saskatchewan River Delta, there is very little time in which to raise or lower water levels without destroying mallard and canvasback nests in particular. He recommended that since 95% of the successful nests were not completed until July 20th, water levels should not be changed before this date.

Relatively stable water levels are important to waterfowl after the broods appear as well as before and during the nesting period. A drawdown of a waterfowl impoundment in Michigan was reported to be extremely detrimental to invertebrate life (Kadlec, 1962). Invertebrates are the principal food of all species of young ducklings and are an important component of their diet as they grow older (Beard, 1953; Sugden, 1965). A change in water level resulting in a sharp reduction in invertebrate populations during the period when broods are young could therefore have an adverse effect on waterfowl production.

* Reabsorption of egg follicles in the females which precludes further egg laying and nesting.

c.) Brood Survey:

1.) Methods:

Two brood surveys were carried out on Isle Lake, Lac Ste. Anne, Matchayaw Lake, and Big Lake. The first survey of these lakes was done between July 8th and July 14th while the second was undertaken from August 1st to August 6th. Broods on Hoople Lake were censused on July 5th and July 29th. A single brood survey of the Sturgeon River was done between July 6th and July 19th. No brood survey was done on the Pembina River because the aerial survey on May 11th indicated that breeding pair use of this river was very low.

An airboat was used for the survey on the four large lakes and parts of the Sturgeon River. This craft was very useful for brood surveys since it could cruise through the centre of the emergent vegetation band along the shoreline. The entire length of the shoreline of each lake and its islands was followed. Travelling at a speed of approximately 15 - 20 mph, it was possible to overtake broods quickly before they could reach dense cover. Where emergent vegetation zones were wide, a zig-zag route was taken to thoroughly cover the area. With three observers watching for broods, it is felt that at least 80% of the broods present were recorded.

The broods were speciated usually by identifying the female, although some broods were unidentified. The number of ducklings in each brood was recorded and the age of the brood was estimated by the method used by Gollop and Marshall (1954). Few counts of the number of ducklings in a brood were complete because they often scattered and dove to escape the airboat. The ages of the broods were recorded primarily so that it could be determined whether or not broods counted during the second survey could have been present during the first survey. In this way it was possible to combine the results of the two surveys without recording the same brood twice. Two brood surveys were conducted so that data on both early and late nesting waterfowl would be obtained.

Sections of the Sturgeon River on which it was not possible to use the airboat were censused by kayak and on foot. During the second brood survey of the lakes, the airboat developed mechanical difficulties after travelling around Isle Lake and the west section of Lac Ste. Anne. This necessitated the use of the kayak and boat for surveys of Big Lake and Matchayaw Lake. The east section of Lac Ste. Anne was not censused a second time.

2.) Results and Discussion:

The numbers of broods of each species of waterfowl observed on Isle Lake during two surveys are shown in Table 40. A total of 98 broods were observed during the first survey while 55 were observed on the second survey. Using the mean age in days given by Gollop and Marshall (1954) for each age class of brood it was possible to determine which broods observed on the second survey were likely to have been observed on the first survey as well.

TABLE 40

Numbers of Waterfowl Broods Observed during Two Surveys on Isle Lake in 1971

	July 8 Survey								August 6 Survey								
	Ia	Ib	Ic	IIa	IIb	IIc	IIIa	Total	Ia	Ib	Ic	IIa	IIb	IIc	IIIa	Total	CT*
Dabblers																	
Mallard	1	1	5	6	11	15	14	53				1	1	3	8	13	59
Pintail			1				1	2									2
Green-winged teal																	
Blue-winged teal	1		2					3			1		2	2	1	6	7
Shoveler																	
Am. Widgeon	2	2	4	4	1			13					2	5	1	8	16
Gadwall		1						1				1				1	2
Total Dabblers	4	4	12	10	12	15	15	72			1	2	5	10	10	28	86
Divers																	
Redhead																	
Canvasback							1	1						1		1	2
Lesser Scaup	1							1				3	3	2	1	9	9
Common Goldeneye		2	4	3				9			1	1			3	5	11
Bufflehead		1						1									1
White-winged Scoter											1					1	1
Total Divers	1	3	4	3			1	12		1	1	4	3	3	4	16	24
Unidentified	1		2	3	3	2	3	14		2	1	2		3	3	11	23
Grand Total	6	7	18	16	15	17	19	98		3	3	8	8	16	17	55	133

Number of broods per mile of shoreline = 4.6

* Combined Total

This resulted in the elimination of 20 of the broods seen on the second survey as they had probably already been counted on July 8. The total number of distinct broods observed during the two surveys combined was 133 or 4.6 broods per mile of shoreline.

It is interesting to note that during the second survey, divers made up a much greater proportion of the total broods seen during the first survey. This reflects their characteristic of generally nesting later than dabbler species.

The most common broods observed were mallards and the most common diver broods were common goldeneye. These results correspond with the most common dabbler and diver breeding pairs observed on Isle Lake (Table 30). Comparing the number of dabbler and diver broods observed (Table 40) with the number of dabbler and diver breeding pairs (Table 30) indicates a production success of 45% for dabblers and 10% for divers. The success rate of 45% for dabblers would be an underestimate since probably not all dabbler broods were seen during the brood survey. This success rate is not unusual, however, since Townsend (1966) calculated the percent nesting success for dabblers on the Saskatchewan River Delta as 56 $\pm$ 14%. The diver success rate given was 70 $\pm$ 7%. This is much higher than the success rate observed for divers in this study. Townsend (1966) points out that the figures he calculated are overestimates since they do not take into account the bias resulting from incomplete nest histories. Dzubin (1969) found that on his study area near Kindersley, Saskatchewan, 48 percent of the indicated population of diver pairs nested in 1956, 38 percent in 1957, 39 percent in 1958 and 3 percent in 1959. These figures are still higher on the average than the productive success found in this study. There are at least five possible reasons for this low success rate. First, it is impossible to differentiate migrating pairs from residents and non-breeding from breeding pairs (Smith and Hawkins, 1948). Some of the pairs seen on June 1st may have been migrating pairs while others were non-breeding pairs. Presence of birds falling into these categories was probably the main factor responsible for the low calculated success rate. Dzubin (1969) found that many pairs of lesser scaup, canvasback, and redhead remained on his study area without making any attempt to nest. Second, nests may have been flooded by rising water levels in June and early July following an extended rainy period. Third, several nests may have been destroyed by people since the lake is heavily used by vacationers. Fourth, some broods may have been missed during the brood surveys. Fifth, other factors such as predation and violent wave action may have destroyed some nests.

Lane and Lynch (1969) estimated brood density on Isle Lake to be approximately 11.1 per mile of shoreline based on three brood beat-outs over 12% of the shoreline. These results are not directly comparable to the results obtained in this study. It appears that Lane and Lynch simply added the number of broods observed on each of three surveys to obtain a total number of broods (Lane and Lynch, 1969 p. 119). This number was then divided by the number of miles sampled (in their case, 3.5 miles) to arrive at the number of broods per mile. There is no indication that ages of broods were taken into account to prevent duplication of counts of broods during surveys subsequent to the first. If this was not done, a significant overestimation of the number of broods could result. In addition, shoreline habitat differs significantly and a sample bias may have occurred in 1969 estimates.

Table 41 shows the results of brood surveys on the portion of Lac Ste. Anne west of the Narrows. Twenty-three broods were seen during the first survey and 23 broods were seen on the second survey. Combining the results of the two surveys taking into consideration ages of broods to prevent duplication of counts, a total of 41 different broods were observed. Since there are approximately 22.8 miles of shoreline in the west section of Lac Ste. Anne, 41 broods represents 1.8 broods per mile of shoreline. This is a significantly lower density of broods than was found on Isle Lake and may be a result of a difference in habitat conditions which will be discussed later.

The proportion of diver broods observed during the second survey was much greater than during the first survey, a phenomenon observed on Isle Lake and attributed to the delayed nesting of divers. Mallards, the most common species of breeding pairs observed on the west section of Lac Ste. Anne (Table 31) produced the most broods. The most common diver broods were lesser scaup. Lesser scaup breeding pairs were slightly less abundant than common goldeneye during the spring.

TABLE 41

Numbers of Waterfowl Broods Observed in 1971 during Two Surveys of Lac Ste. Anne West of the Narrows

	July 9 Survey Ia	Ib	Ic	IIa	IIb	IIc	IIIa	Total	August 6 Survey Ia	Ib	Ic	IIa	IIb	IIc	IIIa	Total	CT*
Dabblers																	
Mallard				2	2	1	11	16		1		2			2	5	19
Pintail																	
Green-winged teal													1			1	1
Blue-winged teal		1						1						2		2	2
Shoveler																	
Am. Widgeon		1						1						2		2	2
Gadwall																	
Total Dabblers		2		2	2	1	11	18		1		2	1	4	2	10	24
Divers																	
Redhead																	
Canvasback														1	1	2	2
Lesser Scaup				1				1			1		4	3	1	9	10
Common Goldeneye				1				1									1
Bufflehead																	
White-winged Scoter																	
Ruddy Duck																	
Total Divers				2				2			1		4	4	2	11	13
Unidentified		1			2			3					1	1		2	4
Grand Total		3		4	4	1	11	23		1	1	2	5	8	4	23	41

Number of broods per mile of shoreline = 1.8

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* Combined Total

Comparison of the number of dabbler and diver broods to the number of breeding pairs of dabblers and divers observed on the west section of Lac Ste. Anne indicates a reproductive success of 11% for dabblers and 33% for divers. It appears from these results that habitat conditions were more favorable for divers than for dabblers.

The numbers of broods seen on a single survey of the east section of Lac Ste. Anne are shown in Table 42. A total of 36 broods were observed. The most common dabbler broods were mallard, and common goldeneye were the most common diver broods. The number of additional broods which would have been seen had a second survey been done, can be estimated on the basis of the number of broods seen on Isle Lake and the west section of Lac Ste. Anne during the second survey of those areas. Calculations result in the addition of 15 broods to the total observed on the east section of Lac Ste. Anne resulting in a new total of 51 broods. This represents a density of 2.6 broods per mile of shoreline; higher than the west section of Lac Ste. Anne but a somewhat lower density than that observed on Isle Lake.

The production success rate for dabblers and divers on the east section of Lac Ste. Anne was 12% and 37% respectively These figures are very similar to the corresponding success rates for the west section of the lake. The reasons for the relatively low calculated production success on Lac Ste. Anne are probably similar to those suggested in the discussion of results for

TABLE 42

Numbers of Waterfowl Broods Observed in 1971 during a Single Survey of Lac Ste. Anne

East of the Narrows

	July 9 Survey Ia	Ib	Ic	IIa	IIb	IIc	IIIa	Total
Dabblers								
Mallard				3	4	6	6	19
Pintail								
Green-winged teal								
Blue-winged teal		2	1					3
Shoveler								
Am. Widgeon				2				2
Gadwall								
Total Dabblers		2	1	5	4	6	6	24
Divers								
Redhead								
Canvasback		1		2				3
Lesser Scaup		1		1				2
Common Goldeneye			1	1	2			4
Bufflehead								
White-winged Scoter								
Ruddy Duck								
Total Divers		2	1	4	2			9
Unidentified			1		2			3
Grand Total		4	3	9	8	6	6	36

Number of broods per mile = 2.6

Isle Lake. The higher success rate for divers may result from less use of Lac Ste. Anne by migrating or non-breeding pairs and from better habitat conditions on Lac Ste. Anne.

Lane and Lynch (1969) report a brood density of 12.6 broods per mile on Lac Ste. Anne. This figure is not directly comparable to results obtained in the present study for reasons previously outlined.

The results of brood surveys on Matchayaw Lake are presented in Table 43. Nineteen broods were seen during the first survey and 15 were seen during the second survey. A total of 30 different broods or an average of 7.5 broods per mile of shoreline were observed on the two surveys combined. Although mallards and blue-winged teal outnumbered American widgeon during the breeding pair survey, the latter species produced the most observed broods. Common goldeneye, outnumbered by lesser scaup during the spring, was the most commonly observed diver species with a brood. The lack of an increase in the number of diver broods during the second survey as occurred on Isle Lake and Lac Ste. Anne may be a result of a higher rise in the water level of Matchayaw Lake following the rainy period. Many of the diver nests, lesser scaup in particular, may have been flooded.

The production success rate for dabblers was 30% while that for divers was only 13%. The reasons for these relatively low calculated success rates are probably similar to these outlined in the discussion of results for Isle Lake.

TABLE 43

Numbers of Waterfowl Broods Observed during Two Surveys of Matchayaw Lake in 1971

	July 9 Survey								August 2 Survey								
	Ia	Ib	Ic	IIa	IIb	IIc	IIIa	Total	Ia	Ib	Ic	IIa	IIb	IIc	IIIa	Total	CT*
Dabblers																	
Mallard			1	1			1	3			2			1	1	4	5
Pintail																	
Green-winged teal																	
Blue-winged teal				2				2									2
Shoveler															1	1	1
Am. Widgeon	1			2			1	4			3	1		3	1	8	12
Gadwall																	
Total Dabblers	1		1	5			2	9			5	1		4	3	13	20
Divers																	
Redhead																	
Canvasback		1						1									1
Lesser Scaup																	
Common Goldeneye			1	2	2			5							1	1	5
Bufflehead																	
White-winged Scoter																	
Ruddy Duck																	
Total Divers		1	1	2	2			6							1	1	6
Unidentified			2	1	1			4							1	1	4
Grand Total	1	1	4	8	3		2	19			5	1		4	5	15	30

Number of broods per mile of shoreline = 7.5

* Combined Total

The extremely high density of broods (41 per mile of shoreline) reported by Lane and Lynch (1969) for Matchayaw Lake is not directly comparable to the figure obtained in this study for reasons previously stated. However, results of both investigations indicated that waterfowl on Matchayaw Lake produce a significantly greater number of broods per mile of shoreline than waterfowl on Isle Lake or Lac Ste. Anne.

Table 44 shows the results of the brood surveys on Big Lake. A total of 121 broods were observed during the first survey of Big Lake. The most common species of dabbler brood observed was blue-winged teal with shoveler and mallard almost as numerous. Diver broods were scarce with scaup as the most abundant. The second survey which was done by motor boat yielded 34 broods, 18 of which had probably been seen during the two surveys. Since it was impossible to travel through much of the shallow marsh area with the motor boat, only a portion of the broods actually present were observed during the second survey. Using the percentage of additional broods seen on Isle Lake and Lac Ste. Anne during the second survey, calculations show that an additional 53 broods may have been present on Big Lake during the second survey. This would result in a total of 174 broods or 8.7 broods per mile of shoreline.

The ratio of diver broods to dabbler broods on Big Lake did not appear to increase significantly between surveys. This was similar to the situation on Devil's Lake. The levels of

TABLE 44

Numbers of Waterfowl Broods Observed During Two Surveys of Big Lake in 1971

	July 12 Survey								August 1 Survey								
	Ia	Ib	Ic	IIa	IIb	IIc	IIIa	Total	Ia	Ib	Ic	IIa	IIb	IIc	IIIa	Total	CT*
Dabblers																	
Mallard			1	3	6	3	7	20					2		2	4	22
Pintail			2	7	1		3	13									13
Green-winged teal																	
Blue-winged teal		5	4	8	2	5	3	27		1	1		1	3		6	29
Shoveler		1	2	5	7	4	4	23				1	2		5	8	25
Am. Widgeon				1				1									1
Gadwall																	
Total Dabblers		6	9	24	16	12	17	84		1	1	1	5	3	7	18	90
Divers																	
Redhead				1				1									1
Canvasback													1	1	1	3	3
Lesser Scaup		1	3					4			1					1	5
Common Goldeneye					1			1									1
Bufflehead																	
White-winged Scoter																	
Ruddy Duck																	
Total Divers		1	3	1	1			6			1		1	1	1	4	10
Unidentified	2	3	7	10	6	1	2	31			2	4	5	1		12	37
Grand Total	2	10	19	35	23	13	19	121		1	4	5	11	5	8	34	137

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* Combined Total

both these lakes appeared to rise more than Isle Lake or Lac Ste. Anne following rain in June. This rise may have resulted in more of the diver nests being flooded on Matchayaw Lake and Big Lake. The production success rate for divers on Big Lake was very low - approximately 5% based on 10% of 174 broods being diver broods. The success rate of dabblers was 14%.

The low calculated success rate for waterfowl on Big Lake is probably primarily an artifact due to the difficulty of distinguishing migrating from resident and breeding from non-breeding pairs. Big Lake is well known as a staging area for waterfowl in spring and fall (Alberta Department of Lands and Forests Fish and Wildlife Division, 1965; Surrendi, 1969, CLI map #83H). Although the other lakes studied appeared to be used for staging also, their use was not as concentrated as on Big Lake. Hence, it is probable that a considerable number of migrating and non-breeding pairs were enumerated as indicated pairs during the spring survey.

Despite the low calculated success rate, actual brood production on Big Lake was high - higher than on any of the other lakes studied. These results confirm statements expressed by the Alberta Department of Lands and Forests Fish and Wildlife Division, 1965 and Surrendi, 1969 regarding the waterfowl productivity of Big Lake.

Two surveys of Hoople Lake resulted in observations of two common goldeneye, two lesser scaup, two widgeon, and one unknown dabbler broods. Both the results of the breeding pair survey and the brood survey indicate that the waterfowl habitat on Hoople Lake is better suited to divers than to dabblers.

Table 45 shows the number of broods observed during a single survey of 46.5 miles of the Sturgeon River where canalization is proposed and 27.4 miles where no canalization will be done. Results show that sections of the river where canalization is proposed had a greater density of broods than the other sections. Forty-seven broods (one brood per mile of stream) were seen along sections proposed for modification while sixteen broods (0.6 per mile of stream) were observed on the sections where no canalization is proposed. The lower brood density on reaches of the river where no modifications are planned corresponds with the lower number of breeding pairs seen on these sections in the spring. The probable explanation for the difference in waterfowl breeding pair use and production in the two types of sections relates to habitat quality. This factor will be discussed in more detail later in the report.

Production on the Sturgeon River is lower than on any of the lakes studied. Production success for both dabblers and divers was low on both sections. Only 6% of the indicated breeding pairs of dabblers and 11% of the divers were successful in raising a brood on sections where canalization is proposed. Five percent of the indicated breeding pairs of dabblers and 7% of the divers were successful on sections where no canalization is proposed. The low calculated success rates are probably primarily related to the fact that many of the indicated breeding

TABLE 45

Numbers of Waterfowl Broods Observed in 1971 during Single Surveys of Sections of the Sturgeon River where Canalization is Proposed and Sections where Canalization is not Proposed.

	Canalization								No Canalization								
	July Survey								July Survey								
	La	Ib	Ic	IIa	IIb	IIc	IIIa	Total	Ia	Ib	Ic	IIa	IIb	IIc	IIIa	Total	CT
Dabblers																	
Mallard		2	2	1	4	1	2	12			1	1	1	1	2	6	18
Pintail							3	3									3
Green-winged teal																	
Blue-winged teal	1	1	1	3				6				1		1		2	8
Shoveler	1		1		2		2	6									6
Am. Widgeon							1	1	1							1	2
Gadwall					1			1									1
Total Dabblers	2	3	4	4	7	1	8	29	1		1	2	1	2	2	9	38
Divers																	
Redhead																	
Canvasback																	
Lesser Scaup										1	1					2	2
Common Goldeneye	2	1	1	3				7				1	1			2	9
Bufflehead																	
White-winged Scoter																	
Ruddy Duck																	
Total Divers	2	1	1	3				7		1	1	1	1			4	11
Unidentified		3	2	6				11		1	1				1	3	14
Grand Total	4	7	7	13	7	1	8	47	1	2	3	3	2	2	3	16	63

Number of broods per mile of stream = 1.0   Number of broods per mile of stream = 0.6

* Combined Total

pairs recorded were actually migrating or non-breeding pairs. In addition flood waters on the river may have destroyed many nests. Other factors including those cited in the discussion of results of the brood survey on Isle Lake may be important.

Since only one survey of the river was conducted, the omission of broods appearing later in the summer would account in part for the low calculated success rates.

d.) Use of the Lakes and Pembina River by Staging Waterfowl:

The use of all four major lakes along the Sturgeon River as migration stops at least by divers was evident from the results of the breeding pair census (see Table 28). Lane and Lynch (1969) found relatively large concentrations of waterfowl using Isle Lake and Lac Ste. Anne during the late summer. These were likely moulting ducks which had moved in from surrounding areas.

Big Lake is heavily used by staging waterfowl according to the Canada Land Inventory and the Alberta Fish and Wildlife Division. In a report by the Alberta Fish and Wildlife Division to the Edmonton Regional Planning Commission (1965), it was reported that 26,000 ducks were seen during an aerial survey of Big Lake on September 3, 1964. In early september of 1971, a large concentration of waterfowl was observed on Big Lake. Photo 13 shows approximately 2,000 waterfowl rising from the west end of Big Lake.

Photo 13: Approximately 2,000 waterfowl rising from the west end of Big Lake. Extensive areas exposed by receding water levels on Big Lake provide loafing areas for thousands of ducks each fall.

Hoople Lake was observed being used as a migration stop by approximately 25 swans on October 16, 1971.

The Pembina River was also heavily used by staging waterfowl in the latter part of September and October. During a boat trip between Sangudo and Belvedere on October 1, 1971, approximately 2,100 ducks, mostly mallards, were observed.

e.) Waterfowl-Habitat Relationships in the Sturgeon and Pembina River Basins:

Table 46 shows that in order of decreasing intensity of use by waterfowl breeding pairs and broods, the major lakes of the Sturgeon River Basin are: Big Lake, Matchayaw Lake, Isle Lake, Lac Ste. Anne (east), and Lac Ste. Anne (west).

TABLE 46

Summary of Waterfowl Use on Four Lakes in the Sturgeon River Basin During the Summer of 1971.

	Breeding pairs per mile	Broods per mile
Big Lake	74.0	8.7
Matchayaw Lake	32.8	7.5
Isle Lake	18.0	4.6
Lac Ste. Anne (east)	17.3	2.6
Lac Ste. Anne (west)	12.7	1.8

The greatest proportion of emergent vegetation to lake shoreline occurred on Big Lake. Emergent vegetation is important as nesting cover especially for diving ducks and as brood and moulting cover for ducks in general. Seeds and invertebrates associated with emergent plants are important duck foods (Beard, 1953; Keith, 1961). Good interspersion of open water with emergent vegetation was characteristic of the vegetation zone around Big Lake (Photos 14 and 15). This is another criterion of good waterfowl habitat (Beard, 1953; Trauger, 1964; Cowardin, 1969). Beard (1953) pointed out that because of their method of feeding, dabbling ducks are restricted to relatively shallow water with approximately 6 - 18" as the optimum depth. Thus, the extensive areas of flooded sedge are ideal for dabbler species. Submergent vegetation in Big Lake, though not as common as in some of the other lakes, was by no means scarce. Water milfoil and sago pondweed, two indicators of environmental conditions productive for broods (Trauger, 1964), were locally abundant. An additional factor contributing to the suitability of Big Lake for waterfowl is its relative freedom from human disturbances during the summer. Nesting cover around Big Lake is generally quite good - the primary limitations being an almost solid forest cover on the south side, cultivated land on the north side, and the tendency of the lake to flood the extensive flat marsh meadow used by diving ducks.

As indicated by the foregoing, a combination of factors are responsible for the fact that Big Lake is an excellent production area for waterfowl. These same factors are also probably responsible for its value as an excellent staging area. The late summer drawdown stimulates seed production in aquatic plants and exposes

Photo 14: Looking north across the Sturgeon River delta on Big Lake. An extensive area of flooded sedge well interspersed with open water forms excellent habitat for broods and moulting ducks. The large shallow area also provides good muskrat habitat. A small reduction in water level would reduce the area of waterfowl and muskrat habitat considerably. A small in-rease in water level may flood many acres of nesting habitat.

Photo 15: Close-up view of waterfowl habitat in Big Lake. A mallard brood which was feeding in a shallow open water area moves toward escape cover provided by sedge close by.

large areas suitable for loafing, an additional attraction for large numbers of waterfowl.

The Canada Land Inventory classifies Big Lake as "IS", an area having no significant limitation to the production of waterfowl and also serving as an important migration stop.

Matchayaw Lake which can be rated as an excellent waterfowl lake on the basis of observed breeding pair and brood use was, however, somewhat less productive than Big Lake. Being a relatively small lake the proportion of littoral zone in the lake was greater than in Isle Lake or Lac Ste. Anne. As was indicated in the section on aquatic vegetation, abundant cattail and bulrush were present to provide nesting and brood cover for ducks. A good growth of sago pondweed, water milfoil and clasping leaf pondweed, all of which are indicators of productive conditions for broods (Trauger, 1964) was present in the lake. Upland meadows on the east side of Matchayaw Lake provide good nesting cover. However, the marsh meadow on the west side of the lake has a tendency to become flooded during periods of high water.

The Canada Land Inventory classifies Matchayaw Lake as an area having slight limitations to the production of waterfowl. The limitation is excessively deep water precluding the development of optimum waterfowl habitat in the central part of the lake.

Isle Lake, a much larger lake than Matchayaw Lake, showed a significant amount of use by waterfowl though would probably not be rated first class. Emergent vegetation associations were abundant and well interspersed. Because of the rather specific water depth tolerances of the various plant associations, in most cases an open or sparsely vegetated area separated one type of association from another. This provided feeding areas with freedom of movement close to escape cover. The most common submergent plants in Isle Lake were once again water milfoil, clasping leaf pondweed and sago pondweed, important food species and indicators of a productive lake for waterfowl. Nesting cover on Isle Lake is somewhat limited by almost complete forest cover along the lake shoreline and by cottage development. Although dabblers nest in forest covered areas, they prefer upland meadow.

Isle Lake is classified by the Canada Land Inventory as having moderately severe limitations to waterfowl production primarily excessively deep water causing a reduced marsh edge.

The east section of Lac Ste. Anne received moderate use by waterfowl. It has previously been pointed out that the composition of the emergent vegetation zone in this section of the lake was very similar to that on Isle Lake. However, interspersion of the plant associations was not as good on Lac Ste. Anne. This becomes apparent when one compares the sums of numbers of plant associations and openings per mile on each lake (see Tables 23 and 25). The result is a total of 6.76 for Isle Lake and 6.35 for Lac Ste. Anne. These might be called indices of interspersion. The slightly higher index for Isle Lake indicates a more favorable habitat for waterfowl on that lake. Reed, a plant generally not favored by waterfowl (Goodman, 1967) was more abundant on Lac Ste. Anne than on Isle Lake. The more abundant growth of submergents in Isle Lake is another more attractive habitat component on Isle Lake which serves to explain the lower waterfowl use of the east section of Lac Ste. Anne. The relatively large amount of forest cover and cottage development along the edge of the east section of Lac Ste. Anne limits to some extent preferred waterfowl nesting cover.

The east section of Lac Ste. Anne is classified by the Canada Land Inventory as having moderate limitations to waterfowl because of excessively deep water. It would appear from the results of this study that limitations to waterfowl production on Isle Lake are less than the limitations on the east part of Lac Ste. Anne, contrary to the CLI rating.

The west section of Lac Ste. Anne received the least amount of use by waterfowl. In general, interspersion of plant associations was less favorable on this section of Lac Ste. Anne than on the east section or Isle Lake. The "index" was only 5.86 (Table 24). The section of Lac Ste. Anne west of the upstream Narrows was characterized by a solid band of sedge and cattail with other plant associations absent. Dense cattail is not characteristically good waterfowl habitat. Keith (1961) found that removal of cattail from potholes in southern Alberta resulted in waterfowl usage being increased almost four times that of unsprayed potholes. Keith felt that dense cattail was undesirable to waterfowl since it decreased accessibility to shoreline loafing areas and their view of shorelines and adjacent terrain. Submergent plants were virtually non-existent in the far west section of Lac Ste. Anne, possibly because of the highly organic substrate (van der Valk, 1970). Preferred nesting habitat is limited by the almost entirely wooded shoreline.

The Canada Land Inventory classifies the major portion of the west section of Lac Ste. Anne as having moderate limitations with respect to waterfowl production with the section west of the upstream Narrows receiving a higher classification. It is interesting to note that in the present study, the far west section received the least amount of waterfowl use. In addition, an area on the east side of the west section received the high rating of Class 2. This area was characterized by extensive growth of reed and little waterfowl use.

These discrepancies are likely a result of the more generalized nature of Canada Land Inventory data and the fact that ratings are oriented towards physical criteria rather than use or actual populations.

Hoople Lake with its sedge border, abundant sago pondweed, and abundant adjacent nesting cover appeared to be ideal habitat especially for divers. The lack of a wide shallow zone with well interspersed emergents probably explains the relatively low use of this lake by dabblers as compared with divers.

Along the Sturgeon River, the best waterfowl habitat corresponds to the sections of the river with the most abundant aquatic vegetation. These sections include most of the stretch between Isle Lake and Lac Ste. Anne, the section between Lac Ste. Anne and Matchayaw Lake especially the marshy section near Lac Ste. Anne, the first 2.5 miles downstream from Matchayaw Lake, and approximately the first 10 miles of river channel downstream from Big Lake. None of these sections, however, contained high quality waterfowl habitat. Sedge was the primary emergent in most sections and along much of the 2.5 miles of river channel downstream from Matchayaw Lake was a dense band of cattail. Interspersion was rarely optimum. However, in most cases, submergent vegetation included species characteristic of the best waterfowl habitat.

Limitations to waterfowl production along the Sturgeon River according to the Canada Land Inventory vary from none to moderately severe. Between Hoople Lake and Isle Lake, limitations are moderate. Between Isle Lake and Lac Ste. Anne, slight limitations result from relatively fast flowing water and reduced marsh edge. From Lac Ste. Anne to Matchayaw Lake, limitations are moderate. The area corresponding to the fist 2.5 miles downstream from Matchayaw Lake is given a first rate classification. Present waterfowl use of this reach is limited by the dense cattail zone along the edge. The remainder of the section of river from Matchayaw Lake to the mouth of the Riviere Qui Barre is within an area generally rated as having slight limitations to waterfowl production. The Sturgeon River from the mouth of the Riviere Qui Barre to Big Lake is within an area rated as having moderately severe limitations. The remainder of the river to the North Saskatchewan River has moderate limitations resulting from inhibition of aquatic vegetation growth by fast flowing water and adverse topography.

Along the Pembina River, the only waterfowl habitat of any significance was contained in the oxbows. Many of these contain emergent and submergent vegetation characteristic of good waterfowl habitat. The maintenance of the vegetation in a successional stage desirable to waterfowl is dependent on periodic flooding by the Pembina River.

According to the Canada Land Inventory, the Pembina River has severe limitations to waterfowl because the usually steep banks and fast water inhibit the growth of marsh vegetation. The reach of the river characterized by an abundance of oxbows was given a somewhat higher classification.

f.) <u>Summary</u>:

1.) Isle Lake is a moderate producer of waterfowl. An average of 8.0 indicated pairs of dabblers and 10.0 indicated pairs of divers per mile of shoreline were observed in 1971. Brood production averaged 4.6 broods per mile of shoreline. The lake is heavily used by staging waterfowl.

2.) The west section of Lac Ste. Anne received the lowest waterfowl use of all the lakes studied. Dabblers averaged 10.9 pairs per mile while divers averaged 1.9 pairs per mile. An average of 1.8 broods per mile of shoreline were observed.

3.) The east section of Lac Ste. Anne received slightly less use by waterfowl than Isle Lake. An average of 15.3 pairs of dabblers and 2.0 pairs of divers per mile of shoreline were observed. Observed brood production averaged 2.6 broods per mile.

4.) Matchayaw Lake is a first rate waterfowl lake with an average of 19.3 dabbler pairs and 13.5 diver pairs observed per mile of shoreline. An average of 7.5 broods per mile of shoreline were observed.

5.) Big Lake received the greatest intensity of waterfowl use. Dabblers averaged 55.4 pairs per mile and divers, 18.6 pairs per mile of shoreline. Brood production averaged 8.7 broods per mile of shoreline.

6.) Overall use of the Sturgeon River by waterfowl was low. Specific sections of the river, particularly sections immediately downstream from the lakes contained good waterfowl habitat and received moderate waterfowl use.

7.) The Pembina River was unproductive of waterfowl but received some use by staging ducks. The only habitat of any significance for waterfowl production occurs in oxbows adjacent to the river.

8.) Differences in intensity of waterfowl use of the lakes and rivers studied generally reflects differences in quantity and quality of waterfowl habitat.

2.) Populations and Nesting of Birds Other than Waterfowl in the Sturgeon River Basin:

Information on populations and nesting of avian species other than waterfowl was obtained incidentally to waterfowl studies. Numbers of western grebe (*Aechmophorus occidentalis*), red-necked grebe (*Podiceps grisegena*), eared grebe (*Podiceps caspicus*), horned grebe (*Podiceps auritus*), American coot (*Fulica americana*), and great blue heron (*Ardea herodias*) were recorded during the spring waterfowl surveys. The greatest numbers observed on any one survey are present in Table 47.

TABLE 47

Spring Populations of Grebes, Coots, and Herons on Four Major Lakes of the Sturgeon River Basin, 1971.

	Numbers of Birds seen					
	Western Grebe	Red-necked Grebe	Eared Grebe	Horned Grebe	Coot	Great Blue Heron
Big Lake	-	21	403	6	219	2
Matchayaw Lake	-	2	47	8	8	2
Lac Ste. Anne	513	402	1	4	56	29
Isle Lake	84	191	35	-	18	25

Western grebe were common on Isle Lake and abundant on Lac Ste. Anne. They were not observed on Big Lake or Matchayaw Lake. Few red-necked grebe were present on Big Lake and Matchayaw Lake but were abundant on Lac Ste. Anne and Isle Lake. Eared grebe exhibited a distribution complementary to that of the red-necked grebe being abundant on Big Lake and Matchayaw Lake but rather scarce on Lac Ste. Anne and Isle Lake. Horned grebes were not common on any of the lakes. Coots were abundant on Big Lake but present in moderate numbers on the other lakes. Great blue herons were more abundant on Lac Ste. Anne and Isle Lake than on Big Lake and Matchayaw Lake.

The relative abundance of grebes and herons on the lakes indicates similarities between Matchayaw Lake and Big Lake and between Isle Lake and Lac Ste. Anne. The waterfowl census indicated that the former pair of lakes were heavily used by breeding pairs while the latter pair received moderate use. These differences in utilization by birds on the two pairs of lakes probably reflects habitat conditions on the lakes. A greater proportion of Matchayaw Lake and Big Lake is shallow than of Isle Lake and Lac Ste. Anne. Emergent cover is restricted to shallow areas. This provides nesting cover for grebes, coots, and diving ducks. It also provides brood and moulting cover for ducks, grebes, and coots. These birds are generally more abundant where the proportion of shallow areas and in turn emergent vegetation is greatest. Eared grebes are more common in shallower marshes than western or red-necked grebes which prefer lakes (Salt and Wilk, 1958; Godfrey, 1966). Eared grebes feed primarily on invertebrates which are most abundant in shallow areas. Western and red-necked grebes include more fish in their diets. The relatively frail nest of the eared grebe would be more subject to destruction by violent wave action, common on larger lakes.

Great blue herons may have been more common on Isle Lake and Lac Ste. Anne than on the other lakes because of the presence of islands on the two former lakes. Colonies of herons often use islands for nesting. One active nest was observed on an island in Isle Lake. The colony on this island had been destroyed previously by vandalism (Vermeer, 1969).

A nesting colony of western grebes located within a stand of reed adjacent to an island in the western section of Lac Ste. Anne (Photo 16) contained approximately 150 nests. Of 115 of the nests examined, 4% contained one egg, 8% contained two eggs, 42% contained three, 41% contained four, 4% contained five, and 1% contained seven. A mid-summer visit to this colony indicated that several nests had been destroyed. Several eggs were seen in the water among remaining nests. The cause of this is unknown but could possibly have been due to flooding, violent wave action or both. A second nesting colony of western grebes was located on the south shore of the main section of Lac Ste. Anne. Salt and Wilk (1958) remarked that the western grebe has suffered from the advance of civilization and that nesting colonies are now found only on the remote lakes. The presence of two colonies on a lake as extensively used for boating as Lac Ste. Anne is therefore unusual.

Nests of the other grebes common to the lakes were frequently observed in emergent vegetation zones. These, however, were not enumerated.

Photo 16: Previous year's growth of reed provides nesting cover for grebes and some diving ducks in spring. In this stand of reed, there were approximately 150 western grebe nests, three of which can be seen in the photograph. Nests such as these, constructed over water, are vulnerable to changes in water levels.

Common terns were found nesting on islands in Lac Ste. Anne and Isle Lake. A total of 78 nests were observed in one of the colonies nesting on Lac Ste. Anne.

Two pairs of nesting ospreys were observed - one pair near Lac Ste. Anne and the other pair on an island in Isle Lake. The nest at Isle Lake was destroyed by strong winds. The presence of the breeding ospreys is of interest since Salt and Wilk (1958) stated that although ospreys formerly nested at many large lakes in central Alberta, they now nest only in small numbers between Lesser Slave Lake and Lake Athabasca and in the Rocky Mountains. Approximately 10 pairs of ospreys were observed along the Pembina River during the summer.

3.) Upland Game Bird Inventory at the Proposed Sites for the Pembina and Magnolia Reservoirs:

As a part of the ecological evaluation of the effects of the proposed Pembina River reservoir and adjacent Magnolia reservoir, an inventory of upland game birds in these areas was undertaken during the period from May 3 through May 5, 1971. The inventory was conducted at the Pembina and Magnolia reservoir sites since flooding of these areas would destroy all the habitat and consequently the upland bird population within the boundaries of the highest level of the reservoir. In addition, areas of habitat around the perimeters of the reservoirs which would be reduced by flooding to areas too small to constitute the required home range of a bird would in effect be eliminated as habitat for upland game birds.

According to the results of a questionnaire which Lane and Lynch (1969) distributed to farmers in the Sturgeon Basin area, upland game birds which might be expected to occur in the area include ruffed grouse (Bonasa umbellus), sharp-tailed grouse (Pedioecetes phasianellus), pheasants (Phasianus colchicus), Hungarian partridge (Perdix perdix), and spruce grouse (Canachites canadensis). This report will deal with what was found with respect to the present status of each of these upland game bird species during the inventory in early May, 1971.

A reconnaissance of the Pembina and Magnolia reservoir sites on April 29, 1971 indicated an abundance of ideal ruffed grouse habitat. Because of this and since ruffed grouse can be fairly accurately and efficiently censused by means of the "drumming count" technique, a ruffed grouse census was the primary aim of the upland bird inventory while observations of other species were to be recorded incidentally.

a.) Ruffed Grouse Census:

1.) Inventory Methods: The method used to census the ruffed grouse population in this investigation was basically the method described by Petraborg et al (1953). With minor modifications, this technique has been used successfully by several researchers including Dorney et al (1958) in Wisconsin, and Sumanik (1966), Boag and Kiceniuk (1966, 1967), and Ewaschuk (1968) in the foothills of southwestern Alberta.

Petraborg et al (1953) suggested that a route be selected and driven between 0500 and 0800 hours stopping for four minutes at one mile intervals to record the number of drumming sounds. He suggested that each route be driven at least three times. The highest count of drummings for each station was used to calculate the number of males per square mile on the assumption that each grouse drummed once in four minutes and could be heard within a 1/8 mile radius.

It is desirable to conduct a ruffed grouse drumming census during the period of peak drumming activity of the male ruffed grouse so that all male ruffed grouse will be heard. Boag and Kiceniuk (1967) and Ewaschuk (1968) have suggested that this peak is related to snow conditions. Drumming activity in a ruffed grouse population in southwestern Alberta peaked on May 17 in 1967, on May 4 in 1966, and on May 4 in 1965 (Boag and Kiceniuk, 1967); and on May 3 in 1968 (Ewaschuk, 1968). The higher elevation of the study area in southwestern Alberta (approximately 5,000 feet) compensates for the fact that snow is generally gone earlier farther south. Therefore, drumming peaks in the Pembina and Magnolia reservoir areas are probably not too far removed from those in the foothills of southwestern Alberta. The drumming counts carried out in this investigation are considered to be fairly close to the peak of drumming. Dorney et al (1958) report that in most years there is a seven to fifteen day plateau when these counts can be made with greatest accuracy.

Ewaschuk (1968) found that the daily peak of drumming activity occurred between 0400 and 0500 hours. A smaller peak of drumming occurred in the late afternoon between 1700 and 1800 hours. Accordingly, each route used in this investigation was driven once between 0415 and 0800 hours and again between 1615 and 2000 hours.

The locations of the two routes used in this study are shown in Figure 5. One route covered the Pembina reservoir area and was driven consistently by one investigator. The other route was in the Magnolia reservoir area and was driven consistently by a second investigator. Each route was driven in opposite directions for both morning and evening runs in an attempt to be at each stop during a peak of drumming activity so that the maximum number of birds present would be recorded.

Stops along the route were a minimum of 0.5 miles apart since it was felt that grouse would not likely be heard drumming more than 0.25 miles away and if stops were 0.5 miles apart no overlap in drumming counts would occur. Researchers in south-western Alberta used stops 0.5 miles apart (Sumanik, 1966); (Boag and Kiceniuk, 1966 and 1967); (Ewaschuk, 1968). No stops were made where all land was cleared within a 0.25 mile radius.

Each route was driven five times, once each on the evening of May 3, morning and evening of May 4, and morning and evening of May 5.

At each stop, the time, number of drumming sounds heard, number of birds responsible for the drumming sounds, temperature, amount of wind, and precipitation were recorded. Table 48 shows a sample of the manner in which the data were recorded.

FIGURE 5

Locations of Stops Used in the Ruffed Grouse Census in the Pembina and Magnolia Reservoir Areas.

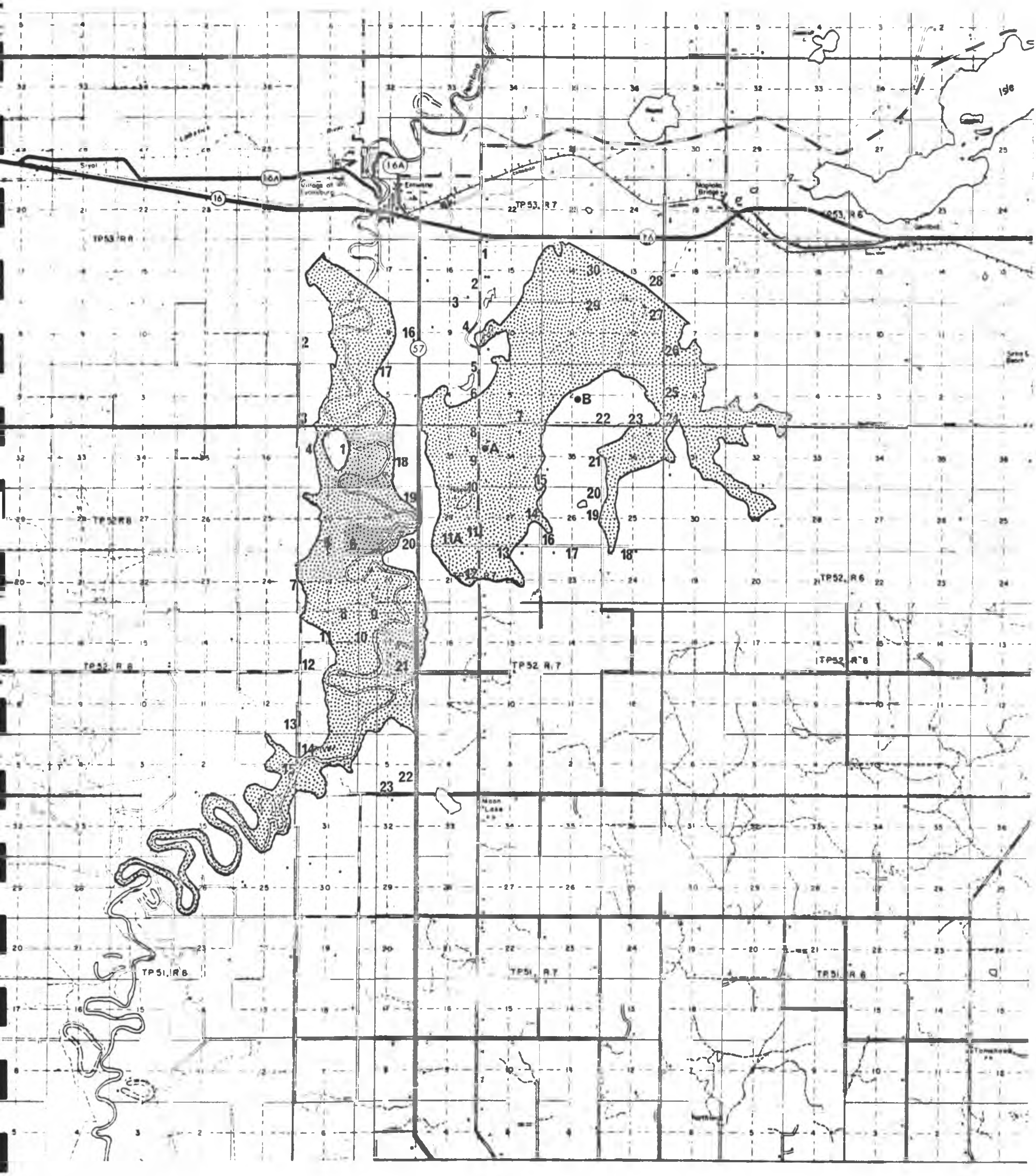

TABLE 48

Sample Data Sheet Showing the Information Recorded during the Ruffed Grouse Drumming Count on the Morning of May 5, 1971.

Stop	Time	Wind	Precipitation	Temp.	No. Drum Sounds	No. Ruffed Grouse
1	5:00-5:04	Calm	nil	49°	3	3
2	4:55-4:59	"	"	50°	3	2
3	4:49-4:53	"	"	52°	11	7
4	4:43-4:47	"	"	50°	4	2
5	4:36-4:40	"	light rain	50°	7	5
6	4:31-4:35	"	nil	56°	2	2
7	4:23-4:27	"	light rain	52°	12	7
8	4:15-4:19	"	light rain	50°	6	3
9	7:09-7:13	"	nil	52°	0	0
10	7:04-7:08	"	"	52°	3	2
11	6:59-7:03	"	"	51°	5	3
11A	6:54-6:58	"	"	51°	1	1
12	6:47-6:51	"	"	52°	1	1
13	6:42-6:46	"	"	54°	1	1
14	6:36-6:40	"	"	50°	1	1
15	6:31-6:35	"	"	50°	1	1
16	6:26-6:30	"	"	52°	3	3
17	6:21-6:25	"	"	51°	3	3
18	6:11-6:15	"	"	50°	1	1
19	6:05-6:09	"	"	50°	7	5
20	6:00-6:04	"	"	50°	1	1
21	5:55-5:59	"	"	50°	0	0
22	5:50-5:54	"	"	50°	4	3
23	5:45-5:49	"	"	50°	3	3
24	5:40-5:44	"	"	48°	1	1
25	5:35-5:39	"	"	48°	2	2
26	5:30-5:34	"	"	48°	3	3
27	5:25-5:29	"	"	49°	0	0
28	5:20-5:24	"	"	50°	1	1
29	5:14-5:18	"	"	50°	1	1
30	5:08-5:13	"	"	52°	4	3

Boag and Kiceniuk (1966) suggested that wind, precipitation, and temperature may be important in influencing drumming activity. However, Ewaschuk (1968) found that during or near the seasonal peak of drumming activity, wind and precipitation had little effect on the drumming activity of an individual male observed from a blind. Ewaschuk suggested that the apparent drop in drumming activity is due almost entirely to the reduced hearing ability of the observer.

2.) Results and Discussion:

The results of the drumming count census for the areas of the proposed Magnolia and Pembina reservoirs are presented in Tables 49 and 50 respectively. Data including the time of the drumming counts and weather information have been summarized for each area in Table 51.

In both areas, the highest counts were obtained on the evening of May 3 and on the morning of May 5. The time and weather conditions for these counts were ideal. Although weather conditions were ideal on the morning of May 4, the counts were begun a little late, and near the end of each of the routes, drumming activity had virtually ceased; hence, the reduced number of birds recorded. The reduced count on the evening of May 4 was a result of lower audibility of drumming sounds due to gusty winds which began during the latter part of the run in each area. Strong winds also resulted in the low count obtained on the evening of May 5.

TABLE 49

Summary of Ruffed Grouse Drumming Counts in the Proposed Magnolia Reservoir Area

Stop	May 3 P.M. Drums	May 3 P.M. Birds	May 4 A.M. Drums	May 4 A.M. Birds	May 4 P.M. Drums	May 4 P.M. Birds	May 5 A.M. Drums	May 5 A.M. Birds	May 5 P.M. Drums	May 5 P.M. Birds	Max. Drums	Max. Birds
1	2	1	6	5	-	-	3	3	1	1	6	5
2	2	2	0	0	-	-	3	2	1	1	3	2
3	2	2	2	2	-	-	11	7	1	1	11	7
4	1	1	2	2	-	-	4	2	0	0	4	2
5	1	1	1	1	0	0	7	5	1	1	7	5
6	2	2	0	0	0	0	2	2	0	0	2	2
7	2	1	1	1	0	0	12	7	2	2	12	7
8	0	0	1	1	1	1	6	3	0	0	6	3
9	2	2	0	0	6	3	0	0	0	0	6	3
10	5	4	2	2	6	4	3	2	0	0	6	4
11	3	2	4	3	3	3	5	3	1	1	5	3
11A	-	-	3	2	1	1	1	1	0	0	3	2
12	1	1	1	1	2	2	1	1	3	2	3	2
13	5	4	5	4	4	3	1	1	2	1	5	4
14	5	3	5	4	4	4	1	1	3	2	5	4
15	4	3	6	4	6	4	1	1	1	1	6	4
16	4	3	4	3	3	3	3	3	3	2	4	3
17	5	4	5	4	2	1	3	3	2	2	5	4
18	3	2	1	1	0	0	1	1	3	3	3	3
19	5	4	10	6	8	5	7	5	0	0	10	6
20	0	0	1	1	2	2	1	1	0	0	2	2
21	3	2	1	1	4	3	0	0	0	0	4	3
22	6	4	0	0	4	4	4	3	1	1	6	4
23	5	3	0	0	0	0	3	3	2	2	5	3
24	4	2	2	1	4	3	1	1	1	1	4	3
25	2	2	1	1	1	1	2	2	0	0	2	2
26	3	2	0	0	4	2	3	3	2	2	4	3
27	0	0	0	0	0	0	0	0	0	0	0	0
28	2	1	0	0	0	0	1	1	2	2	2	2
29	0	0	0	0	0	0	1	1	1	1	1	1
30	4	2	0	0	2	2	4	3	2	2	4	3
TOTAL	83	60	64	50	67	51	95	71	35	31	146	101
MEAN	2.77	2.00	2.07	1.61	2.48	1.90	3.06	2.29	1.13	1.00	4.71	3.26

TABLE 50

Summary of Ruffed Grouse Drumming Counts in the Proposed Pembina Reservoir Area

Stop	May 3 P.M. Drums	May 3 P.M. Birds	May 4 A.M. Drums	May 4 A.M. Birds	May 4 P.M. Drums	May 4 P.M. Birds	May 5 A.M. Drums	May 5 A.M. Birds	May 5 P.M. Drums	May 5 P.M. Birds	Max. Drums	Max. Birds
1	4	4	2	2	5	5	2	2	-	-	5	5
2	1	1	-	-	0	0	0	0	-	-	1	1
3	0	0	1	1	4	4	2	2	-	-	4	4
4	1	1	2	1	1	1	1	1	-	-	2	1
5	0	0	0	0	0	0	0	0	-	-	0	0
6	3	3	2	2	3	3	3	3	-	-	3	3
7	1	1	2	2	0	0	1	1	-	-	2	2
8	6	6	5	5	1	1	6	5	-	-	6	6
9	4	3	2	2	2	2	1	1	-	-	4	3
10	6	6	5	4	2	2			1	1	6	6
11	5	4	4	4	1	1			1	1	5	4
12	4	4	4	4	1	1	5	5	1	1	5	5
13	6	6	4	3	3	3	5	5	2	2	6	6
14	4	4	3	2	1	1	0	0	1	1	4	4
15	3	3	2	2	2	2	1	1	2	2	3	3
16	3	3	2	2	1	1	2	2			3	3
17	3	2	2	2	6	5	3	3			6	5
18	-	-	1	1	0	0	1	1			1	1
19	-	-	0	0	2	2	6	6			6	6
20	-	-	0	0	0	0	3	3			3	3
21	-	-	0	0	1	1	2	2			2	2
22	-	-	-	-	1	1	2	2			2	2
23	-	-	-	-	0	0	7	6			7	6
TOTAL	54	51	43	37	37	36	53	51	8	8	86	81
MEAN	3.18	3.00	2.15	1.85	1.60	1.51	2.52	2.44	1.33	1.33	3.74	3.52

TABLE 51

Time and Weather Conditions during the Ruffed Grouse Drumming Counts in the Proposed Areas of the Magnolia and Pembina Reservoirs.

	May 3 P.M.	May 4 A.M.	May 4 P.M.	May 5 A.M.	May 5 P.M.
Magnolia Area:					
Starting Time	1636	0447	1640	0415	1635
Ending Time	1934	0753	1923	0713	1917
Temperature (°F)	64 - 78	44 - 62	64 - 74	48 - 56	58 - 74
Precipitation	nil	nil	nil	light rain at 3 stops	nil
Wind	calm-light	calm	calm-strong	calm	calm-strong
Pembina Area:					
Starting Time	1614	0458	1643	0422	1645
Ending Time	2000	0806	1954	0713	1725
Temperature (°F)	64 - 72	42 - 63	62 - 71	48 - 54	63 - 64
Precipitation	nil	nil	nil	light rain at 4 stops	nil
Wind	calm-light	calm	calm-strong	calm-light	light-strong

Drumming sounds were recorded at the majority of the stops during a period of peak activity; either between 0400 and 0500 hours or between 1700 and 1800 hours and with ideal weather conditions prevailing. As a result, probably all or nearly all drumming birds within hearing distance at each stop were heard drumming. The maximum number of birds recorded at each stop should therefore represent a fairly accurate estimate of the population of drumming males present within the hearing area of each stop.

The mean number of drumming males per stop in the Magnolia area was 3.26 giving a total of 101 drumming males for all 31 stops. The mean number of drumming males per stop in the Pembina area was 3.52, agreeing closely with the corresponding figure for the Magnolia area. A total of 81 drumming males was obtained for the 23 stops in the Pembina area.

It is often difficult to distinguish grouse drumming at different locations especially when the grouse are at the outer limits of one's hearing range. Sumanik (1966) calculated a linear regression equation ($Y = 0.50 + 1.24X$) for the relationship between the number of sounds produced (Y) and the number of birds producing them (X). Using this formula, the population of drumming ruffed grouse along the stops in the Magnolia area would be 117 or a mean of 3.77 per stop, and in the Pembina area, 68 or a mean of 2.96 per stop.

The number of male ruffed grouse heard drumming at all stops in the Magnolia area is probably between 101 and 117 and in the Pembina area, between 68 and 85.

In order to use the data obtained during this census to estimate the ruffed grouse population in the area, it is necessary to know the radius of audibility of ruffed grouse drumming sounds. Petraborg et al (1953) used a radius of audibility of 1/8 mile while Dorney et al (1958) typically could hear ruffed grouse drumming at a distance of about 1/4 mile in flat wooded country when there was no wind. An examination of aerial photographs of the area censused in this study indicated that where open fields occurred between the road and forest, grouse were heard drumming at least 1/4 mile away. However, where the area was forested to the edge of the road, the audibility radius would undoubtedly be reduced. It was therefore felt that the radius of audibility was, on the average, approximately 3/16 mile.

In order to determine the ecological density* of the ruffed grouse population in the areas of the proposed Magnolia and Pembina reservoirs, the areas of each forest type within a radius of 3/16 mile of each drumming count stop were measured. This was done from vegetation maps prepared in conjunction with the inventory of wildlife habitat.

Disregarding black spruce bog, and a small amount of birch and willow (these forest types were assumed to be unsuit-

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* Density of birds per unit of suitable habitat rather than on an arbitrary acreage or square mile basis which contains unproductive habitat (crude density).

able as ruffed grouse habitat), a total of 1165 acres of suitable habitat were calculated to be in the areas within which drumming sounds were considered audible. This "suitable habitat" consisted of 1132 acres of deciduous dominated mixed forest and 33 acres of aspen. Salt and Wilk (1958) and Godfrey (1966) state that ruffed grouse habitat is mainly deciduous and mixed-wood forest.

Survey data show that the number of drumming male ruffed grouse heard in the Magnolia area was between 101 and 117 while the number in the Pembina area was between 68 and 85. The total number of males heard in the combined areas was therefore between 169 (101 + 68) and 202 (117 + 85). This represents an ecological density of between 93 and 111 drumming male ruffed grouse per square mile of suitable habitat. In other words, one drumming male was present for every 5.8 - 6.9 acres of suitable forest habitat.

The ecological density of 93 to 111 drumming males per square mile of suitable habitat estimated above does not include non-drumming males, females, and young of the year. Dorney et al (1958) found that the error due to the non-enumeration of "silent cocks" was of little importance. However, during a period of high population density, as was the case in this study, a possible lack of suitable territories may result in a substantial number of non-drumming males. If one assumes a 1:1 sex ratio of male to female grouse, this would indicate a breeding population with an ecological density of 186 to 222 birds per square mile of suitable habitat. To take this a step further, assuming that 50% of the females are successful in raising a brood and the brood size averages 7.4 chicks (Stelfox, 1964), the result would be a total production of 344 to 411 young ruffed grouse. Assuming mortality among young and adult grouse to be negligible until fall, a total fall population with an ecological density of 530 to 633 ruffed grouse per square mile of suitable habitat in the proposed Magnolia and Pembina reservoir sites is indicated.

According to Table 7 (Page 20), a total of 218 acres of suitable ruffed grouse habitat (deciduous dominated mixed forest, aspen, and balsam popular) were present, on the average in every square mile of area in the proposed sites of the Magnolia and Pembina reservoirs. The two dam sites cover approximately 19.4 square miles of land which includes 6.61 square miles of suitable ruffed grouse habitat. The total fall population of ruffed grouse in the reservoir areas would therefore be approximately 3500 - 4180 birds.

The ruffed grouse population on the study area in 1971 was probably at its peak if the population follows a ten-year cycle. Smith (1966) states that the ruffed grouse population is supposed to follow a 9 - 10 year cycle although there is some dispute as to whether there are true cycles south of the tundra. Stelfox (1964) reported that a peak population of ruffed grouse in the area investigated in this study occurred in 1961. After 1961, ruffed grouse populations declined but by 1966, they were increasing again (Stelfox; 1964, 1966).

Lewin (1962) also reported peak populations of ruffed grouse as well as sharp-tailed grouse, Hungarian partridge and other animals in the winter of 1961-62. He predicted the next peak to occur in about 1971.

The population of ruffed grouse observed in 1971 probably represents close to the maximum density that the area would ever support. The capability of habitat along the Sturgeon and Pembina rivers would likely be similar to that in the Magnolia and Pembina reservoir areas. Potential population densities in deciduous and mixed wood forest types would be similar to the ecological density determined for the reservoir areas. However, along the Sturgeon River from Lac Ste. Anne to the North Saskatchewan River, population densities could be expected to be somewhat lower. It has already been pointed out that the majority of the forest cover in this area is composed of small woodlots many of which would be too small to constitute a territory for a drumming male ruffed grouse. Most forest habitat of suitable size for ruffed grouse is adjacent to the river.

An additional factor limiting ruffed grouse populations along the Sturgeon river from Lac Ste. Anne to the North Saskatchewan river is the greater amount of deciduous forest in proportion to mixed forest. Petraborg _et al_ (1953) obtained highest drumming counts in a mixed hardwood - coniferous forest type. La Roi _et al_ (1967) state that the ruffed grouse though relatively scarce in spruce or aspen stands, are much more common in areas where the two trees are intermingled. The reason for this is the availability of dense cover provided by spruce and the rich middlestory and understory containing food species characteristic of the aspen forest. Boag and Sumanik (1969) found that male ruffed grouse in southwestern Alberta selected drumming sites where canopy coverage and frequency of young white spruce was greater than at sites where grouse did not drum.

The main factor limiting ruffed grouse populations in the Sturgeon and Pembina River Basins is, as pointed out by Lane and Lynch (1969), land clearing for agriculture. This has severely limited the amount of suitable ruffed grouse habitat especially along the Sturgeon River from Calahoo to the North Saskatchewan River. Here, forest covers only between 5% and 13% of the land within one mile of the river; the majority of the cover being restricted to a narrow strip adjacent to the river. Between Calahoo and Lac Ste. Anne, approximately one-quarter of the land is forested. From Lac Ste. Anne to the headwaters of the Sturgeon, more than 40% of the land is forested.

b.) <u>Sharp-tailed Grouse</u>

Although sharp-tailed grouse were observed only once in the Pembina area (three were seen flying at stop #12), they were more common in the Magnolia area. Two leks were located in the Magnolia area. These are identified as A and B on the map in Figure 5. On the morning of May 4 at 0545 hours, 12 sharp-tailed grouse were flushed off lek A. Before these 12 were flushed off, several others could be heard vocalizing within about 1/4 mile surrounding the lek. The farmer on whose land the lek is located said that he had flushed up to 25 sharp-tailed grouse off the lek.

Lek B was located after vocalizations of displaying males on the lek were heard from stops #22 and #23 used in the ruffed grouse census. At 0815 hours on May 5, seven sharp-tailed grouse were flushed from lek B. As this was well past the peak of activity on the lek, one might reasonably expect several more grouse to be using lek B.

The presence of a sharp-tailed grouse near stop #17 in the Magnolia area on the morning of May 4 and again on the morning of May 5 may be indicative of another lek in the area since the grouse rarely wander far from the lek with which they are associated. Rippin (1968) found that the great majority of movements of sharp-tailed grouse in Camp Wainwright were within 1/2 mile of the lek with which they were associated.

Although not enough data were gathered to warrant an estimate of the sharp-tailed grouse population in the Magnolia and Pembina areas, observations suggested that they were at least fairly common.

Observations of sharp-tailed grouse in the Westlock area indicate excellent populations of this species.

Stelfox (1964 and 1966) reported that the trend in sharp-tailed grouse populations in an area partly composed of the

Sturgeon and Pembina River basins was similar to the trend for ruffed grouse populations. The population peaked in 1961, subsequently crashed, and by 1966 was increasing again.

With reference to factors presently limiting sharp-tailed grouse populations, Stelfox (1966) stated that "large scale land clearing and intensive agricultural use has resulted in a reduced number of sharp-tail dancing grounds in the Edmonton, Barrhead, and Evansburg areas. Spring burning of stubble fields along fence rows and around potholes has eliminated a great deal of nesting habitat. Wholesale clearing of spruce bogs such as seen in the Evansburg - Edson area has removed a great deal of critical winter habitat. Due to this large amount of habitat removal it is highly improbable that sharp-tails will again attain the peak numbers reached in 1961-62 in the Edmonton area".

c.) Status of Other Upland Game Birds:

No special effort was made to determine the populations or occurrence of other gallinaceous birds in the areas of the proposed reservoirs. However, it is significant that no other upland game bird species were observed. It is doubtful that a breeding population of pheasants exists in the area since no crowing sounds were heard while carrying out the ruffed grouse drumming counts. Pheasants were occasionally observed along the Sturgeon River downstream from Lac Ste. Anne. Data presented by Stelfox (1963) indicate that pheasant population trends were similar to those of ruffed and sharp-tailed grouse with the peak population occurring in 1961 in the Edmonton - Stony Plain - Sturgeon River area. In 1961 pheasant crowing count indices at two-minute stops were 8.1 and 4.9 along transects identified as Edmonton - Stony Plain and Sturgeon River N.W. respectively. These figures presumably represent the number of crowing cocks per square mile. Stelfox (1964) reported pheasant cock densities of 1.82 per square mile and 0.82 per square mile in 1963 and 1964 repectively in the Stony Plain area. Pheasants were still scarce in 1966 (Stelfox, 1966). It is conceivable that pheasant populations in the Edmonton - Stony Plain and Sturgeon River area would approach the 1961 population in 1971 on the assumption that major habitat changes have not occurred. At any rate, the 1961 population likely represents the largest population which would occur in the area.

No Hungarian partridge were observed in the Magnolia and Pembina areas during the period of the ruffed grouse drumming counts. These birds were present in the area west of Seba Beach to the Pembina River during at least 1960-63 as evidenced by hunter harvest data, (Stelfox, 1964). Lane and Lynch (1969) report that fair numbers of Hungarian partridge occur along the Sturgeon River from Lac Ste. Anne to Matchayaw Lake and from the confluence of the Riviere Qui Barre to the North Saskatchewan River.

No spruce grouse were seen during the ruffed grouse census and it is not likely that any occur in areas to be affected by proposed developments in the basin.

d.) Summary:

Ruffed grouse and sharp-tailed grouse are the most important upland birds present along the Sturgeon and Pembina rivers. The 1971 census indicated a peak population density of 93 - 111 drumming male ruffed grouse per square mile of suitable habitat. Less than 25% of the land along the Sturgeon River from Lac Ste. Anne to the North Saskatchewan River is forested with suitable ruffed grouse habitat. At present, the primary limiting factors to ruffed grouse and sharp-tailed grouse populations are land clearing, and spring burning of stubble fields and the vegetation along fence lines and around potholes.

Pheasant and Hungarian partridge are present but in relatively small numbers. Populations of spruce grouse are insignificant.

4.) Furbearing Mammal Resource of the Sturgeon and Pembina Rivers:

There have been no known investigations of furbearing animals in the Sturgeon and Pembina River Basins. The Alberta Fish and Wildlife Division have some data on these animals along the Sturgeon River since they sell resident trapping licenses, and have frequent requests to blow up beaver dams. Some resident and registered trapline licenses are sold to trappers along the Pembina River. The Fish and Wildlife Division also keeps records of the fur tax returns from these areas.

As this appeared to be the only data available, a study was undertaken in June 1971 to estimate the numbers of furbearers trapped in this area. It was felt that those figures would give at least part of the economic value of furbearers in the Sturgeon and Pembina River Basins and thus a monetary value to some of its wildlife. No attempt was made to evaluate, in economic terms, the aesthetic value or the value of furbearers to the ecosystem in these areas.

Beaver are one of the larger, more valuable furbearers dependent on the water of the Sturgeon and Pembina rivers. Therefore a survey was attempted to estimate the number of colonies in the study area. It was conducted independently from the aforementioned fur study and was carried on throughout the summer of 1971.

a.) Methods:

For the purpose of the investigation of fur tax returns, the study area was divided into three sections: the Sturgeon River including lakes from Magnolia Bridge to the North Saskatchewan River, the Pembina River from Entwistle to the Athabasca River, and the proposed Pembina and Magnolia dam sites. The license numbers and addresses of the trappers trapping in these areas within one mile on either side of the rivers and lakes as well as the proposed dam sites were chosen from licenses sold at the five nearest Fish and Wildlife offices. These are located at; Athabasca, Barrhead, Edmonton, Evansburg and Stony Plain. The figures for the numbers of animals taken by holders of resident and registered traplines in the Sturgeon and Pembina River Basins were taken from the fur tax returns as received by the Department of Lands and Forests. These data, on the number of pelts sold on the license numbers, were taken from the returns filed by the following local fur dealers: Rita Birkigt, Athabasca; C.O. Conrad, Darwell; V. Baxandall, Westlock; Alex Gordon, Edson; and Edmonton dealers: Sam Jamha, Halford Hide and Fur Co., Arctic Fur and Hide Co., Edmonton Furrier, Edmonton Fur Auction, Hudson's Bay Co., P.M. Wright, K. Belcourt, and Slutker Furs.

There is a great deal of difficultly in collecting data from fur dealer returns. Often there are no license numbers included with the trapper's name, several numbers used by the trapper or given to him by the dealer, misspellings of names, and wrong addresses given. Registered traplines may be found under their trapline number or their license number. Therefore, a telephone survey was conducted as a cross-check to the data collected from fur tax returns.

As a result, the names of 54 resident trappers and 7 registered trappers trapping in the Sturgeon and Pembina River Basins were collected. Of these, the fur tax returns yielded data for 26 resident trappers and 3 registered trappers. The telephone survey yielded data for 34 of these trappers (Table 52).

Although beaver surveys are best done in the fall, an attempt was made to determine the abundance of beaver in the Sturgeon and Pembina River Basins during the summer of 1971. Along the Sturgeon River, foot surveys, designed also to count breeding pairs and broods of waterfowl, were conducted in the months of May and June to establish the numbers of lodges and beaver dams along a representative section of the Sturgeon River. Approximately 76 miles of the 136 miles of Sturgeon River were surveyed.

The Pembina River and lakes along the Sturgeon River were surveyed by boat. The sections of the Pembina River between Fawcett and Flatbush; Flatbush and the Athabasca River were surveyed in late September while the section between Sangudo and Belvedere was surveyed on October 1. This included 80 miles of a total of 236 miles of Pembina River below the proposed dam near Entwistle.

b.) Results and Discussion:

The species of furbearers trapped in the Sturgeon and Pembina River study area include: beaver (*Castor canadensis*), coyote (*Canis latrans*), ermine (*Mustela* spp.), red fox (*Vulpes fulva*), lynx (*Lynx canadensis*), mink (*Mustela vison*), muskrat (*Ondatra zibethicus*), jack rabbit (*Lepus americanus*), red squirrel (*Tamiasciurus hudsonicus*), and timber wolf (*Canis lupus*). The most common species trapped were beaver, muskrat, squirrel, ermine and coyote.

A comparison of telephone and fur tax data for 21 trappers shows that 16% more animals were reported by telephone conversation than found from fur tax return data (Table 53). This is due to the fact that it was difficult to find all of the fur tax returns from the fur sold by any one trapper. The reasons for this difficulty have been previously outlined, except for

TABLE 52

Numbers of Trappers for whom Trapping Data was Collected Either through Fur Tax Returns or by Telephone Interviews

	Pembina	Sturgeon	Pembina-Magnolia	Total
Total no. of trappers	27	22	5	54
No. with fur tax data	11	14	4	29
No. telephone	16	14	4	34
No. phoned with fur tax data	7	10	4	21

TABLE 53

Total Numbers of Animals Trapped in the Pembina-Sturgeon Study Area by Trappers for whom both Fur Tax Records and Telephone Interview Data were Available.

	Fur Tax Data	Telephone Interview Data
Beaver	201	223
Muskrat	1195	1279
Weasel	63	83
Squirrel	68	123
Lynx	4	-
Coyotes	28	80
Mink	10	26
Total	1569	1814

the fact that not all returns filed by all companies could be checked due to the time involved and the fact that some returns had not yet been compiled.

Table 54 compares the numbers of animals found to be taken by trappers in the study of fur tax returns and the numbers reported taken by trappers in telephone interviews. These figures indicate a minimum number of animals trapped since only 47% of the trappers had fur tax returns representing them and only 63% of the trappers were interviewed by telephone (Table 52).

Table 55 gives the average value of pelts for three years as given by the Department of Lands and Forests Fish and Wildlife annual reports. These values are then multiplied against the numbers of furs taken to give the figures presented in Tables 56 and 57. The value of fur as calculated from the fur tax data is $6,258.30 while that found in the telephone survey data is $6,572.99. These figures are relatively close because of the fact that while 63% of the trappers were telephoned, a larger percentage of these trapped very little. Extrapolating on the telephone survey figures, 100% of the trappers would have taken $10,433.32 worth of fur from the Sturgeon - Pembina study area. This is a minimum figure since there may be more trappers working in the area than found in this study. Additional fur may originate from the area that is recorded under licenses to trap elsewhere or is unrecorded. The amount of fur taken illegally can not be calculated.

TABLE 54

A Comparison of the Number of Pelts Taken by Trappers in the Sturgeon - Pembina Study Area as Recorded in Fur Tax Returns and Reported during Telephone Interviews.

	Fur Tax Returns				Telephone Survey							
	1970/71				1970/71				1969/70			
	P*	S*	PM*	Total	P*	S*	PM*	Total	P*	S*	PM*	Total
Beaver	152	174	15	341	147	123	15	285	99	115	17	231
Coyote	15	19	1	35	22	98	6	126	2	9	6	17
Ermine	11	63	15	89	40	72	2	114	40	74	-	114
Red Fox						1		1				
Lynx	3	1		4	2			2	1			1
Mink	2	14		16	1	21		22	1	34		35
Muskrat	160	1092	7	1259	102	1259	6	1367	134	907		1041
Jack Rabbits						2		2				
Squirrel	108	33	22	163	100	70	8	178	150			150
Timber Wolves	1			1								
Total	452	1396	60	1908	414	1646	37	2097	443	1123	23	1589

* P - Pembina River, S - Sturgeon River, PM - Pembina - Magnolia Dam Sites

TABLE 55

Average Value of Pelts Sold in Alberta as Reported by the Department of Lands and Forests.

	1968/69	1969/70	1970/71
Badger	$10.23	$4.76	$7.11
Bear	24.76	20.97	24.16
Beaver	16.84	13.29	11.58
Coyote	13.12	9.85	9.11
Ermine	0.73	0.65	0.63
Fisher	12.28	13.66	20.86
Silver Fox	8.25	8.25	23.54
Cross Fox	10.62	13.67	16.50
Red Fox	13.75	7.57	10.42
White Fox	18.48	18.48	17.36
Blue Fox	6.50	6.50	6.50
Lynx	27.05	24.54	23.03
Marten	10.00	11.55	10.56
Mink	12.17	11.11	9.33
Muskrat	1.25	1.09	1.27
Otter	23.27	20.42	26.21
Jack Rabbits	0.32	0.16	0.16
Skunk	0.36	0.36	0.36
Squirrel	0.46	0.32	0.31
Timber Wolves	29.65	15.79	43.74
Wolverine	27.25	27.25	61.17

TABLE 56

The Value of the Pelts Taken by Trappers in the Sturgeon-Pembina Study Area as Calculated from Data from Fur Tax Returns.

	Fur Tax Data 1970 - 1971			
	P*	S**	PM***	Total
Beaver	$1760.16	$2014.92	$173.70	$3948.78
Coyote	136.65	173.09	9.11	318.85
Ermine	6.93	39.69	9.45	56.07
Lynx	69.09	23.03		92.12
Mink	18.66	130.62		149.28
Muskrat	203.20	1386.84	8.89	1598.93
Squirrel	33.48	10.23	6.82	50.53
Timber Wolves	43.74			43.74
Total	$2271.91	$3778.42	$207.97	$6258.30

* P - Pembina River
** S - Sturgeon River
*** PM - Pembina-Magnolia Reservoir Sites

TABLE 57

The Value of the Pelts Taken by Trappers in the Sturgeon-Pembina Study Area as Calculated from Data from Telephone Interviews.

	1970-71				1969-70			
	P*	S**	PM***	Total	P*	S**	PM***	Total
Beaver	$1702.26	$1424.34	$173.70	$3300.30	$1182.81	$1528.35	$225.93	$2937.09
Coyote	200.42	892.78	54.66	1147.86	19.70	88.65	59.00	167.45
Ermine	25.20	45.36	1.26	71.82	26.00	48.10		74.10
Red Fox		10.42		10.42				
Lynx	46.06			46.06	24.54			24.54
Mink	9.33	195.93		205.26	11.11	377.74		388.85
Muskrat	129.54	1598.93	7.62	1736.09	146.06	988.63		1134.69
Squirrel	31.00	21.70	2.48	55.18	48.00			48.00
TOTAL	$2143.81	$4189.46	$239.72	$6572.99	$1458.22	$3031.47	$285.03	$4774.72

* P - Pembina River,
** S- Sturgeon River,
*** PM - Pembina-Magnolia Reservoir Sites.

As can be seen in Table 54 the greatest number of animals were generally taken along the Sturgeon River. The largest percentage (75%) of the animals, trapped along the Sturgeon River, were muskrats. Approximately 7 to 12 times as many muskrats were trapped along the Sturgeon as along the Pembina River.

In the proposed Pembina and Magnolia reservoir sites, 5 trappers were found to have taken approximately 15 beaver, 6 coyotes, 15 ermine, 7 muskrats, and 22 squirrels.

Since approximately the same number of trappers were found along both the Sturgeon and Pembina rivers (Table 52), then the difference in muskrats trapped must be accounted for by differences in habitat and resultant populations. According to McLeod (1949) a soft clay or muddy type of soil of considerable thickness must be present for good muskrat habitat. He states that plants of greatest value as food, cover, and building material are short-lived perennials which must be replaced by reproduction every few years if a vigorous stand is to be maintained. The seeds germinate and the seedlings become established only on exposed mud banks or flats during periodic lowering of the water levels. The most important species of marsh plants, as given by McLeod, Bondar, and Diduch (1951) for muskrats are:

Scirpus acutus, Hardstem bulrush

Scirpus validus, Softstem bulrush

Scirpus fluviatilis, River bulrush

Typha latifolia, Cattail

Typha angustifolia, Cattail

Equisetum limosum, Horsetail

Phragmites maximus, Reed

Potamogeton spp., Pondweeds

Myriophyllum, Water milfoil

Ceratophyllum demersum, Coontail

Sparganium eurycarpum, Burreed

Acorus calamus, Calamus

Carex, spp., Sedge

Referring back to data presented on aquatic vegetation, it is obvious that the Sturgeon River and its associated lakes: Big Lake, Matchayaw Lake, Lac Ste. Anne, and Isle Lake represent good quality muskrat habitat. These areas generally have a muddy bottom and large amounts of aquatic vegetation. The most abundant associations of emergent vegetation on the lakes are bulrush, and cattail (Figure 2) which are important species for muskrat.

Big Lake is the most important lake in terms of muskrat habitat. There is an average of 8.56 stands of bulrush per mile with an average length of 4,567 feet per mile. Moreover, Big Lake is generally shallow and the optimum depth for muskrat lodge construction is 6 to 24 inches (Bellrose, 1950). In the Big Lake area, one trapper took 277 muskrats, one pair of trappers took 156 muskrats and another pair of trapping partners took 156 muskrats in 1970/71.

Along the Sturgeon River, itself, the best muskrat habitat is associated with marsh areas containing large amounts of emergent and submergent species. These are the same areas of good quality waterfowl habitat that are described in detail in the section on aquatic vegetation of the Sturgeon River. These areas include: The areas of Sturgeon entering and leaving Isle Lake and Lac Ste. Anne, 2.5 miles downstream of Matchayaw Lake and approximately the first 10 miles downstream from Big Lake.

The Pembina River, on the other hand, has a sandy or rocky bottom, a swift current, marked fluctuations and is turbid over much of the growing season. As a consequence, it has little aquatic vegetation of any significance to muskrats. The natural and artificial oxbows along the Pembina River referred to in the section on aquatic vegetation, contain suitable muskrat habitat. Muskrat sign was, however, noted along the Pembina River in the form of small piles of fresh-water clam shells. According to Bird (1961) muskrats may consume many clams and piles of empty shells accumulate at feeding sites.

Table 54 shows that the numbers of beaver taken along the Sturgeon and Pembina rivers were similar. The field survey of beaver showed very little beaver use of the lakes but indicated similar population densities of beaver along the Sturgeon and Pembina rivers as suggested by the fur tax data. Along the Sturgeon River, a total of 23 recent lodges, 18 older lodges, 35 recent dams and 19 older dams were counted. The above data are interpreted to represent 23 colonies of beaver or 0.30 colonies per mile of river. Along the Pembina River a total of 26 beaver lodges were counted which are thought to represent 26 colonies. This would be approximately 0.32 colonies per mile of river. These are minimum densities since many beaver live in bank burrows and do not construct lodges. Census of beaver populations utilizing bank burrows is extremely difficult both from aircraft and during ground surveys.

The designation of an active beaver colony was based on criteria used by Radvanyi (1960), ie; a lodge in good repair, recently covered with mud and sticks. Since data were collected during the spring and summer, the accuracy of colony counts is limited. Lodges may have been abandoned for this part of the year since beavers, except females with young, tend to become transitory (R. Ruttan, pers. comm.; Gunson, 1970). The presence of a food pile could not be used, even though this may be the best indicator (Novakowski, 1959) since they are produced in fall and washed away by spring floods. Photos 17 and 18 illustrate beaver activity on the Sturgeon River.

c.) Summary:

1.) Records of a total of 1,908 animals trapped in the Pembina - Sturgeon study area during the 1970/71 season were found in the fur tax returns of the Department of Lands and Forest.

2.) A total of 2,097 animals were reported trapped during the 1970/71 season in the Pembina - Sturgeon study area by trappers interviewed by telephone.

3.) The minimum value of fur coming out of the study area in the 1970/71 season was calculated at $10,433.32.

Photo 17: A beaver dam on the Sturgeon River between Hoople Lake and Isle Lake creates a reservoir in which marsh plants grow providing better waterfowl and muskrat habitat than in the stream itself. The pond provided allows muskrats to overwinter in a section of river which would normally be almost dry in the fall.

Photo 18: Close-up view of a beaver dam on the Sturgeon River. Note the beaver cuttings in the background which have thinned out forest cover bordering the stream. This, in effect, sets back succession and allows for a greater growth of middle and understory plant species which are utilized by upland game birds and ungulates.

4.) Muskrats comprised the majority of animals taken and were most abundant in the Sturgeon River system - a reflection of the quality and quantity of muskrat habitat available.

5.) Data from fur tax returns as well as the results of a field survey of beaver colonies indicated significant populations of beaver along the Sturgeon and Pembina rivers. These data also indicated that the densities of the beaver population along the two rivers were similar.

5.) <u>Big Game in the Sturgeon and Pembina River Basins</u>:

This section includes a brief review of literature on ungulate habitat requirements which is used as the basis for an assessment of the quantity and quality of habitat for big game animals along the Sturgeon and Pembina rivers.

a.) <u>Soil</u>:

Of major importance to a study of habitat are the soil types found in the area. A general relationship between soil fertility, food quality and the abundance, health, and vigor of wild animals has long been known (Giles, 1969).

According to Siegler (1968), the best agricultural soils in Belknap, Cheshire, and Merrimack counties of New Hampshire produced the highest kills during the period of peak deer harvest - 1947 through 1956. He further states that Herman-Gloucester-Whitman soils, where small farming operations are typically interspersed with mixed stands of soft and hard woods, produced significantly higher kills than the state as a whole. However, he points out that the advantages of more productive soils and milder climates may be negated by more intensive urban and industrial development.

Further reasons, as to the importance of soil to habitat analysis, have also been given by the Canada Land Inventory, ARDA (1967). This states:

"Although wildlife directly depends upon the plant community in which it lives, the latter is in turn dependent upon physical characteristics of the environment such as soil composition, climate and topography. Because it is known that plant communities can be manipulated through management to stages of seral succession which are productive for wildlife and because such management is limited by the physical characteristics of a given site, land capability ratings are applied to land surface units described in physical terms, significant from a wildlife standpoint."

Therefore, a map of soil types, showing the extent and quality of soil, such as the one compiled by the Alberta Soil Surveys, Research Council of Alberta, makes a good basis from which to calculate the potential quality of habitat. The soils found in Alberta in order of fertility are black, shallow black, transition (dark grey and dark grey wooded), dark brown, and grey wooded.

The black soil zone,which is the most fertile and therefore potentially the best habitat, is found along the Sturgeon River from Matchayaw Lake to the North Saskatchewan River. Transition soils are next in fertility and are found in the proposed Magnolia and Pembina reservoir sites as well as the length of Pembina River included in the study area. Grey wooded soils are found around Isle Lake and Lac Ste. Anne indicating that this area is potentially one of the poorest habitat zones as represented by provincial soil zones. However, it should again be noted that the encroachment of agriculture and industry on areas of the best soil can have a significant impact on the present status of habitat in these areas. In turn while grey wooded soils may not potentially support as many animals as the black soils they may in fact support higher wildlife populations than altered areas of more productive soil zones.

b.) Climate:

A second important factor in ecological and habitat evaluations is climate. Since climate changes over long cycles and weather varies from year to year, food production and quality also fluctuate (Giles, 1969). Siegler (1968) states that weather rarely becomes dominant in ordinarily favorable habitat, and in itself, is seldom disasterous. He feels that its severity can be mitigated by manipulation of cover in borderline areas. However, climate, in consideration with other factors, can be detrimental to ungulates. Of major importance are temperature and snow depth. For example, according to Verme (1968) deer mortality is greatly increased at a reading of 100 on his scale which takes into consideration chill and snow depth factors.

Deer:

Gerstell (1937) (in Taylor, 1956) found that an average mean temperature of about 40° F. was the critical point for deer. When the average temperature was below 40°F. the weight curve of immature deer with the best foods available tended to follow the trend of temperature and those having only poorer foods showed a general decrease in weight. When the temperature was considerably below 30 degrees F. the animals lost from 3 to 12 pounds per 100 pounds of body weight per week, irrespective of the amount or quality of food.

Loveless (1964) reported that snow 10 to 12 inches deep impeded mule deer movements and that 20 to 24 inches essentially precluded their use of an area. Further studies by Severinghaus (1947) and Edwards (1956) also show a correlation between snow depth and deer mortality.

Moose:

According to Rausch (1967), winter temperatures of 50 to 60 degrees below are common in Alaska yet seem to have no effect on moose numbers. Stelfox (1967) also points out that winter snow depths and cold temperatures are not important to moose to the extent they are with deer and elk in Alberta. He states that in the cold winters with deep snow (1961-62, 1962-63, 1964-65) moose populations continued to increase while deer and elk populations declined. Des Meules (1964) (in Telfer, 1970) reported that moose do not normally venture into areas where depths of soft snow exceed 107 to 122 cm. Nasimovitch (1955) (also in Telfer, 1970) suggested that 90 to 100 cm. may be considered as a critical limit for moose.

In consideration of the aforementioned weather conditions, data have been obtained from the Federal Department of Transport and included as Appendices 1 to 9. They include representative weather data for the study area and can be used as an index to the severity of weather conditions for the area.

The lowest recorded temperature for this period is -49°F which indicates that winter temperature is not a limiting factor for moose populations. The average mean daily temperatures for 1968, 1969, and 1970 are as follows:

Month	Mean Degrees F
January	- 5.3
February	15.3
March	28.0
April	40.0
May	51.8
June	62.6
July	61.0
August	57.8
September	49.2
October	37.6
November	23.5
December	5.9

According to figures given by Taylor (1956) October, November, December, January, February, and March are all below the critical temperature for deer. Furthermore, December, January, and February would be very hard on the deer with some losses in body weight occurring. McGillis (1967) reported that deep snow and cold weather conditions in the winter of 1964-65 reduced deer and elk numbers in Elk Island National Park while moose continued to increase.

The greatest depth of snow remaining on the ground in the study area in the last three years was 21 inches (February, 1969). According to the literature previously cited, moose will not be affected by these snow depths. However, deer will probably be confined to "preferred areas" during December, January, February, and March. This factor combined with the cold temperatures makes winter a limiting factor for deer populations in the study area. In terms of winter conditions the most critical factors may be temperature, snow depth, cover, preferred areas or food. No doubt it is a combination of these leading to low fawn production and survival.

Hunting pressure in most of the area is most likely negligible due to the presence of large tracts of good escape cover. Furthermore, according to the Lane and Lynch (1969) questionnaire survey most hunters were thought to be road hunters. Generally, deer in the study area are thought to be under-harvested in terms of white-tailed deer potential.

c.) Vegetation:

Of final importance in considering habitat requirements are various factors that can be included under the general heading of vegetation.

The vegetation of an area reflects to a large degree the characteristics of the abiotic portion of the environment - the type of soil, climate, topography, etc. Big game animals such as the deer and moose depend directly upon vegetation for escape cover, shelter from inclement weather, and food. The "edge effect" associated with vegetation is also important to ungulates and is similar to the importance of interspersion of vegetation and open water to waterfowl.

In an attempt to analyse the suitability of escape cover in the study area, a cover density evaluation was done.

In each of the 1/100 - acre plots examined in the different forest types, the escape cover was classified as follows:

rare
sparse
medium
abundant
dense

Table 58 shows the results of escape cover classifications for forest communites in the study area. Summer escape cover was mostly abundant or dense in all forest types examined except pine. Whereas, winter escape cover would be reduced in the

TABLE 58

Escape Cover Density Recorded in the Different Forest Community Types in the Study Area

Classification	Plots Sampled	Numbers of plots that were: Rare	Sparse	Medium	Abundant	Dense
Aspen dominant	25	-	-	7	14	4
Balsam dominant	25	-	-	4	14	7
Mixed, deciduous	25	-	1	4	20	-
Mixed, coniferous	20	-	-	10	10	-
Black spruce	25	-	2	1	5	17
White spruce	10	-	-	4	6	-
Pine	5	-	5	-	-	-
Total	135	0	8	30	69	28

deciduous forest types, the reduction would be less severe in the mixed and coniferous forests. Winter escape cover could, therefore, be limiting to deer populations in the deciduous forest.

Along the Sturgeon River from Lac Ste. Anne to the North Saskatchewan River where the greatest proportion of deciduous forest occurred, suitable deer habitat was fairly restricted to the river valley. The effect of hunting pressure upon the deer population using this habitat may be significant since the hunting season occurs when escape cover in this area would be at a minimum.

The second use of vegetation by ungulates is for shelter from inclement weather. According to Webb (1967) "whitetail distribution in grassland and southern parkland zones is determined primarily by the presence or absence of overhead cover in winter. This fundamental need may be a function of the species general wariness or,more likely, may represent a seeking-out of niches that afford shelter from wind."

The results of vegetation studies showed that canopy cover of the trees in the overstory of all forest types examined except the black spruce bog was usually in the 51% - 75% range. This would be considered adequate to shelter the animals from inclement weather. Cover provided by the deciduous forest would lose most of its value after the leaves are shed in the fall. Areas with adequate shelter would, therefore, be confined to coniferous and mixed forest. Telfer (1970) reported that the winter activity of white-tailed deer as well as moose, in central New Brunswick, was concentrated in dense coniferous type habitats during March 1967. Taylor (1956) stated that in the northern forest region, hardwoods, mixed softwood-hardwood stands and abandoned agricultural lands where shrubs and trees are becoming established, are commonly used in summer. During winter, where available, the conifer and conifer-hardwood types furnish principal cover. Coniferous forests were found to be rare in the study area although mixed forest was fairly common, especially in the western part of the study area (see results presented in the section on terrestrial vegetation).

The third requirement of vegetation by big game animals is for food. Deer and moose are primarily browsing animals. They are adapted physiologically for a coarse diet of leaves, twigs, and buds although in spring all species eat a wide variety of forbs and grasses. Food preference depends on season, availability, palatability, and nutritional value. Due to these factors, it is difficult to ascertain from the literature what food types are being utilized in a specific area. Even closely located areas can be different due to differences in soil type, climate, topography, cover and present land uses. For example, data collected at the Wainwright Military Base or in the Rocky Mountains can hardly be considered typical of the Sturgeon River area.

However, these data are useful in that they indicate species of plants which are utilized by deer. If the same species occur along the Sturgeon River, it might be expected that they would be used by deer there also. Table 59 indicates the utilization of plant species common to the Sturgeon River Basin by mule deer and white-tailed deer in Camp Wainwright, Alberta (Hall, unpublished data). A similarly prepared list of plants utilized by moose (Dennington, 1967) is also presented in Table 59. Referring back to the section on terrestrial vegetation, it is apparent that the four plants most utilized by mule deer and white-tailed deer - aster, aspen, snowberry, and rose - were very common (in at least 50% of the plots examined) in the deciduous and mixed-wood forest types. Many of the other indicated food items were well represented in these forest types as well. Utilization of available food species by deer in the Sturgeon River Basin was slight, in fact, browsed shrubs were rarely noticed.

Dennington's (1967) data shows that willow and red osier dogwood were the two most commonly utilized plant species by moose in the Saskatchewan River delta. Although willow was largely confined to the edge of the Sturgeon River and lakes, red osier dogwood was very common in the deciduous and mixed wood forest types.

It would appear that on the basis of data on the abundance of deer and moose food in the deciduous and mixed forest of the Sturgeon River Basin and the apparent under-utilization of this supply that lack of food is not limiting the size of present populations of big game animals.

To summarize the results of the analysis of escape cover,

TABLE 59

Frequency Occurrence of Plants Found in Rumen Samples from Mule Deer, White-tailed Deer, and Moose*

Species	Frequency of Occurrence in Mule Deer	White-tailed deer	Moose
Aspen	11	42	
Aster	12	42	
Balsam			3
Bearberry	3	14	
Bedstraw	2	5	
Birch			3
Bishop's cap		5	
Chokecherry	10	26	
Current		1	
Dandelion		1	
Dogwood		5	5
Grass	2	22	4
Horsetail		21	
Peavine	7	21	
Pyrols		2	
Raspberry		5	
Rose	11	35	
Saskatoon	3	15	
Snowberry	12	38	
Solomon Seal		1	
Strawberry		1	
Three-flowered avens		2	
Unidentified			9
Willow	1	7	10
Yarrow		1	
Total Sampled:	12	49	10

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* Data for Mule deer and white-tailed deer from Wainwright, Alberta. W.K. Hall (Unpublished data).

Data for Moose from the Saskatchewan River Delta (Dennington (1967).

shelter, and food in the forest communities of the Sturgeon River, it is apparent that escape cover is abundant in all forest types except pine. Shelter is best in the mixed and coniferous forest. Food is most plentiful in the deciduous and mixed forest. The mixed forest types are the only ones which best satisfy the three requirements of escape cover, shelter, and food. La Roi et al (1967) pointed out that the proximity of food and shelter in mixed forest is more attractive to ungulates that pure spruce or aspen forest.

The extent of mixed forest in the study area has been summarized in the section on terrestrial vegetation and is generally more plentiful along the upper portion of the Sturgeon River.

A further vegetative requirement in terms of deer habitat is the presence of "edges". According to Taylor (1956) edges and good white-tailed deer habitat are synonymous. The white-tailed deer has always found its best environment and therefore produced its greatest populations where edges were most abundant. The province of Alberta, as a whole, is a prime example of the "edge effect". At the turn of the 1900's there were few white-tailed deer in the province, however, due to the advent of agriculture there are now over 90,000 animals (Soper, 1964).

The amount of edge available is roughly indicated by the number of woodlots per square mile of area. In general, the greater the number of woodlots, the more edge there is available. Data on the number of woodlots per square mile along the Sturgeon

River have been presented in the section on terrestrial vegetation in Tables 1 through 7. The least amount of edge occurs along the Sturgeon River between Big Lake and a point due north of Calahoo. Here, there were only 8.4 woodlots per square mile because of the extremely small amount of forest cover resulting from intensive agricultural development. The amount of edge in the proposed areas of the Pembina and Magnolia reservoirs was also relatively small (9.5 woodlots per square mile) due to the large size of several of the woodlots. In most cases edge was abundant within these large woodlots. Edge, as indicated by the number of woodlots per square mile, was most abundant along the Sturgeon River between a point due north of Calahoo and Lac Ste. Anne. Along this section was an average of 15.3 woodlots per square mile.

To summarize the assessment of big game habitat along the Sturgeon River, between Calahoo and the North Saskatchewan River, there is a general lack of forest cover. The forest is mostly restricted to the edge of the river. In this narrow forested zone, escape cover and shelter during the winter are somewhat deficient due to the relative lack of coniferous trees. The amount of edge is low to average. Food species are abundnat because of the deciduous canopy and fertile black soil. The presence of southern exposures, a general feature characteristic of the Sturgeon River where it travels in a west to east direction in a fairly deep valley, is valuable as wintering habitat (Taylor, 1956) since these areas are relatively free of deep snow which impedes deer movements.

Between Calahoo and Lac Ste. Anne, there is an increase in the amount of forest and proportion of mixed forest. Escape cover, food, and shelter are therefore in good supply. The amount of edge is greater here than along any other section of the Sturgeon. The only limitation is that the soil is the transition type between black and grey wooded, somewhat less fertile than along the previously considered section of the Sturgeon.

Around Lac Ste. Anne and Isle Lake, forest cover, especially mixed forest is abundant, providing good escape cover, shelter, and food. Edge is better than average. However, the grey wooded soil is relatively infertile resulting possibly in food of inferior quality and abundance compared to the other areas.

The sites of the Pembina and Magnolia reservoirs are similar to the area around Isle Lake and Lac Ste. Anne but are present in the transition soil area. The quality of the habitat along the Pembina River is probably much the same as well.

In general, the river banks provide the most favorable habitat in the area as a whole (Fish and Wildlife Division, 1966). These areas provide a refuge for deer during winters characterized by excessive snow depths on the flat bench-land.

d.) Recorded Population Densities of Ungulates in the Sturgeon - Pembina Region:

Since the study was conducted in spring, aerial surveys were not conducted for big game. However, the following sightings were made:

- two white-tailed deer on an island in Lac Ste. Anne,
- one white-tailed deer along Sturgeon River,
- two white-tailed deer along Pembina River,
- two white-tailed deer between Isle Lake and Lac Ste. Anne,
- six mule deer in Magnolia area,
- one moose along the Pembina River.

Some recorded densities of big game populations are found in Progress Reports of the Alberta Department of Lands and Forests. The study area is known generally as Wildlife Management Unit F 336. It is bounded as follows: on the west by the Pembina River and Highway 57; on the south by the North Saskatchewan River; on the east by a line running south of Stony Plain to the North Saskatchewan River and on the north by Highway 43.

In 556.3 miles of transects flown in the area by the Alberta Fish and Wildlife Division between 1961 to 1966, the following animals were seen:

Species	No. Observed	Animals per mile
Moose	30	0.053
White-tailed deer	37	0.065
Mule deer	20	0.035
Unidentified deer	130	0.229
TOTAL	217	0.382

The Wildlife Investigations Progress Report by the Fish and Wildlife Division (1966) reported a minimum density of deer in the Stony Plain - Onoway region as 3.4 deer per square mile. In considering the whole of F 336 the reported densities are 1.7 deer per square mile and 0.2 moose per square mile.

Since the river banks are on the average, the best areas for deer, the population densities of deer and moose in the study area are probably higher than the mean densities listed above.

e.) Summary:

1.) The primary limiting factors to deer populations in the Sturgeon and Pembina River Basins are cold winter temperatures and deep snow.

2.) Additional limiting factors to deer along the Sturgeon River from Calahoo to the North Saskatchewan River include a general lack of forest cover due to agriculture and a lack of coniferous trees required for escape cover and shelter. However, forest cover in this area is largely restricted to the edge of the river, soil is fertile, south facing slopes are prevalent, and food in the forest is plentiful.

3.) From Calahoo to the headwaters of the Sturgeon River and along the Pembina River forest cover is adequate and mixed forest supplying food, escape cover, and shelter is abundant. The soil is, however, less fertile than in the area downstream.

4.) Deer populations are between 1.7 and 3.4 per square mile and probably average approximately 3 per square mile.

5.) Moose populations, probably limited primarily by excessive land clearing, average approximately 0.2 animals per square mile.

IV. FISHERY STUDY

A.) Sturgeon River

1.) Habitat Evaluation

a.) Introduction

The assessment of gamefish habitat involves an evaluation of the physical and chemical environment. A good stream should provide suitable habitat throughout the year, and especially during critical periods. The critical periods are (1) the mid-summer period of maximum temperature, minimal flows, and maximum production of aquatic vegetation and (2) the winter period characterized by minimal flows and low water quality. Therefore an extensive habitat evaluation should include assessments during these periods. The water analyses data presented indicate water quality in the Sturgeon River during the period May through September 1971. Unfortunately, water analysis was not continued into winter, usually the most critical period for a fish population.

Stream characteristics such as gradient, substrate type, occurrence of lakes along the channel and water quality are a function of the natural geographical and geological features of the watershed. Human activities in the watershed (i.e. agricultural land use, industrial and urban development) influence natural stream conditions, often adversely.

The study involved primarily the stream channel, and the inlet-outlet sections of the related lakes. The present condition of the lakes and their ability to produce gamefish is well documented (Lane, 1969). Poor conditions within the Sturgeon River indicate problems in the watershed which are and will continue to degrade the quality of the associated lakes. An attempt was made to compare the habitat suitability of the Sturgeon River during 1971 to that in previous years strictly on the basis of flow data. This is valuable since current fish populations reflect the condition of the environment over a period of years. The actual role of the Sturgeon River as it relates to the success of gamefish in the entire lake-stream system was examined. Factors examined included importance of the stream as a spawning, rearing, and feeding area, and its ability to support distinct stream populations.

b.) Methods

Water analysis was carried out throughout the period May 22 - September 13, 1971. A weekly sampling schedule was employed until June 22 at which time a bimonthly schedule was adopted. Air and water temperature, dissolved oxygen, specific conductance and hydrogen ion concentration (pH) were measured in the field. Air and water temperature readings were taken with a hydrographic thermometer. The Winkler method was used for dissolved oxygen determinations. Specific conductance was measured with a portable conductivity meter. Hydrogen ion concentrations were measured with a portable color comparator. Total alkalinity, total hardness, and calcium hardness were measured in the laboratory. A temperature compensation chart (Standard Methods, 1960) was used to standardize specific conductance readings to michromhos/cm. at 25°C.

The degree of chemical uniformity between stations was determined by comparing the seasonal trends for the following constituents: Specific conductance, total alkalinity, calcium hardness, and total hardness. The chemical uniformity test involved the assigning of relative percentage values for each constituent at each station (Clifford, 1966). Dissolved oxygen and water temperature were not included in the test since they undergo marked diurnal variation and sampling times were not uniform in the study.

c.) Results

The results of the chemical uniformity test (Table 60) indicate a relatively low similarity between the Sturgeon River water analysis stations, which reflects the complex nature of the Sturgeon River system. The locations of the water analysis stations are indicated in Figure 6. As a group, Stations 1, 2, and 3 exhibited a moderate uniformity but a much lower uniformity to other stations. Stations 5 and 6 were similar at a 95% uniformity level. Station 4 was inter-

TABLE 60

Degree of Chemical Uniformity (in %) between Stations on the Sturgeon River (May - September 1971)

Stations:	1	2	3	4	5	6	7	8	9	10
1	-									
2	95	-								
3	94	99	-							
4	86	88	89	-						
5	71	73	62	85	-					
6	68	70	71	82	96	-				
7	64	66	67	78	88	88	-			
8	64	65	67	77	90	87	97	-		
9	63	65	66	77	87	89	99	96	-	
10	61	63	64	75	86	87	97	97	97	-
Mean Uniformity	74	76	75	82	82	82	83	82	82	81

FIGURE 6

Water Analysis Stations (S1-10) and Sections Electrofished (E1-7), on the Sturgeon River, 1971.

mediate in similarity between the two groups. Stations 7, 8, 9, and 10 were extremely similar (95% uniformity level) and exhibited a moderate uniformity (85%) to Stations 5 and 6.

Stations 1, 2, and 3 monitored water quality above Lake Isle, above Lac Ste. Anne, and below Lac Ste. Anne, respectively. Monitoring at station 1 was discontinued on August 19. Dishcharge at this time was negligible and the habitat consisted of isolated pools and exposed riffles (Photo 19). Station 5 indicates water quality below Matchayaw Lake while station 6 indicates water quality between Riviere Qui Barre and Big Lake. Stations 7, 8, 9, and 10 indicate the general water quality between Big Lake and the North Saskatchewan River. The influence of the town of St. Albert on water quality would be best indicated by the results at stations 7 and 8.

1.) Water Temperature: The mean water temperature for all stations over the study period (May 27 - September 13) was 18°C. The mean minimum temperature for all stations, recorded in mid-September, was 12.3°C. Maximum temperatures were recorded at the following sample times: June 21-22, July 19-20, and August 2-3. The mean maximum temperature for the three sample times was 22.3°C., 22.3°C., and 23.9°C., respectively. These results represent the temperature regime of the Sturgeon River at baseflow conditions (for 1971) and reflect mid-summer condition. The maximum temperature recorded for any station was 25°C. (Station 3, August 2). The river exhibited

Photo 19: Water Analysis Station 1, Sturgeon River, August 1971. Low flows and bank disturbance by livestock combined to reduce the habitat quality.

a rapid temperature increase over the one-week period, June 14-15 to June 21-22. The average temperature increase for all stations was 8°C. however, the increase for stations 7 and 8 was 11°C. and 10.5°C., respectively, in this period. A summary of recorded values is shown in Table 61.

2.) Specific Conductance: The mean conductivity recorded for all stations over the study period was 344 micromhos/cm. The conductivity showed a general downstream increase. The mean conductivity was 254 micromhos/cm. for the upper stations (1-4) and 403 micromhos/cm. for the lower stations (5-10). Recorded values were inversely related to the amount of surface run off. The maximum values were recorded for the lower stations during base-flow conditions. A value of 549 micromhos/cm. was recorded for station 9 on June 22. A summary of recorded values is shown in Table 61.

3.) Total Alkalinity: The mean bicarbonate ion concentration for all stations over the study period was 184 ppm. $CaCO_3$. A maximum value of 256 ppm. was recorded at station 6 on June 7. A summary of recorded values is shown in Table 61.

4.) Total Hardness and Calcium Hardness: Seasonal concentrations of calcium and total hardness appear to be dependent upon the amount of surface run off. A summary of results is shown in Table 61. The highest values were recorded during periods of base-flow in the third week of June, and in the latter part of the study period. The maximum values recorded

TABLE 61

Summary of Water Analysis Data, Sturgeon River,

May 22 - September 13, 1971

Station	Bicarbonate Alkalinity (ppm)			Calcium Hardness (ppm)			Total Hardness (ppm)			Conductance Micromhos/cm.			Water Temperature (°C)		
	max	min	mean	max	min	mean	max	min	mean	max	min	mean	max	min	mean
S1	171	120	136	86	68	80	154	103	124	248	169	216	22.0	13.5	16.8
S2	171	120	152	103	68	77	137	103	116	267	212	242	23.0	12.5	17.5
S3	171	120	155	94	60	77	137	103	117	290	216	250	25.0	13.0	18.0
S4	256	154	189	111	60	86	171	103	133	387	292	309	24.5	13.0	18.2
S5	272	154	212	120	68	108	222	103	169	437	322	379	24.5	13.5	19.2
S6	272	197	221	137	86	107	222	103	170	501	364	419	24.0	12.5	17.9
S7	239	137	191	171	94	133	256	137	196	544	298	406	24.5	10.5	17.7
S8	239	171	200	154	94	132	239	137	202	505	293	388	24.5	11.5	18.2
S9	222	154	191	154	94	133	230	137	197	549	297	418	24.5	12.0	18.0
S10	222	154	197	188	94	139	240	137	206	533	282	410	23.5	12.0	18.0

were 188 ppm. for calcium and 256 ppm. for total hardness at station 10 on June 22. There is a direct relationship between distance downstream and the concentration of both constituents. The mean calcium concentration and total hardness for the upper stations (1-4) was 80 ppm. and 123 ppm. respectively. For stations 5 and 6 the mean concentrations were 108 and 170 ppm. For the lower stations (7-10) the mean concentrations were 134 ppm. and 200 ppm.

5.) Hydrogen Ion (pH): All pH measurements were on the alkaline side for all stations over the study period. The pH ranged between 7.6 - 9.0 indicating a well-buffered system. The seasonal fluctuation of hydrogen ion concentration reflected the amount of buffered substances (bicarbonate) present in the water.

6.) Dissolved Oxygen: Dissolved oxygen concentrations and percentage saturations showed considerable variation over the study period. The results are shown in Table 62. The degree of variation is determined by the geographical location of the station within the lake-river system, and the physical-biological features of the station. Most of the stations exhibited three peaks of oxygen saturation over the study period, all which occurred during periods of base-flow in (a) mid-May to early June, (b) late June, and (c) September. A reduction of river stage is associated with a decrease in turbidity and a decrease in the influx of allocthonous organic material.

TABLE 62

Percentage Saturations and Dissolved Oxygen Concentrations, Sturgeon River,

1971

Station		May 22	June 1	June 8	June 15	June 22	July 5	July 19	Aug 3	Aug 19	Aug 30	Sept 14
S1	ppm	8	-	7	8	7	6	6	6	-	-	-
	% Sat.	80	-	67	76	75	55	65	68	-	-	-
S2	ppm	8	9	5	6	8	5	5	1	3	-	8
	% Sat.	81	95	48	59	92	47	56	11	32	-	74
S3	ppm	9	7	6	9	6	7	7	5	3	5	8
	% Sat.	92	75	57	88	64	67	80	61	32	54	75
S4	ppm	8	-	7	7	6	6	5	4	6	4	7
	% Sat.	85	-	67	67	67	59	58	48	64	44	66
S5	ppm	12	13	7	12	14	5	5	6	3	8	7
	% Sat.	127	132	68	108	153	50	58	72	31	86	67
S6	ppm	9	9	10	6	5	5	5	3	5	8	8
	% Sat.	97	92	93	58	57	49	58	35	53	86	74
S7	ppm	6	7	5	5	8	6	2	1	3	4	1
	% Sat.	62	73	48	47	95	58	22	11	32	43	8
S8	ppm	5	5	5	4	7	6	1	3	2	3	4
	% Sat.	52	52	50	38	83	62	11	35	21	32	36
S9	ppm	7	5	8	5	6	5	3	2	1	2	3
	% Sat.	82	51	77	50	68	51	35	24	21	21	27
S10	ppm	6	9	8	8	9	7	7	6	8	9	8
	% Sat.	50	91	80	89	105	82	80	70	86	98	74

Increased photosynthetic activity and a lowering of the oxygen demand follow the decrease in flow and turbidity.

Sampling stations were not uniform in saturation levels attained under base-flow conditions. While station 5 attained supersaturation values during the two summer peaks, stations 7, 8, and 9 reached only moderate saturation levels. The late-June maximum was followed by generally low percentage saturation values throughout July and August at all stations. The duration and intensity of the low saturation period varied between stations. The degree of recovery also varied.

A graphical representation of chemical values and trends found at all stations on the Sturgeon are found in Appendices 10 - 19.

d.) Discussion

When discussing the habitat suitability of a stream, both the physical and chemical features of the environment must be considered. To support healthy and diversified gamefish populations a stream must provide suitable habitat over a period of years. Since habitat suitability is dependent to a large degree upon flow regime, a habitat evaluation should relate data during the study period to flow patterns in previous years.

The chemical environment in a section of stream is largely controlled by the physical features of the channel and characteristics of the watershed both locally and at its extremities.

Excessive removal of the natural forest cover and other disturbances which alter the run-off pattern result in an unstable flow regime. Natural flow patterns usually result in an environment which is suitable to the production of gamefish. The contrast in flow regime between 1969 and 1971 illustrates the extreme variability in habitat quality that occurs in the Sturgeon River. The flow pattern during the 1971 study resulted in a much higher habitat suitability for warm-water gamefish than described for the Sturgeon River in 1969 by Lane. The July and August mean monthly discharges at Fort Saskatchewan were 4.9 and 7.5 c.f.s. in 1969. For the same months in 1971 the mean monthly discharges were 354 and 441 c.f.s. The winter conditions will also be more favorable in 1971. The September 30th discharge at Fort Saskatchewan was 25.6 c.f.s. for 1969 and 146 c.f.s. in 1971. Lane (1969) felt that "discharge in much of the river over winter is probably negligible".

Winter conditions in the stream during 1971-72 will be more favorable due to the higher flows. However, it is difficult to determine the extent of over-wintering which will occur. Other factors such as high oxygen demand probably preclude over-wintering despite the presence of sufficient flow volume. In 13 of the years during the period 1950-1971, the Sturgeon River exhibited a September 30th discharge equal to or less than that recorded in 1969. This indicates that 1969 is quite typical in regards to actual over-winter conditions. In contrast, the September conditions for 1971 have been exceeded only three times during the same period.

Water quality at individual stations probably represents the condition of the river for some distance upstream. Therefore, by assessing habitat quality at each station a general representation of the river can be developed. Of the chemical constituents monitored, only the seasonal trend for dissolved oxygen was of critical importance.

Total alkalinity, specific conductance, etc., serve as an index of potential stream productivity. The Sturgeon River, notably the lower stretches, can be classified as a "hard water" stream indicating a high potential production for aquatic plants and animals. The bicarbonate alkalinity, the main contributing factor to the specific conductance, is especially important in this regard, since bicarbonates serve as reservoirs of carbon for the photosynthetic processes. During the 1971 study period, the potential productivity was not maintained due to the influences of high flows and turbidity. The degree of influence varied between stations. The level of plant growth during 1971 did not equal that described for 1969 by Lane. Dense growths of aquatic vegetation usually preclude the existence of a healthy gamefish population due to high oxygen demand, particularly during the winter (Photo 20).

In a natural stream, dissolved oxygen concentrations are at or near 100% saturation throughout the open water period. The occurrence of supersaturation indicates a high rate of photosynthetic activity. Lower than saturation levels are expected during periods of runoff when turbidity is high. Extended periods of low dissolved oxygen that occur during periods of

Photo 20: Water Analysis Station 7, Sturgeon River, August 1971, downstream from St. Albert. A situation in which low gradient, lack of bank cover, mud bottom, dense growth of aquatic vegetation and high oxygen demand combine to form poor gamefish habitat.

Photo 21: Sturgeon River, August 1971, downstream from Lac Ste. Anne. A relatively hign gradient situation in which a favorable riffle-pool separation, adequate bank cover and a rubble-boulder substrate combine to maintain a higher water quality.

low flow, when concentrations are expected to be high, indicate that the oxygen demanding processes are taking place to override the effects of photosynthesis. The dissolved oxygen levels were generally well below saturation throughout July, August, and September. The extent to which this phenomenon occurred varied between stations and was determined by proximity to lakes, and the gradient at and above the station.

The ability of a stream to support fish populations can be limited by its ability to maintain adequate dissolved oxygen levels over the years. Adequate levels allow fish to grow, feed actively and reproduce normally. Warm-water gamefish require oxygen concentrations above 5 ppm to maintain normal activity, assuming that there are normal seasonal and daily variations above this concentration. "Under extreme conditions and with the same stipulations, the dissolved oxygen may range between 5 ppm and 4 ppm for short periods of time, provided that the water quality is favorable in all other respects". (Water Quality Criteria, 1968). It is also stated the 3 ppm does not allow normal growth and activity. A period of summer stagnation was most severe and prolonged at Stations 7, 8, and 9. Dissolved oxygen concentrations were not sufficient for gamefish during this period and more important, no significant recovery had occurred by mid-September. Therefore, winter conditions will probably be unsuitable for overwintering gamefish in the section of river between Stations 7 and 9, and for an undetermined distance below Station 9. The factors which indirectly led to this condition were the fluctuating discharge and low gradient. High water results in an influx of allochthonous organic material and in increased turbidity (Dorris _et al_ 1963). "The combination of silt and organic matter in a stream seriously complicates the normal aeration processes". (Dunham, 1958 cited in Cordone _et al_). This combination results in benthal decomposition a process involving the settling out of organic material in sections of low current velocity. The low gradient between Big Lake and Station 9 (1.59 feet per mile) probably facilitates this process.

Station 10 exhibited a high chemical uniformity with Stations 7, 8, and 9, but was not characterized by a period of severe summer stagnation and did exhibit a marked recovery by mid-September. Low oxygen concentrations did not cccur, probably because of the increased gradient in the upstream channel (5.3 feet per mile). Increased current velocity is associated with rough stream beds, hence turbulent water, which produces a more rapid restoration of equilibrium and a more stable environment in respect of dissolved gases (Hynes, 1971). In addition, oxidizable substances do not accumulate in high gradient sections (Photo 21).

Station 4 is situated in a hihh gradient zone (6.3 feet per mile) and exhibits a similar degree of stability. Station 5 was the most productive station in terms of aquatic plant growth indicated by the supersaturation values (132% and 153%) reached during period of base-flow and maximum plant growth. (Photo 22). Water clarity was generally higher at

Photo 22: Water Analysis Station 5, August 1971, downstream from Matchayaw Lake. A situation in which high water clarity and relatively stable flow combine to permit dense growths of submergent vegetation. Dissolved oxygen supersaturations were common. An extended period of summer stagnation did not occur due to the non-organic nature of the substrate and the moderate gradient.

this station due to effectiveness of Matchayaw Lake in reducing the sediment content of the water.

The water temperature of a stream especially during mid-summer can be a limiting factor to gamefish. High temperatures and low dissolved oxygen concentrations can result in exclusion of gamefish directly or indirectly by creating conditions more suitable to coarse fish. During the 1971 study period the maximum temperature recorded was 25°C (77°F) which is within the tolerance listed for warm-water gamefish. Maximum temperatures exceeding 84°F do not permit the normal growth and activity of northern pike and walleye (Water Quality Criteria, 1968). The optimum temperature for these species is probably considerably less than 84°F. The maximum temperature recorded by Lane in 1969 was 82°F. Higher flows in 1971 were probably effective in keeping the water temperatures within a reasonable upper limit.

Temperature, however, is probably of secondary importance to dissolved oxygen in limiting fish populations in the Sturgeon River, since the effects of low oxygen concentrations extend into the critical winter period. Rapid increases in water temperature, although they may not be directly harmful to fish populations are usually indicative of severe changes in the bank cover of the watershed. Clearing of vast tracts of the watershed for agricultural purposes, causes radical changes in the patterns of runoff which "tend to make the water more silty, the minimal flows lower and the maximal temperatures higher" (Hynes, 1971). The section of the river between

Big Lake and station 9 is especially susceptible to rapid increases since the channel is wide and the current velocity low, which results in maximum sun exposure. Extensive bank cover is necessary in this type of situation to keep water temperature within tolerance limits.

During the 1971 study period, most sections of the Sturgeon River provided suitable fish habitat in regards to chemical characteristics and temperature. Low gradient sections between Big Lake and station 9 were probably marginal to unsuitable during the period of summer stagnation. The section of stream above Lake Isle was not capable of supporting gamefish from late summer through mid-September due to extremely low flows.

The primary factors which presently affect the well-being of the Sturgeon River fishery are related to the amount of natural forest cover removed and subsequent use of the land for agricultural purposes. Changes in the flow-patterns associated with agriculture lands cause increased eutrophication of the river channel by providing minimal summer flows which results in dense growths of aquatic vegetation. Run-off from agricultural lands also increases the amount of nutrients entering the stream. Agricultural fertilizers and cattle grazing activities are important in this regard.

A lake-stream system, such as the Sturgeon River drainage, provides habitat for both a lotic and lentic invertebrate fauna. A description of the lentic bottom fauna of the Sturgeon River basin is found in Lane (1969). The complex Sturgeon River channel provides a great variety of habitat types. Cursory examination of the invertebrate fauna at the water analysis stations was carried out with a Surber sampler, which is ineffective at sampling mud or silt substrates. As a result, sampling was not carried out at stations 7, 8, and 9, and involved only visual examination.

Invertebrates were generally abundant at all stations. Black fly larvae (*Simulium* sp.) were the most abundant invertebrates at stations 1, 2, and 3. Large concentrations of *Gammarus* sp. were observed at stations 5 - 9. This invertebrate is usually associated with slow-moving stretches of stream, which simulate a lake environment. Trichopteran larvae (caddis) were present in the samples at all stations but were most abundant at stations 4 - 10. Ephemeroptera (mayflies) were most abundant at stations 1 and 10.

The Sturgeon River has a high potential productivity for aquatic plants. Unfortunately, when conditions are optimum as in 1969 the resulting habitat is unsuitable to gamefish. The Sturgeon River during peak years of macrophyte growth is probably marginal summer habitat and unsuitable winter habitat. In these years the importance of the Sturgeon would be limited to spawning and rearing habitat in spring and early summer. During 1971 due to higher flows and lower vegetation density, gamefish utilized a greater portion of the river. The Sturgeon River would probably exist only as an intermittent stream during low-flow years were it not for the lakes situated along its course. However, the current trends of eutrophication in each of the lakes, particularly Big Lake, will aggravate further the current trend toward excess productivity within the Sturgeon River per se. The river then has a low capacity for overwintering gamefish. Most fish probably overwinter in the lakes.

e.) Summary:

1.) Increased flows in 1971 provided better than normal summer habitat. The ability of the Sturgeon River to overwinter fish will likely be higher during the winter of 1971-72. The extent of overwintering, should it occur, is difficult to predict.

2.) Habitat quality in low-flow years will be considerably lower than that described for 1971.

3.) Maximum temperatures were within the tolerance of warm-water gamefish. However, rapid temperature increases occurred at some of the lower stations.

4.) Specific conductance, total alkalinity, total hardness and calcium content increased downstream, reaching maximum levels at the lower stations. The values for the above constituents indicate a high potential productivity for aquatic biota.

5.) Growth of aquatic vegetation did not reach potential levels at most stations due to the physical interference of turbidity, siltation and unstable flows.

6.) Hydrogen ion concentration (pH) fluctuated within a narrow range, well within the tolerance of gamefish. This indicates a well buffered system, due to the high alkalinity.

7.) Extremely low dissolved oxygen saturations were recorded during July and August. The duration, intensity, and degree of recovery varied between stations.

8.) Summer stagnation was most severe at stations 7, 8, and 9. Low gradient is probably the main causative factor.

9.) Stations 4 and 10 exhibited the highest habitat suitability due to the maintenance of adequate oxygen concentrations. Relatively high gradient at and above these stations, results in an adequate riffle-pool separation.

10.) Station 5 below Matchayaw Lake was the most productive in terms of aquatic vegetation. Relatively high dissolved oxygen saturations were recorded. Water clarity was highest at this station throughout the study.

11.) Station 1 was discontinued on August 19th. The stream at this time consisted of exposed riffles and isolated pools.

12.) Land use in the Sturgeon Basin results in unstable flows which contribute to a reduction in habitat quality.

2.) Fish Populations:

a.) Introduction:

Objectives of the present study were to determine the relative abundance and diversity of gamefish populations (1) in the Sturgeon River near the lakes, and (2) in sections of the river between the lakes.

It was hoped, initially that fish collections would reveal whether Sturgeon River fish populations are distinct or whether summer populations within the stream result from dispersal from the lakes. However, since this involved a rather extensive study in itself a secondary objective was to determine the relationship between habitat and the current fish populations.

An assessment of the role of the Sturgeon in providing spawning and rearing habitat was also undertaken. Fish collections were designed to determine the extent of fish movements into the Sturgeon from the North Saskatchewan River. The fish collection data were interpreted on the basis of the habitat available during 1971. Basing long range trends on the 1971 results is not feasible since flow patterns are very important in the annual distribution of gamefish. Problems incurred in the study included sustained high flows, difficulty in maneuvering the boat-adapted electrofisher, and poor launching accessibility.

b.) Methods:

Fish were collected with a boat-adapted electroshocking unit. The sample sections were selected on the basis of the availability of launching sites and channel suitability (i.e. sufficiently wide to permit boat maneuverability, etc.). The location of electrofishing sections are found in Figure 6. An attempt was made to include all major habitat types in the collections. Upon capture the fish were anesthesized with M.S. 222 (Tricane methanesulfonate). All fish were weighed and fork lengths were recorded. Mature gamefish were tagged with number coded FD67 anchor tags using an FDM 68 applicator gun. (Floy Tag Co.)

c.) Results and Discussion:

The following species of gamefish were found in the Sturgeon River system: northern pike, walleye, yellow perch, sauger, and goldeye. Northern pike were the only gamefish found throughout the river. All other species exhibited a localized distribution. Table 63 lists all fish species sampled during the study period.

No attempt was made to determine species diversity or relative abundance in the lakes since both have been well documented (Lane, 1969).

The respective winter habitat suitabilities inferred from the flow data during the period 1950-1971 indicate that the Sturgeon River (not including the lakes) is incapable of sustaining significant populations of gamefish. The existence of

TABLE 63

A List of Species Collected on the Sturgeon River, Summer 1971

Walleye	*Stizostedion vitreum vitreum* (Mitchill)
Sauger	*Stizostedion canadense* (Smith)
Northern Pike	*Esox lucius*
Goldeye	*Hiodon alosoides* (Rafinesque)
Yellow Perch	*Perca flavescens* (Mitchill)
Northern Redhorse	*Moxostoma macrolepidotum* (Lesueur)
White Sucker	*Catostomus commersoni* (Lacepede)
Burbot	*Lota lota* (Linnaeus)
Spottail Shiner	*Notropis hudsonius* (Clinton)

gamefish in the river requires the presence of suitable over-wintering areas from which dispersal might occur when conditions in the river are suitable. The fish collections of 1971 indicate that the North Saskatchewan River and the associated lakes are important in this regard. There may be, however, specific locations within the Sturgeon River itself which are able to over-winter fish.

Sections E6 and E7 were electrofished on August 21 and 23 respectively. Both are situated in a relatively high gradient zone (5.3 feet per mile) which provides an adequate pool-riffle separation and a diversified habitat. Six species of fish were collected, the highest diversity recorded in any part of the Sturgeon River. This probably reflects the higher quality habitat and the proximity of E6 and E7 to the North Saskatchewan River. White suckers were the most abundant species and northern pike were the most abundant gamefish species. The species composition included several fish which are of North Saskatchewan River origin. The occurrence of northern redhorse, sauger, and goldeye has been documented in that system, and near the mouth of the Sturgeon River (Paetz and Nelson, 1970). The northern pike are probably members of a North Saskatchewan population as well.

White suckers were concentrated in pools above and below riffle areas. The habitat preferences of the northern red-horse were similar. Aquatic vegetation was not extensive in the main part of the channel, however submergent growth did occur in the quiet waters at the stream edge. Northern pike and goldeye preferred such areas. The water remained quite turbid throughout the study period a feature preferred by goldeye and tolerated by sauger. Northern redhorse are often associated with riffles or areas of fast water (Paetz and Nelson, 1970). None of the three species known to be of North Saskatchewan origin were sampled in Section E5 near St. Albert. Presumably the poor quality habitat between the two zones prevented further upstream movements. The Sturgeon River may provide spawning habitat in the spring to fish from the North Saskatchewan River. Whether this is true for goldeye is not known since they apparently do not spawn in the Edmonton area. (Patterson, 1966). High flows throughout the summer and fall probably allowed all species to utilize the Sturgeon over a longer period during 1971.

Section E5 was electrofished on August 19. This section included the outlet from Big Lake downstream to a point west of St. Albert. Diversity and abundance were low in comparison to sections E6 and E7. Only northern pike, white suckers, and a single walleye were collected. The walleye was sampled approximately 3/4 mile west of St. Albert and was probably a wanderer from the North Saskatchewan River. The low diversity and abundance in this section is probably related to the uniformity and poor quality of the habitat provided.

A significant population of northern pike was found to inhabit Big Lake, particularly in the weedy margins near the outlet. Sampling success decreased for all species in a downstream direction from St. Albert. The data indicate that northern pike below Big Lake rely on the lake when habitat conditions within the channel become unfavorable.

Section E3, which includes the outlet of Matchayaw Lake, was sampled on two occasions, August 20 and September 7. The channel pattern alternates between large, shallow marshy areas and a narrow channel less densely vegetated with aquatic submergents. The current velocity was meagre in all sections, and water clarity was high.

Large numbers of northern pike and white suckers were collected (Table 64). Large numbers of young-of-the-year yellow perch were concentrated in the marsh areas. Mature northern pike were also abundant in these areas and stomach analyses indicated that they were feeding almost exclusively on young perch.

As the channel narrows further downstream from the lake, a decrease in abundance in all species was noted. This is probably related to the increasing occurrence of pools and channel which did not support dense aquatic growth. The average size of pike collected in the downstream sections was smaller than close to the lake. Young-of-the-year pike were also abundant downstream.

It appears that the weed-choked marsh areas near Matchayaw Lake provide spawning and rearing habitat for yellow perch and subsequently a feeding area for northern pike. The same areas probably provided excellent spawning habitat for northern pike.

TABLE 64

Electrofishing Results for Sturgeon River, 1971

Species	Section Designation and Length in Miles E1 16	E2 2.25	E3 3.36	E4 2.4	E5 4	E6 1.9	E7 2.4	Total 17.91
Northern Pike	7	4	52	17	21	7	14	122
Walleye	-	-	-	-	1	-	-	1
Yellow Perch	6	3	6	-	-	-	-	15
Goldeye	-	-	-	-	1	4	-	5
Sauger	-	-	-	-	-	-	1	1
White Sucker	-	13	27	49	13	59	101	262
Northern Redhorse	-	-	-	-	-	4	4	8
Burbot	-	-	-	-	-	-	1	1
TOTAL	13	20	85	66	36	74	121	415

Young pike appear to have shifted downstream, perhaps as a result of competition.

The general downstream decrease in abundance for pike and perch suggests that they are components of the lake populations. This is especially true of the perch since none were captured in the downstream collections. The numbers of each species of fish collected in the sample section are indicated in Table 64.

Section E, a stretch below the entry of the Riviere Qui Barre, was electrofished on August 24. The channel provided few riffle areas, and in some places the channel widened and became quite shallow. Current velocity, aside from in the few minor riffle areas, was negligible. Submergent vegetation was scarce in the channel and some emergent vegetation occurred along the margin. Large numbers of white suckers and lesser numbers of northern pike were collected. (Table 64). The habitat provided in this section was not entirely suitable to northern pike. This is attributed to the uniformity and general lack of submergent vegetation in the channel. Variable flows which result in turbidity and excessive siltation limit the fish productivity in this section of the stream.

Sections E1 and E2 were electrofished on July 23 and July 26 respectively. The sections had a common origin and the combined results relect the fish populations between Isle Lake and Lac Ste. Anne. Due to the closeness of the lakes and the similar species composition in each, it is difficult to determine the origin of fish sampled. Accessibility to this stretch however, would be easier from Isle Lake. Yellow perch and northern pike were collected in both sample sections. No white suckers were collected in the upstream sample while walleye were sampled in Section E2. Individual measurements of gamefish species are found in Appendix 20.

d.) Summary:

1.) The flow conditions during mid-summer and winter, in most years during the period 1950-1971, did not provide suitable habitat in most sections of the Sturgeon River.

2.) The flow pattern during the 1971 study period probably permitted maximum dispersal throughout the river.

3.) The associated lakes are important in the harboring of fish during periods of summer stagnation and during winter. The North Saskatchewan River appears to provide the same function to fish in the lower Sturgeon.

4.) Dispersal of fish from the lakes and the North Saskatchewan River are important in repopulating the stream following periods of severe habitat limitation.

5.) The Sturgeon River, especially in the region of lakes (inlets and outlets) provides important spawning and rearing habitat for northern pike and yellow perch. The lower Sturgeon may provide the same for North Saskatchewan River fish.

6.) Northern pike were present throughout the river but were most abundant in the marshy areas close to the lakes.

7.) Yellow perch were relatively abundant in sections close to lakes, but were scarce in distant sections.

8.) Walleye were scarce throughout the river.

9.) Goldeye, sauger, and northern redhorse, species which occur normally in the North Saskatchewan River, were collected in the lower reaches of the Sturgeon River.

B.) Pembina River

1.) Habitat Evaluation:

a.) Introduction:

Streams display gradual, and in some cases abrupt changes in physical, chemical and biological conditions from source to mouth. The objectives of the Pembina River habitat study were to define and describe in general terms the variation in habitat quality between Easyford and the Pembina-Athabasca confluence. The following physical parameters were considered to be important in assessing habitat quality: percentage of pool, percentage of riffle, pool quality, riffle quality, substrate type and condition, average gradient, surface velocity, bank stability, water level fluctuation, and water clarity.

The habitat study was conducted during the period September 21-28, 1971. An evaluation at near base-flow conditions is desirable since the habitat characteristics indicate the condition of the river as it enters the critical winter period. Base-flow in dry or wet years, relative to 1971, would result in poorer or better over-winter conditions, respectively.

Since water quality can be important in determining habitat suitability, monitoring of selected chemical constituents was carried out during the period May 22 - September 15, 1971.

b.) Physical Environment:

1.) Methods:

The location of sample stations was related to linear distribution and available access. Typical station procedure involved the determination of the various habitat parameters for a known distance upstream and downstream from a predetermined sample site.

Percentage of Pool and Riffle:

The percentage of pool and riffle is the percent of surface area each water type contributed to the total surface area at a station. Pool and riffle water were further differentiated into classes reflecting relative quality. The distinction between pool and riffle was made on the basis of current velocity.

Pool Quality Criteria:

Four pool types were recognized. "A" pools were considered to be those most valuable to gamefish populations, and "D" pools those with a minimal value.

Pool Type "A":

1.) High-riffle association i.e. pool situated at the base of a high-class riffle (tail water), or situated within a high-class riffle (backwater).

2.) Deep with little pool cover to moderately deep with significant pool cover.

3.) Substratum of a rubble-boulder type without excessive siltation.

Pool Type "B":

"B" pools are separated from "A" pools on the basis of one major deficiency or several minor deficiencies.

1.) Moderate riffle association i.e. pools which are not directly associated with a high class riffle or are directly associated with a lower class riffle. (e.g. could either be distinct pools with minor deficiencies, the fringe area around class "A" pool, or the water directly below class "A" pool).

2.) Depth may be a minor limiting factor in low-water years, particularly in winter.

3.) Siltation of substrate significant, though not severe.

Pool Type "C":

"C" pools were separated from "B" pools on the basis of one major habitat deficiency or several minor deficiencies.

1.) Low to moderate riffle association i.e. pools are separated from high-class riffles to such an extent that they do not derive direct benefits, or are associated with a low-class riffle.

2.) Depth may be a limiting factor.

3.) Substrate siltation significant, possibly severe.

Pool Type "D":

Pool "D" is characterized by several minor or severe basic habitat deficiencies.

1.) Low to non-existent riffle association.

2.) Deep with poor riffle association, or shallow with moderate association.

3.) Substrate of non-productive type i.e. sand-silt.

Riffle Quality Criteria:

A section of river was labelled riffle if the current velocity was greater than the adjacent upstream and downstream water. Four riffle types were recognized. Type "1" riffles were considered to be the most productive, and type "4" was the least productive.

Riffle Type "1" (Deep - Fast):

1.) Deep enough to allow fish movement.

2.) Desiccation during low-flow, and freezing during winter, not likely to be a problem.

3.) Sufficient current velocity to maintain a clean substratum.

4.) High productivity.

Riffle Type "2" (Shallow - Fast):

1.) Deep enough to allow fish movements during open water.

2.) Desiccation and freezing could be limiting factors in low-flow situations.

3.) Current velocity sufficient to maintain clean substratum.

4.) Moderate productivity.

Riffle Type "3" (Deep - Slow):

1.) Deep enough to allow fish movements.

2.) Desiccation and freezing not likely to be a problem.

3.) Current velocity not sufficient under normal flow to maintain clean substratum.

4.) Moderately productive.

<u>Riffle Type "4" (Shallow - Slow)</u>:

1.) Shallow such that fish passage under normal conditions is difficult.

2.) Prone to desiccation and freezing.

3.) Current velocity not sufficient to maintain clean substratum.

4.) Productivity lower than types "1", "2", "3".

<u>Substrate Types Designated</u>:

Boulder - Rocks over 12 inches in diameter.

Rubble - Rocks 3 to 11.9 inches in diameter.

Gravel - Rocks 0.1 to 2.9 inches in diameter.

Sand-silt - Particles less than 0.1 inch in diameter.

Other - Other matter (sunken logs or other debris).

<u>Average Gradient</u>:

Average gradients were determined for the Pembina River study section. Actual stream lengths between contour intervals were determined from 1:50,000 topographic maps using the method described in Herrington and Toscher, (1967).

2.) Results:

Habitat analysis was carried out at 31 locations between Easyford and the Pembina-Athabasca confluence (Fig. 7).

The survey data show that a definite relationship exists between average gradient and habitat quality. MacPhee (1966) has stated that,"Correlations between stream gradient and environment exist insofar as the steepness of the stream bed determines the velocity of current which, in turn, is largely responsible for the pool-riffle ratio, the scouring of the stream bottom, the gravel size, the amount of siltation present, ..." A longitudinal profile of the Pembina River study section (Fig. 8) indicates the presence of six major gradient zones. The gradient zones are not distinct due to the gradual, often imperceptible, blending that occurs along the river in response to major geographical features of the watershed. Abrupt changes and recovery in habitat characteristics within a zone reflect the presence of geographical irregularities. An example of this would be an artificial or natural meander cutoff resulting in an increased gradient (Photo 23).

The abundance and characteristics of riffles and pools within each gradient zone is presented in Figure 9. The substrate types within each gradient zone are shown in Figure 10. A summary of the habitat characteristics for each zone is presented in Table 65. The habitat stations found within each zone are also indicated. Habitat stations which fell into the same zone exhibited similar physical characteristics

FIGURE 7

Habitat Sampling Sites (1-31) on the Pembina River, 1971.

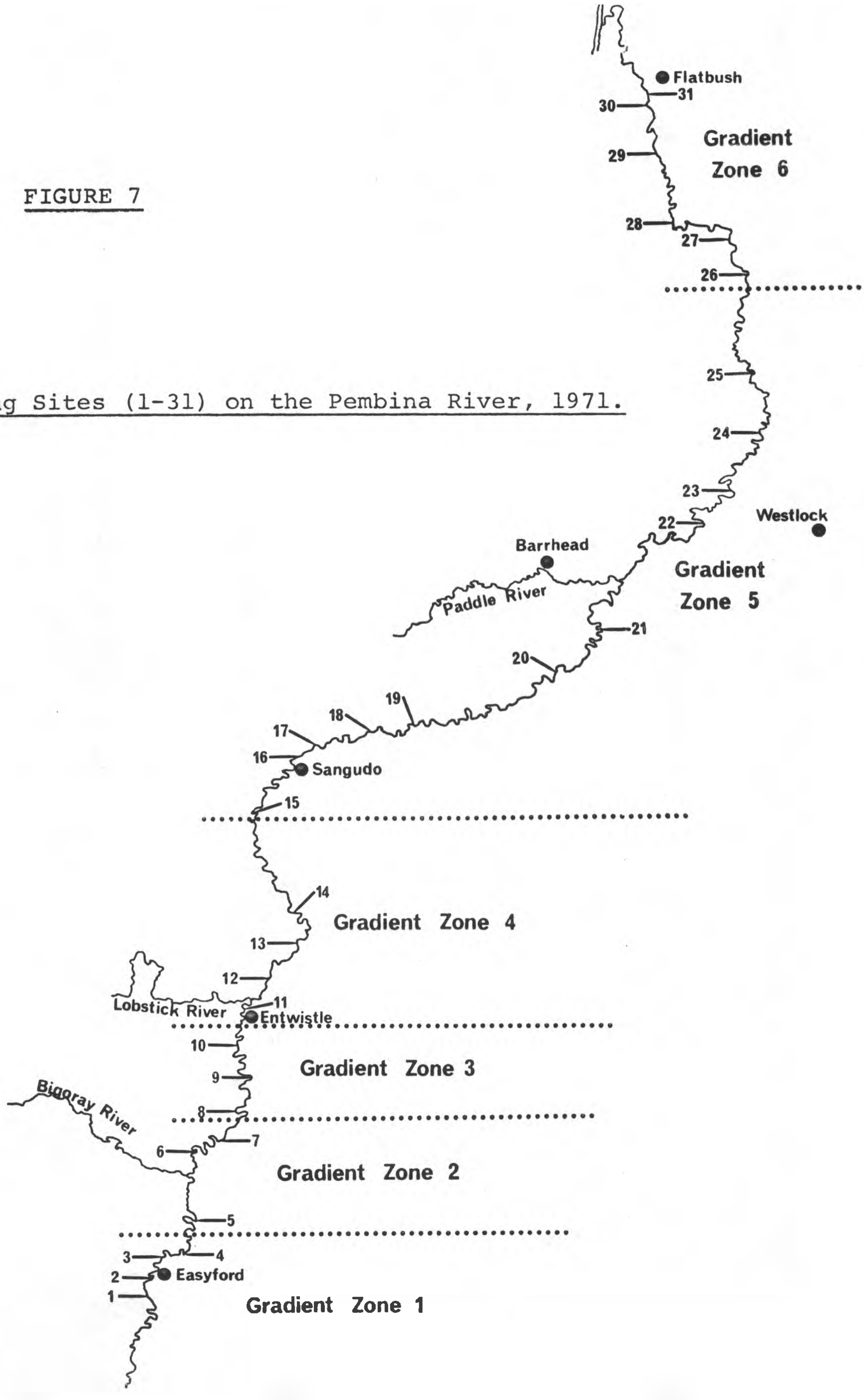

FIGURE 8

Longitudinal Profile of the Pembina River (Easyford to the Confluence with the Athabasca River).

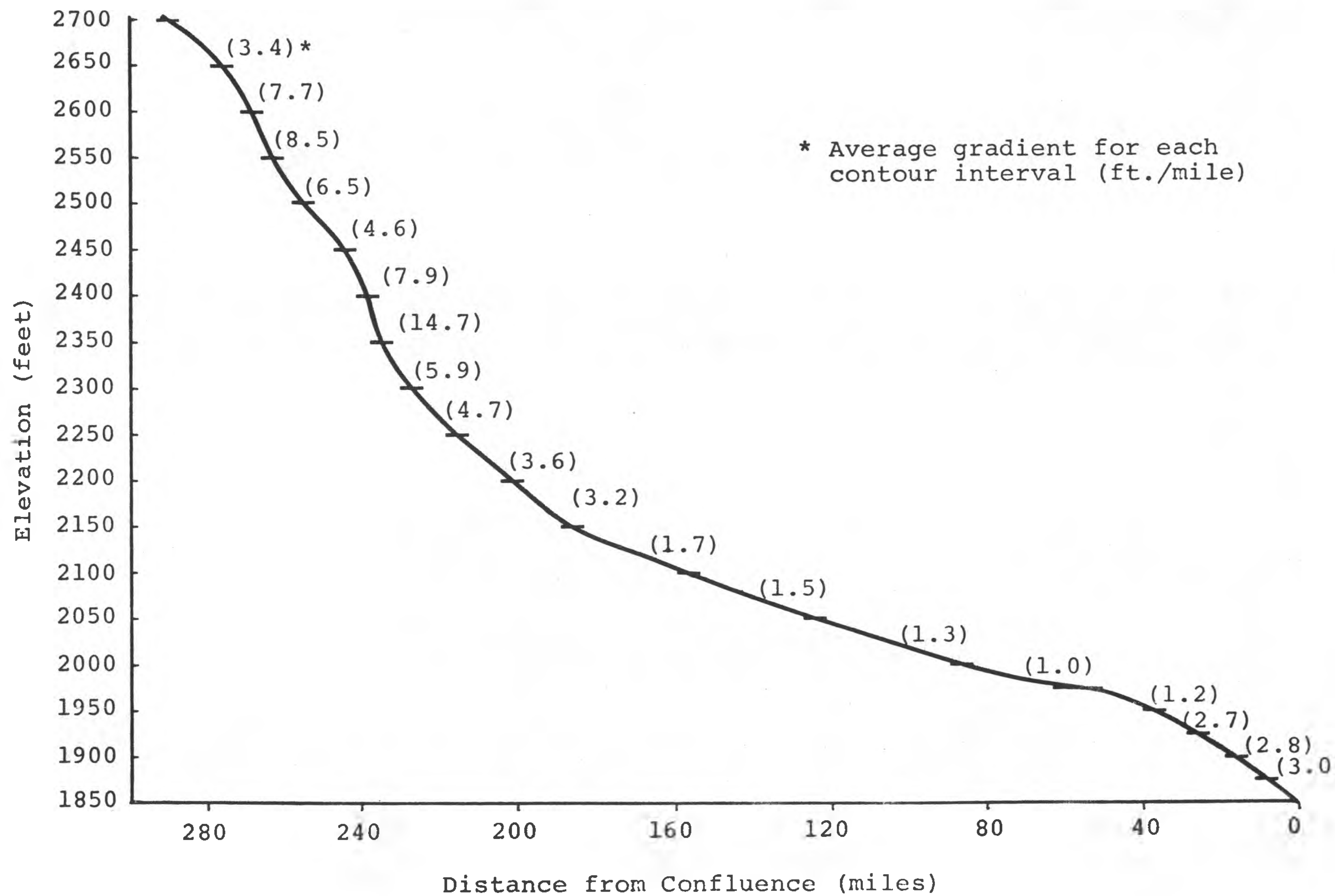

Photo 23: A large riffle, resulting from a natural meander cutoff, in a low gradient section of the Pembina River, upstream from Sangudo. This riffle provides a measure of habitat diversity in a section of river characterized by low current velocity and extensive low quality pool.

FIGURE 9

Percentage of Water - Types in Gradient Zones

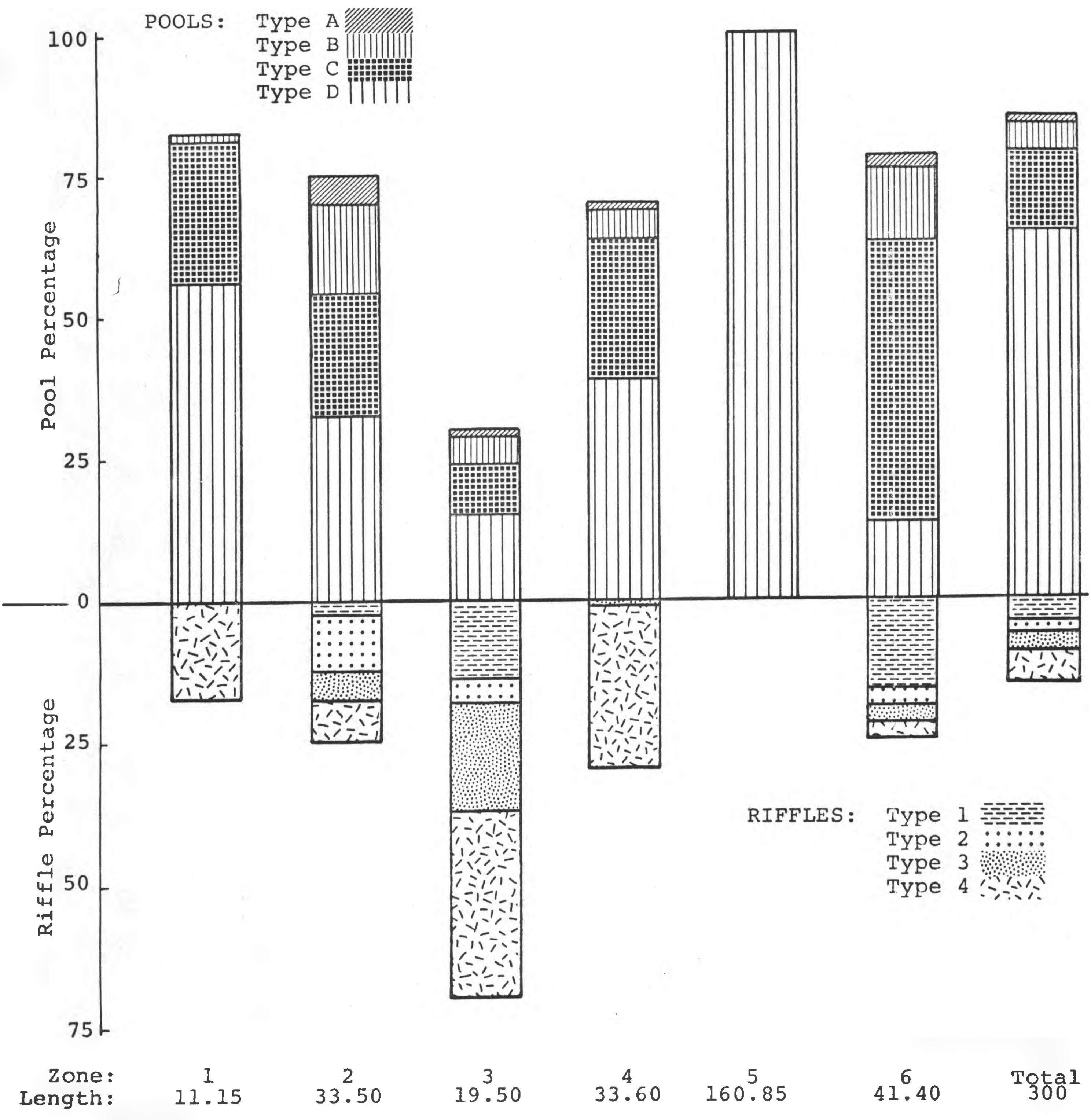

FIGURE 10

Percentage of Each Substrate Type in Gradient Zones

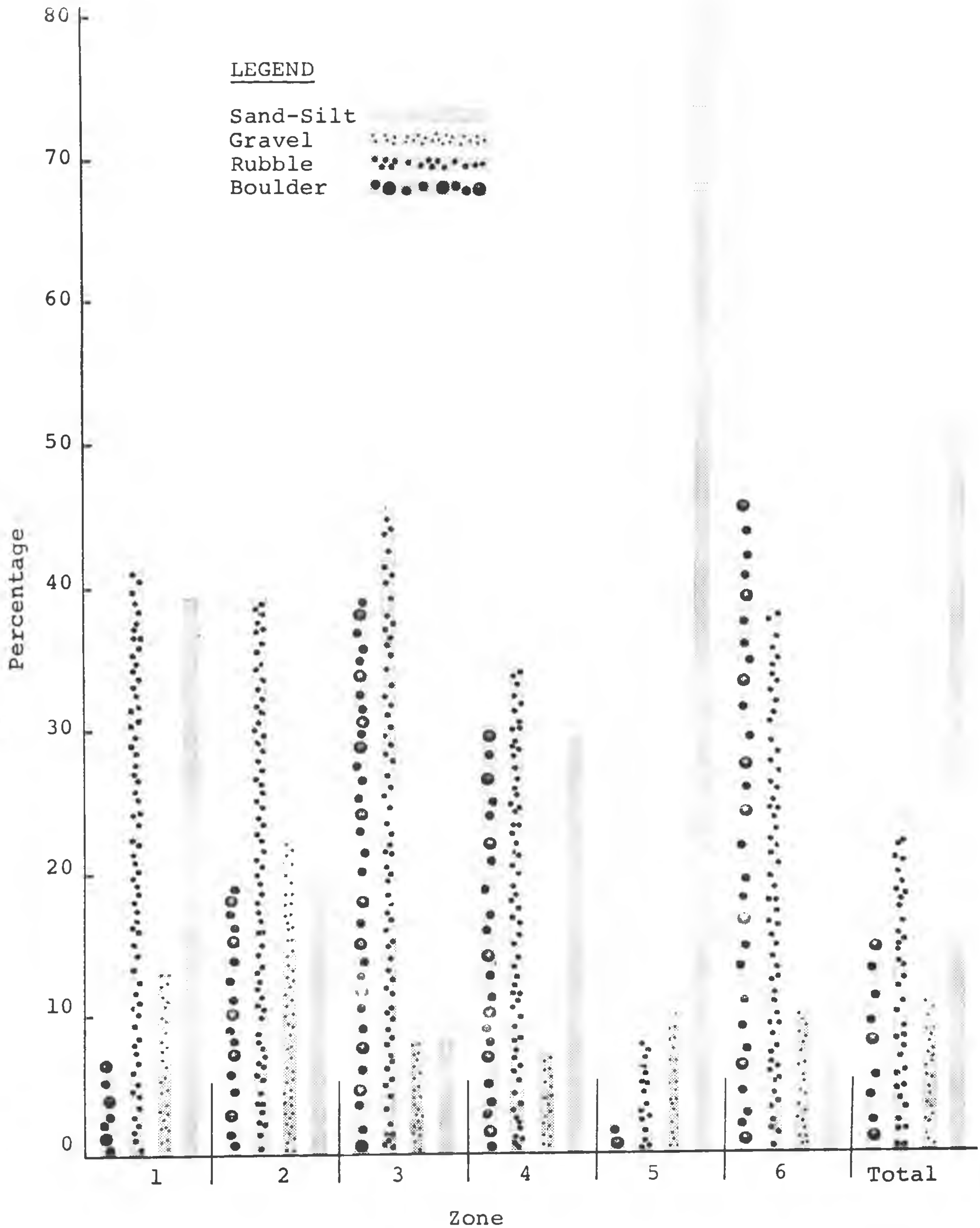

TABLE 65

Summary of Habitat Characteristics of the Pembina River; Summer, 1971

Gradient Zones	Zone Length (miles)	% of Total River	Habitat Sites Included In Zone	Average Gradient (ft/mi.)	Substrate Type				Pool Type					Riffle Type				
					B	R	G	S-S	A	B	C	D	Total	1	2	3	4	Total
1	11	3.7	1-4	2.34	7	41	13	39	0	1	25	57	83	0	0	0	17	17
2	34	11.2	5-8	5.98	19	39	22	20	5	16	22	32	75	2	10	5	8	25
3	20	6.5	9-11	7.28	39	45	8	8	1	5	9	15	30	14	4	19	33	70
4	34	11.2	12-15	4.23	30	34	7	29	1	5	25	39	70	0	0	2	28	30
5	161	53.6	16-28	1.51	2	8	10	80	0	0	0	98	98	0	0	1	1	2
6	41	13.8	29-31	2.58	46	38	10	6	2	13	50	13	78	16	3	3	0	22

indicating a good correlation between average gradient and habitat type. The average gradient in Zones 1 - 4, and 6 varied between 2.34 and 7.28 feet per mile. The average gradient in Zone 5 was a relatively uniform 1.5 feet/mile.

Zone 5 is approximately 161 miles in length and includes the section of river between Sangudo and Fawcett. Habitat stations 16 - 28 fell within this zone. Station data were combined in order to determine an overall habitat suitability for the zone. Low gradient results in a low incidence of riffle areas, which results in low habitat diversity. Approximately 98% of the stream surface area in Zone 5 was low value pool (Class D), (Photo 24). The substrate type was 80% dominated by a silt-sand combination which reflects the low current velocity. Relief to the generally flat gradient was provided by local irregularities such as channelized sections, and natural meander cutoffs.

Zones 1 - 4, and 6 have a combined length of 139 miles which constitutes 46.4% of the study section. These zones have been grouped since, unlike Zone 5, they provide a measure of habitat diversity due to the incidence of riffles. The zones are not uniform in this regard, however, and do not provide similar habitat suitability. The steepest gradient, 7.28 feet per mile, occurred over Zone 3. The highest average gradient, 14.7 feet per mile, occurred over a subsection of this zone. The lowest average gradients for this group, 2.34 and 2.58 feet per mile occurred in Zones 1 and 6. Zones 2 and 4 had average gradient values which were intermed-

Photo 24: Class D pool water typical of gradient zone 5 of the Pembina River. The lack of riffles combined with the sand-silt substrate result in a low habitat diversity. This habitat type has a limited potential to support gamefish.

iate (4.23 feet/mile and 5.98 feet/mile). A direct relationship existed between average gradient and riffle incidence. Riffle water comprised 70% of the stream surface area in Zone 3 and only 17% and 22% for Zones 1 and 6. The zones also differ in the occurrence of high value riffles and pools. Zone 1 is poor in this regard, when compared to other zones within the group. A substrate dominated by boulders, rubble, and gravel is characteristic of streams with moderate to high current velocity. The percent occurrence of silt-sand varies between 6% and 39%, which is considerably less than that calculated for Zone 5 (80%).

3.) Discussion:

Assigning a habitat rating to a stretch of water is useful for many reasons, two of which are:

a.) It allows the isolation of obvious physical and chemical limiting factors.

b.) It provides a basis for explaining present fish distribution.

However, a classification cannot be considered rigid since the habitat requirements of gamefish are not easily determined. Also, irregularities in the stream profile occur periodically which provide habitat typical of another zone. Strictly speaking, the data apply only to the habitat provided at the time of survey since quality varies seasonally and over the years. Various combinations of flow regimes and climatic conditions can result in the upgrading and downgrading of habitat quality in relation to that provided in 1971. It is important that this be considered, since well balanced gamefish populations are found in environmental situations where quality habitat is provided over a period of years.

Following is an evaluation of the physical habitat that was provided by the Pembina River at the time of the 1971 survey.

The periodic occurrence of riffles usually results in a good quality stream. However, variable flow, gradient extremes, climatic conditions, erosion, silt or combination of the above, often override the beneficial effects of a favorable pool-riffle periodicity. Either a lack or an overabundance of riffles usually results in a reduction of productivity. Zone 5 is typical of the habitat type which results when gradient is insufficient to provide adequate riffle areas.

The survey results indicate that Zone 5 provides only small amounts of desirable habitat features. Current velocity was generally low and in some situations, imperceptible. Bank erosion was severe in most sections, due to the lack of gradient and the sinuous course of the river. Huge deposition sand bars, which in some cases occlude over one-half the channel, are evidence of the tremendous silt loads carried and deposited in the river channel. There was little evidence of the growth of submergent vegetation, either microphytic or macrophytic in this zone. Extreme turbidity, sustained over lengthy periods, an unstable bottom composed of silt-sand and fluctuating discharge precluded significant growth of aquatic vegetation. It appears as though Zone 5, at least in 1971, did not provide substantial amounts of spawning or rearing habitat nor was it capable of supporting a healthy, diversified biota on an annual basis.

The remaining gradient zones provide a more favorable pool-riffle periodicity. The results indicate that a gradation exists between these zones for the various characteristics surveyed. In addition to the variability in riffle occurrence there are important differences in the percentages of quality water types. This reflects major differences in flow regime and degree of siltation. Zones 1 and 6 have similar gradients but differ greatly in habitat quality. Zone 6 provides significant amounts of the high quality pools and riffles (Photo 25). In addition, siltation of the substrate is only light to moderate.

Higher flow volumes in the lower zones, due to their downstream position in the drainage system, are probably effective in maintaining good quality water types on an annual basis. High flow volumes also increase current velocity which prevents excessive siltation. The light siltation and the moderate turbidity throughout the study period, probably combined to reduce productivity and influence fish distribution in Zone 6. Zone 1 was marginal summer habitat and would not provide suitable over-wintering conditions (Photo 26).

Zones 2, 3, and 4 have the highest gradients in the study section. The lack of good quality pools is the main limiting factor

Photo 25: A class 1 (deep-fast) riffle situated in gradient zone 6 of the Pembina River. The combination of deep-fast riffles and associated high quality pools provide excellent gamefish habitat. The flow volume is sufficient to maintain high-quality throughout the year.

Photo 26: A typical section of Class D pool in gradient zone 1 of the Pembina River. Relatively low gradient and seasonally low flow result in a preponderance of shallow pool with a significant amount of siltation. This type of water is of limited value to gamefish.

in each of the zones. However, Zones 2 and 4 provided significantly more good quality pools than did Zone 3 (Photo 27). Pool water comprised approximately 70% of the surface area in Zones 2 and 4 and only 30% in Zone 3. Zone 3 provided a larger number of good quality riffles. However, these were considered to be of secondary importance, since good quality pools were limiting (Photo 28). Zones 2 and 4 provide more favorable habitat for gamefish than Zone 3.

4.) <u>Summary</u>:

a.) The section of river studied included the lower 300 miles of the Pembina River, and was divided into major gradient zones.

b.) The habitat stations which fell within a zone exhibited similar physical characteristics indicating a positive correlation between average gradient and habitat type.

c.) The average gradients of the zones varied between 1.5 feet per mile for Zone 5 to 7.28 feet per mile for Zone 3.

d.) The periodic occurrence of riffles usually results in a quality stream. An overabundance or a paucity of riffles however, results in a relatively unproductive environment.

e.) Variable flow, gradient extremes, climatic conditions, erosion, silt or combination of the above often override the beneficial effects of a favorable pool-riffle periodicity.

f.) In terms of length, Zone 5 is most important. It is

Photo 27: Class A pool in association with deep-fast riffles in gradient zone 2 of the Pembina River. September, 1971. This situation provides ample habitat diversity and is considered excellent gamefish habitat.

Photo 28: A section of river in gradient zone 3; September, 1971. Although riffles are abundant, a lack of high quality pool degrades the overall habitat quality.

approximately 161 miles long and comprises 53.6% of the study section.

g.) Habitat diversity in Zone 5 is minimal due to the low gradient. Approximately 98% of the total surface area is comprised of low quality pool. The substrate was dominated by a silt-sand combination. Large deposition sand bars are common, and in some cases occluded over one-half the channel.

h.) Gradient zones 1, 2, 3, 4, and 6 provide more favorable pool-riffle separations than Zone 5 but differ widely in actual habitat quality.

i.) The variability in habitat quality of various zones is mainly due to differences in flow volume, degree of siltation, bank shelter, and turbidity.

j.) Zones 1 and 6 have similar gradients yet the latter provides a more suitable habitat due to higher mean flows. This reflects its downstream position in the drainage system.

k.) Low mean flows and subsequent heavy siltation result in a preponderance of low quality water in Zone 1.

l.) Light to moderate siltation and turbidity maintained throughout the study period, combined to reduce productivity in Zone 6.

m.) Zone 2, 3, and 4 represent the higher gradient sections surveyed in the study. The occurrence of high quality riffles varies considerably; Zone 3 having the highest percentage.

n.) Gradient Zones 1 and 5 were considered poor fish habitat.

o.) Select areas within gradient Zones 2, 3, 4, and 6 provided suitable habitat for gamefish.

c.) <u>Chemical Environment</u>:

1.) <u>Methods</u>:

(See methods - Sturgeon River, Page 188).

2.) <u>Results</u>:

The locations of sampling sites are shown in Figure 11. The results of the chemical uniformity test (Table 66) indicate a high degree of similarity between the Pembina River water analysis stations. A somewhat higher uniformity exists between the upper stations (1, 2, 3) and the lower stations (7, 8, 9). Much of the variation attributed to the middle stations (4, 5, 6) was probably due to Lobstick River discharge which enters the Pembina River at a point upstream from Station 4 (Photo 29). The Paddle River enters the Pembina River upstream from Station 7. It

FIGURE 11

Water Analysis Stations (P1-9) and Artificial Substrate Sites (A1-7) on the Pembina River, 1971.

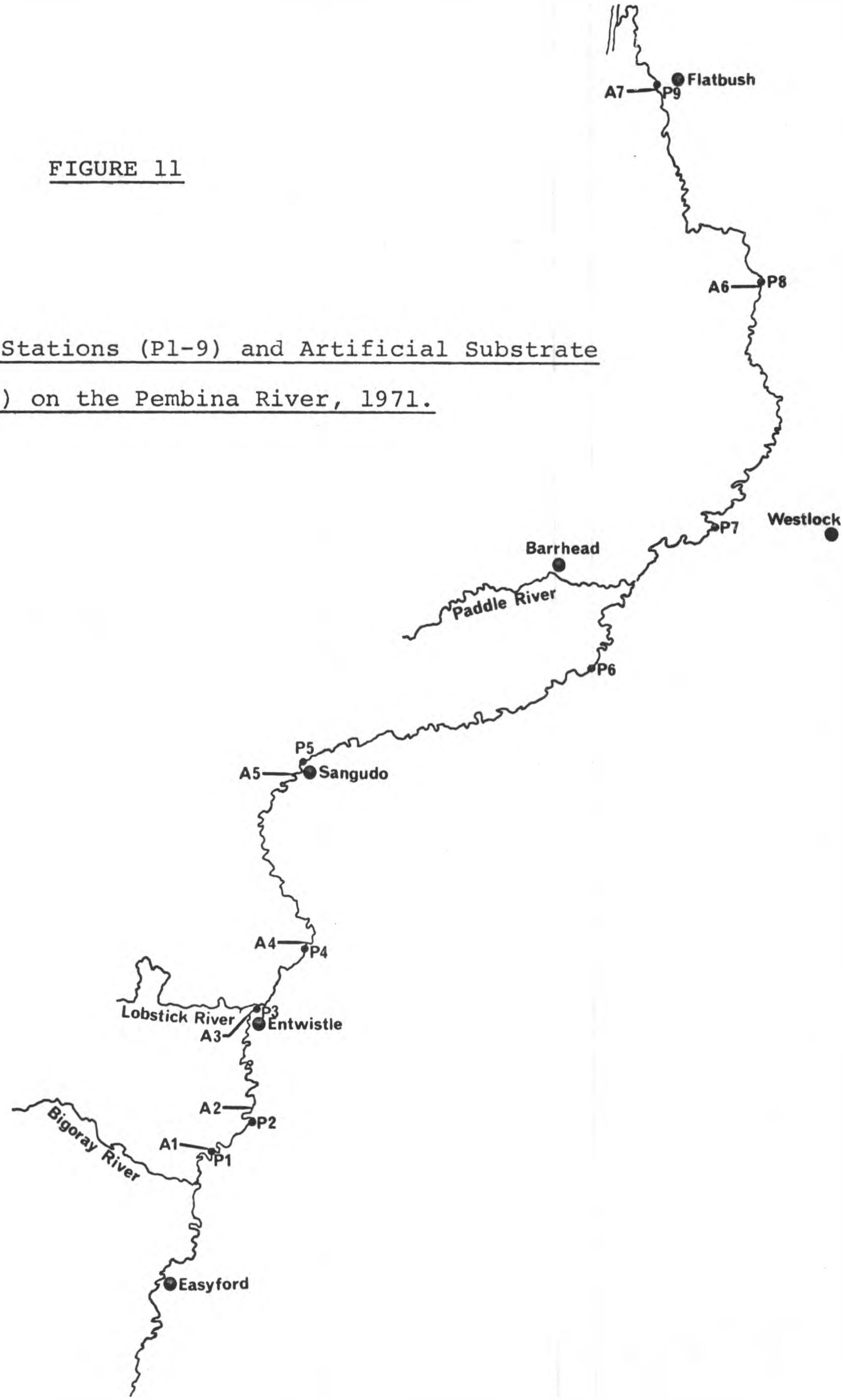

TABLE 66

Degree of Chemical Uniformity (in %) between Stations on the Pembina River (May - September 1971)

Stations:	1	2	3	4	5	6	7	8	9
1	-								
2	98	-							
3	97	97	-						
4	91	90	92	-					
5	93	92	94	96	-				
6	91	90	92	96	97	-			
7	96	95	96	94	96	95	-		
8	96	95	96	90	91	90	95	-	
9	97	96	97	90	92	90	96	97	-
Mean Uniformity	95	94	95	92	94	93	95	94	94

Photo 29: The confluence of the Pembina and Lobstick Rivers; September, 1971. The Lobstick River maintained high flows throughout the study period and exerted considerable influence on the water chemistry of the Pembina River.

appears to have been less effective in modifying the seasonal water quality trends. This may be a result of the fact that the Pembina River is a larger stream at this point and therefore less susceptible to modification. The seasonal trends for the various parameters, at each station, are presented graphically in Appendices 21 - 29. They are interpreted in the following sections.

a.) Water Temperatures:

The mean water temperature for all stations over the study period was 17.4°C. The mean minimum recorded temperature was 9°C which occurred in mid-September. The mean maximum recorded temperature of 24.5°C, occurred in early August. The maximum temperature recorded at any station was 25°C. Throughout spring and early summer the water temperature was inversely related to the amount of surface runoff. The peak discharge recorded in mid-July however was not as effective as air temperature in regulating the water temperature. The mean temperature recorded for all stations, over the period (July 20 - August 31) was 21.4°C. This figure better represents the temperature regime over the mid-summer season, since the effects of high discharge were minimal over this period. All stations exhibited uniform temperature regimes over the study period.

b.) Specific Conductance:

Specific conductance is a measure of total dissolved solids in the stream. The mean conductivity recorded for all stations over the study period was 213 micromhos/cm (at 25°C). The mean value for the base flow period (Aug. 20 - Sept. 13) was 274 micromhos/cm. The maximum value of 334 micromhos was recorded in mid-September. The minimum value recorded was 135 micromhos/cm on June 21st. Conductivity was inversely related to the amount of surface runoff which is expected since high water adds proportionately more insoluble materials (erosion silts) than soluble electrolytes (Ellis, 1936). The Lobstick River, because it remained at a relatively high stage throughout the study period, was effective in reducing the conductivity of the middle station below that of Stations 1, 2, and 3. Partial recovery had occurred before the downstream stations. The mean conductance values for the station groups (1, 2, 3, - 4, 5, 6, - 7, 8, 9) over the base flow period were 288, 263, and 270 micromhos/cm respectively.

c.) Total Alkalinity:

Total alkalinity is a measure of the carbonate content of waters (expressed in ppm $CaCO_3$). Total alkalinity consisted almost entirely of bicarbonates throughout the study period. The seasonal trend for bicarbonate alkalinity is closely associated with that for specific conductance indicating that the bicarbonate ion and its associated anions account for most of the dissolved solids. The mean concentration for all stations, over the study period, was 140 ppm. The mean maximum value was 185 ppm. The higher values were recorded in mid-September. The mean minimum concentration of 100 ppm was the result of high discharge in late June. The maximum value attained was 222 ppm, recorded at Station 1 on September 15th. The mean bicarbonate concentrations for the three station groups, over the base-flow period (Aug. 19 - Sept. 15), were 195, 142 and 173 ppm, respectively. These values are significantly higher than mean values determined for the entire study period. The diluting effect of high flows therefore is evident. The Lobstick River was effective in maintaining the concentrations of the middle stations at a lower level. Partial recovery occurred before the downstream stations.

d.) <u>Total Hardness and Calcium Hardness</u>:

Bicarbonates make up the greatest percentage of the salts in natural waters. Other salts, however, also contribute to the total hardness (expressed in ppm $CaCO_3$). They include the sulphates and chlorides of calcium and magnesium.

The bicarbonates are mainly associated with calcium and to a lesser degree with magnesium. Calcium hardness is the concentration of calcium present in the water (in ppm). The seasonal trend for calcium concentration was relatively similar for all stations. The mean value for all stations throughout the study period was 84 ppm. The mean value over the base-flow (Aug. 19 - Sept. 14) was 110 ppm. The calcium content is inversely related to the amount of surface runoff. Total hardness trends approximate those for calcium content indicating that the majority of the bicarbonates are associated with the calcium ion. The mean value for all stations over the study period was 125 ppm $CaCo_3$; the mean value over the base flow period was 148 ppm. The upper station group had a total hardness mean over the base flow period of 167 ppm, the middle group, 125 ppm, and the lower group 153 ppm.

e.) Hydrogen ion (pH):

All pH measurements were on the alkaline side for all stations over the entire study period. The pH ranged between 7.5 and 8.5 over the season, indicating a well buffered system. The seasonal fluctuation of hydrogen ion concentration reflected the amount of buffered substances (bicarbonates) present in the water which in turn was dependent on the amount of surface runoff. The higher values were recorded during base-flow conditions.

A summary of chemical analysis data is found on Table 67.

f.) Dissolved Oxygen:

The seasonal trends for dissolved oxygen, and percentage saturation exhibited much variability during the study (Table 68). Percentage saturation relates the actual, recorded dissolved oxygen concentration to the maximum allowable level at that particular water temperature and elevation. In a good quality

TABLE 67

Summary of Water Analysis Data, Pembina River,

May 22 - September 13, 1971

Station	Bicarbonate Alkalinity (ppm)			Calcium Hardness (ppm)			Total Hardness (ppm)			Conductance Micromhos/cm.			Water Temperature (°C)		
	max	min	mean	max	min	mean	max	min	mean	max	min	mean	max	min	mean
P1	222	103	149	120	60	87	188	85	129	292	151	213	23.5	9.5	15.9
P2	205	86	147	120	69	91	171	103	128	290	174	216	25.0	11.0	16.6
P3	205	86	145	120	60	86	171	86	123	317	146	223	25.0	9.5	17.1
P4	171	103	132	103	60	80	137	77	111	306	133	201	24.5	9.5	19.5
P5	154	103	128	94	60	78	180	103	121	334	146	213	24.5	9.5	17.9
P6	162	103	131	103	60	77	171	103	123	250	129	193	24.0	8.0	17.3
P7	171	103	136	103	51	84	154	103	125	273	157	212	24.0	7.5	17.3
P8	200	103	140	103	60	87	171	103	135	300	135	227	24.5	8.5	17.7
P9	188	103	148	103	51	84	162	86	131	305	154	225	24.5	8.0	16.9

TABLE 68

Percentage Saturations and Dissolved Oxygen Concentrations, Pembina River, 1971

Station		May 22	June 1	June 8	June 15	June 22	July 5	July 19	Aug 3	Aug 19	Aug 30	Sept 14
P1	ppm	8	8	7	7	7	7	6	8	8	6	9
	% Sat.	75	80	69	64	67	63	66	93	89	65	78
P2	ppm	9	8	7	7	7	7	6	7	8	6	9
	% Sat.	88	80	69	69	68	63	66	94	89	64	82
P3	ppm	9	7	9	7	8	7	6	7	4	6	9
	% Sat.	90	72	88	69	78	64	67	83	45	66	78
P4	ppm	8	8	8	7	6	7	7	7	5	9	9
	% Sat.	83	87	79	66	60	64	78	83	55	98	78
P5	ppm	7	8	8	7	7	6	7	7	8	7	8
	% Sat.	76	90	77	66	72	55	79	82	33	80	69
P6	ppm	-	7	6	7	7	6	6	7	5	-	10
	% Sat.	-	82	58	67	71	56	69	82	55	-	93
P7	ppm	9	8	8	7	8	6	4	7	4	-	9
	% Sat.	93	95	80	67	75	57	45	83	44	-	74
P8	ppm	8	8	8	7	8	6	5	7	7	7	8
	% Sat.	85	93	81	68	81	58	57	83	76	68	68
P9	ppm	-	-	9	8	7	6	4	7	8	8	8
	% Sat.	-	-	94	75	71	58	45	83	88	80	67

stream much of the seasonal variation in dissolved oxygen is due to the pattern of photosynthetic and respiratory activity of the aquatic plants. In this type of situation the dissolved oxygen levels are at or near 100% saturation throughout much of the year. Large, rapid fluctuations in flow-volume can result in significant departures from the normal state.

Two major oxygen maxima occurred during the study period and were evident at all stations. The early pulse occurred during the period May 22 - June 8. The river was at base-flow, following the spring run-off. The second major oxygen pulse occurred in early August; again the river was approaching base-flow after the July discharge peak. Maximum saturation levels were recorded in these periods and in some cases the levels approached 100% saturation. High water results in an influx of allocthonous organic material and a decrease in photosynthesis caused by turbidity, (Dorris *et al*, 1963 in Hynes, 1970). The higher levels during base-flow then are probably due to increased photosynthetic activity and the decreased presence of organic materials in the stream. A fall in percentage saturation following the August maximum and subsequent recovery occurred at most stations. The severity of the saturation decline varied between stations and was probably related to the decomposition of organic material creating a high oxygen demand. The decline was most severe at Station 5 and 7 and was least noticeable at Station 8 and 9.

3.) Discussion:

In most cases the importance of the chemical environment is of secondary importance to the physical condition in a natural stream. Physical features such as flow patterns and current velocity are, as a rule, more important in determining habitat suitability. One condition that must be met however, is the maintenance of dissolved oxygen concentrations at the preferential levels of the gamefish present in the river. The electrolytes which contribute to the alkalinity, specific conductance, etc., seldom reach critical levels, unlike dissolved oxygen. However, they are important in determining the potential productivity of an aquatic ecosystem. Likewise, hydrogen ion concentrations seldom reach extreme values in natural streams, due to the presence of buffered substances. Water temperature, a physical characteristic, is included with the chemical data due to its effects on dissolved oxygen levels. Dissolved oxygen and water temperature were the only physicochemical constituents monitored which had a potential importance in determining habitat suitability.

The dissolved oxygen requirements of gamefish must be known before an accurate evaluation of habitat suitability can be made. Unfortunately this information has not been specifically determined for gamefish in Alberta. The section of the Pembina River studied included cold-water species as well as the more prevalent warm-water species. Cold-water gamefish are known to have higher oxygen requirements than warm-water gamefish. Coarse fish such as suckers have lower oxygen requirements which enable them to utilize a wider range of habitat than is available to either group of gamefish. "For cold-water biota, it is desirable that dissolved oxygen concentrations be at or near saturation." (Water Quality Criteria, 1968). The report states that dissolved oxygen levels should not go below 6 ppm, but may range between 6 and 5 ppm for short periods. Oxygen concentrations were consistently below saturation throughout the study period and probably approached the critical lower limit in certain sections of the stream. The presence of mountain whitefish populations indicates that either:

1.) The oxygen tolerance is higher than expected, or
2.) The fish successfully sought out areas which exhibited a more favorable oxygen regime, or
3.) The fish are presently limited due to the unavailability of well oxygenated water.

Although dissolved oxygen levels may not have been critical during 1971, in other years which provided a less suitable combination of flow pattern and climatic conditions, the situation could be considerably worse. The dissolved oxygen levels in 1971, however, were well within the desirable range for warm-water gamefish. For a diversified warm-water biota, daily dissolved oxygen should be above 5 ppm, but may be at 4 ppm for short periods, (Water Quality Criteria, 1968). Dissolved oxygen levels are subject to marked diurnal variation, with minimum levels being reached in early morning before daylight. Sample times usually concurred with periods of near maximum dissolved oxygen levels, therefore the habitat suitability may be lower than indicated. This is particularly true in stream sections with a high oxygen demand and with borderline dissolved oxygen concentrations. A complete assessment of habitat suitability would necessarily include the dissolved oxygen levels provided during the critical winter period.

Gamefish in this region do not thrive in environmental situations in which sustained high temperatures prevail. Cold-water species prefer temperatures well below those which allow warm-water species to function normally. The temperature regime during the 1971 study period indicates that the Pembina River (in the section studied) is not entirely suitable for the production of cold-water gamefish. The Committee on Water Quality Criteria, 1968, lists 68°F (20°C) as being the maximum temperature compatible with the well-being of salmonids (including mountain whitefish). All sections of the river studied exhibited temperatures above this value for a considerable time during the summer. The maximum temperature recorded at a station was 28°C (77°F). Water temperature regimes of this type probably occur frequently and might involve even higher temperatures. The existence of mountain whitefish suggests that either one or both of the following statements are true:

1.) This species has a greater tolerance of high temperatures than previously thought.
2.) The distribution of mountain whitefish in the Pembina is being limited by sub-optimum temperature conditions.

Whether the high temperatures are important in reducing habitat suitability is not known, however the high potential of the river to reach and maintain upper range temperatures, precludes its value as an important cold-water gamefish stream. A reduction in suitability due to high temperatures is often associated with altered flow patterns, which are usually caused by disruptive land use practices within the watershed. The temperatures during the 1971 study period did not approach the maximum temperature of 84°F listed for the normal growth and activity of warm-water species. Therefore, the Pembina River, in the sections studied was suitable habitat in respect of temperature for walleye, northern pike, goldeye and other warm-water species. It is doubtful if even warm-water species can operate normally in water at a temperature of 84°F. However, high temperatures are probably not the most important limiting factors in the Pembina River for this group of fish.

The values recorded for total alkalinity, specific conductance, etc., indicate a high potential productivity for aquatic plants and animals. The potential was not realized during 1971 owing to the negative influences of sustained high flows, turbidity, and siltation. These factors will gain in importance in the future due to increased land use in the watershed.

In order to accurately isolate habitat deficiencies in the Pembina River it is necessary to assess habitat conditions over a period of years, since flow patterns and climatic conditions combine to provide vastly differing habitat quality. When the relationship between these deficiencies and gamefish success are clear it is then possible to predict the future of gamefish in this system, since many of the deficiences are directly caused by current land use practices.

4.) Summary:

a.) In a stream, physical factors are generally the most significant determinants of habitat suitability if dissolved oxygen levels are maintained at levels within the preferential range for gamefish.

b.) Of the parameters monitored in the water analysis study, only dissolved oxygen and water temperature were potential limiting factors.

c.) Both cold and warm-water gamefish are present in the Pembina River. The former have higher dissolved oxygen requirements and exhibit a decreased tolerance to high temperatures.

d.) For the normal growth and activity of salmonids (which includes mountain whitefish) the dissolved oxygen levels should not fall below 6 ppm., but may drop to 5 ppm. for short periods of time.

e.) According to the foregoing minimum oxygen requirements, certain sections of the river provided only marginal habitat for mountain whitefish during a period of the 1971 study. Dissolved oxygen levels in other years might be considerably lower, owing to the annual variation in flow-regime and climatic conditions.

f.) Dissolved oxygen levels were within the preferential range for warm-water gamefish.

g.) The maximum temperature compatible with salmonids is listed as 20°C (68°F). Temperatures of 25°C (77°F) were recorded during 1971.

h.) Water temperatures were within the preferential range of warm-water gamefish.

i.) The Pembina River appears to have a high propensity to reach and maintain upper range temperatures. This reduces its habitat suitability to most gamefish but more so to cold-water forms.

j.) Total alkalinity, and specific conductance values indicate a high potential productivity for aquatic plants and animals, however, this potential was not reached in 1971 due to negative physical influences associated with variable discharge, turbidity, and siltation.

k.) A detailed assessment of the fisheries productivity and habitat quality of the Pembina River would require winter studies of habitat and several years' additional data.

d.) Invertebrate Collections:

1.) Introduction:

The macroinvertebrate fauna of streams and rivers are a vital component of the stream ecosystem. In addition to being a major food source for fish, the invertebrate fauna is a valuable indicator of the physical and chemical habitat quality, and of stream productivity.

Sampling of the invertebrate fauna of the Pembina River with artificial substrate samplers was undertaken during late August and early September to determine the relative abundance of immature insects, community structure, and possible relationships between invertebrate populations and stream condition. Documentation of stream insect populations not only increases the knowledge of invertebrate distribution and habitat preference, but serves as a base-line study for the assessment of subsequent changes in the stream environment.

2.) Methods:

Various methods for the collection of benthic invertebrates have been devised and tested. The sampler used was a basket-type artificial substrate similar to that described by Scott (1958) and Dickson et al (1971). The sampler consisted of a cube, one foot on each side, constructed of 1/2" mesh hardware cloth. The cube was filled to a weight of twenty pounds with 1 1/2"-2 1/2" dolomite (limestone) chips. Grass was mixed with the chips to provide an organic base.

A total of twenty-five samplers were placed in the Pembina River at seven locations (Fig. 11). Criteria used in the selection of sampling sites were spatial separation, road access and the presence of an adequate riffle. One sampler only was placed at sample site 6, in a shallow pool, since no riffles were present. All other samplers were placed directly in riffles. The depth of placement ranged between 14"-24". In some cases, it was necessary to anchor the samplers with large boulders. Failure to provide adequate anchoring resulted in the loss of two samplers at site 4.

The substrate type was recorded at each sample site using the same method employed in the habitat survey. The degree of siltation was indicated as being either nil, light, or heavy. The degree of turbidity was indicated as being either low, moderate or high. A scale from one to six was used to quantify relative surface velocities. A value of one on the scale indicates pool water, while a value of six indicates the velocity of the fastest riffle. The amount of vegetation or plant detritus on the substrate was also noted. The habitat characteristics of individual sample sites are shown in Table 69.

Samplers were removed from the river after a period of fifteen days. To prevent the loss of insects that occurs during sampler removal, a fine-mesh net was placed about the basket

TABLE 69

Habitat Characteristics of Artificial-Substrate Placement Sites

Sample Site No.	1	2	3	4	5	6	7
Gradient Zone	1	2	3	4	5	5	6
Date Placed	Aug 23	Aug 23	Aug 23	Aug 24	Aug 24	Aug 25	Aug 25
Date Removed	Sept 7	Sept 7	Sept 7	Sept 8	Sept 8	Sept 9	Sept 9
No. Baskets Placed	4	4	4	4	4	1	4
No. Baskets Removed	4	4	4	2	4	1	4
Water Depth	9-20"	16-24"	16-20"	14-16"	14-20"	20"	14"
Substrate Types -							
% Boulders	70	20	40	10	20	-	20
% Rubble	20	60	30	80	70	-	60
% Gravel	10	20	30	10	10	-	20
% Sand Silt	-	-	-	-	-	100	-
Siltation	Nil	Nil	Light	Light	Heavy	Heavy	Moderate
Water Clarity	High	High	High	Low	Low	Low	Moderate
Surface Velocity*	6	4	3	5	2	1	5

* 1 (very low) - 6 (high)

sampler. The invertebrates and the vegetation associated with the basket were removed and preserved in 10% formalin.

All specimens were divided into their respective orders and counted. All invertebrates from one basket were identified to general to gain a more detailed knowledge of the community structure.

3.) Results and Discussion:

The structure of the invertebrate community is a product of physical, chemical and biological variables in the stream. A relationship can therefore be expected between the generic composition of the sample site fauna and these variables.

Table 70 indicates the percent occurrence of each insect order at the various sample sites. The results are based on the contents of 23 basket samplers. Variability between baskets at the same station was evident which was expected due to the heterogeneous nature of the habitat. However, variations were sufficiently small to allow a valid comparison between stations. The orders Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddis) were dominant at all stations. In terms of biomass contribution, stonefly nymphs and caddis larvae were most important. A few individuals of the orders Diptera, Coleoptera, and Odonata were recorded throughout the stream.

Table 71 lists the genera recorded, and also the distribution and numbers of each at each sample site. Since results

TABLE 70

A Summary of Invertebrate Collections from the Pembina River, 1971.

Order		Sample Site 1 A*	B*	C*	D*	Total	Sample Site 2 A	B	C	D	Total
Ephemeroptera	No.	27	5	13	2	47	9	15	2	13	39
	%	5.9	2.8	9.7	1.3	5.1	6.6	9.6	2.9	9.7	7.8
Plecoptera	No.	95	55	46	62	258	93	57	56	46	252
	%	20	30	34	42	27.9	68.4	36.3	80	34.3	50.7
Trichoptera	No.	336	118	52	82	588	34	54	12	52	152
	%	73	66	39	55	63.8	25	34.4	17.1	38.8	30.6
Diptera	No.	2	0	23	0	25	0	31	0	23	54
	%	0.43	0	17	0	2.7	0	19.7	-	17.2	10.9
Coleoptera	No.	0	0	0	2	2	0	0	0	0	0
	%	0	0	0	1.3	0.2	0	0	0	0	0
Odonata	No.	0	1	0	0	1	0	0	0	0	0
	%	0	0.56	0	0	0.1	0	0	0	0	0
Others	No.	0	0	0	1	1	0	0	0	0	0
	%	0	0	0	0.67	0.1	0	0	0	0	0

* Representing individual substrate sampler.

TABLE 70 (cont'd)

Order		Sample Site 3 A*	B*	C*	D*	Total	Sample Site 4 A	B	Total
Ephemeroptera	No.	20	13	16	20	69	84	21	105
	%	5.1	4.1	2.1	13.8	4.3	27	13	22.5
Plecoptera	No.	94	47	115	61	317	105	55	160
	%	24.1	14.7	15.4	42.4	19.8	34.2	34	34.3
Trichoptera	No.	258	256	613	62	1188	110	83	193
	%	56.2	80	82	43.1	74.2	36	51.8	41.3
Diptera	No.	16	3	2	0	21	4	1	5
	%	4.10	0.93	0.26	0	1.3	1.3	0 .63	1.1
Coleoptera	No.	1	0	0	0	1	4	0	4
	%	0.26	0	0	0	0.1	1.3	0	0.8
Odonata	No.	1	1	0	1	3	0	0	0
	%	0 .26	0.31	0	0.70	0.2	0	0	0
Others	No.	0	0	2	0	2	0	0	0
	%	0	0	0.26	0	0.1	0	0	0

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* Representing individual substrate sampler.

TABLE 70 (cont'd)

Order		Sample Site 5 A	B	C	D	Total	Sample Site 6 A	Total	Sample Site 7 A	B	C	D	Total
Ephemeroptera	No.	23	32	44	60	159	5	5	20	10	7	2	39
	%	10	14	15.4	21	16.6	10.4	10.4	3.4	1.9	1.2	.3	1.7
Plecoptera	No.	41	34	41	37	153	4	4	24	19	22	17	82
	%	17.9	21.8	14.3	12.9	16	8.3	8.3	4.1	3.6	3.8	2.6	3.5
Trichoptera	No.	148	86	183	179	596	38	38	536	499	539	620	2194
	%	64.6	55	64	62.6	62.3	79.2	79.2	91.8	93.6	93.7	96.1	94.0
Diptera	No.	1	0	0	0	1	0	0	3	5	5	5	18
	%	0.4	0	0	0	-	0	0	0.6	.94	0.8	0.7	0.8
Coleoptera	No.	0	0	0	1	1	0	0	0	0	0	0	0
	%	0	0	0	0.34	-	0	0	0	0	0	0	0
Odonata	No.	9	3	17	9	38	1	1	1	0	0	0	1
	%	3.9	1.9	5.9	3.1	4.0	2.1	2.1	0.21	0	0	0	-
Others	No.	7	1	1	0	9	0	0	0	0	0	1	1
	%	3.1	0.64	0.34	0	0.9	0	0	0	0	0	0.04	0

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* Representing individual substrate sampler.

TABLE 71

The Diversity and Abundance of Immature Insects at Sample Sites (A1-A7) on the Pembina River, 1971.

ORDER: Ephemeroptera

Genus:	Sample Site 1	2	3	4	5	6	7	Total
Stenonema	5	0	4	24	22	1	0	56
Heptagenia	3	0	6	25	15	2	5	56
Baetis	14	4	3	25	5	1	3	55
Rithrogena	1	1	5	6	4	0	1	18
Cinygma	1	0	1	0	5	0	1	8
Pseudocloeon	0	0	0	3	2	0	0	5
Tricorythodes	3	0	0	0	0	0	0	3
Anepeorus	0	0	0	0	3	0	0	3
Ephemerella	0	1	0	1	1	0	0	3
Edmundsius	0	0	0	0	2	0	0	2
Seristoma	0	2	0	0	0	0	0	2
Lachlania	0	0	0	0	1	0	0	1
Paraleptophlebia	0	0	0	0	0	1	0	1
F. Siphlonuridae	0	0	0	1	0	0	0	1
TOTAL	27	8	20	84	60	5	10	214

ORDER: Plecoptera

Genus:	1	2	3	4	5	6	7	Total
Pteronarcys	40	90	41	35	20	3	8	237
Chloroperla	38	1	25	56	11	1	10	142
Taeniopteryx	14	2	7	6	5	0	0	34
Isogenus	3	0	20	6	0	0	1	30
Paragnetina	0	0	1	0	0	0	0	1
Claassenia	0	0	0	2	1	0	0	3
TOTAL	95	93	94	105	37	4	19	447

TABLE 71 (cont'd)

ORDER: Trichoptera

Genus:	Sample Site 1	2	2	4	5	6	7	Total
Hydropsyche	137	22	114	61	110	12	479	935
Cheumatopsyche	196	2	135	32	46	4	4	419
Arctopsyche	1	4	3	11	11	0	2	32
Brachycentrus	1	5	5	6	12	13	14	56
F. Glossomatidae	0	1	0	0	0	0	0	1
Psychomyia	0	0	1	0	0	0	0	1
Ptilostomis	0	0	0	0	0	9	0	9
TOTAL	335	34	258	110	179	38	499	1453

ORDER: Diptera

Genus:								
Simulium	2	0	13	3	0	0	4	22
F. Chironomidae	0	0	3	1	0	0	1	5
TOTAL	2	0	16	4	0	0	5	27

ORDER: Coleoptera

Genus:								
Galerucella	0	0	1	0	0	0	0	1
Neoelmis (larvae)	0	0	0	1	0	0	0	1
Neoelmis (adult)	0	0	0	3	1	0	0	4
TOTAL	0	0	1	4	1	0	0	6

ORDER: Odonata

Genus:								
Hagenius brevistylus	0	0	1	0	9	1	0	11
TOTAL	0	0	1	0	9	1	0	11

are based on the detailed analysis of only one basket per sample site, it is reasonable to expect that additional genera not recorded were present.

Although the order Ephemeroptera was not the most important order in terms of biomass, it represented the greatest diversity of species. A total of 13 genera were identified over the seven sample sites.

The most common genera were *Stenonema*, *Heptagenia*, and *Baetis*. *Rithrogena* and *Cinygma* were present in smaller numbers but were also distributed widely. The remaining general occurred sporadically and were never abundant.

The occurrence of low numbers and diversity generally corresponded with a lack of clean rubble substrate. A high diversity and abundance at station 5 was not expected due to the moderate current velocity and silt covered substrate. Since this station is situated at the downstream end of a higher gradient zone, organic materials may be settling out in this area increasing the nutrient content of the substrate. Diversity and numbers were low at station 6 which reflects the low current velocity and sand-silt substrate.

The abundance and diversity of Plecoptera was greatest at the upper sample sites (1 - 4). These stations provided a substrate dominated by boulder and coarse rubble, and siltation was low due to the relatively high current velocity. Stonefly populations at station 5 were somewhat lower than station 1-4 but greater than downstream stations. Station 6 was unsuitable to plecopterans due to the presence of a sand-silt substrate and low current velocity. Current velocity and substrate type were suitable at station 7, however, the degree of siltation was probably a limiting factor.

The genus *Pteronarcys* was represented at all sample sites. This nymph, because of its general abundance and large size, contributed more to the total biomass than any other insect.

Chloroperla, another abundant genus, was abundant at several of the sample sites. *Taeniopteryx* and *Isogenus* were present in lesser numbers, and were not as widely distributed.

Larval Trichoptera dominated over other groups in numbers of individuals in the community, and contributed extensively to the biomass. Seven genera of Trichoptera were identified. *Hydropsyche* and *Cheumatopsyche* were the most abundant genera. The genus *Arctopsyche* was found at all sample sites, and although its numbers were not great, its large size contributed considerably to the biomass. The genus *Brachycentrus* occurred at all sample sites. The genus *Ptilostomis* was represented by nine individuals at sample site 6. *Ptilostomis* is a large caddis fly with a cylindrical vegetal case, that is best suited to life in slow moving water.

The abundance of *Hydropsyche* and *Cheumatopsyche* appears to be directly related to the amount of aquatic vegetation or or plant detritus available. The filamentous alga, *Cladophora* seems to provide a particularly favorable habitat for trichopterans. It is possible that the results do not provide an accurate picture of trichopteran abundance due to the effectiveness of the basket in catching displaced vegetation, particularly *Cladophera* sp. A basket of reduced height would reduce this sampling bias.

Algal growth, and the corresponding trichopteran populations were heaviest at stations 1, 3, 5, and 7. The abundance of the genus *Hydropsyche* was nearly constant at stations 1, 3, and 5 and rose abruptly at station 7. The genus *Cheumatopsyche* was less abundant at the downstream sample sites.

The order Odonata (dragonflies) was represented by the species *Hagenuis brevistylus*. The species was encountered at all sample sites except stations 2 and 4, but only at station 5 did it contribute significantly to the biomass. The apparent scarcity of these carnivorous insects is probably due to the sampling period chosen, as large numbers of nymphal cases were observed on the banks of the river in early summer.

Dipteran larvae (flies, mosquitos, midges) were not abundant at any station and did not contribute significantly to the sample biomass. *Simulium* sp. larvae (blackfly) and chironomid larvae (midges) were the only dipterans recorded. Station 2 had the greatest abundance of dipterans. The low numbers recorded may be partially attributed to sampling time.

Only a few individuals belonging to the orders Coleoptera (beetles) and Hemiptera (true bugs) were recorded in the invertebrate survey.

4.) <u>Summary</u>:

a.) The Pembina River, particularly the upper sections, supported a rich benthic macrofauna dominated by three orders of immature insects: Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddis).

b.) The highest diversity occurred in the Ephemoroptera (13 genera) followed by Trichoptera (7 genera) and Plecoptera (6 genera).

c.) Plecopterans were most abundant at stations 1-4, relecting the high percentage of boulder and coarse rubble substrate at these sites. The high current velocity at these stations was effective in preventing significant siltation.

d.) Ephemeropterans were also more abundant and diverse in the upper stations. Station 5 was particularly productive of mayflies, despite its moderate to low current velocity. The occurrence of a sand-silt substrate at station 6 and the degree of siltation at station 7 probably is reflected in a lower diversity and abundance of Ephemeroptera and Plecoptera.

e.) Trichoptera populations were also low at station 6 but were abundant at station 7. Their distribution was regulated more by the occurrence of aquatic vegetation, particularly *Cladophora* sp.

e.) Fish Populations:

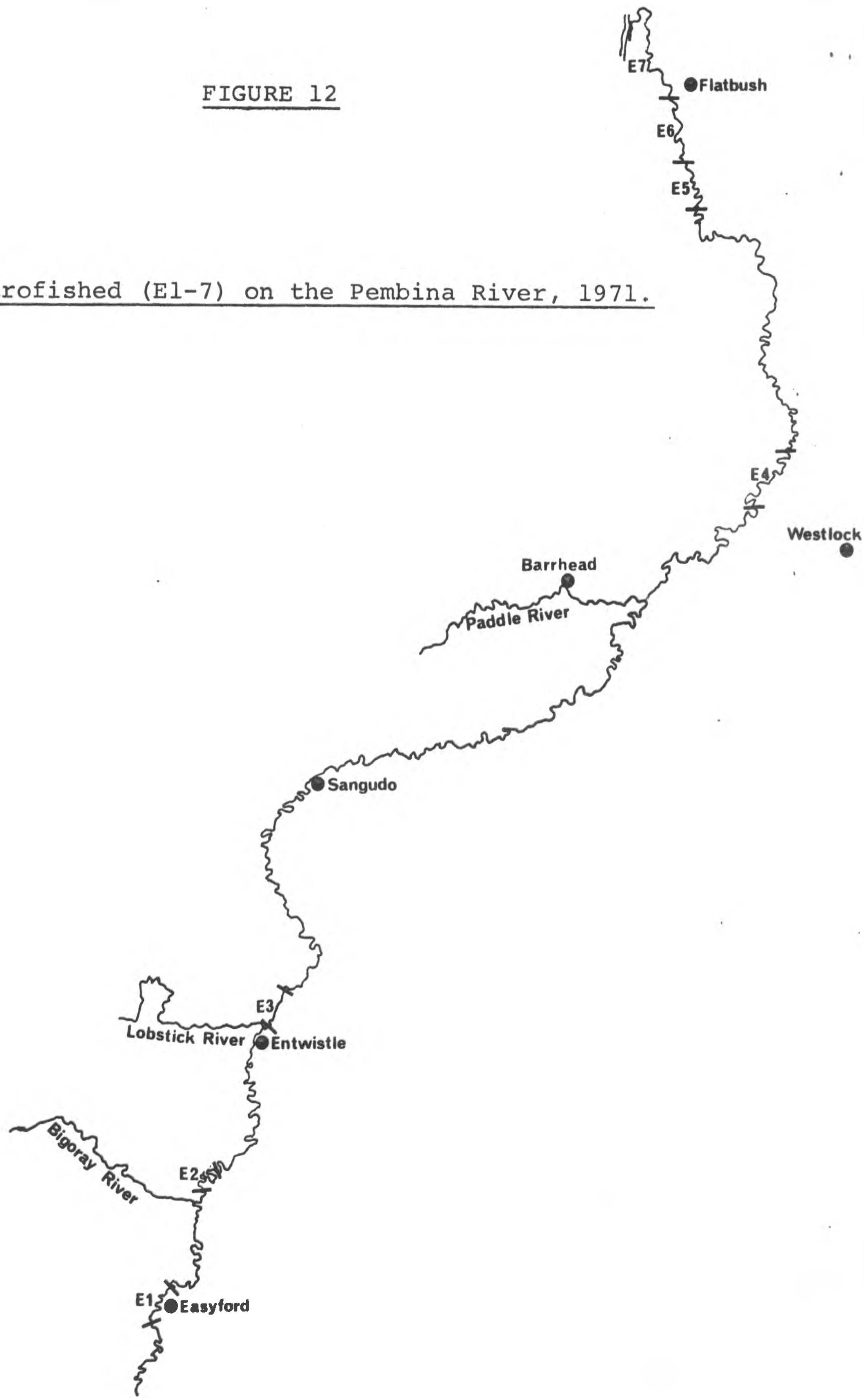
1.) Introduction:

Electroshocking was carried out on the Pembina River over seven sample sections during the period June 28 - September 10, 1971. The locations of the sample sections are presented in Figure 12. The objectives of this survey were to determine to as great an extent as possible the diversity, distribution and relative abundance of gamefish in the lower 300 miles of the Pembina River. An attempt was made to sample all representative sections. Gaps between sample sections are the result of lack of launching accessibility, and the length of river to be sampled in the time available. Low flows in late summer precluded repeat sampling in the upstream reaches. Although numerous difficulties were incurred, owing to river conditions, valuable data on the diversity and distribution of species were obtained. Unfortunately sample sizes were insufficient to accurately determine the relative abundance of species. However, inferences to this effect were made on the basis of habitat analysis results combined with sampling data.

A fish tagging operation was carried out to facilitate actual population estimates. However, the procedure requires numberous repeat runs which time did not allow, therefore, actual estimates are not available.

FIGURE 12

Sections Electrofished (E1-7) on the Pembina River, 1971.



2.) Methods:

Fish were collected with a boat-adapted electroshocking unit. Sample sections were selected on the basis of launching accessibility and linear distribution. Captured fish were anesthesized with M.S.222 (Tricane methanesulfonate). All fish were weighed and fork lengths were recorded. Mature gamefish were tagged with number coded FD 67 anchor tags using an FDM 68 applicator gun (Floy Tag and Manufacturing Co.). The fish were allowed to regain their swimming ability in a recovery tank placed in the stream current. Nylon gillnets were used to sample fish at the Pembina-Athabasca confluence.

3.) Results and Discussion:

Warm-water gamefish collected included walleye, northern pike, and goldeye. Mountain whitefish were the only cold-water species collected. A list of all species of fish collected is shown in Table 72. The numbers and location of capture are indicated in Table 73. Size records for gamefish are provided in Appendix 30.

Habitat data indicate a wide variety of habitat types in the study section. Due to the varying habitat requirements of fish it is not unusual to find a zonation of gamefish along a river course. Mountain whitefish are known to inhabit the headwater reaches of the river, and their occurrence has been

TABLE 72

A List of Species Collected in the Pembina River, Summer 1971

Walleye	*Stizostedion vitreum vitreum* (Mitchill)
Northern Pike	*Esox lucius*
Mountain Whitefish	*Prosopium williamsoni* (Gerard)
Goldeye	*Hiodon alosoides* (Refinesque)
Longnose Sucker	*Catostomus catostomus* (Forster)
White Sucker	*Catostomus commersoni* (Lacepede)
Burbot	*Lota lota* (Linnaeus)
Flathead Chub	*Platygobio gracilis* (Richardson)
Lake Chub	*Couesius plumbeus* (Agassiz)
Spoonhead Sculpin	*Cottus ricei* (Nelson)
Trout-perch	*Percopsis omiscomaycus* (Walbaum)
Longnose Dace	*Rhinichthys cataractae* (Valenciennes)

TABLE 73

Distribution and Abundance of Fish Collected in the Pembina River, 1971.

Electro-fishing Section	Times sampled	Mountain Whitefish	Walleye	Goldeye	Northern Pike	Longnose Sucker	White Sucker	Burbot	Flathead Chub	Total	Section Length
E1	1	2	2	-	-	10	1	1	-	16	3.7
E2	2	11	1	-	-	25	6	-	-	43	9.2
E3	2	2	6	-	1	78	3	2	2	94	7.3
E4	1	-	1	1	-	14	8	-	-	24	13.8
E5	1	-	7	2	-	56	12	3	4	84	7.2
E6	1	1	4	3	-	61	5	1	1	76	10.6
E7	1	2	13	25	4	36	20	3	2	105	17.0
TOTAL		18	34	31	5	280	55	10	9	442	

documented near Lodgepole. Arctic grayling inhabit tributaries of the Upper Pembina (Paetz and Nelson, 1970). Grayling have also been recorded in the upper Lobstick River (Miller and Macdonald, 1949) and in the Bigoray River (Clifford, 1969). This species is known to inhabit tributary streams in the summer months. (Ward, 1951). Therefore, grayling could have been present in certain tributary streams within the study section. However, it is unlikely that substantial populations occur since habitat conditions within the Pembina River itself are unsuitable for this species and suitable tributaries are infrequent.

The 1971 collections documented an extended distribution of mountain whitefish. This species was collected in favorable habitat from Easyford downstream to a point below Entwistle. A total of 15 whitefish were sampled in sections E1, E2, and E3. Section E2 provided the most suitable habitat and yielded most of the total sample. This section is situated within gradient zone 2 which is characterized by a high incidence of riffles. The habitat data indicates that zone 2 provides the highest percentage of high quality riffles in the study area. Mountain whitefish showed a definite preference for high quality riffles and were present in such habitat in large numbers. (Photo 30).

The electrofisher was extremely effective in sampling riffle species. Since only a small percentage of each suitable riffle was sampled, substantial whitefish populations are

Photo 30: A high quality riffle in gradient zone 2 of the Pembina River, September, 1971. Extremely transparent water, high current velocity and a clean rubble-boulder substrate provide excellent habitat for mountain whitefish.

indicated. However, suitable riffles are not particularly abundant on the Pembina which tends to reduce the overall value of large sections of the river. If section E2 is typical of the habitat type provided throughout gradient zone 2, then mountain whitefish are probably locally abundant in suitable riffles throughout its length. Section E1 and E3 also yielded whitefish, however, the species was not as abundant as in the middle section. Sections E1 and E3 are located in gradient zones 1 and 4 respectively. Neither zone provided significant amounts of good quality riffle; indicating a lower habitat suitability for whitefish. The current velocity in zone 1 was not sufficient to prevent substrate siltation. Turbidity and substrate siltation in zone 4 probably results in the degradation of an otherwise favorable whitefish zone. The species was not collected in E4 and E5, which reflects their generally low habitat quality. A single specimen was collected in E6 and two individuals were sampled in E7. Both sections are situated in gradient zone 6. Whitefish populations throughout the zone are sparse which reflects the sustained level of turbidity and the presence of light to moderate siltation which reduces riffle quality. The specimens collected may be associated with the nearby Athabasca River or may be members of a distinct population. According to anglers, mountain whitefish are caught occasionally at the Pembina-Athabasca confluence. The largest specimen had a fork length of 345 mm. (approximately 13.5 inches) and a weight of 585 grams (approximately 1.3 pounds), and was collected in section E2.

Walleye are the principal gamefish in the study section in terms of angling effort. Most of the present angling is restricted to specific areas where concentrations occur or have occurred in the past. Thirty-two walleye were collected during the study period. The distribution and abundance of walleye in the Pembina is probably dependent upon the occurrence of high quality pools. Walleye were most abundant in sections E5, E6, and E7 which are situated in gradient zone 6. This zone contains an adequate pool-riffle separation and significant amounts of good quality pools (Table 65). In addition, flow-volumes throughout the year are probably sufficient to maintain adequate pool depth. The habitat in sections E1, E2, and E3 provided some high quality pools but due to the occurrence of low summer and winter flows, pool quality might not be maintained on a seasonal or year-to-year basis.

Walleye are most abundant at the confluences of the Lobstick, Paddle and Athabasca Rivers. Anglers tend to concentrate their efforts at these locations. Gill-netting carried out at the Pembina-Athabasca confluence indicates the presence of substantial populations of medium to large-sized walleye. The largest specimen was collected at the confluence and had a fork length of 529 mm. (approximately 21 inches) and weight of 1840 grams (approximately 4 pounds). Only one walleye was collected in E4, which probably indicates a low abundance throughout the entire gradient zone since this section appears to be representative.

The Pembina River probably does not support a large walleye population over its total length, however, populations may be locally abundant according to habitat conditions. The actual populations of walleye may be higher than the results of this study indicate since the effectiveness of electroshocking units in sampling deep pools is limited.

The distribution and habits of goldeye in the province are poorly known, and not well-documented. They apparently prefer turbid water, undertake lengthy river migrations and spawn in the spring over rocky, gravelly buttoms in slow current (Paetz and Nelson, 1970). Collections in the study indicate the presence of substantial populations of goldeye in the lower reaches of the Pembina River.

A single goldeye was sampled in E4, which represents the furthest upstream collection. Much of the habitat in E4 was not well suited to goldeye nor to gamefish in general. The goldeye sampled was associated with an irregularity in the stream profile which resulted in the formation of a riffle area. The electrofishing results indicate that E5, E6, and E7 provide areas of suitable habitat, and support the highest goldeye populations. On the basis of the habitat preferences shown, much of gradient zone 5 is probably poor goldeye habitat. However, more extensive sampling would be required to substantiate this point. In the remainder of the study section it appears that only gradient zone 4 supplies potentially suitable habitat. Gill-netting results at the Pembina-Athabasca confluence indicate the presence of a relatively high goldeye population (Photo 31). Additional study is required to determine whether the species is resident in the lower Pembina River.

While goldeye may be migrants from the Athabasca River, the lower Pembina appears capable of supporting a population on an annual basis. The lack of available spawning areas does not appear to be a limiting factor. Further studies are required to determine whether goldeye do successfully spawn in the lower Pembina. According to Paterson (1966) they do not successfully reproduce in the Edmonton area, and are not found in this vicinity until they are 3 or 4 years old. All of the individuals sampled in the 1971 study were mature adults which might indicate that the same situation applies to the lower Pembina River.

An interesting finding of this study involved the feeding habits of goldeye. Food items normally utilized include insects, snails, crayfish and fish. (Paetz and Nelson, 1970). In the present study, stomach analyses showed that numerous individuals were consuming mice and shrews in addition to immature caddis and dragonflies. These food items were recorded on several occasions throughout the lower reaches of the river.

Goldeye specimens obtained were generally of large size. The largest individual collected in E6 had a fork length of 450 mm. (approximately 17.7 inches) and a weight of 990 grams (approximately 2.2 pounds). Several fish in the 1 1/2 pound

Photo 31: Goldeye collected from turbid pools in gradient zone 6 of the Pembina River, September, 1971 Fork lengths recorded in this zone varied between 320 - 450 mm. and weights between 360 - 990 grams.

category were sampled. Angling, effort oriented toward goldeye, does not appear to be high, although they are probably caught frequently at the mouth of the Pembina by anglers attracted to the walleye fishery.

Although northern pike are not the primary gamefish in terms of angling effort on the Pembina, they probably contribute most to the annual catch. This is likely a reflection of their ease of capture rather than the size of the population. During the study only five pike were collected and four of these were sampled in E7. Obviously a larger population exists than is indicated by the 1971 sample. The electrofisher was probably relatively inefficient in sampling this species due to their localized distribution and difficulties involved in shocking the areas they inhabited. The largest specimen sampled weighed 3200 grams (approximately 7 pounds) and was taken near the Pembina-Athabasca confluence. Other individuals collected or sighted were small and appeared to be in relatively poor condition. The combined fish collection and habitat analysis data indicates that the habitat provided by the Pembina River is marginal and is incapable of producing large numbers of medium to large-sized pike. The present status of the species probably reflects its ability to exist in diverse habitat situations which do not provide the necessary requirements to support a thriving population.

The lack of aquatic vegetation in the Pembina River appears to be a severe limiting factor to the spawning, rearing and feeding success of pike. Turbidity, siltation and fluctuating discharge were effective in preventing growth of aquatic macrophytes in suitable areas during the 1971 study (Photos 32 and 33). It appears as though northern pike exhibit a localized distribution along the river course in response to the occurrence of suitable habitat, and are otherwise sparsely distributed.

Of the larger non-gamefish, longnose suckers were the most abundant. This species preferred the semi-fast water adjoining riffle areas. White suckers were next in abundance and generally exhibited a more localized distribution than longnose suckers. They preferred the quieter, deeper sections which simulated a lake environment. The large sample of suckers obtained probably indicates both the presence of large populations and the effectiveness of shocker in sampling both species. Their tendency to occur in groups and their sedentary habits make them very susceptible to electroshocking.

4.) Summary:

a.) The following gamefish species were collected in the Pembina River: walleye, northern pike, goldeye and mountain whitefish.

b.) High quality riffles in gradient zone 2 supported populations of mountain whitefish. The results of fish collections in section E2 indicate the presence of substantial populations in suitable riffles. However, the sporadic occurrence of quality riffle results in a localized distribution

Photos 32 and 33: Station 9 on the Pembina River. The upper photo was taken in July, the lower in late August. These photos illustrate the tremendous variation in discharge which occurred during the 1971 study.

for the species.

c.) Riffle habitat, favorable to mountain whitefish, was not as abundant in gradient zones 1 and 4. As a consequence, whitefish exhibited a limited distribution and were never abundant.

d.) Mountain whitefish occur in suitable areas of habitat within gradient zone 6. The results indicate the presence of low populations with a sporadic distribution.

e.) Walleye were most abundant in certain reaches of gradient zone 6. The occurrence of high quality pools determined the distribution of this species.

f.) Walleye were present where favorable pools occurred in the upper reaches of the Pembina River.

g.) A concentration of walleye occurs at the Pembina-Athabasca confluence and apparently they concentrate to some degree at the confluences of the Lobstick and Paddle Rivers.

h.) Goldeye were present in substantial numbers in gradient zone 6. They were most abundant at the Pembina-Athabasca confluence.

i.) Northern pike appear to exhibit a wide distribution in the Pembina river as a result of their ability to survive in a variety of habitats. They are not abundant, however, and do not attain a large size. Low-gradient reaches near the Pembina-Athabasca confluence and areas near the mouths of tributaries, probably support the highest pike populations.

j.) The lack of submergent macrophytic vegetation in potentially suitable sections of the Pembina River probably limit seriously, the spawning, rearing and feeding success of northern pike.

k.) Fluctuating discharge, sustained turbidity, and severe siltation were effective in preventing the growth of macrophytes and in general reducing the habitat suitability for all gamefish species.

l.) Gradient zone 5 did not provide habitat suitable to any gamefish specie due to the extremely low habitat diversity and the unproductive nature of the substrate.

C.) Conclusions:

On the basis of the 1971 study, it appears that only specific reaches of the Pembina River study section are capable of a significant sport fishery, in terms of Provincial importance. However, where habitat conditions are favorable, angling potential could be substantial. Variation in discharge, high turbidity and excessive siltation are currently reducing the quality of the habitat for all gamefish species. The Pembina River has considerable aesthetic appeal throughout much of its length, a fact which enhances its recreational value. It is important that objectives be determined regarding the future trends of land use in the Pembina River watershed. If extensive forest cover removal is continued and cattle grazing is allowed to extend along the banks, it is reasonable to predict that the Pembina River will deteriorate even further.

The potential value of the Pembina River has not been fully realized, although its potential for recreational utilization is significant as a result of its proximity to the large urban population of the Edmonton area.

The Sturgeon River basin is an example of a watershed which has been badly abused, and the current condition of the river and associated lakes reflects this abuse.

The Pembina River has probably reached the critical point at which further deterioration will result in irreversible changes such as those which have occurred on the Sturgeon River.

APPENDIX 1

Meteorological Data Collected at the Edmonton-Stony Plain Weather Station during 1968.

Month	Temperature: Mean Min.	Mean Daily	Mean Max.	Max.	Min.	Inches Precip.	Days Below Freezing	Month End Snow Depth
January	-3.7	5.0	13.6	54	-25	11.0	30	2
February	11.2	19.3	27.3	54	-22	1.2	26	1
March	25.9	33.1	40.3	61	12	5.8	25	0
April	28.4	38.8	49.1	72	11	6.5	22	0
May	39.0	50.0	61.0	77	23	1.15*	3	0
June	45.9	56.4	66.9	80	33	2.67*	0	0
July	51.2	62.1	72.9	86	43	2.37*	0	0
August	47.0	56.1	65.2	79	36	2.73*	0	0
September	42.3	50.6	58.9	75	31	1.33*	2	0
October	31.8	40.8	48.1	63	23	4.4	18	0
November	21.8	28.8	35.8	48	-3	1.6	28	0
December	-3.6	2.0	7.6	30	-32	15.9	31	6

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* Rain

APPENDIX 2

Meteorological Data Collected at the Edmonton-Stony Plain Weather Station during 1969.

Month	Temperature: Mean Min.	Mean Daily	Mean Max.	Max.	Min.	Inches Precip.	Days Below Freezing	Month End Snow Depth
January	-22.7	-15.7	-8.9	39	-38	6.0	31	8
February	0.7	9.4	18.0	31	-19	7.6	28	12
March	13.5	22.5	31.5	47	-8	3.0	30	8
April	33.3	43.3	53.2	71	20	3.7	15	0
May	40.9	51.7	62.5	83	33	1.38*	0	0
June	48.5	59.4	70.3	86	34	1.39*	0	0
July	49.9	60.1	70.3	86	44	3.62*	0	0
August	49.5	60.3	71.0	81	37	4.9*	0	0
September	41.0	49.2	57.3	78	28	3.24	4	0
October	27.8	36.2	44.5	63	10	5.2	22	0
November	21.9	30.0	38.1	59	-10	8.1	25	0
December	14.3	21.1	26.8	41	-3	4.9	30	2

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* Rain

APPENDIX 3

Meteorological Data Collected at the Edmonton-Stony Plain Weather Station during 1970.

Month	Temperature: Mean Min.	Mean Daily	Mean Max.	Max.	Min.	Inches Precip.	Days Below Freezing	Month End Snow Depth
January	-4.8	2.5	9.7	43	-37	6.9	31	3
February	13.6	21.5	29.4	46	-11	6.5	28	4
March	11.2	19.7	28.1	51	-14	7.8	31	2
April	29.3	38.7	48.1	57	19	1.3	26	0
May	40.3	51.2	62.0	81	31	0.58*	3	0
June	52.4	62.6	72.7	92	44	4.75*	0	0
July	52.9	62.3	71.6	85	47	4.32*	0	0
August	49.0	60.9	71.8	85	40	1.95*	0	0
September	38.6	49.5	60.4	80	25	2.6	7	0
October	29.7	38.9	48.1	77	10	14.6	21	1
November	8.9	15.3	21.7	41	-26	14.1	30	7
December	-5.8	2.0	9.8	37	-28	7.1	31	9

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* Rain

APPENDIX 4

Meteorological Data Collected at the Edmonton-Namao Weather Station during 1968.

Month	Temperature: Mean Min.	Mean Daily	Mean Max.	Max.	Min.	Inches Precip.	Days Below Freezing	Month end Snow Depth
January	-5.8	2.6	10.9	50	-29	8.5	30	2
February	10.3	18.0	25.6	52	-22	5.3	27	1
March	25.2	32.9	40.5	61	9	6.7	24	1
April	27.5	38.6	49.7	74	8	9.7	24	0
May	38.2	50.3	62.4	77	19	0.26*	8	0
June	45.8	56.8	67.8	81	35	2.07*	0	0
July	50.1	61.9	73.6	87	41	2.74*	0	0
August	46.7	56.6	66.5	78	39	2.85*	0	0
September	40.9	50.2	59.5	74	28	1.0	4	0
October	30.5	39.7	48.9	60	24	1.7	22	0
November	20.1	28.2	36.2	49	-3	0.8	29	0
December	-6.3	1.2	8.6	29	-32	15.5	31	8

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* Rain

APPENDIX 5

Meteorological Data Collected at the Edmonton-Namao Weather Station during 1969.

Month	Temperature: Mean Min.	Mean Daily	Mean Max.	Max.	Min.	Inches Precip.	Days Below Freezing	Month end Snow Depth
January	-24.6	-17.4	-10.1	40	-42	9.7	31	12
February	-1.0	7.5	15.9	29	-22	11.4	28	17
March	10.4	19.8	29.2	45	-10	4.5	31	10
April	33.1	43.4	53.6	72	20	3.4	15	0
May	39.1	51.1	63.0	83	27	1.0*	5	0
June	45.8	58.9	71.9	87	30	0.31*	1	0
July	49.3	60.5	71.6	87	42	3.81*	0	0
August	48.5	60.3	72.1	81	37	3.43*	0	0
September	40.5	49.2	57.9	78	26	3.23	4	0
October	26.0	35.1	44.1	62	10	3.4	24	0
November	20.4	28.5	36.5	57	-4	9.0	27	1
December	11.6	18.7	25.8	45	-4	7.7	31	8

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* Rain

APPENDIX 6

Meteorological Data Collected at the Edmonton-Namao Weather Station during 1970.

Month	Temperature: Mean Min.	Mean Daily	Mean Max.	Max.	Min.	Inches Precip.	Days Below Freezing	Month End Snow Depth
January	-7.5	-0.3	7	40	-39	7.0	31	7
February	11.2	19.2	27.2	44	-15	4.1	28	5
March	9.6	18.3	27.0	51	-14	13.1	31	4
April	28.8	38.6	48.6	59	18	1.5	28	0
May	39.3	51.1	62.8	81	29	0.91*	3	0
June	52.4	63.2	73.9	92	44	3.19*	0	0
July	52.8	62.0	71.2	84	46	5.04*	0	0
August	49.3	60.6	71.9	85	39	1.29*	0	0
September	38.3	49.7	61.1	80	25	3.1	7	0
October	29.5	38.3	47.0	71	14	4.2	22	0
November	8.4	14.6	20.8	38	-22	10.2	30	7
December	-9.0	-1.0	7.0	35	-32	12.4	31	14

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* Rain

APPENDIX 7

Meteorological Data Collected at the Athabasca Weather Station during 1968.

Month	Temperature: Mean Min.	Mean Daily	Mean Max.	Max.	Min.	Inches Precip.	Days below Freezing	Month end Snow Depth
January	-12.5	-2.1	8.4	53	-46	11.3	31	8
February	7.4	17.2	26.9	61	-30	3.3	27	3
March	20.9	30.0	39.1	60	-2	9.5	30	0
April	26.2	37.7	49.2	69	10	7.0	21	0
May	36.8	49.2	61.6	78	24	1.45*	10	0
June	44.8	55.8	66.7	78	32	3.62*	0	0
July	47.7	59.7	71.6	85	41	2.78*	0	0
August	-	-	-	77	-	1.54*	0	0
September	39.2	48.7	58.1	74	26	1.85*	3	0
October	30.1	38.1	46.0	58	23	4.0	23	0
November	17.8	25.9	34.0	51	0	0.3	30	0
December	-9.8	-2.4	5.0	29	-38	15.5	31	10

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* Rain

APPENDIX 8

Meteorological Data Collected at the Athabasca Weather Station during 1969.

Month	Temperature: Mean Min.	Mean Daily	Mean Max.	Max.	Min.	Inches Precip.	Days below Freezing	Month end Snow Depth
January	-29.0	-20.0	-10.9	32	-49	7.7	31	15
February	-3.5	6.6	16.6	29	-27	9.5	27	21
March	7.5	19.5	31.4	45	-11	11.2	30	17
April	31.0	42.5	54.0	69	19	6.2	21	0
May	37.0	49.7	62.4	82	24	1.8*	10	0
June	44.1	56.9	69.7	83	30	0.72*	0	0
July	47.5	59.5	71.4	88	41	4.32*	0	0
August	46.5	58.1	69.6	79	37	2.06*	0	0
September	39.8	47.4	55.0	76	25	4.21	3	0
October	25.9	34.6	43.2	62	8	6.2	23	0
November	16.4	25.3	34.1	56	-6	12.5	30	4
December	8.7	16.1	23.4	43	-12	3.8	31	6

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* Rain

APPENDIX 9

Meteorological Data Collected at the Athabasca Weather Station during 1970

Month	Temperature : Mean Min.	Mean Daily	Mean Max.	Max.	Min.	Inches Precip.	Days below Freezing	Month end Snow Depth
January	-9.8	-2.4	5	41	-44	9.5	31	12
February	9.4	18.9	28.3	54	-23	6.8	28	9
March	7.6	17.5	27.3	50	-16	21.0	31	18
April	26.9	38.1	49.2	60	11	0.09*	16	0
May	37.5	50.0	62.4	78	26	0.70*	5	0
June	50.5	61.8	73.0	94	39	6.03*	1	0
July	51.3	61.0	70.7	81	43	5.01*	0	0
August	48.0	59.2	70.4	85	36	1.96*	0	0
September	37.3	48.6	59.8	81	24	4.0	3	0
October	28.2	37.3	46.2	73	11	8.0	24	0
November	9.2	14.9	20.6	44	-25	7.5	27	6
December	-14.5	-4.6	5.3	40	-37	13.6	31	17

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* Rain

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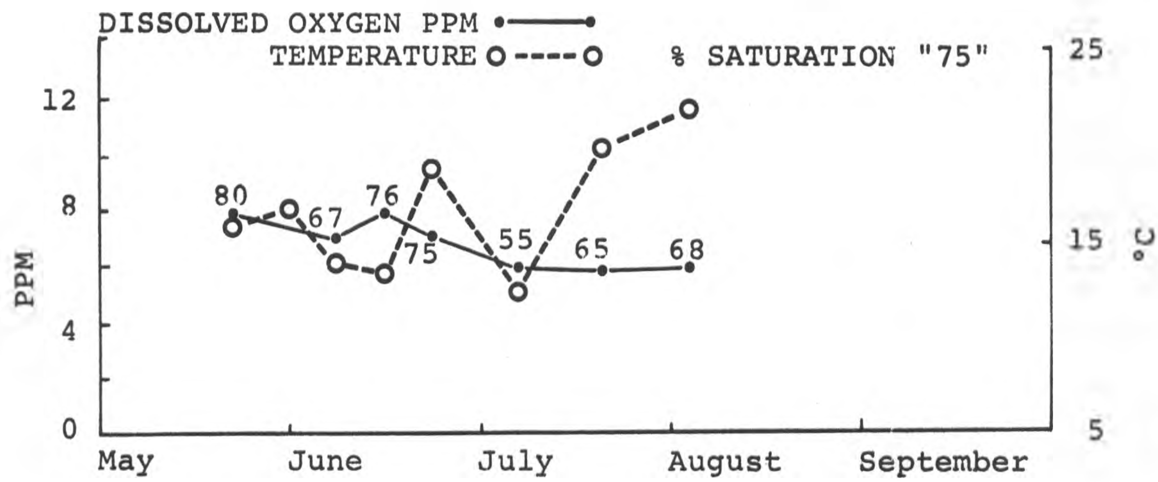
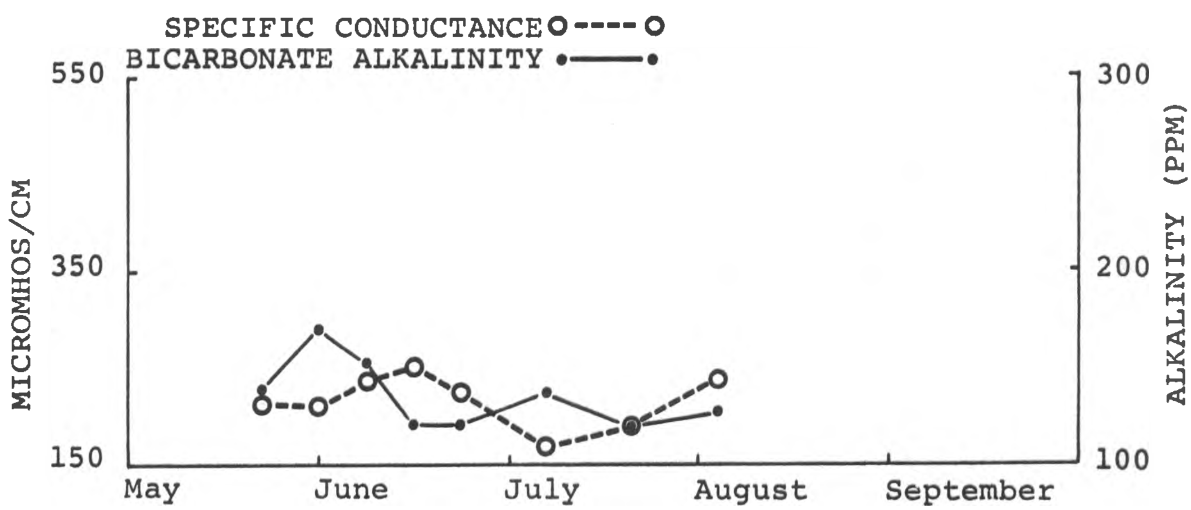
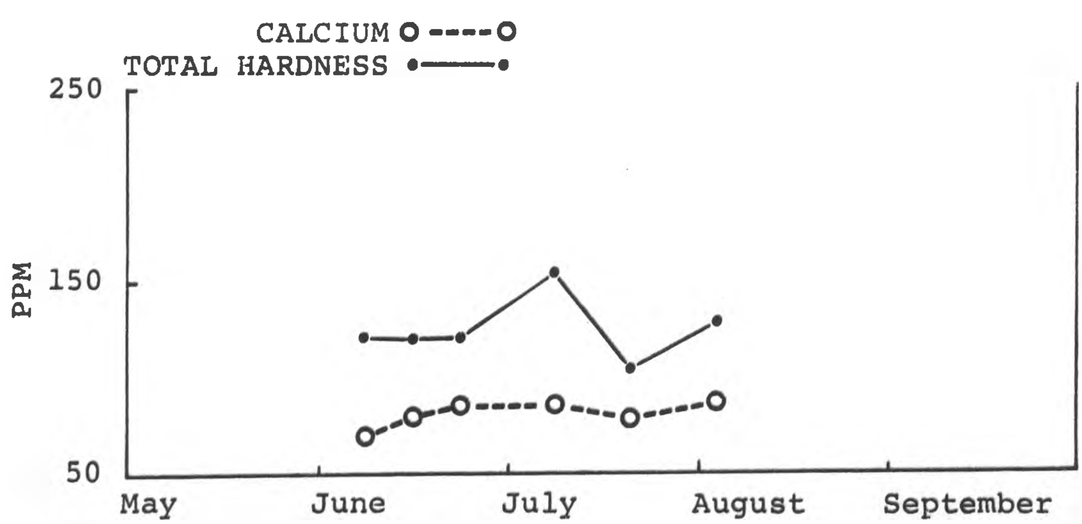
APPENDIX 10

Variation in Selected Chemical and Physical Parameters for Station 1 on the Sturgeon River, Summer 1971.

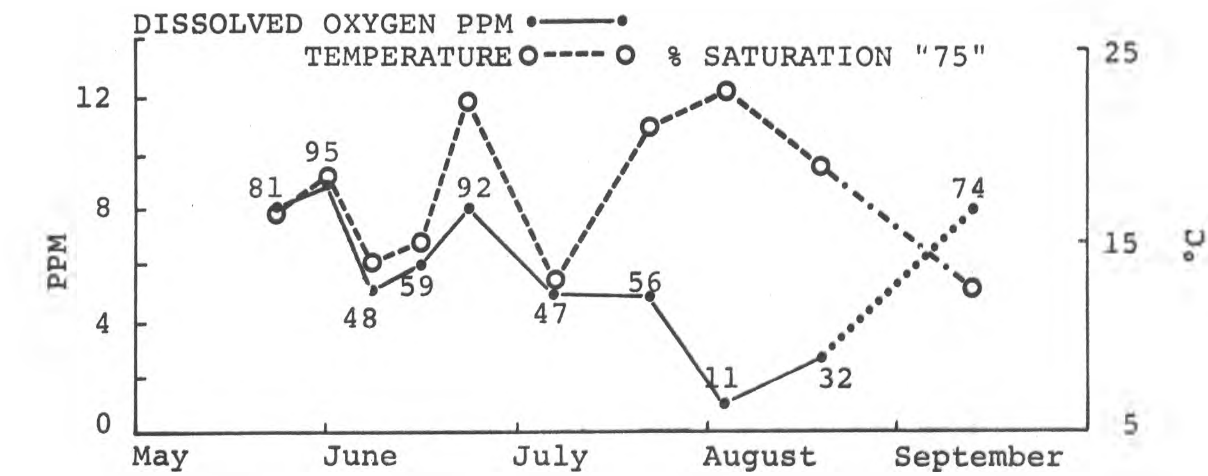


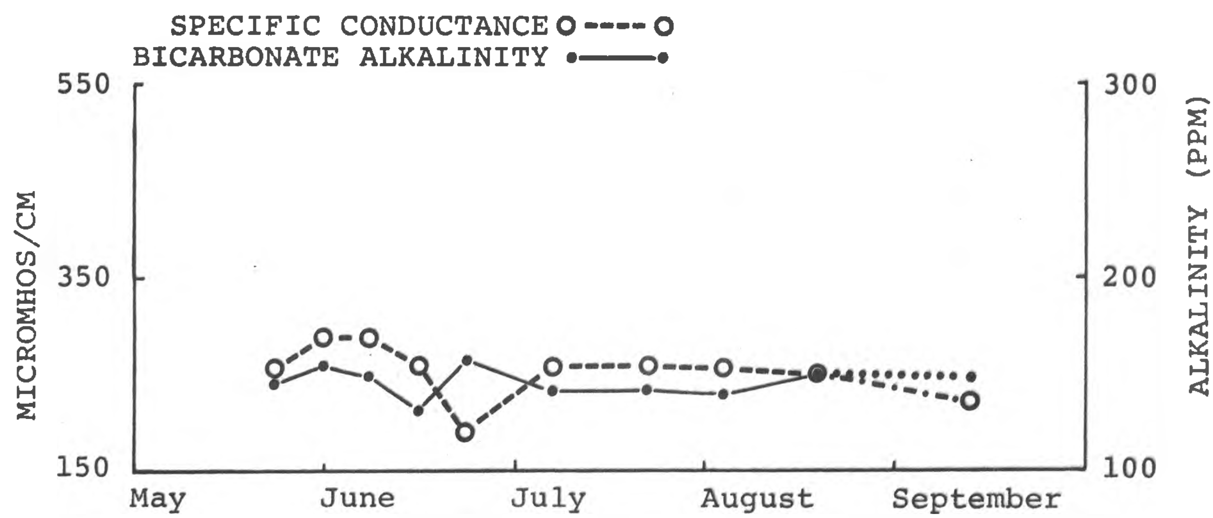


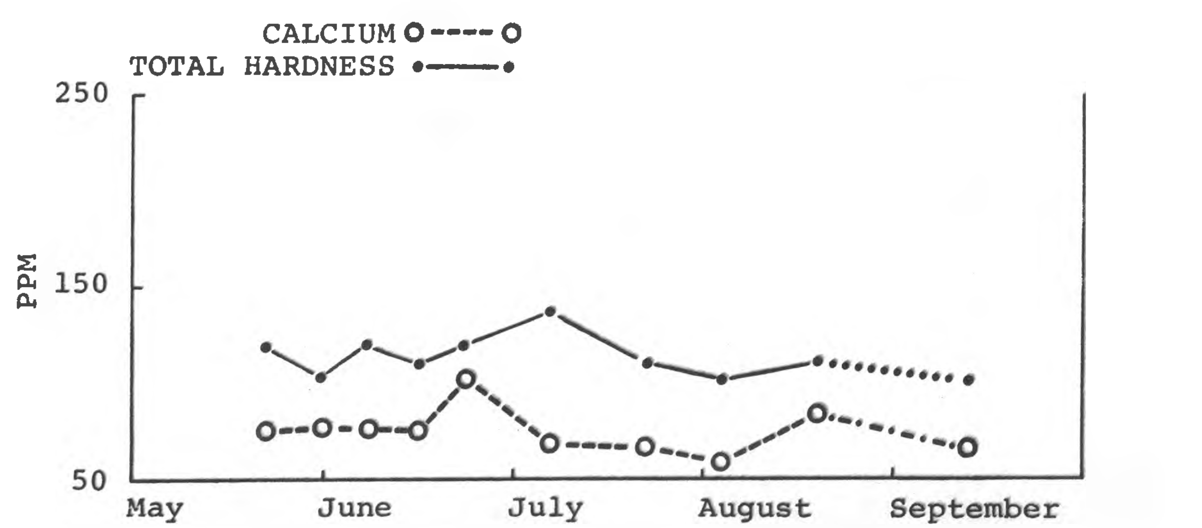


APPENDIX 11

Variation in Selected Chemical and Physical Parameters for Station 2 on the Sturgeon River, Summer 1971.

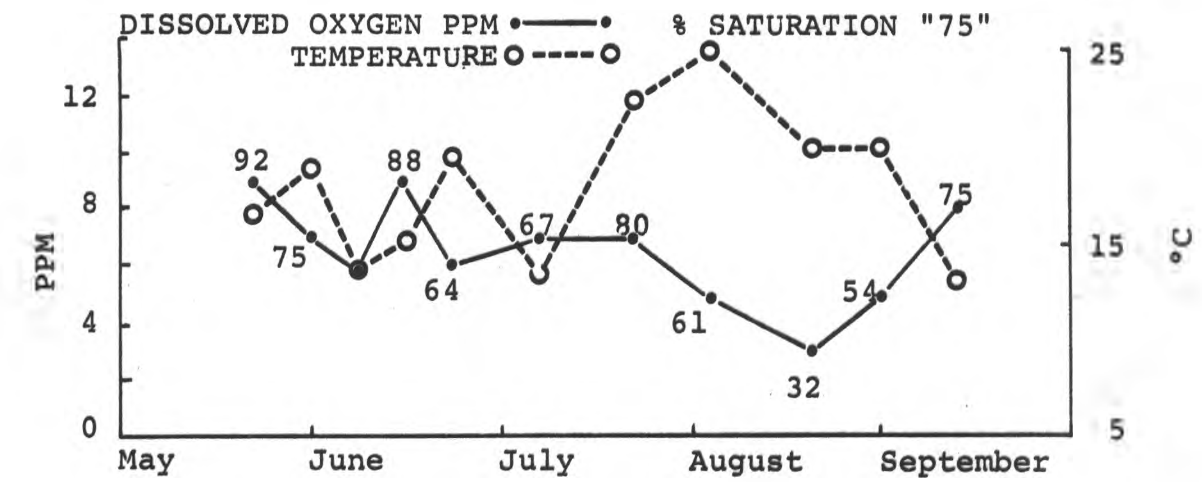


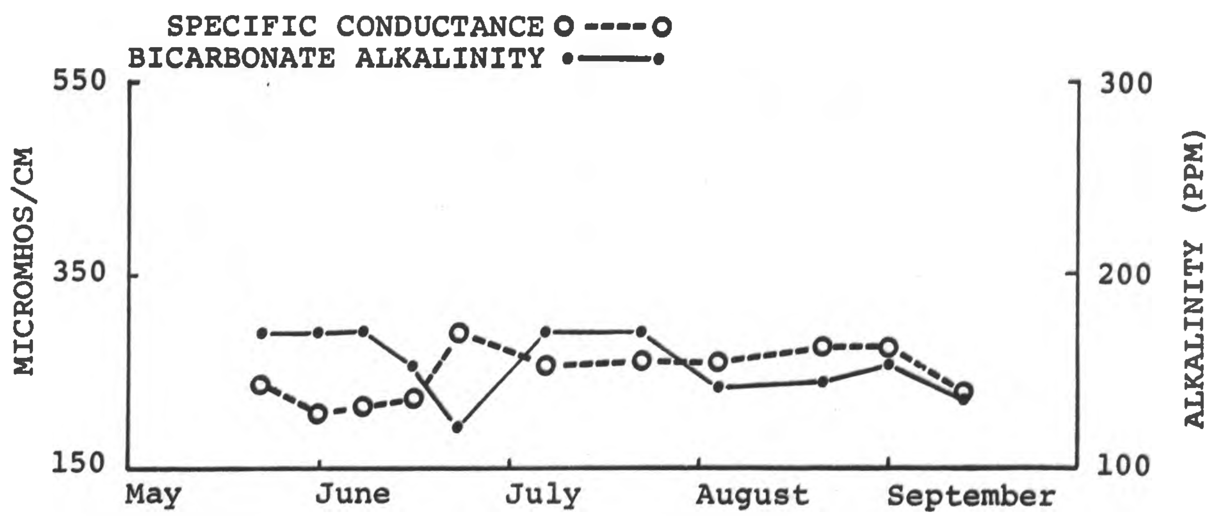


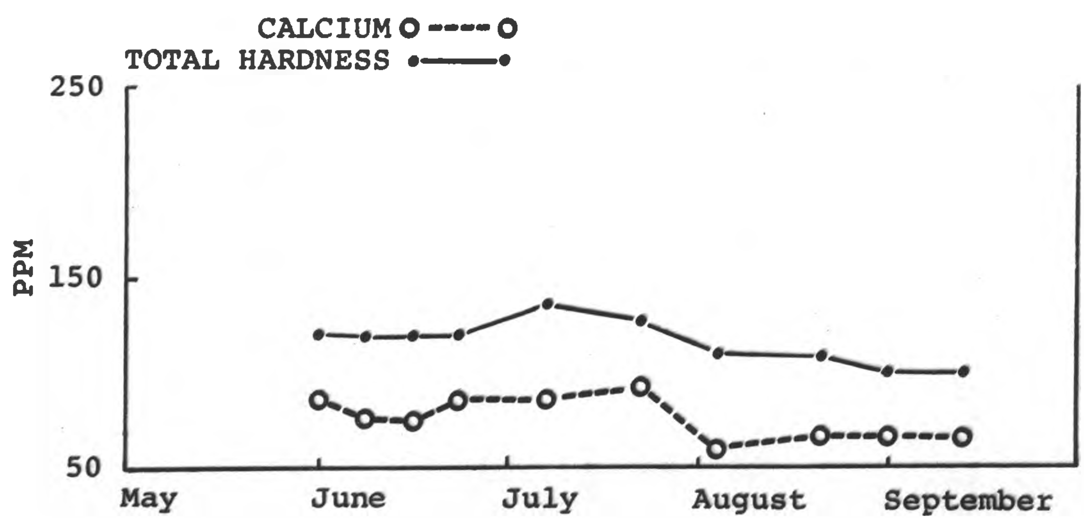


APPENDIX 12

Variation in Selected Chemical and Physical Parameters for Station 3 on the Sturgeon River, Summer 1971.

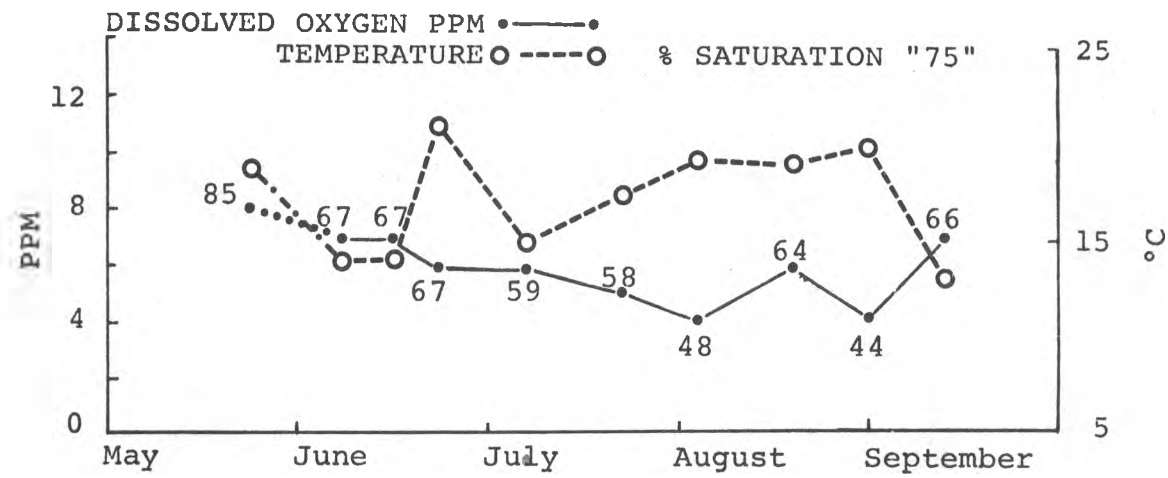


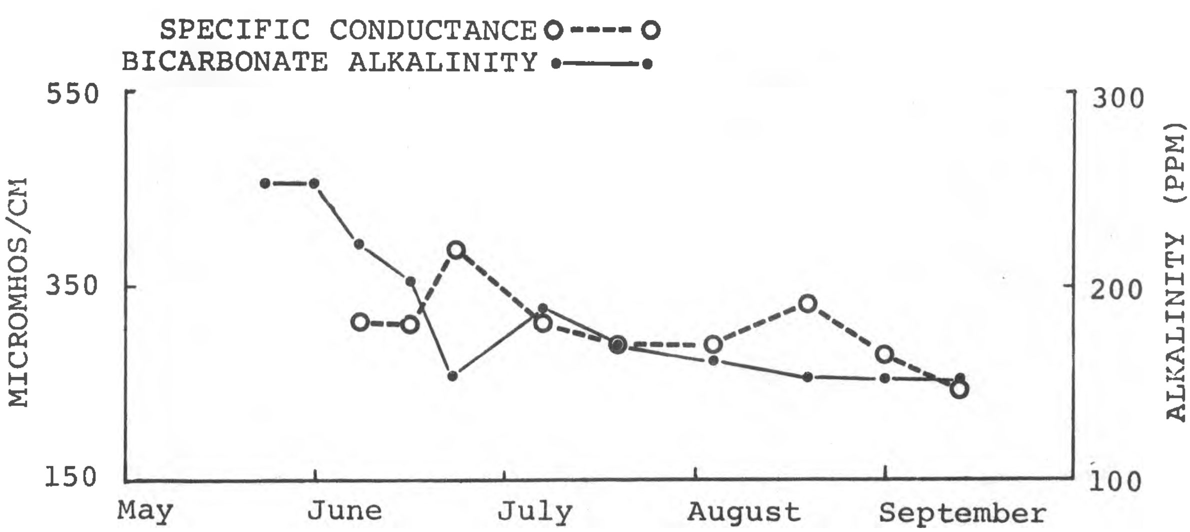


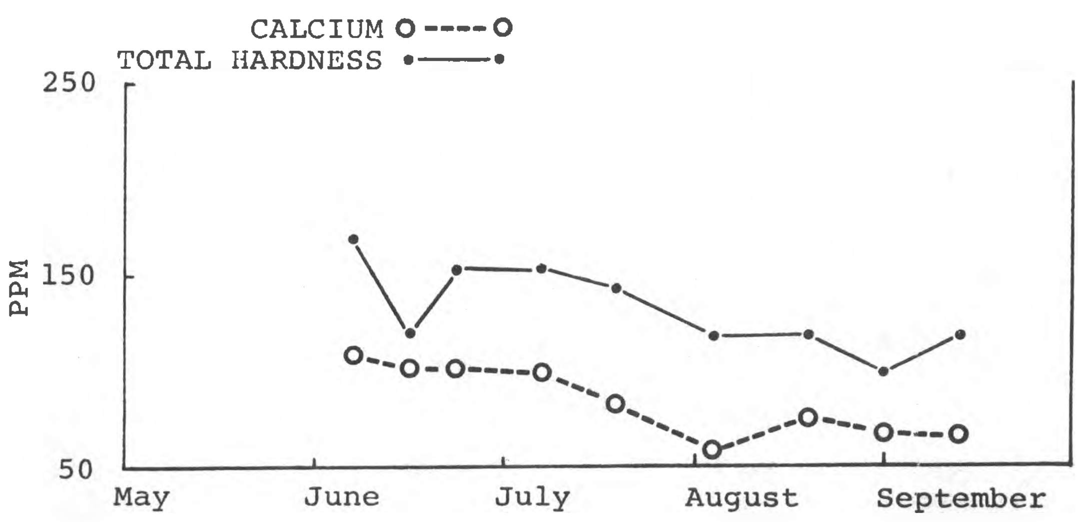


APPENDIX 13

Variation in Selected Chemical and Physical Parameters for Station 4 on the Sturgeon River, Summer 1971.

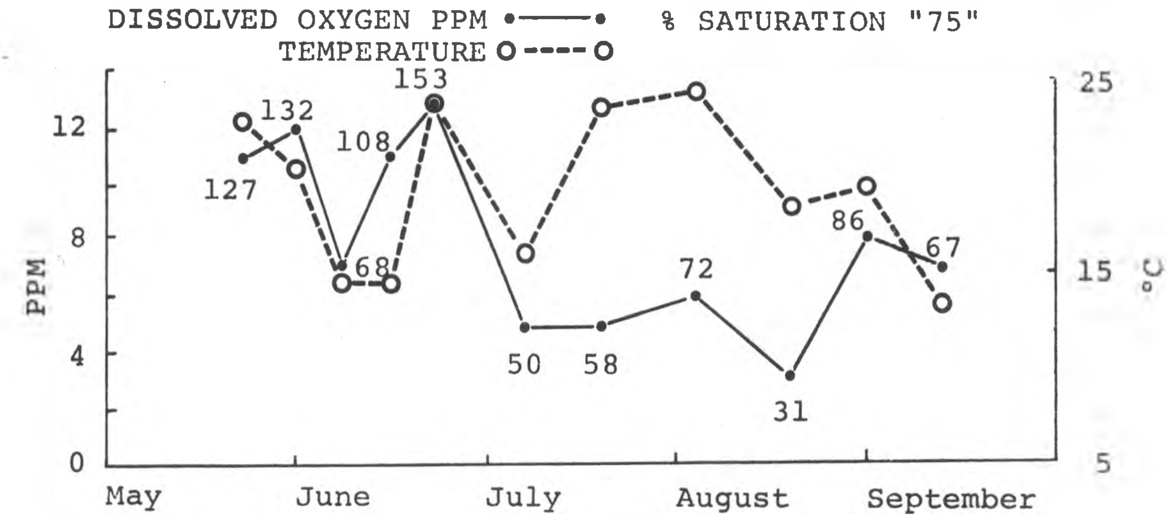


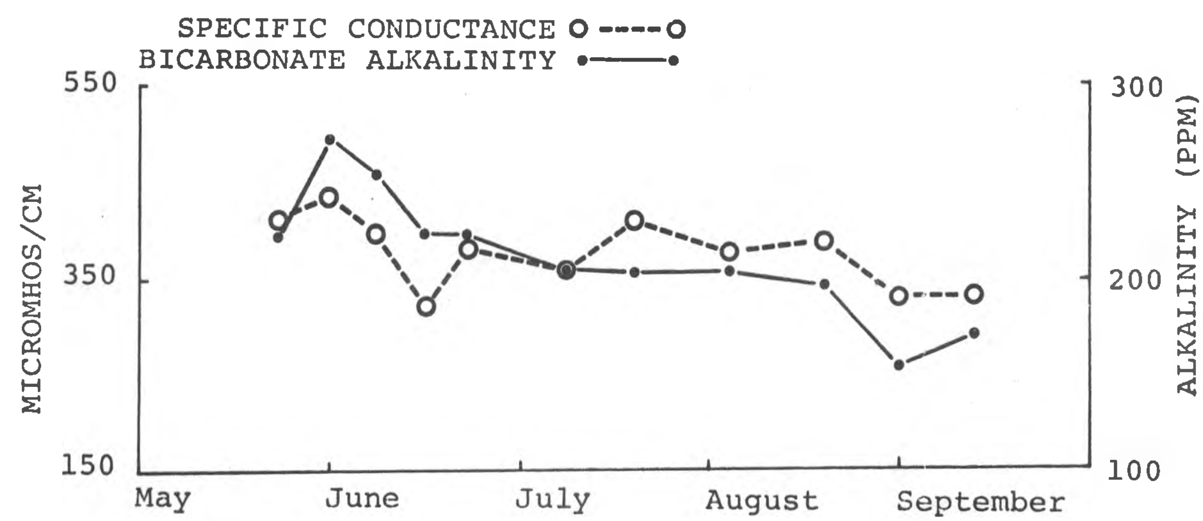


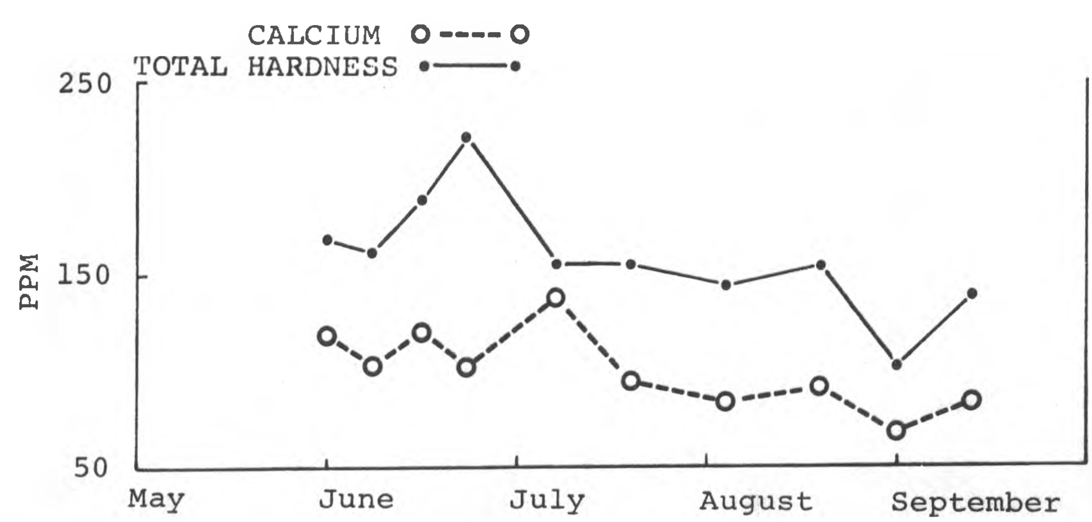


APPENDIX 14

Variation in Selected Chemical and Physical Parameters for Station 5 on the Sturgeon River, Summer 1971.

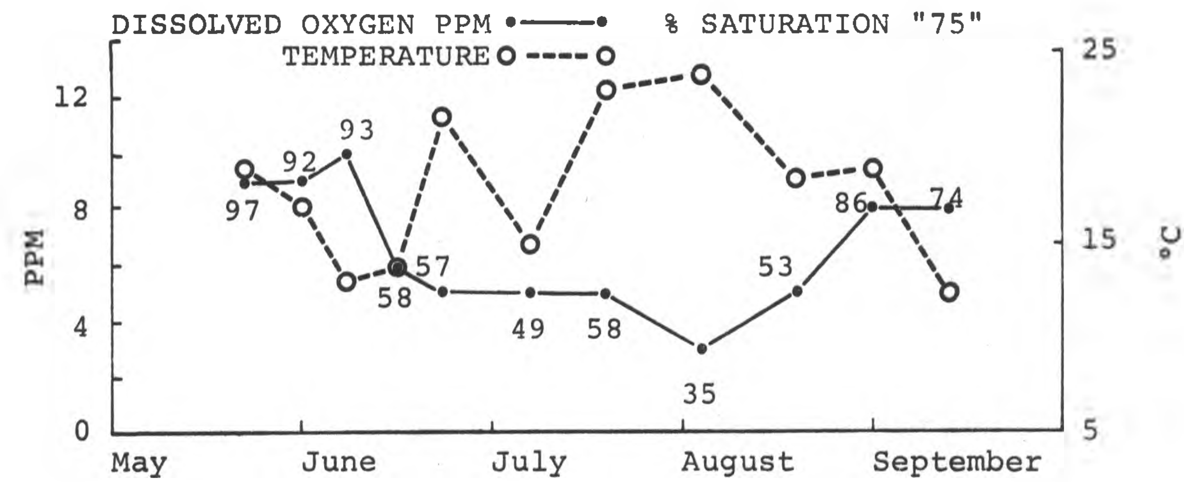


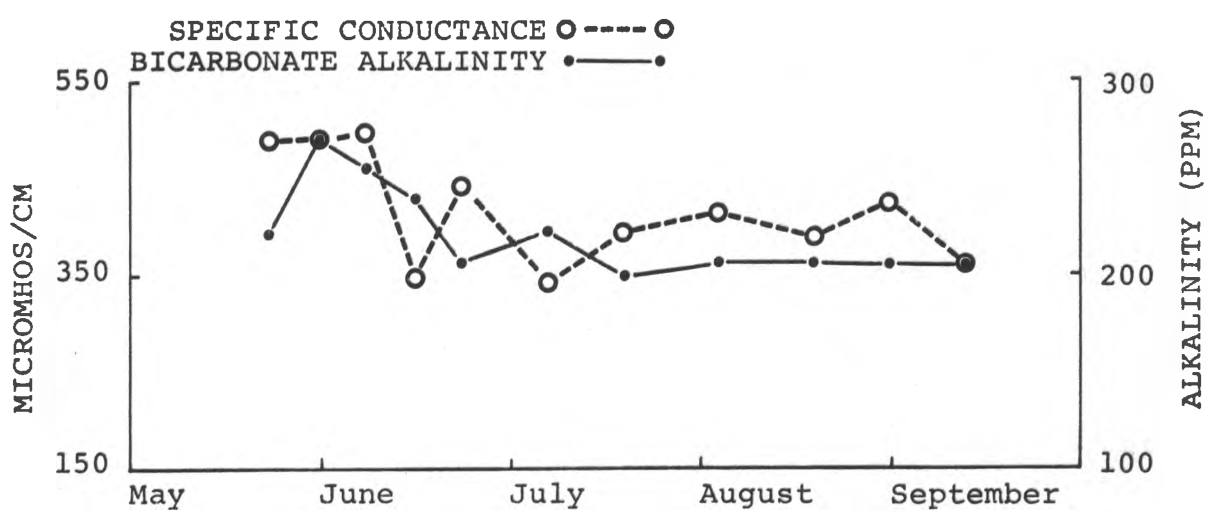


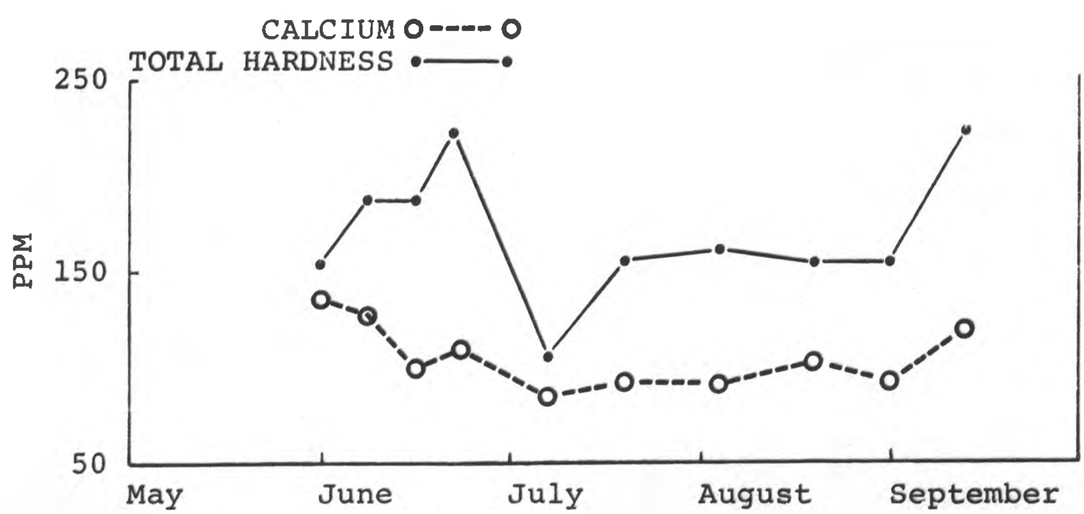


APPENDIX 15

Variation in Selected Chemical and Physical Parameters for Station 6 on the Sturgeon River, Summer 1971.

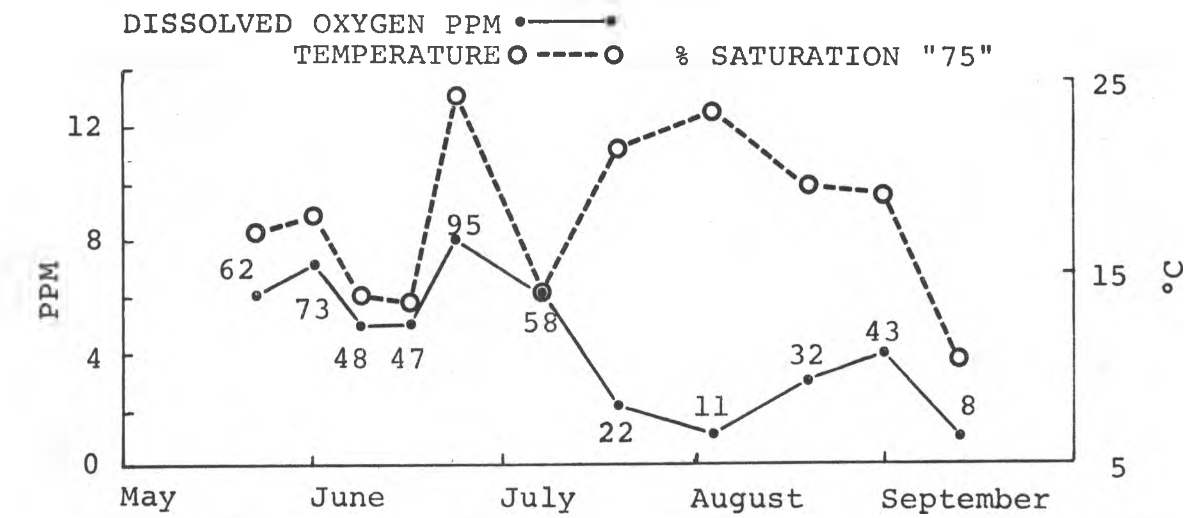


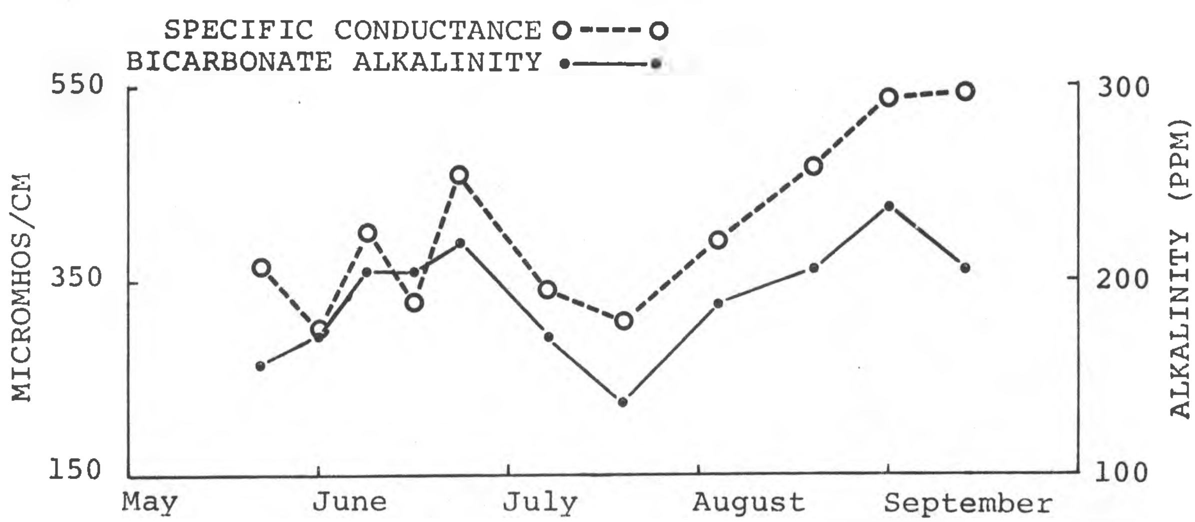


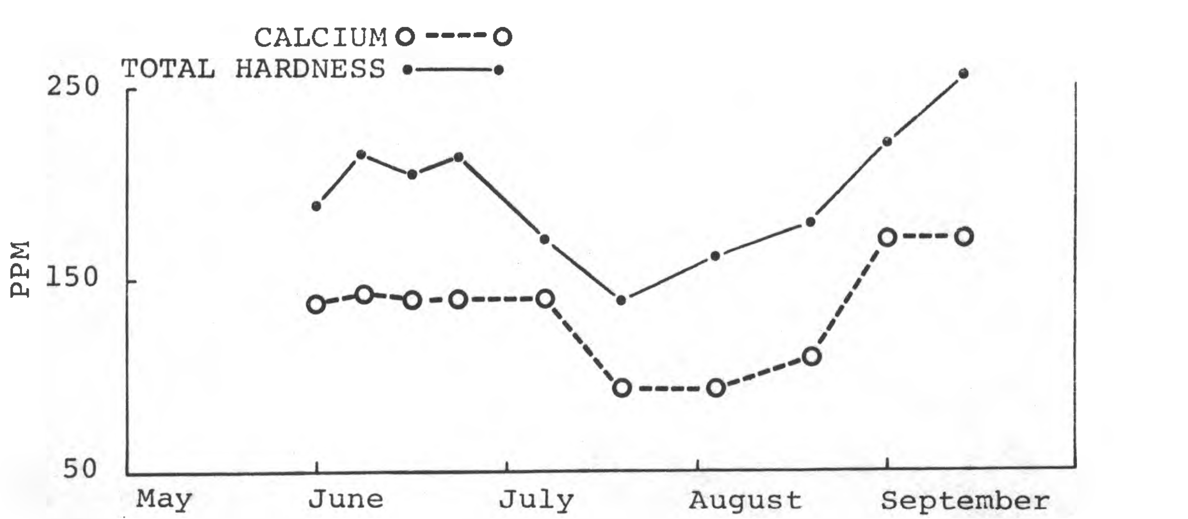


APPENDIX 16

Variation in Selected Chemical and Physical Parameters for Station 7 on the Sturgeon River, Summer 1971.

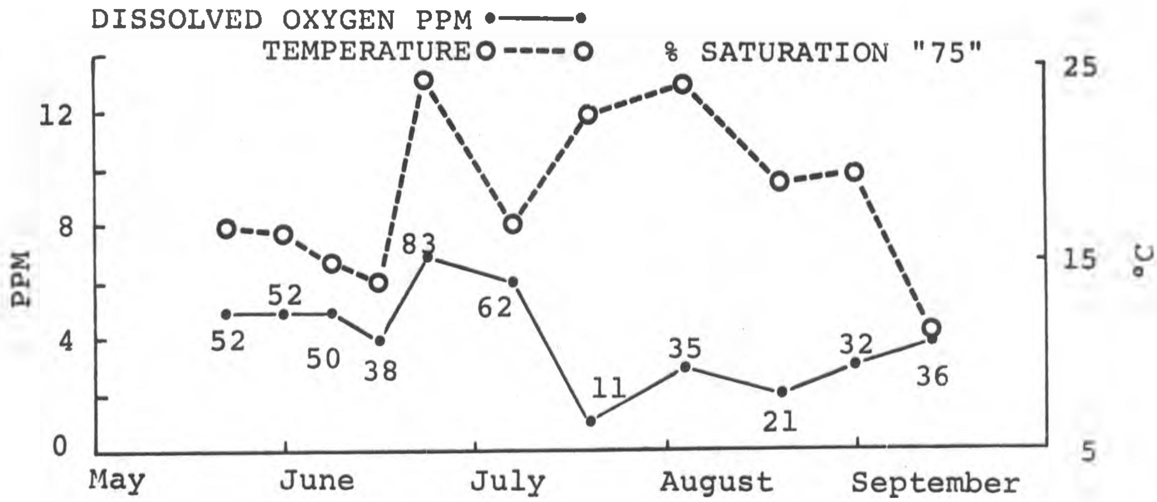


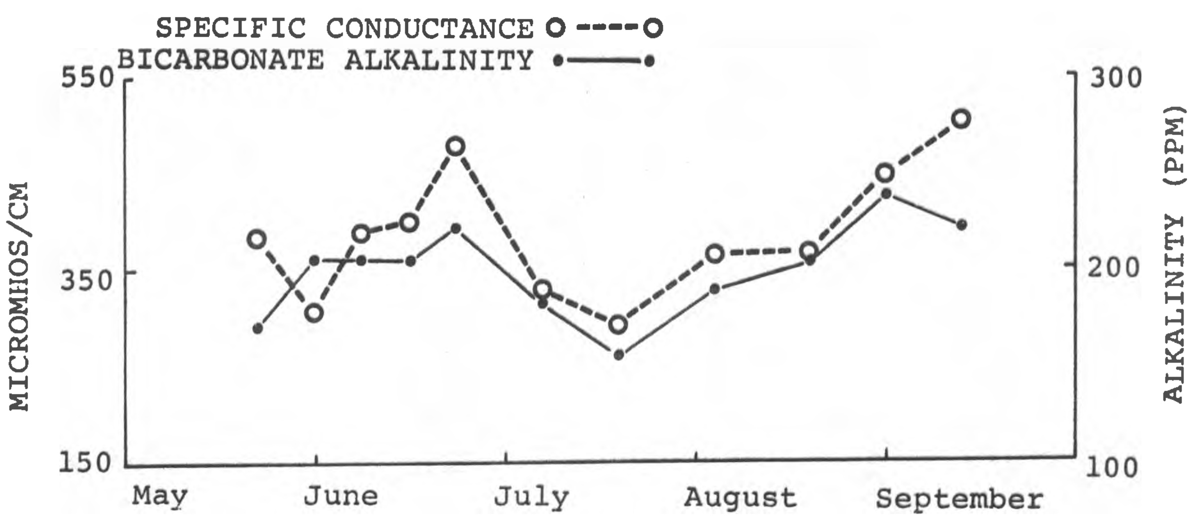


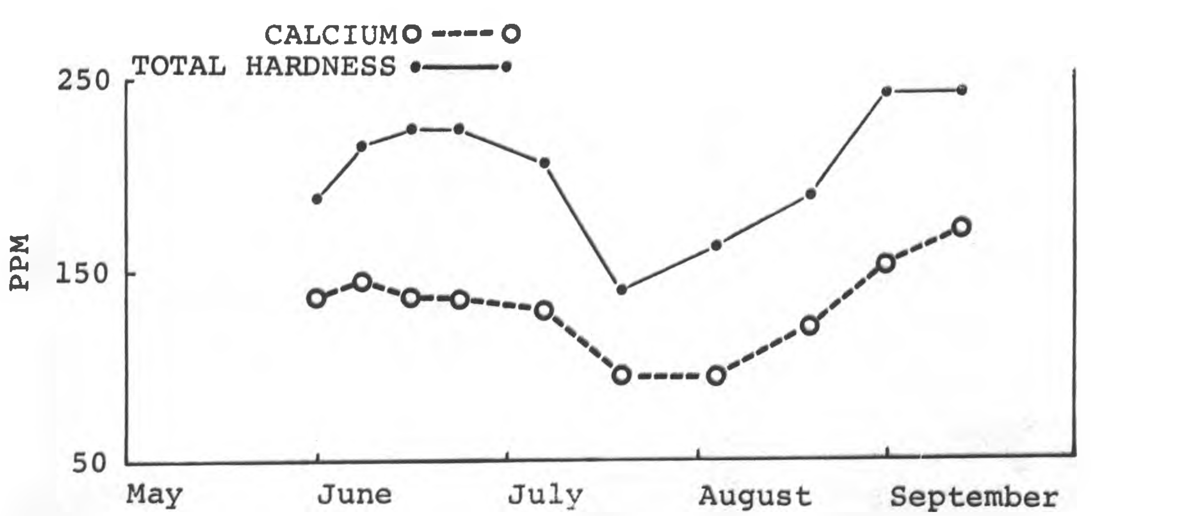


APPENDIX 17

Variation in Selected Chemical and Physical Parameters for Station 8 on the Sturgeon River, Summer 1971.

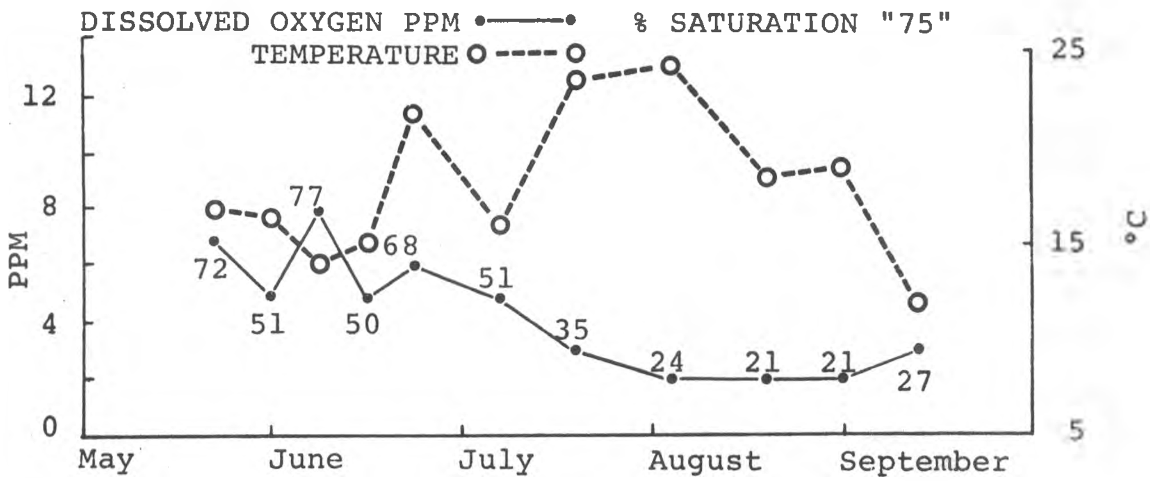


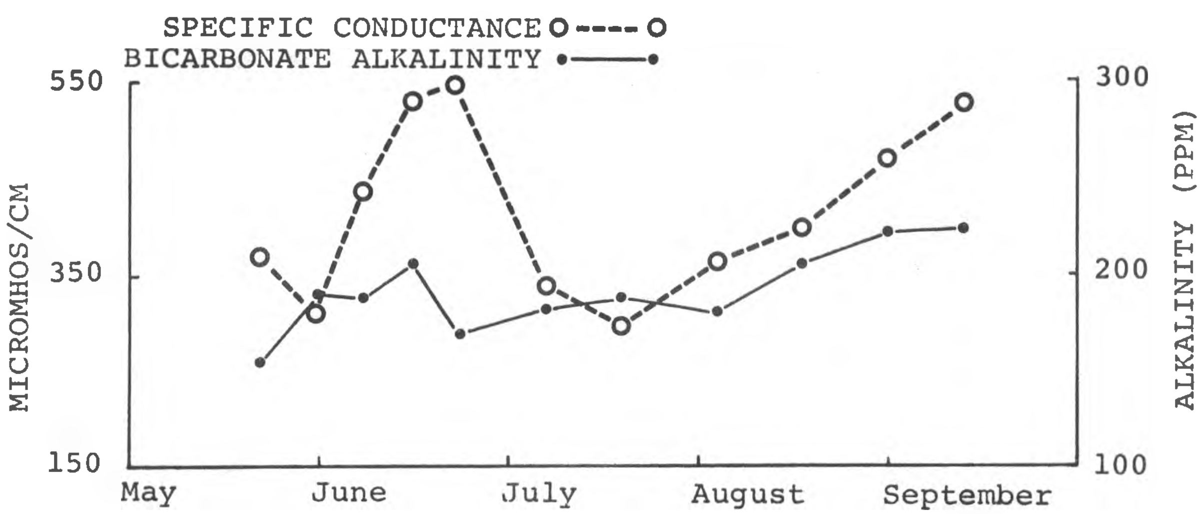


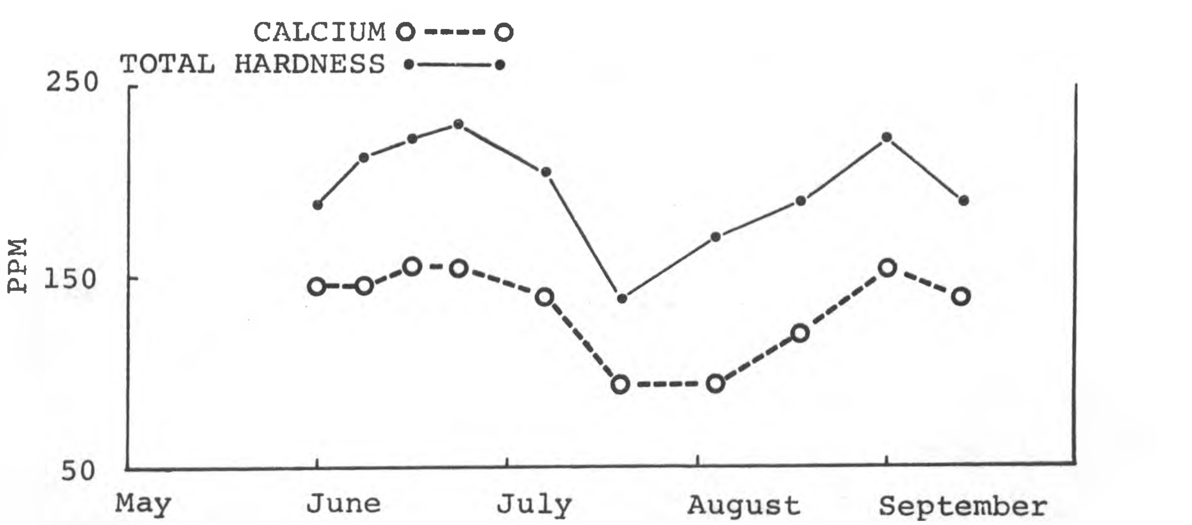


APPENDIX 18

Variation in Selected Chemical and Physical Parameters for Station 9 on the Sturgeon River, Summer 1971.

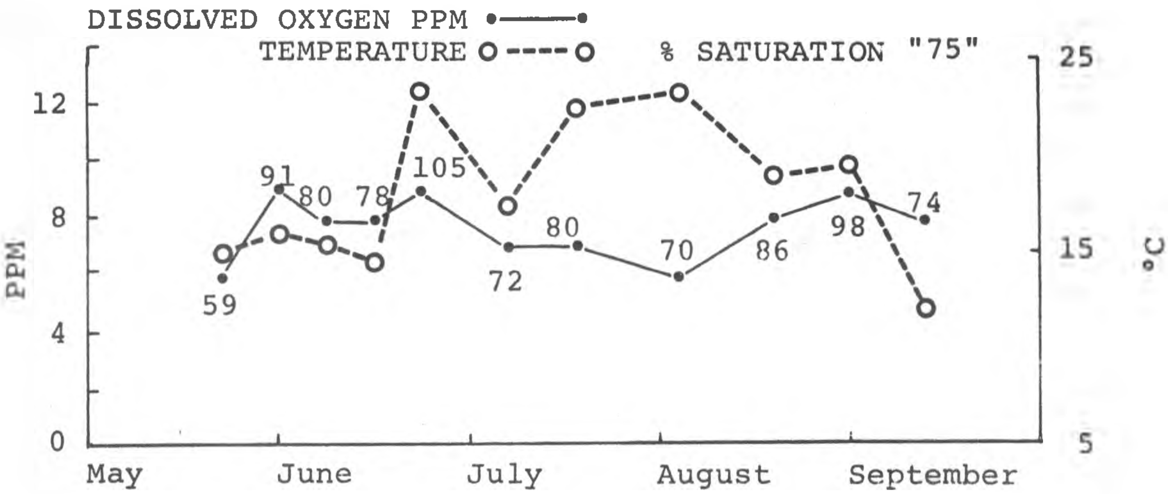


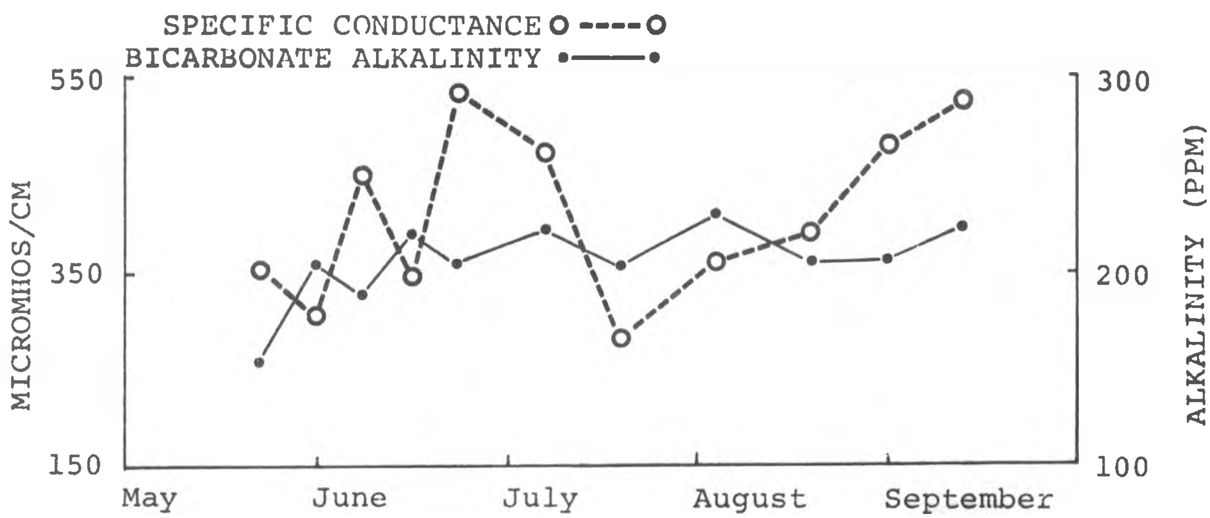


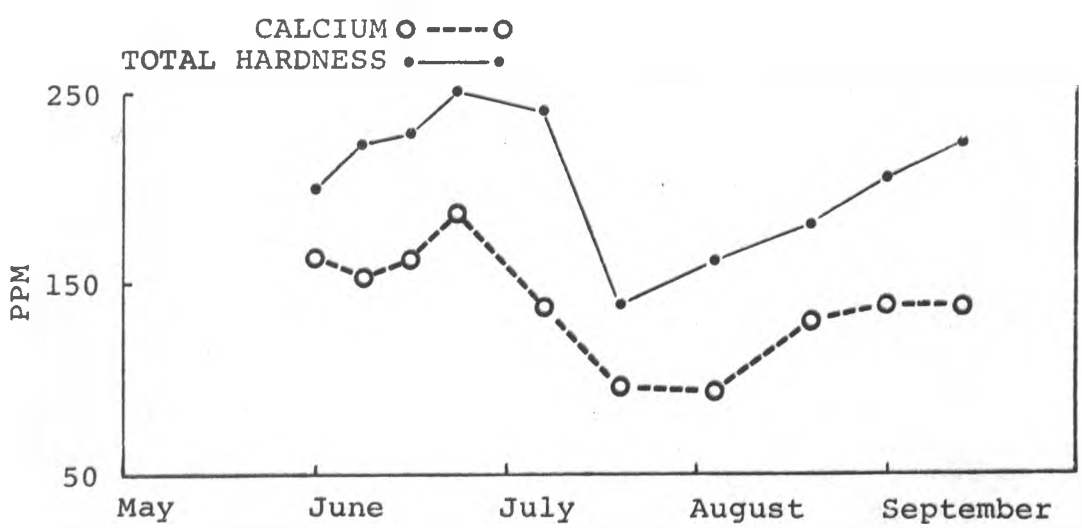


APPENDIX 19

Variation in Selected Chemical and Physical Parameters for Station 10 on the Sturgeon River, Summer 1971.







APPENDIX 20

Size of Gamefish Species Taken in Sturgeon River

Section	Species	Fork Length (mm)	Weight (g)
E1	Northern Pike	555	1420
	"	578	1170
	"	430	630
	"	397	420
	"	360	360
	"	290	190
	"	100	-
	Yellow Perch	190	-
	"	170	-
	"	150	-
	"	145	-
	"	145	-
	"	140	-
E2	Northern Pike	168	-
	"	165	-
	"	148	-
	"	140	-
	Walleye	180	-
	Yellow Perch	160	-
	"	145	-
	"	135	-
E3	Northern Pike	690	2600
	"	678	2440
	"	690	2440
	"	680	2200
	"	655	2200
	"	615	1960
	"	660	1920
	"	670	1870
	"	660	1740
	"	610	1520
	"	583	1400
	"	570	1320
	"	575	1260
	"	570	1060
	"	535	1060
	"	540	1020
	"	510	1000
	"	510	1000

APPENDIX 20 (cont'd)

Section	Species	Fork Length (mm)	Weight (g)
E3	Northern Pike	503	970
	"	510	950
	"	500	940
	"	520	920
	"	500	840
	"	495	840
	"	468	820
	"	400	800
	"	467	790
	"	480	760
	"	470	760
	"	465	740
	"	452	675
	"	436	595
	"	440	590
	"	450	570
	"	429	565
	"	420	560
	"	420	520
	"	400	500
	"	418	490
	"	390	480
	"	300	410
	"	335	400
	"	377	340
	"	330	320
	"	320	280
	"	320	260
	"	285	180
	"	280	180
	"	285	170
	"	260	140
	"	270	130
	"	260	120
	"	210	100
	Yellow Perch	240	220
	"	240	200
	"	215	120
	"	180	40
	"	160	40
	"	125	20

APPENDIX 20 (cont'd)

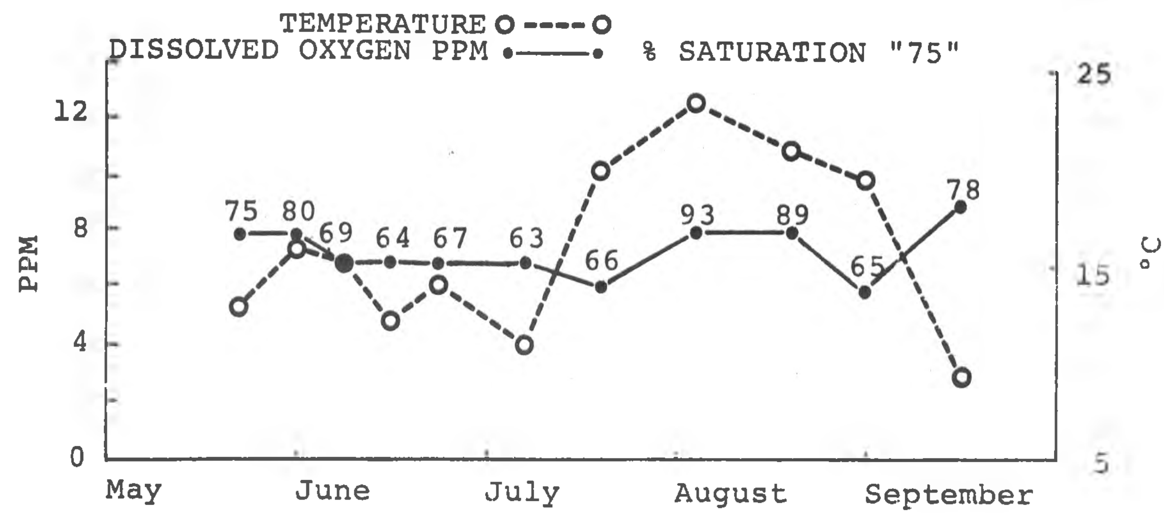
Section	Species	Fork Length (mm)	Weight (g)
E4	Northern Pike	527	1180
	"	440	840
	"	354	560
	"	343	360
	"	335	370
	"	344	355
	"	369	340
	"	345	340
	"	344	340
	"	300	340
	"	325	300
	"	330	260
	"	306	210
	"	279	170
	"	265	160
	"	198	110
E5	Northern Pike	560	1250
	"	490	910
	"	490	858
	"	450	770
	"	460	720
	"	400	700
	"	440	690
	"	440	690
	"	450	640
	"	427	585
	"	405	545
	"	410	540
	"	390	510
	"	330	300
	"	290	240
	"	315	205
	"	310	200
	"	285	200
	"	290	156
	Walleye	320	200

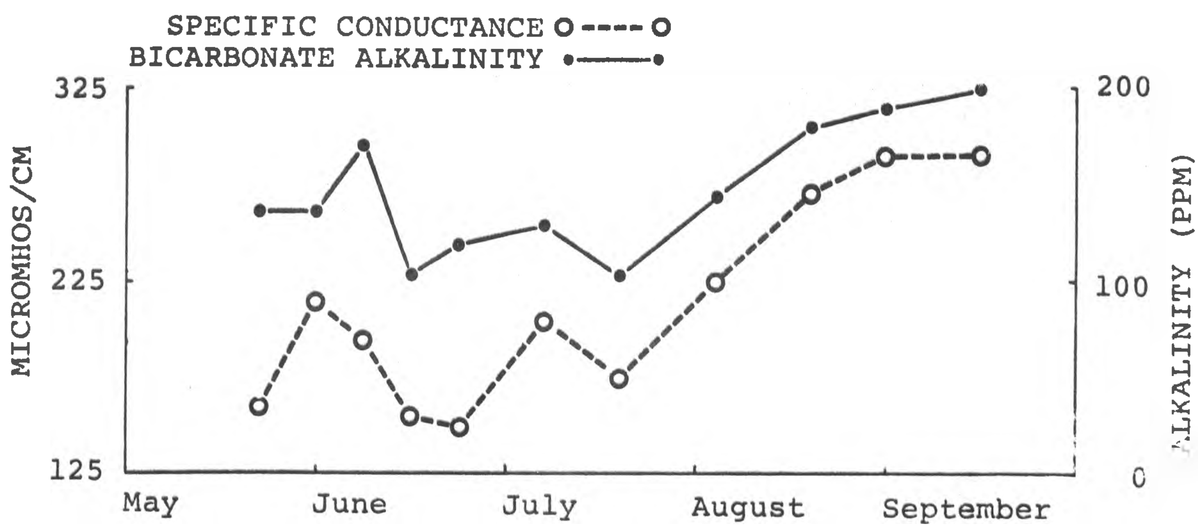
APPENDIX 20 (cont'd)

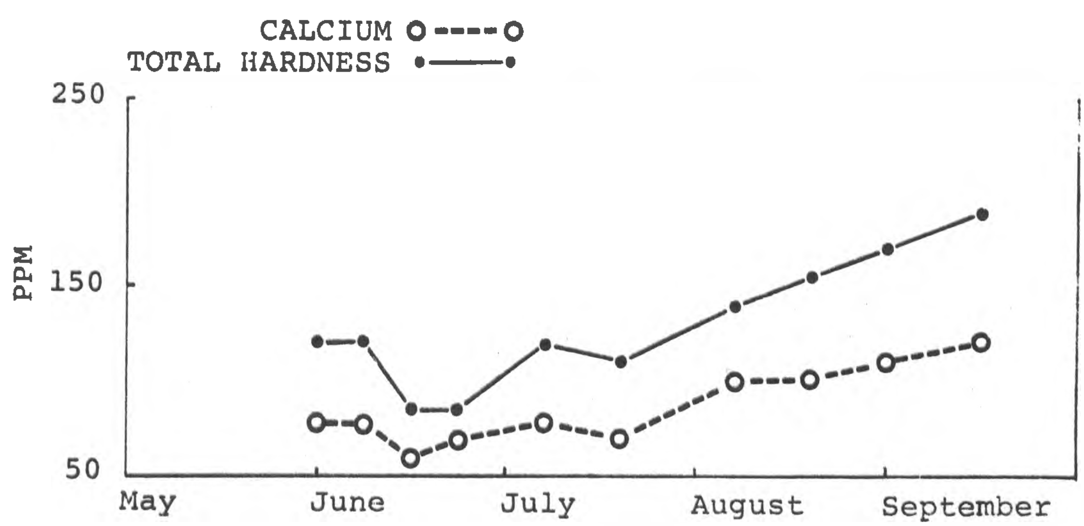
Section	Species	Fork Length (mm)	Weight (g)
E6	Northern Pike	397	395
	"	403	380
	"	353	365
	"	358	360
		3 juveniles	
	Goldeye	371	560
	"	356	480
	"	341	470
	"	338	402
E7	Northern Pike	396	605
	"	385	365
	"	370	305
	"	375	300
	"	355	285
	"	355	280
	"	330	245
	"	330	240
	"	323	225
	"	349	205
	"	317	180
	"	260	100
	"	250	85
	"	246	60
	Sauger	287	285

APPENDIX 21

Variation in Selected Chemical and Physical Parameters for Station 1 on the Pembina River, Summer 1971.

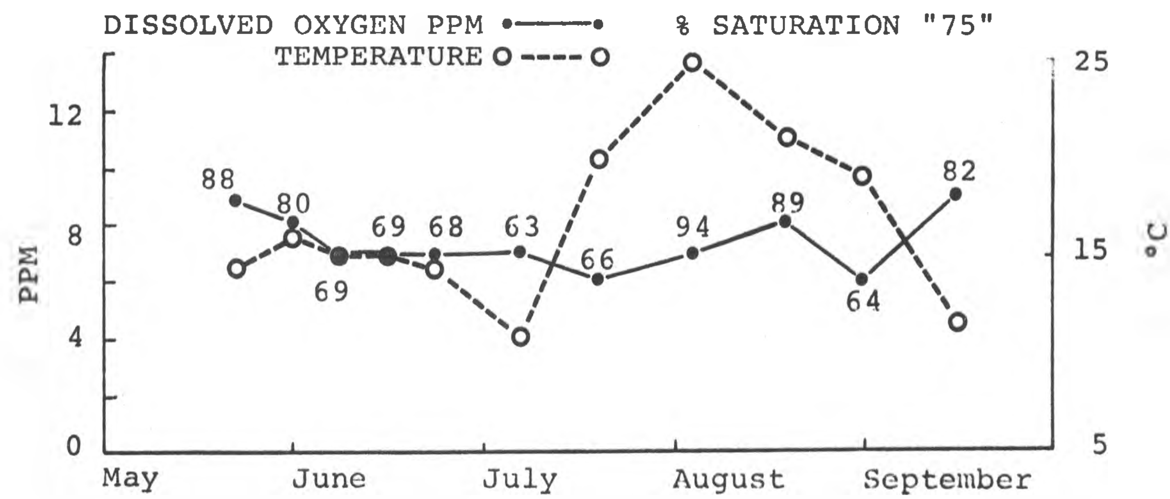


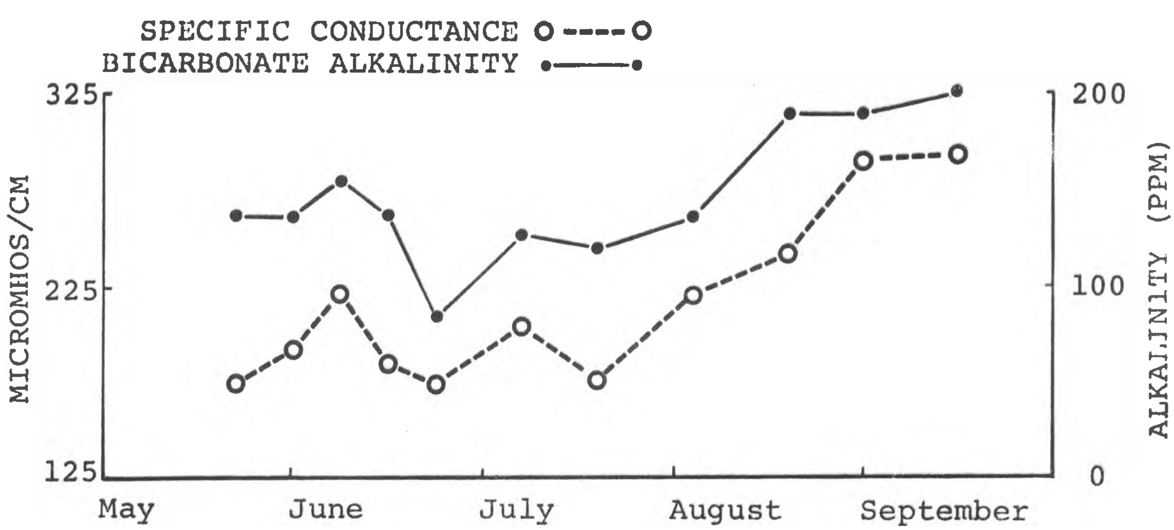


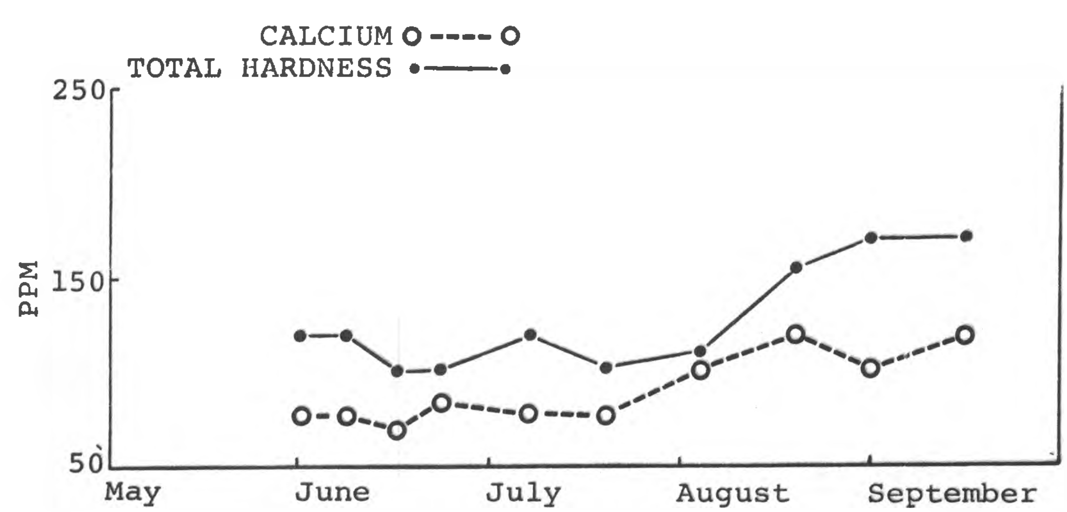


APPENDIX 22

Variation in Selected Chemical and Physical Parameters for Station 2 on the Pembina River, Summer 1971.

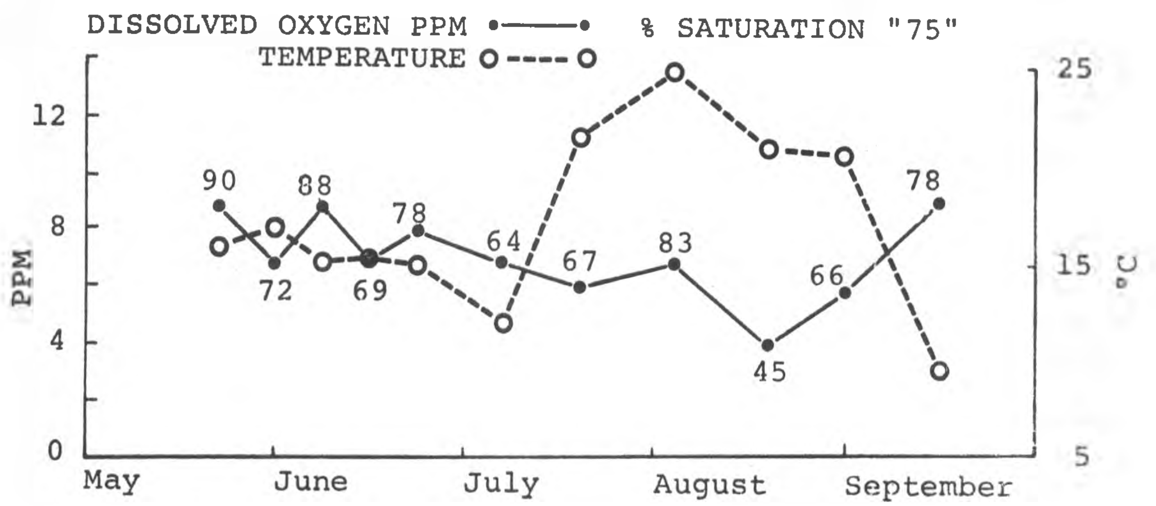


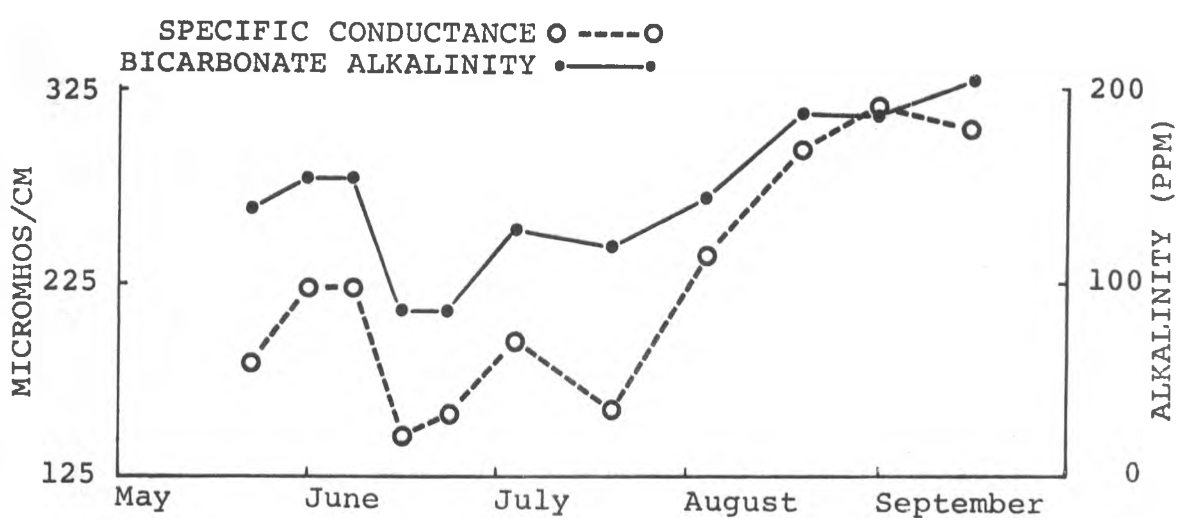


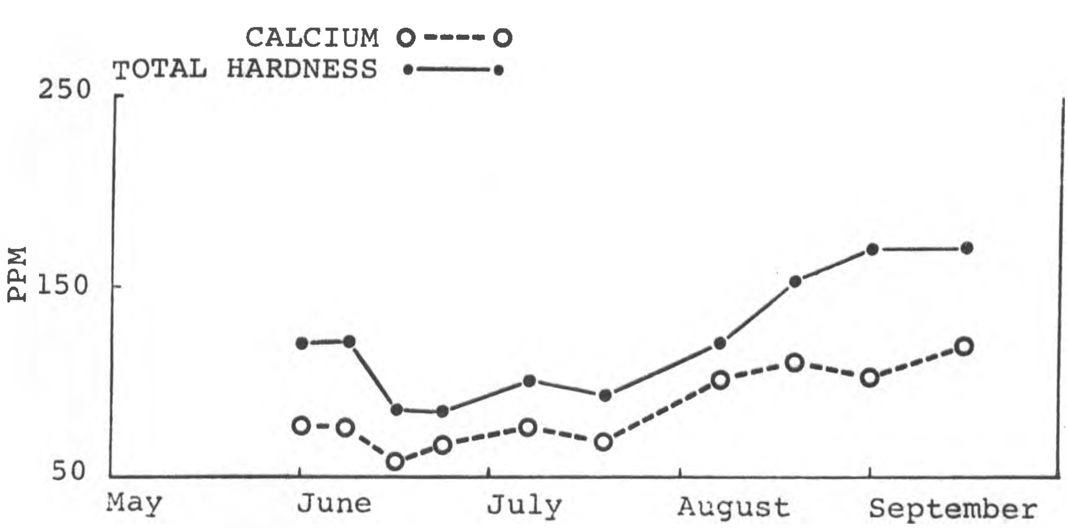


APPENDIX 23

Variation in Selected Chemical and Physical Parameters for Station 3 on the Pembina River, Summer 1971.

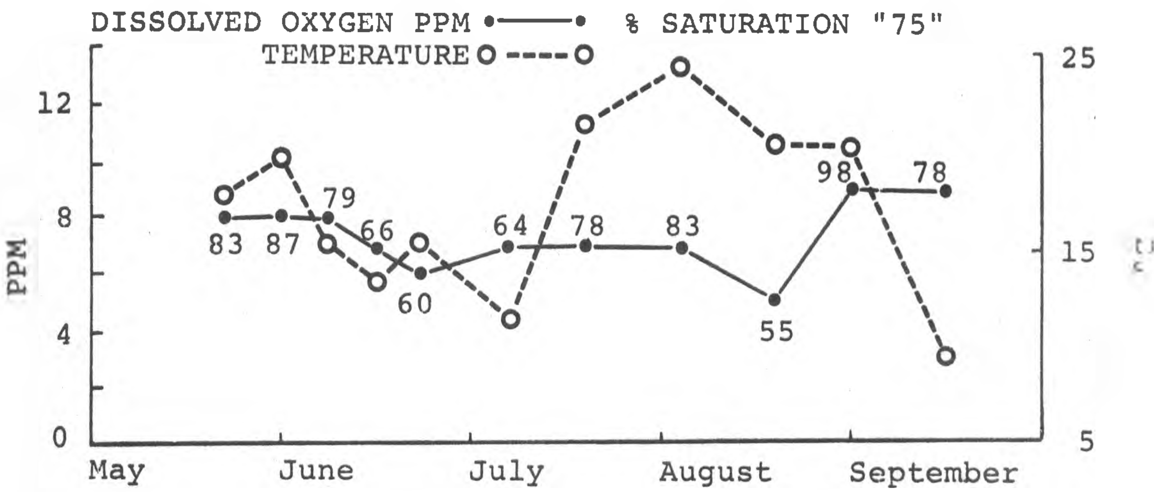


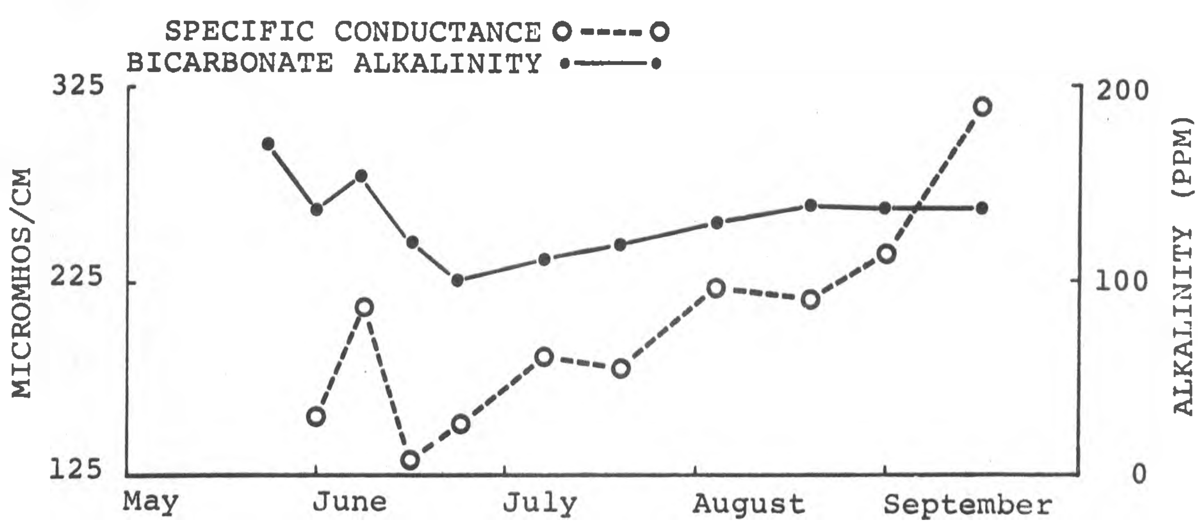


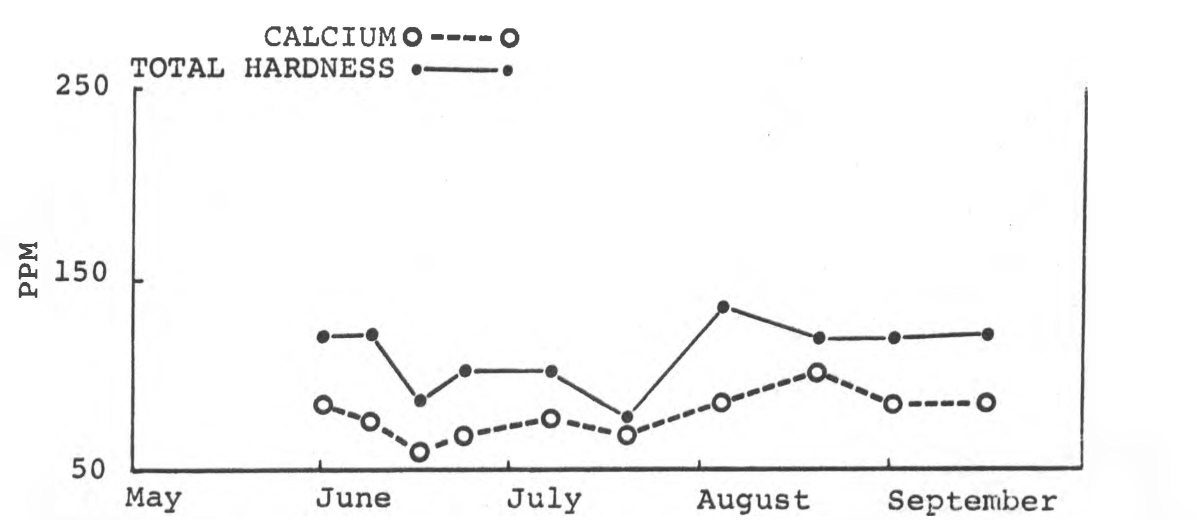


APPENDIX 24

Variation in Selected Chemical and Physical Parameters for Station 4 on the Pembina River, Summer 1971.

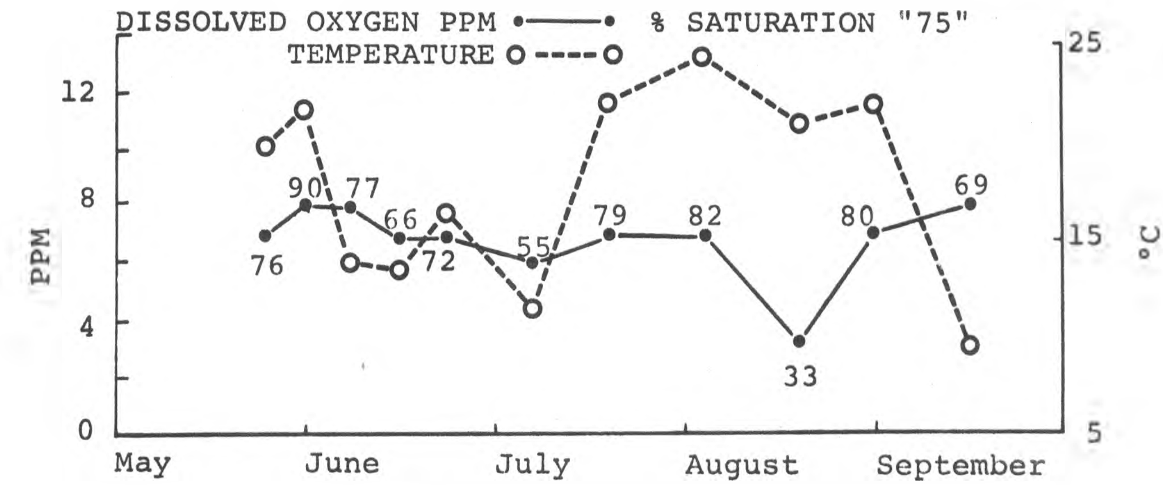


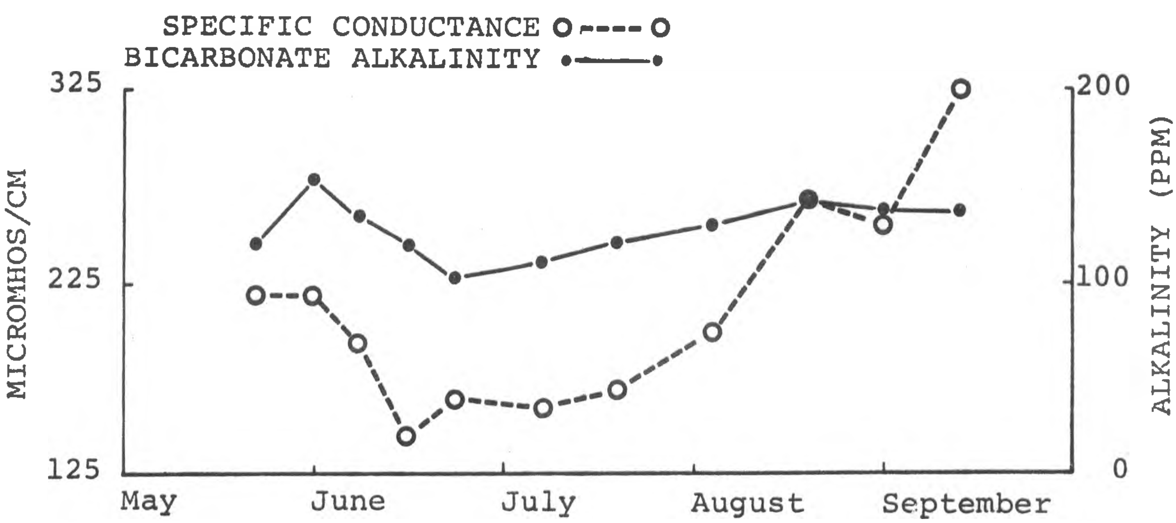


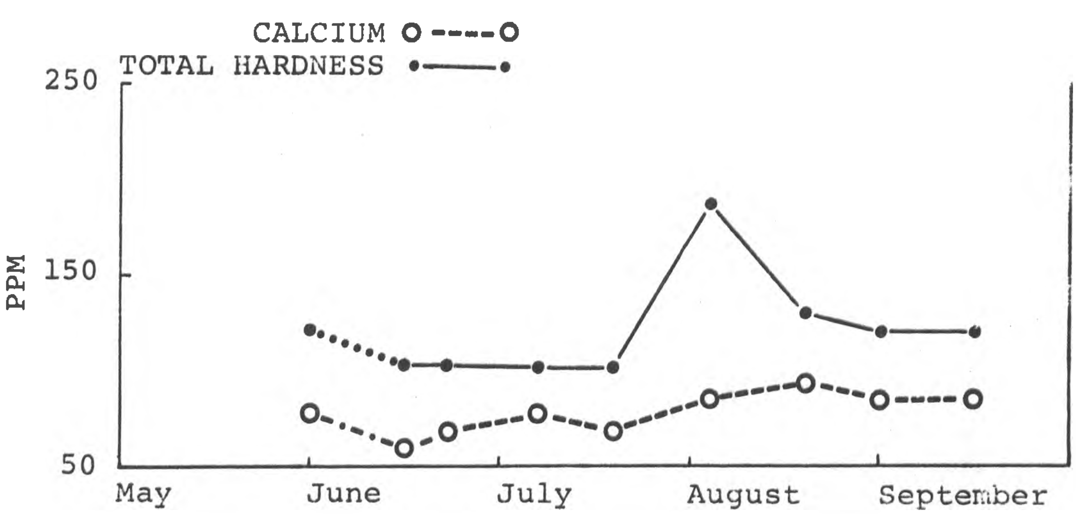


APPENDIX 25

Variation in Selected Chemical and Physical Parameters for Station 5 on the Pembina River, Summer 1971.

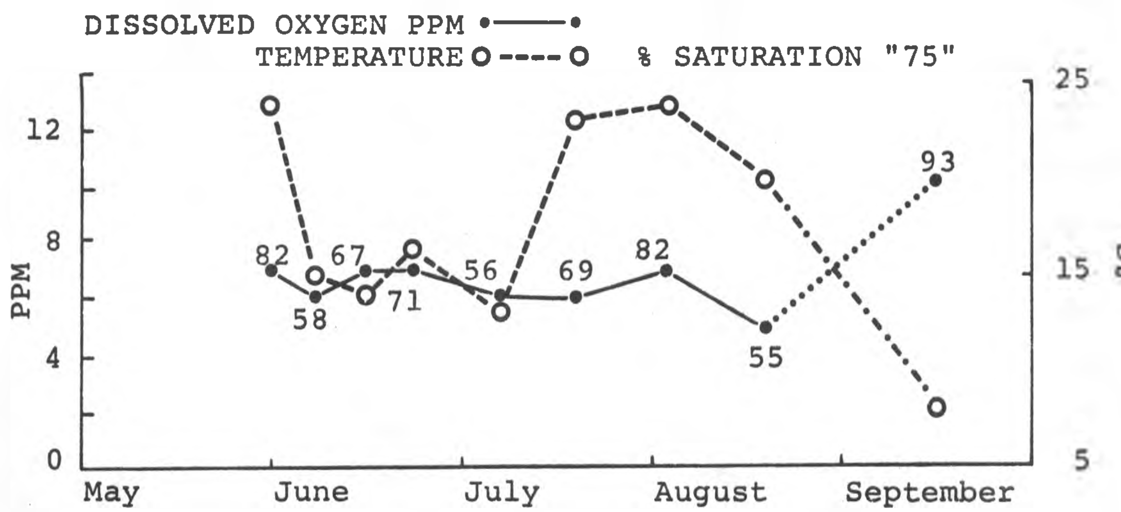


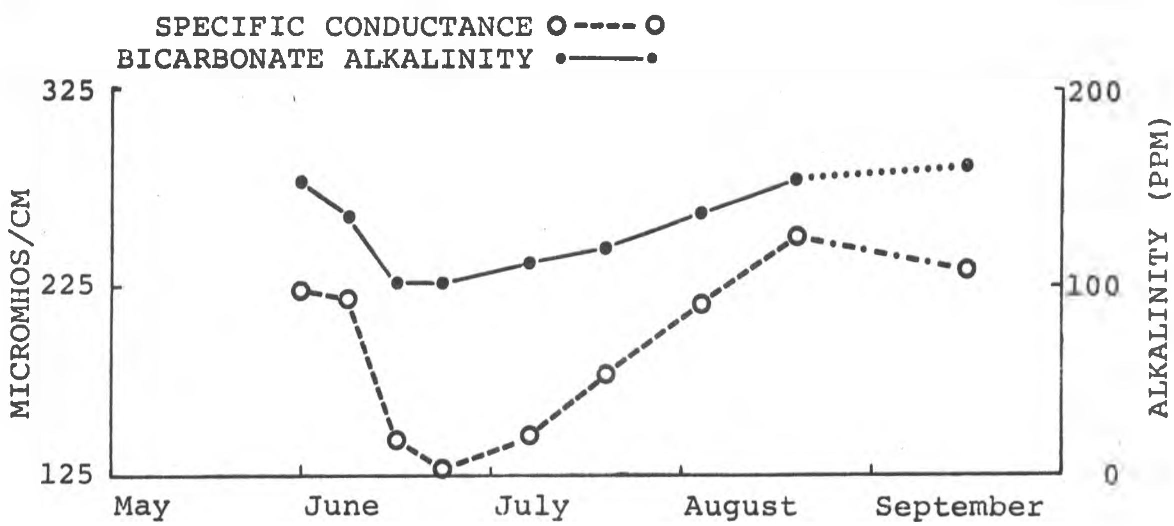


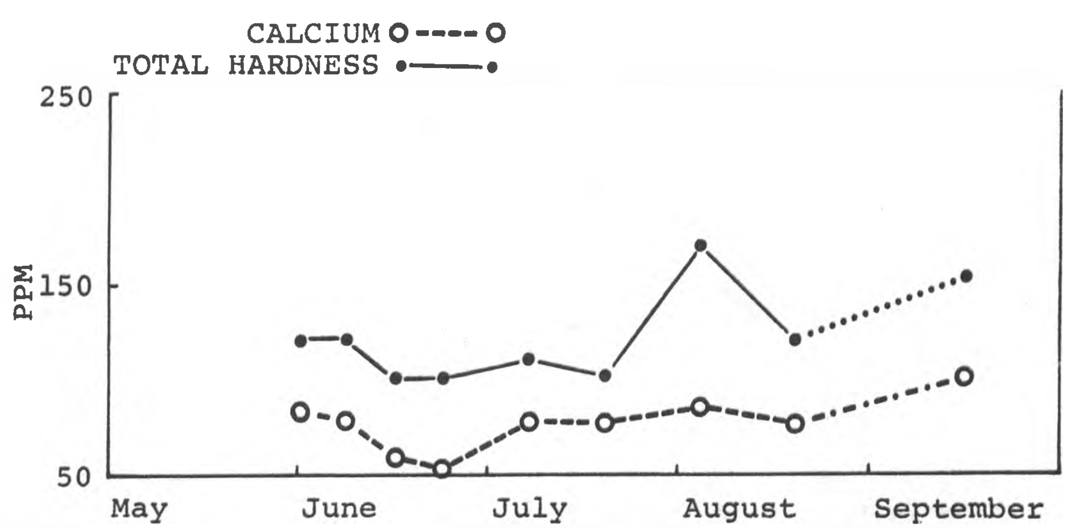


APPENDIX 26

Variation in Selected Chemical and Physical Parameters for Station 6 on the Pembina River, Summer 1971.

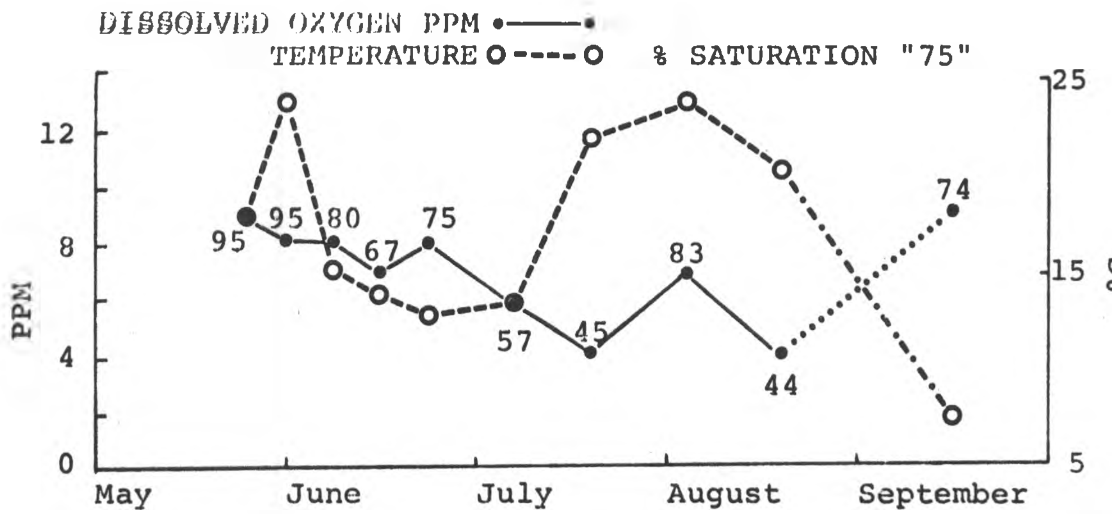


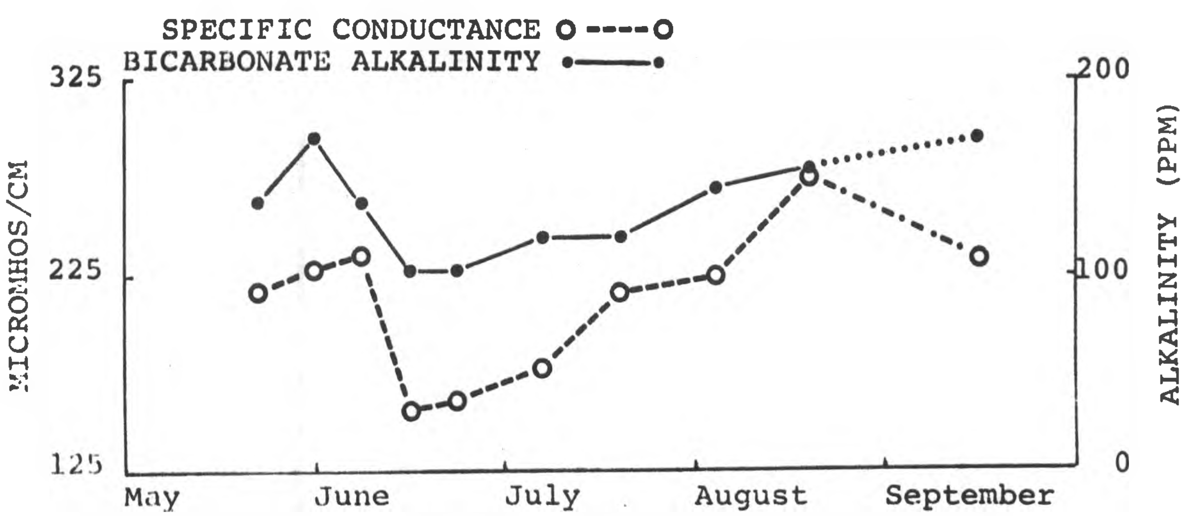


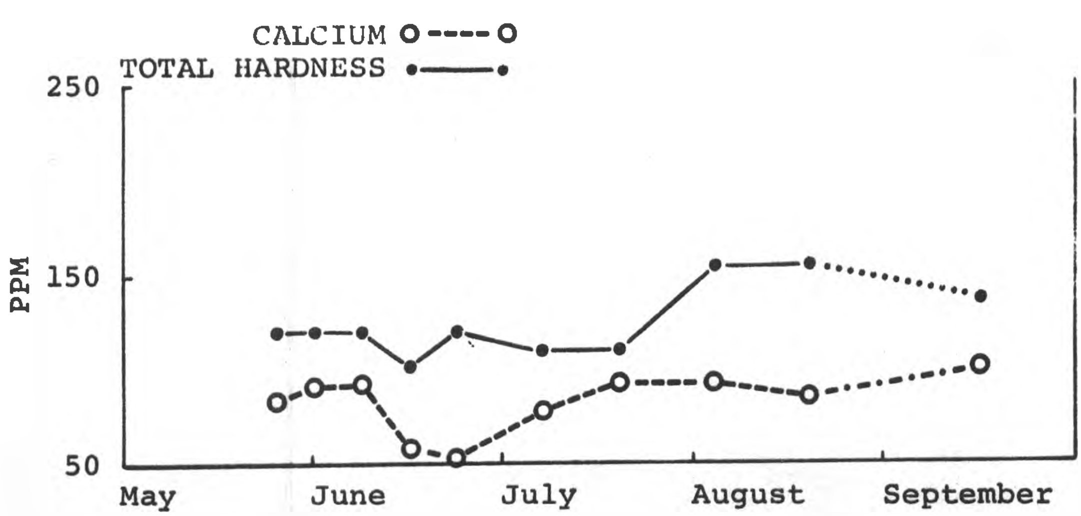


APPENDIX 27

Variation in Selected Chemical and Physical Parameters for Station 7 on the Pembina River, Summer 1971.

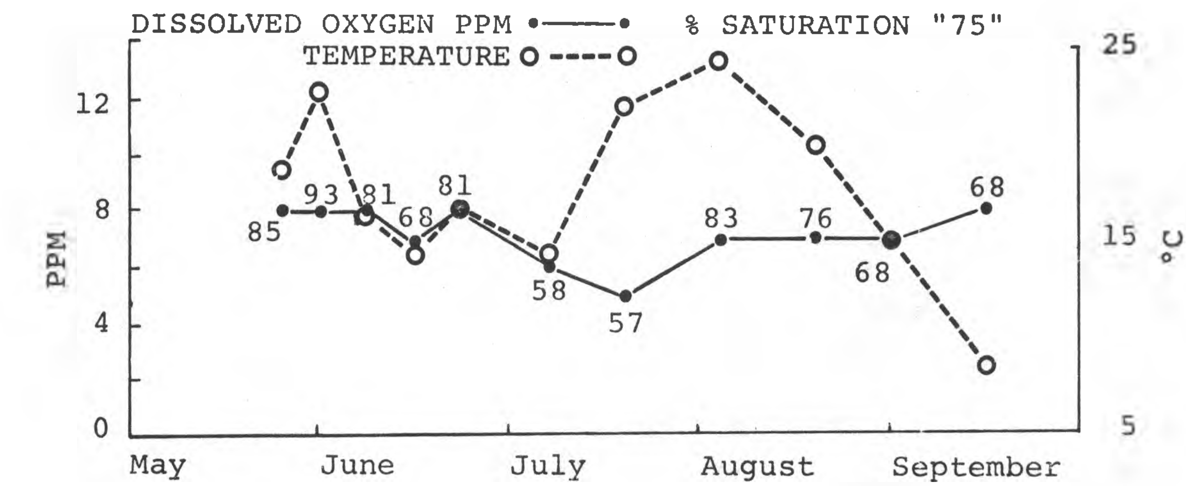


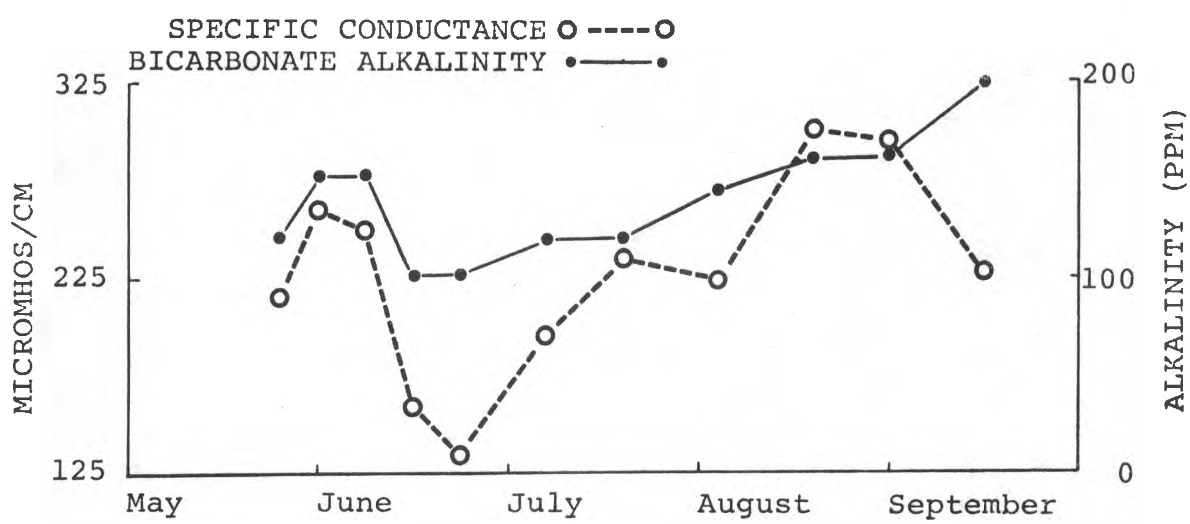


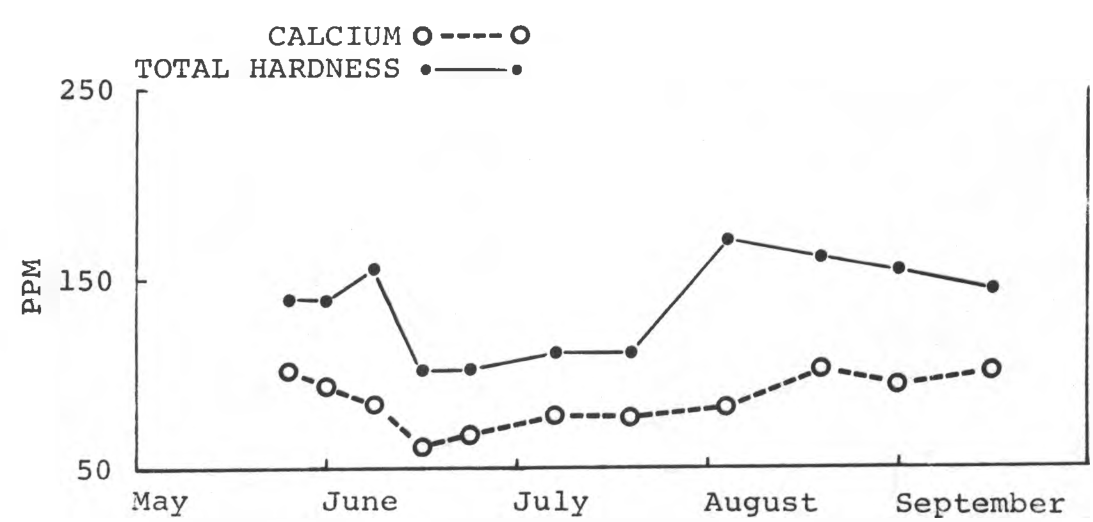


APPENDIX 28

Variation in Selected Chemical and Physical Parameters for Station 8 on the Pembina River, Summer 1971.

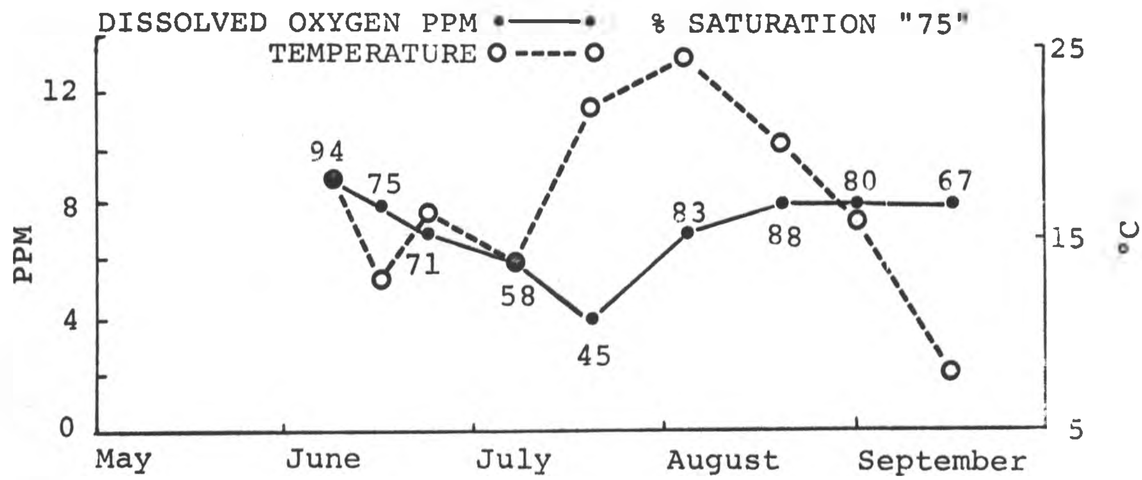


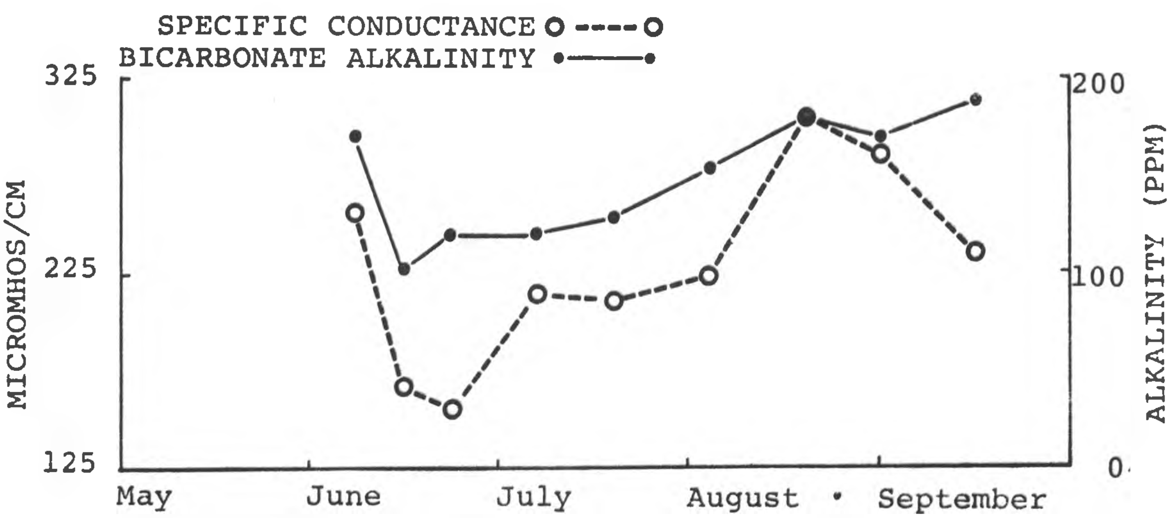


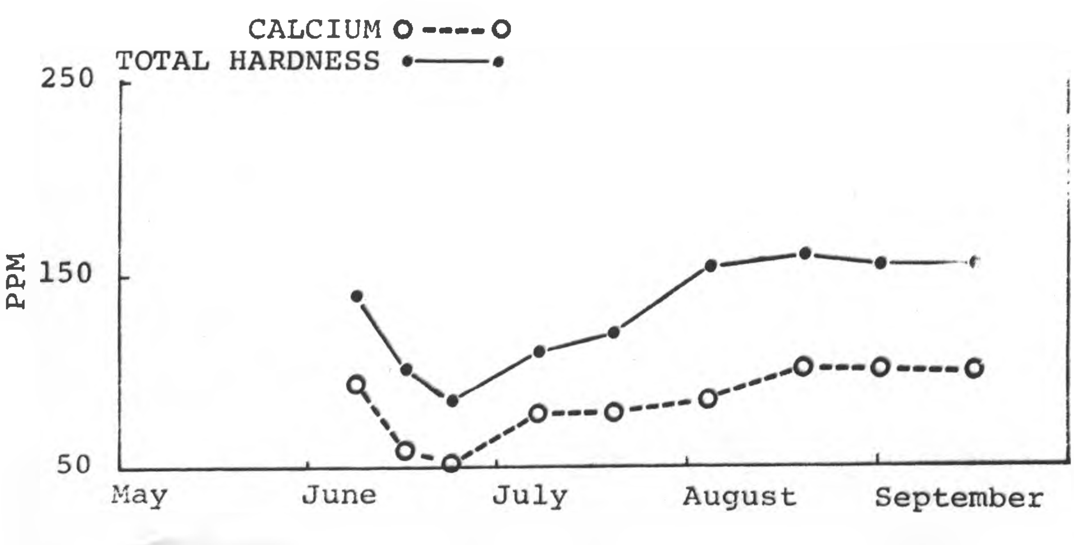


APPENDIX 29

Variation in Selected Chemical and Physical Parameters for Station 9 on the Pembina River, Summer 1971.







APPENDIX 30

Measurements of Gamefish Collected in Pembina River, 1971

Location	Date	Length (mm.)	Weight (g.)
Mountain Whitefish			
E1	August 8, 1971	310	300
		260	205
E2	August 8 and 13, 1971	345	585
		325	360
		290	250
		276	220
		265	195
		251	175
		249	170
		245	140
		220	195
		215	100
E3	July 28, 1971	310	290
	August 11, 1971	300	280
E6	September 10, 1971	one approx. 100mm.	
E7	September 27, 1971	230	125
		one approx. 100 mm.	
Walleye			
E1	August 8, 1971	370	600
		285	200
E2	August 7, 1971	320	320
E3	July 28, August 10, 11, 1971	325	290
		320	390
		304	250
		300	223
		291	215
		175	125
E4	August 24, 1971	343	365
E5	September 9, 1971	420	740
		size approx. 150 mm.	

APPENDIX 30 (cont'd)

Location	Date	Length	Weight
Walleye (continued)			
E6	September 10, 1971	287	243
		239	
		one approx. 150 mm.	
E7	September 27, 1971	529*	1840
		510	1270
		420*	720
		417*	840
		394*	600
		385*	540
		370*	520
		357	385
		325*	320
		310	240
		one approx. 190 mm.	
Goldeye			
E4	August 27, 1971	345	445
E6	September 10, 1971	450	990
		380	660
		371	560
E7	September 27, 1971	403	770
		400	760
		400	720
		397	730
		395*	720
		385	710
		373	560
		370	520
		368*	600
		368*	600
		367*	620
		365	590
		362*	410
		360*	520
		355	480
		354*	520
		353	440
		350*	460
		350	520
		349*	540

APPENDIX 30 (cont'd)

Location	Date	Length	Weight
Goldeye (continued)			
E7	September 27, 1971	347	460
		343	385
		342*	480
		328	400
		327*	360
		322	400
Northern Pike			
E3	July 28, 1971	352	250
E7	September 27, 1971	700	3200
		466	680
		465	630
		400	460

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* Collected with gill nets at the confluence of the Pembina and Athabasca Rivers.

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